Evolving Legal Standards for the Admissibility of Scientific Evidence

BERT BLACK

Ensuring the scientific validity of scientific evidence has always posed problems for judges and lawyers largely untrained in science. As recent cases involving the health effects of chemicals and drugs make clear, however, irrational and inconsistent decisions result when courts do not hold expert witnesses to the standards and criteria of their own disciplines. A trend toward more thorough judicial review of scientific claims has developed, and it should be encouraged.

THE LAW LOOKS TO SCIENCE FOR ANSWERS TO FACTUAL questions that lie beyond the understanding and knowledge of nonscientists, but at the same time judges without scientific training must determine whether those answers are reliable enough to warrant their use at trial (*1, 2*). This need to evaluate expertise while simultaneously depending on it creates a fundamental tension that permeates and shapes the way in which courts decide the admissibility of scientific evidence. The law's contact with science almost always comes through expert witnesses, who are called precisely because of their special ability to reason and draw inferences (*3*). Judges, however, have generally refused to probe the validity of the reasoning behind a scientist's conclusions or to hold experts to the standards and criteria of scientific practice (*4*).

Instead, courts have developed two modes of analysis that focus on surrogate factors not always indicative of valid scientific reasoning (*5*). For forensic techniques or methods, such as polygraph lie detection, the traditional legal standard is general acceptance (*6*). For medical testimony, however, the analysis usually centers on an expert's credentials (*7*), the kind of data or information upon which he or she bases an opinion (*8*), or on the certainty with which the opinion is expressed (*9*).

This fragmented approach has never worked well, but in recent years its deficiencies have become increasingly apparent, especially in litigation about latent diseases allegedly caused by exposure to chemicals, or the use of pharmaceuticals or other products. Such cases are often referred to as "toxic tort" cases (*10*). Although they involve complex and controversial medical science, some courts have persisted in focusing on the traditional surrogate factors for deciding admissibility, rather than on the reasoning underlying expert opinions. Perhaps because of ill-defined concerns that plaintiffs who make latent injury claims will not be able to meet their burden of proving causation, these courts refuse to hold experts to the standards of their own professions. Decisions wholly out of keeping with accepted scientific knowledge have resulted. Other courts, however, have undertaken more searching analyses of the reasoning underlying disputed medical testimony. Their decisions point the way to a consistent and rational standard for judging the admissibility of all scientific evidence.

The author is an attorney with Venable, Baetjer and Howard, 1800 Mercantile Bank Building, Two Hopkins Plaza, Baltimore, MD 21201.

Forensic Science and the General Acceptance Test

The general acceptance test for forensic science originated in *Frye v. United States* (*11*), a case decided by the United States Court of Appeals for the District of Columbia in 1923. The defendant in *Frye* had been convicted of a murder he claimed he had not committed. At trial he had unsuccessfully attempted to introduce evidence that he had passed a systolic blood pressure deception test, a precursor of the modern polygraph lie detector. In affirming the trial court's refusal to admit this evidence, the Court of Appeals articulated the now venerable rule of general acceptance:

> Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.

Although *Frye* can be interpreted as requiring a generally accepted reasoning process, its focus on "the thing from which [a] deduction is made," rather than on the way in which the deduction is made, has caused great confusion. Courts using the test generally do not address the validity of the reasoning used by an expert to reach his or her conclusions, and legal decisions entirely out of keeping with accepted scientific practice often result. Two cases, both decided since 1980, and both involving the analysis of bloodstains with electrophoresis, illustrate how the traditional approach to forensic science fails to provide a clear standard, and why it is necessary for courts to consider scientific criteria when deciding the admissibility of testimony based on forensic techniques. The courts in both cases purported to apply the *Frye* test, but because one considered the reasoning underlying the disputed technique, and the other did not, they reached quite opposite results.

In the first case, *State v. Washington* (*12*), the defendant was convicted of a rape-murder. During the crime the murderer had apparently cut himself, and part of the evidence against the defendant was an analysis supposedly showing that his blood matched bloodstains found at the crime scene. The defendant appealed, claiming that the method of analysis was neither accepted nor reliable, and that the state crime laboratory technician who had testified was not a qualified expert.

The Supreme Court of Kansas affirmed the conviction in *Washington*, relying heavily on the fact that the contested analysis was accepted by law enforcement professionals as fast, consistent, and reliable (*12*, p. 989). The court's consideration of the underlying reasoning was so cursory, however, that it failed even to mention that the "multisystem" technique at issue was intended to maximize the amount of information obtained from a single sample through the separation of different kinds of molecules by electrophoresis (*13; 14*, p. 279). Layered gel media are used, and after electrophoretic separation of proteins (including enzymes), stains are applied to the gel surface to identify which genetic markers (proteins) are present (*14,* p. 279).

Although electrophoresis is generally recognized and used for a multitude of purposes (*14,* p. 277; *15*), the multisystem technique is different from other applications. It was designed by police scientists for police work, and it involves unresolved questions about the reliability of the use of several stains sequentially on a single gel layer to identify several specific genetic markers (*14,* p. 279). There are also questions about how the deterioration of blood affects the reliability of the test (*14*, pp. 277–279), and about the effects of crime scene contaminants, such as bacteria, in a sample (*14*, pp. 281–283). The conflicting expert testimony in *Washington* involved differing views about the meaning of an unpublished study of the multisystem test's ability to make a precise and accurate determination of a match between samples. The Law Enforcement Assistance Administration had sponsored this study, but had decided not to publish the results (*14*, p. 280n.47). The court, however, did not consider the validity of the reasoning connecting this study to the claim that the test produced reliable and accurate results.

The court's refusal to look behind the assertions of the state's witness led to a decision that diverged sharply from the accepted practices and criteria of science. In particular, the ability of the multisystem method reliably to identify specific blood enzymes had not been established through the kind of objective experimentation, criticism, and review upon which scientists typically rely (*16*). Faced with similar evidence, and two of the same experts, the Supreme Court of Michigan undertook the examination of reasoning from which the Kansas Court had abstained and came to the opposite holding on admissibility. Its decision in *People v. Young* (*14*) makes clear the deficiencies overlooked in *Washington*.

The defendant in *Young* was also linked to a murder by comparing his blood with stains found at the scene of the crime, and he also appealed the admissibility of multisystem evidence. Where the court in *Washington* failed to mention electrophoresis, the *Young* court provided a description of the theory underlying the test, explaining how electrophoresis separates proteins through the use of an electric current (*14,* p. 273), and how proteins are thereafter identified by staining (*14,* p. 279). In *Washington*, the underlying theory was essentially ignored, and the court accepted a technician's testimony as sufficient evidence to establish the reliability of the disputed test (*12*, pp. 993–994). In *Young*, however, the court's recognition of the importance of the underlying theory led it to hold that a scientist's testimony was required (*14*, pp. 274–275).

The *Young* court further recognized that evaluation of scientific testimony requires consideration of the way scientists themselves determine whether a theory or its application is valid. "The scientific tradition expects independent verification of new procedures. . . . It is scientists not responsible for the original research that [sic] confirm its validity" (*14*, p. 283). On the basis of this standard, the multisystem test failed. The only data supporting it were found in the unpublished study, which had been conducted by the developer of the technique (*14*, pp. 283–284). By basing its decision on a review of scientific reasoning in the light of scientific criteria, the *Young* court avoided the mistakes of *Washington*. The contrast between the two decisions clearly demonstrates that although the traditional *Frye* approach permits thorough analysis, its failure to focus on the question of reasoning and the standards of science can lead to less than adequate consideration of the scientific validity of expert opinions.

Not surprisingly, *Frye* has evoked considerable criticism. As Judge Edward Becker of the Third Circuit put it in a 1985 opinion, general acceptance "has proved to be too malleable to provide the method for orderly and uniform decision-making envisioned by some of its proponents" (*17*, p. 1237). The principal alternative to *Frye* is to treat scientific evidence in the same way that other evidence is treated, by weighing its probative value against its potential to mislead or confuse (*18*, p. 194). In practice, many courts that take this approach consider a number of factors, including acceptance (*18*, p. 194), and the resulting decisions are often similar to those that follow *Frye* (*19*, p. 209). The rejection of *Frye* may, however, mean less judicial review of scientific evidence and more reliance on the adversary system to expose shortcomings to the jury (*18*, p. 195; *20*).

Forensic Psychiatry and the Dangers of Insufficient Review

The dangers inherent in judicial reluctance to hold expert witnesses to the standards and practices of their scientific disciplines become particularly striking when testimony is presented that does not derive from relatively simple and well-defined techniques like electrophoresis or polygraph lie detection. For example, without reference to *Frye* or any other special test for admissibility, courts have both accepted and rejected the use of psychiatric predictions of future dangerousness for purposes of sentencing. This kind of expert testimony may quite literally mean the difference between life and death, but many courts are unwilling to accept the overwhelming consensus among psychiatrists that such predictions cannot be made reliably.

The U.S. Supreme Court's decision in *Barefoot v. Estelle* (*21*) is perhaps the most egregious example of how courts refuse to accept the limitations of psychiatry and refuse to hold psychiatrists to the accepted standards of their own profession. The defendant in *Barefoot* was convicted of murdering a police officer, and under the applicable Texas law, he was sentenced at a hearing separate from the guilt phase of his trial. One of the factors the jury had to consider on sentencing was the probability "that the defendant would commit [future] criminal acts of violence that would constitute a continuing threat to society" (*22*). To establish this probability, the state called two psychiatrists, who testified that Mr. Barefoot would pose such a threat. The jury then sentenced him to death.

In affirming *Barefoot*, the Supreme Court explicitly rejected the position taken by the American Psychiatric Association that clinical predictions of dangerousness are fundamentally of low reliability, and that psychiatrists possess no special qualifications for making such forecasts (*23, 24*). Instead, the court reasoned that if lay people can reach conclusions about future dangerousness, psychiatrists must surely be able to do so too (*21*, pp. 896–897), which completely reverses the justification for admitting expert opinions. Experts testify because their training permits them rationally to draw inferences that others cannot reach, not because they can do as well as nonexperts.

Not all courts agree with *Barefoot*. In *People v. Murtishaw* (*25*), for example, the Supreme Court of California reversed the imposition of a death sentence, holding that it was improper to admit psychiatric predictions of future violent conduct during the penalty phase of a trial. Though the court did not follow *Frye,* its decision, unlike that

of the U.S. Supreme Court in *Barefoot*, was largely influenced by the reservations voiced by members of the psychiatric profession about predictions of future violent behavior.

Thus judicial decisions reached without reference to *Frye* vary just as widely as those that follow the *Frye* precedent. Whatever rule is ostensibly followed, decisions about the admissibility of scientific evidence will consistently accord with scientific reality only if courts look to the criteria and practices recognized by scientists. This holds true for medical as well as forensic science, but courts have been especially hesitant to examine the reasoning through which medical doctors reach their conclusions.

Traditional Medical Testimony

The deviation from scientific practice in *Barefoot* reflects the deference accorded medical doctors in American society, and the tendency of courts to place very little constraint on their testimony. Indeed, the Supreme Court emphasized the fact that despite the consensus against predicting antisocial conduct, "there are those doctors who are quite willing to testify at the sentencing hearing" (*21*, p. 899). This rationale merely begs the question, however, of how a court is to prevent a jury from relying on a doctor whose conclusions do not derive from medical science.

The traditional approach to medical testimony does little to address this question. When the opinion of a medical expert is disputed, courts generally look to his or her qualifications, the kind of facts upon which the opinion is based, and the certainty with which the opinion is expressed. The reasoning connecting facts to conclusions is usually ignored.

The qualifications test is not at all rigorous. The law presumes, without much concern about field of specialization, that any licensed physician is a qualified expert (*26*). Even in malpractice cases, which usually involve the standard of practice within a speciality, doctors frequently testify about areas outside their own fields (*27*). In fact, doctors are sometimes allowed to testify about matters completely outside the scope of their profession. Forensic pathologists, who examine gunshot wounds, often testify about how guns work and offer opinions about the caliber of deformed bullets (*28*).

When courts focus on the factual basis for a doctor's opinion, rather than on his or her qualifications, the legal analysis is not much improved. In *Pike County Highway v. Fowler* (*29*), an osteopath testified that an injury to the plaintiff's foot had caused circulatory problems that eventually led to the amputation of the foot, but the treating surgeon thought arteriosclerotic obstructive disease had been the cause. Though the defendant argued that the osteopath's theory of causation was logically impossible, the Indiana Court of Appeals did not see his reasoning as an important issue. "Except for his subsequent explanation . . . [the osteopath] had already laid out a thorough factual foundation for his opinion" (*29*, p. 635).

The expressed certainty test similarly fails as a rational approach to deciding the admissibility of medical testimony. In *Bertram v. Wunning* (*30*), a doctor testified that there was a 90% chance that an automobile accident had caused the plaintiff's hernia, but he would not say that this constituted "reasonable medical certainty," because he did not know what this meant. This refusal to use the "magic words" of certainty led the Missouri Court of Appeals to reverse a verdict for the plaintiff and to remand for retrial. The second time around the witness gave almost the same testimony, but added that for him 90% would be reasonably medically certain. After a second plaintiff's verdict, both sides appealed on a number of points, and still a third trial was ordered. On the expert's opinion, however, the appellate court made it clear that "the testimony in the instant case materially differs from that he gave at the first trial . . . [because there was] a definite affirmance [of] 'reasonable medical certainty' " (*31*, p. 125).

Only rarely do courts probe the meaning of reasonable certainty and how a doctor arrives at it, and when they do look beyond the phraseology the results can be quite amusing. In *Leibowitz v. Ortho Pharmaceutical Corp.* (*32*), a Pennsylvania case, the testimony of one of the plaintiff's experts became so confused that the judge intervened to ask if the witness meant to say that there was reasonable medical certainty about causation. Thus pressed, the doctor said he thought oral contraceptives made by the defendant company had been a "significant factor" in bringing about the plaintiff's thrombophlebitis. On cross-examination, however, he said "I refuse to use the term 'cause' in any part of my practice" (*32*, p. 454). What he really thought about medical certainty was never made clear.

Despite its flaws, the traditional way of dealing with medical testimony does have seeming procedural virtues. A court that does not look beyond factors like qualifications and expressed certainty need not expend time looking into a doctor's reasoning process and how it measures up to the standards and criteria of medical science. As cases like *Pike County Highway* and *Bertram v. Wunning* show, however, this uncritical approach can break down even for testimony about relatively simple traumatic injuries. When courts have to resolve disputes about more complex and controversial medical testimony, the breakdown becomes more apparent, and the consequences more significant.

Toxic Torts, Sympathy for Plaintiffs, and the Rejection of Scientific Standards

In toxic tort cases involving latent diseases such as cancer, the central issue is usually the adequacy of the proof of causation, and the disagreements between experts can be quite profound. The seriousness of the diseases, plus multiple plaintiffs and extensive publicity, can make the outcome of the debate a matter of millions of dollars (*33*). The litigation over Agent Orange settled for $180 million (*34*), and at one point the company that made Bendectin (an antinausea drug for pregnant women) offered a total of $120 million to settle with plaintiffs who claimed the drug had caused birth defects (*35*, p. 1216). The company has won most cases that have actually gone to trial (*36*). In one case, however, the plaintiff won a verdict for $95 million, since reduced to $20 million (*36*). Both sides have appealed.

Cases like these have made scientific issues increasingly apparent, but some courts have continued to base decisions about disputed science on traditional surrogate factors like expressed certainty. In *Ferebee v. Chevron Chemical Co.* (*37*), for example, the U.S. Court of Appeals for the District of Columbia held that for questions "at the frontier of current medical and epidemiological inquiry, if experts are willing to testify [about causation], it is for the jury to decide whether to credit such testimony" (*37*, p. 1534). The plaintiff in *Ferebee* claimed his pulmonary fibrosis had resulted from exposure to Paraquat, an herbicide made by Chevron. After losing at trial, Chevron appealed, arguing that all recognized ill-effects of Paraquat occur within a short time of exposure and cease when exposure ends, and that the plaintiff's illness did not come close to this pattern. He had not experienced any symptoms until 10 months after he had last used the herbicide (*37*, p. 1535).

The Court of Appeals refused to consider the substance of this argument, relying instead on its "willing testifier" rule. In its decision the court explicitly rejected scientific standards. "In a courtroom the test for allowing a plaintiff to recover in a tort suit of this type is not scientific certainty but legal sufficiency. . . . [T]he fact that . . . science would require more evidence before conclusive-

ly considering the causation question resolved is irrelevant" (*37*, p. 1536).

In the toxic tort context, this refusal to judge an expert's opinions according to the criteria of his or her profession can lead to results that clearly conflict with accepted scientific knowledge. In *Wells v. Ortho Pharmaceutical Corp.* (*38*), which involved birth defects allegedly caused by a spermicidal jelly, the U.S. Court of Appeals for the 11th Circuit followed *Ferebee* and affirmed a plaintiff's verdict for about $5 million. The medical community, in a rare outcry, took the legal system to task for essentially ignoring the well-established scientific consensus that spermicides are not teratogenic (*39*). At least one court in a Bendectin case has also followed *Ferebee* (*40*), producing a result in direct contradiction to other decisions, in which courts have rejected testimony about causation as having no scientific merit (*41, 42*).

Wells highlights the failings of the traditional judicial analysis of evidence based on medical science, but some commentators see the approach as a useful and desirable way to facilitate plaintiffs' verdicts in toxic tort cases. Indeed, this viewpoint may well be the real motivation behind the decisions in both *Wells* and *Ferebee*. The law places on a plaintiff the burden of proving that allegations of a causal link between a disease and exposure to a chemical are more likely than not true (*43*, pp. 764–765), which can make gaps in scientific knowledge fatal to a plaintiff's claim. To avoid this result, a few commentators have advocated circumvention of the usual plaintiff's burden by applying a special standard to scientific claims when they appear in a legal context.

One recent law review note concludes that "[a]t the heart of the problem presently confronted by the courts in toxic tort suits is the inability to determine causation quantitatively when trans-scientific [beyond the scope of scientific knowledge] issues are involved" (*44*, p. 431). The note goes on to call for a new standard of liability, adjusted "to the inability of trans-science to quantify the effects of a substance. It must also resolve or circumvent the evidentiary and procedural problems resulting from the inherently hypothetical, rather than factual, nature of trans-science" (*44*, p. 443). Law professor Charles Nesson goes even further, advocating not only relaxed standards, but also presuming to explain how scientists should conduct their work. Although scientists are reluctant to extrapolate from studies of laboratory animals to reach conclusions about the effects of chemicals on humans (*45*), he has written that doctors should assume that humans are more susceptible than rats to latent disease after exposure to a suspect substance (*46*, p. 532).

Although it would make it easier for some ill people to obtain money, the Nesson approach (*46*) would do far more harm than good. When, as in the *Wells* case, the law becomes uncoupled from scientific reality, uncertainty and the inhibition of scientific progress necessarily result (*47*). A manufacturer contemplating the development of new drugs or other products cannot make rational decisions if the risk of liability is unrelated to scientific evidence about causation. *Ferebee* and *Wells* do not, however, represent the only judicial response to toxic tort cases.

Active Judicial Review of Scientific Evidence

In a growing number of toxic tort cases, courts have begun to take the kind of approach followed in *People v. Young*, the Michigan forensic blood analysis case. These courts look closely at experts' reasoning, and they require that scientists conform to the standards and criteria of science. Perhaps the best known example of more active judicial control comes from the Agent Orange litigation, a class action in which Vietnam veterans and their families sued companies that had made an herbicide used for defoliation in Vietnam. The plaintiffs sought compensation for diseases and injuries allegedly caused by dioxin, a trace impurity in the Agent Orange defoliant. When some plaintiffs refused to settle, and insisted on pressing their claims, Chief Judge Jack Weinstein of the U.S. District Court for the Eastern District of New York held their evidence of causation to be insufficient as a matter of law and granted judgment in favor of the defendants.

The plaintiffs' experts had endeavored to extrapolate from studies on the effects of high-level exposure of animals. The court noted of one expert that his reasoning reduced to this: "the [plaintiffs] complain of various medical problems; animals and workers exposed to extensive dosages of [dioxin] have suffered from related difficulties; therefore assuming nothing else caused the [plaintiffs'] afflictions, Agent Orange caused them" (*48*, pp. 1237–1238). This use of animal studies was held inadmissible. There was no evidence that the plaintiffs had been exposed to the high animal study concentrations, and in any event the differences between humans and other species meant the studies were more likely to mislead than to help the jury (*48*, p. 1241).

Other courts have taken a similar approach. In *Johnston v. United States* (*49*), a case in which plaintiffs claimed that they had been injured by low-level radiation, the U.S. District Court for Kansas was even more emphatic in its rejection of reasoning that fell short of scientific standards. The court castigated the plaintiffs' experts for giving testimony that, "in the Court's view, they would not dare report in a peer reviewed format" (*49*, p. 415). They had been unable to cite any confirmation of their conclusions, and as the court put it, "[a]nyone who has been trained in the scientific method realizes that a hypothesis is a scientists's educated speculation. The scientist then designs experiments to test his hypothesis in order to determine whether or not his speculation is correct. . . . That is how scientists learn what is fact and what is not true" (*49*, p. 393).

At least two courts have been equally demanding in Bendectin cases. In *Lynch v. Merrell-National Laboratories* (*41*), the Court of Appeals for the First Circuit, like the court in the Agent Orange case, rejected attempts to extrapolate animal test results to humans and also rejected a reanalysis of epidemiologic data because the reanalysis had never been refereed or published (*41*, p. 1195). In *Richardson v. Richardson-Merrell, Inc.* (*42*), the U.S. District Court for the District of Columbia held that "the issue [of causation] being a scientific one, reasonable jurors could not reject [the scientific] consensus [that Bendectin is safe] without indulging in precisely the same speculation and conjecture which the multiple investigations undertook, but failed to confirm" (*42*, p. 803).

The choice between the Agent Orange and *Lynch* line of decisions and the decisions in cases like *Ferebee* and *Wells* should be clear. When courts allow deviation from accepted scientific practices, litigation becomes little more than a "crapshoot," a term used by one of the plaintiffs' lawyers to describe the Bendectin litigation (*50*). The current trend seems to favor active and more searching judicial review of scientific evidence (*51*), and this trend should be encouraged.

Conclusion

Although courts have traditionally avoided evaluation of the theory or reasoning underlying scientific evidence, a more active approach has begun to evolve. Especially in toxic tort cases, a growing number of courts now delve into the reasoning behind an expert's conclusions and require that this reasoning reflect accepted scientific practice. As society grows more tied to science and technology, and more enamored of litigation, this development becomes increasingly necessary. The law should seek verdicts con-

sistent with scientific reality, and with each other, and it can achieve this goal only by requiring scientific evidence to conform to the standards and critiera to which scientists themselves adhere.

REFERENCES AND NOTES

1. P. C. Giannelli, *Columbia Law Rev.* **80**, 1197 (1980).
2. J. W. Strong, *Univ. Ill. Law Forum* **1970**, 1 (1970).
3. A. H. McCoid, *UCLA Law Rev.* **2**, 356 (1955).
4. B. Black, *Fordham Law Rev.*, in press.
5. The approach taken in any given case will depend to some extent on the jurisdiction. In 1975 Congress adopted the Federal Rules of Evidence, which apply in all federal courts. Thirty-one states, the military, and Puerto Rico have also adopted various forms of these rules [J. Weinstein and M. Berger, *Weinstein's Evidence* (Bender, New York, 1987), vol. 1, p. T-1]. There is still variation in the treatment of scientific evidence, however, even within the federal court system, and almost all jurisdictions, both before and since the adoption of the new rules, tend to view forensic science differently than they do medical science.
6. S. M. Egesdal, *Georgetown Law J.* **74**, 1769 (1986).
7. The qualification aspect of the traditional approach is reflected in Rule 702 of the Federal Rules of Evidence, which allows experts qualified by "knowledge, skill, experience, training, or education" to give opinion testimony if it will assist in understanding the evidence of a case or in determining a fact in issue.
8. The data or information aspect is reflected in Rule 703 of the Federal Rules of Evidence, which allows an expert to base an opinion on facts or data not in evidence if "of a type reasonably relied upon by experts in the particular field."
9. The expressed certainty aspect is not explicitly codified in the Federal Rules of Evidence, but derives from numerous cases. For example, the highest courts in Pennsylvania and Missouri have sustained plaintiffs' verdicts for cancer allegedly caused by trauma because of the certainty expressed by plaintiffs' experts. *Menarde v. Philadelphia Transportation Co.*, 103 A.2d 681 (Pa. 1954); *Peterson v. Kansas City Public Service Co.*, 259 S.W.2d 789 (Mo. 1953).
10. An excellent discussion of the variety of cases that fall within the "toxic tort" rubric is provided by K. R. Feinberg, *Houston Law Rev.* **24**, 155 (1987).
11. *Frye v. United States*, 293 F. 1013 (D.C. Cir. 1923).
12. *State v. Washington*, 622 P.2d 986 (Kan. 1981).
13. R. N. Jonakait, *Emory Law J.* **31**, 833 (1982).
14. *People v. Young*, 391 N.W.2d 270 (Mich. 1986).
15. R. C. Allen, C. A. Saravis, H. R. Maurer, *Gel Electrophoresis and Isoelectric Focusing of Proteins* (DeGruyter, New York, 1984).
16. H. Siegel, *Philos. Sci.* **52**, 517 (1985); J. Ziman, in *Introductory Readings in the Philosophy of Science*, E. D. Klemke, R. Hollinger, A. D. Kline, Eds. (Prometheus, Buffalo, NY, 1980), p. 35; I. Lakatos, in *Scientific Revolutions*, I. Hacking, Ed. (Oxford Univ. Press, New York, 1981), p. 107.
17. *United States v. Downing*, 753 F.2d 1224 (3rd Cir. 1985).
18. P. C. Giannelli, in *Symposium on Science and the Rules of Evidence*, W. A. Thomas, Ed., 99 Fed. Rules Decisions 187, p. 189 (1983).
19. S. A. Saltzburg, in *ibid.*, p. 208. An example of how courts can reject *Frye* and still go through a very thorough analysis is provided by the Oregon Supreme Court's decision in *State v. Brown* [687 P.2d 751 (Ore. 1984)], in which polygraph evidence was excluded, just as it would have been under the general acceptance test.
20. As an example, the Supreme Court of Wisconsin, in *Watson v. State* [219 N.W.2d 398 (Wis. 1974)], held hair comparison evidence to be admissible without even considering what technique had been used to make the comparison. The court based its decision on the belief that any deficiencies would be exposed by cross-examination.
21. *Barefoot v. Estelle*, 463 U.S. 880, rehearing denied, 464 U.S. 874 (1983).
22. *Texas Code Crim. Proc. Ann.*, Art. 37.071(b)(2) (Vernon 1981).
23. See *Barefoot v. Estelle (21)*, J. Blackmun, dissenting, p. 916.
24. B. L. Diamond, *Univ. Penn. Law Rev.* **123**, 439 (1974).
25. *People v. Murtishaw*, 631 P.2d 446 (Cal. 1981), cert. denied, 455 U.S. 922 (1982).
26. E. F. Rose, *Toledo Law Rev.* **5**, 237 (1974).
27. Annotation, "Competency of physician or surgeon as an expert witness as affected by the fact that he is not a specialist," 54 *Am. Law Rep.* 860 (1928).
28. A. A. Moenssens, *William Mary Law Rev.* **25**, 545 (1984).
29. *Pike County Highway v. Fowler*, 388 N.E.2d 630 (Ind. App. 1979).
30. *Bertram v. Wunning*, 385 S.W.2d 803 (Mo. App. 1965).
31. ——, 417 S.W.2d 120 (Mo. App. 1967).
32. *Leibowitz v. Ortho Pharmaceutical Corp.*, 307 A.2d 449 (Pa. Sup. Ct. 1973).
33. D. Wagner, *Am. Bar Assoc.* **72**, 44 (February, 1986).
34. *In re "Agent Orange" Product Liability Litigation*, 597 F. Supp. 740 (E.D. N.Y. 1984), aff'd in part, rev'd in part, 818 F.2d 145 (2nd Cir. 1987).
35. *In re Richardson-Merrell, Inc. "Bendectin" Products Liability Litigation*, 624 F. Supp. 1212 (S.D. Ohio 1985).
36. *Inside Litigation* **1**, 44 (September 1987).
37. *Ferebee v. Chevron Chemical Co.*, 736 F.2d 1529 (D.C. Cir.), cert. denied, 469 U.S. 1062 (1984).
38. *Wells v. Ortho Pharmaceutical Corp.*, 788 F.2d 741, rehearing denied en banc, 795 F.2d 89 (11th Cir.), cert. denied, 107 S.Ct. 437 (1986).
39. J. L. Mills and D. Alexander, *New Engl. J. Med.* **315**, 1234 (1986), L. B. Holmes, *Am. Med. Assoc.* **256**, 3095 (1986) (letter).
40. *Oxendine v. Merrell Dow Pharmaceuticals, Inc.*, 506 A.2d 1100 (D.C. 1986).
41. *Lynch v. Merrell-National Laboratories*, 830 F.2d 1190 (1st Cir. 1987).
42. *Richardson v. Richardson-Merrell, Inc.*, 649 F. Supp. 799 (D. D.C. 1986) (currently under appeal).
43. B. Black and D. E. Lilienfeld, *Fordham Law Rev.* **52**, 732 (1984).
44. W. E. Wagner, *Yale Law J.* **96**, 428 (1986).
45. B. N. Ames, R. Magaw, L. S. Gold, *Science* **236**, 271 (1987); P. H. Abelson, *ibid.* **237**, 473 (1987).
46. C. Nesson, *Boston Univ. Law Rev.* **66**, 521 (1986).
47. P. Huber, *Columbia Law Rev.* **85**, 277 (1985).
48. *In re "Agent Orange" Product Liability Litigation*, 611 F. Supp. 1223 (E.D. N.Y. 1985), aff'd on other grounds, 818 F.2d 187 (2nd Cir. 1987).
49. *Johnston v. United States*, 597 F. Supp. 374 (D. Kan 1984).
50. J. Skinner, quoted in *The Cincinnati Enquirer*, 13 March 1985, p. A-16.
51. P. F. Rothstein and M. Crew, *Inside Litigation* **1**, 19 (April 1987).

52. I am indebted to J. H. Morris, Jr., and S. Black for their many helpful suggestions, both substantive and editorial.