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JUDGING SCIENCE: SCIENTIFIC KNOWLEDGE AND THE FEDERAL COURTS

By Kenneth R. Foster [1] & Peter W. Huber.[2]
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Scientists and lawyers cannot afford to speak like regular people. Expertise requires a special vocabulary replete with unusual words for unusual concepts, providing precise phrasing to convey distinct ideas. Specialists become fluent in their own professional tongues, absorbing the concepts and the peculiar meanings that allow them to communicate with each other. When specialties intersect, the clashing languages can create a Babel of confusion.

That Babel is never more confusing than when scientists enter the courtroom or lawyers enter the laboratory. One might ask, "What is scientific knowledge?" A simple enough question on the surface becomes a morass as these specialists disagree on even an approach to the issue. Who should decide: expert peers or lay juries? When do we need answers: after years of debate and experimentation or before the statute of limitations expires? The fundamental question must be answered, at least in the courtroom, because scientific knowledge can control the outcome in disputes as varied as murder prosecutions, drug recalls, paternity suits, and car accidents. Judges need to decide how to identify scientific evidence and how to weigh scientists' opinions.

In 1993, the Supreme Court made a new attempt to solve this problem. In *Daubert v. Merrell Dow Pharmaceuticals, Inc.*,[3] the Court cast aside seventy years of precedent by rejecting the rule set down in *Frye v. United States*[4] that scientific testimony is inadmissible unless it is based on a technique which is generally accepted within its field.[5] Instead, the Court presented judges with a new test of admissibility to apply when a party offers evidence claiming to be based on scientific expertise:

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3. 509 U.S. 579 (1993).
4. 293 F. 1013 (D.C. Cir. 1923).
5. *See id.* at 1014.

> [T]he trial judge must determine . . . whether the expert is proposing to testify to (1) scientific knowledge that (2) will assist the trier of fact to understand or determine a fact in issue . . . . Many factors will bear on the inquiry, and we do not presume to set out a definitive checklist or test. But some general observations are appropriate.[6]

In his dissent, Chief Justice Rehnquist complained that the majority's "general observations" were vague, abstract, and relied on amicus briefs filled with scientific and philosophical sources — "matters far afield from the expertise of judges."[7]

In their book, *Judging Science: Scientific Knowledge and the Federal Courts,* Kenneth Foster and Peter Huber attempt to explain those odd sources cited in the majority opinion, to educate lawyers about basic scientific thinking, and to give lawyers a context for the factors suggested by the Court's "general observations." The book uses the *Daubert* case itself, which involved litigation over whether the drug Bendectin caused birth defects, both to show the problems with flawed scientific testimony and to explain each of the concepts raised by the majority opinion. Remarkably free of the jargon of either profession, *Judging Science* offers a valuable way to think about science and its use in the courtroom.

This accomplishment makes *Judging Science* the perfect stocking stuffer for the federal judge in your life and an excellent volume for anyone interested in *Daubert* and the larger debate about science in the courtroom. This is neither a litigator's manual describing evidence that will meet the *Daubert* test nor an academic's critique offering a theoretical alternative; this is a polemic. While Foster and Huber's perspective mirrors Huber's earlier concerns about bad science[8] and about plaintiffs' attorneys and experts,[9] the authors' thorough analysis and their skillful writing make the book an invaluable tool for any lawyer venturing into the world of scientific thought.

6. *Daubert*, 509 U.S. at 592-93.

7. *Id.* at 599.

8. *See* PETER W. HUBER, GALILEO'S REVENGE: JUNK SCIENCE IN THE COURTROOM (1991).

9. *See, e.g.*, PETER W. HUBER, LIABILITY: THE LEGAL REVOLUTION AND ITS CONSEQUENCES (1988).

I. THE *DAUBERT* FACTORS

Judging Science breaks apart the *Daubert* opinion into its basic concepts, outlining what Foster and Huber believe the Justices intended. To determine whether evidence should be admitted as scientific, *Daubert* did not mandate a checklist. Rather, the Court suggested factors that judges should consider, and in distinct, readable chapters, *Judging Science* relies on scientific and philosophical sources to explain these factors. Among these are:

Testability and Falsification: A proposition is "scientific" if critics can somehow test it and prove it false. The Justices built on the theories of philosopher Karl Popper, who defined scientific knowledge as that which can be empirically refuted rather than that which has been proven undeniably true (p. 38). However, until a theory is actually proven false, its falsifiability is unsettled. For example, while modern critics say that Creation Science is unfalsifiable and therefore unscientific, Creation Scientists could similarly point to the innumerable assumptions inherent in paleontology to argue that Darwinism is as unfalsifiable as their own theories (p. 53).

While philosophers have largely abandoned Popper's exacting standard (p. 46), the authors maintain that falsifiability provides judges with a useful, although not definitive, test (pp. 234-35). For example, in the *Daubert* case, plaintiffs' expert Dr. Shanna Swan claimed that there was no evidence that Bendectin did not cause birth defects (pp. 12-13, 64). The authors maintain that the *Daubert* judges were correct to dismiss this ostensible scientific evidence because the conclusion was impossible to prove wrong (pp. 65-67).

Errors in Science: Errors may make scientific evidence either unreliable, because it is unrepeatable, or invalid, because it is interpreted incorrectly (p. 69). Foster and Huber admit that a large percentage of scientific claims turn out to contain errors (p. 83), but they do not offer judges any special way to detect the mistakes. Instead, they provide a basic education in error types, statistics, and meta-analysis. They note the flaws in how scientists detect error and encourage judges to be skeptical of all scientific claims (p. 235).

Reliability: If for nothing else, the book is worth its price for the nineteen pages in Chapter 5 in which Foster and Huber explain Bayes' Theorem and its application to decision-making (pp. 113-31). The mathematical theorem developed by Thomas Bayes has powerful uses in any situation where one must determine whether to believe another person's observation. Everyone from philosophers to prosecutors has tried to explain the concept to lay readers, and the muddled, jargon-encrusted failures far outnumber the successes. Happily, Foster and

Huber's concise, yet example-rich version successfully explains Bayes' Theorem.

Readers would benefit by reading *Judging Science* in the original, but an abridgement may show the practical value of Foster and Huber's prose. Bayes' Theorem explains problems that trip up the uninitiated, such as whether to trust the result of a Human Immunodeficiency Virus ("HIV") test that correctly detects the virus in 98% of infected people while producing false-positives for only 0.2% of uninfected people. The HIV test is said to have a sensitivity of 98% and a specificity of 99.8%, far better than most medical tests (p. 116). Juries convict defendants beyond a reasonable doubt on weaker evidence. Yet no doctor should rely on this test to determine that a patient has HIV.

Why? Because, as Bayes' Theorem explains, the reliability of any observation depends on both the accuracy of the test itself and the rate at which the measured event occurs in the world. According to Foster and Huber, very few Americans, about one in 3000, are infected with the HIV virus (p. 116). Therefore, even if only 0.2% of the uninfected people register as false positives, those false positives will far outnumber the true positives; of the people who test positive for HIV, only 14.8% actually have the disease (pp. 116-17).[10] The following Table shows that the test is both very accurate and very unreliable.

Table (reproduced from p. 116).

	HIV-Infected	**Not Infected**
Tests Positive	1,325 (true positives)	7,648 (false positives)
Tests Negative	23 (false negatives)	3,816,372 (true negatives)

Reliability is crucial when judges weigh the value of various tests. A test that professes to prove that a person suffered from chickenpox during childhood is probably reliable because almost everyone suffers from the disease; scientists and psychics would be equally as reliable on the issue (pp. 117, 119). Yet, a test for a rare condition (HIV or, as Foster and Huber claim, child exposure to sexual molestation) will be unreliable even if it were extremely accurate (p. 119). In toxic tort cases

10. *See* Paul D. Cleary et al., *Compulsory Premarital Screening for the Human Immunodeficiency Virus*, 258 JAMA 1757 (1987) (showing that the number of false positives outnumbered the number of true positives by more than five times).

like *Daubert*, the plaintiffs often claim that the defendant's product causes birth defects, but they can only claim that the product causes a small number of the birth defects within the general population. If even 10% of the world's birth defects were caused by a single product, Foster and Huber note that a test would have to claim 90% accuracy in order for a specific claim ("The product caused this child's defect") to be correct within 50% probability (p. 127). *Judging Science* goes on to point out the problem when the base rate cannot be calculated (p. 129).

II. THE EVOLUTION OF SCIENCE

Despite the authors' skills and the laudatory blurbs on the book jacket, *Judging Science* cannot be the final word on science and law. Foster and Huber view science as an ongoing process, in which a central core of solid knowledge is surrounded by rings of progressively newer, less accredited theories which are accepted, modified, or discarded over time as they make their way through the "knowledge filter" (pp. 157, 159). In determining admissibility, judges must act like editors of scientific journals, identifying faulty claims and probing how far the underlying principles have progressed through the knowledge filter (p. 241).

Judging Science optimistically views science as spreading outward methodically over ignorance, stopping occasionally to correct a mistake on the edges, but remaining perpetually secure that only truth can pass through the knowledge filter. In fact, science seems far less predictable, because it is subject to revolutions that discard even the most-accepted truths and because it is often unclear about the boundary between truth and conjecture. In *The Structure of Scientific Revolutions*,[11] Thomas S. Kuhn[12] explicitly rejected the model of relentless scientific advance. Instead, Kuhn described science as consisting of long periods of methodical work punctuated by revolutions that alter the way scientists consider the most basic facts: "Cumulative acquisition of unanticipated novelties proves to be an almost non-existent exception to the rule of scientific development."[13] Every revolution or paradigm shift allows scientists "to account for a wider range of natural phenomena or to account with greater precision for some of those previously known. But

11. THOMAS S. KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS (3d ed. 1996).

12. Late professor of linguistics and philosophy at the Massachusetts Institute of Technology.

13. KUHN, *supra* note 11, at 96.

that gain was achieved only by discarding some previously standard belief or procedures . . . ."[14]

Judging Science cites Kuhn's theory of paradigm shifting to show that whether evidence "fits" the question of a court case — yet another factor suggested by *Daubert* — depends on the dominant paradigm of the day (pp. 26-27). As Foster and Huber note, physicians in 1793 urged Philadelphia's leaders to clean trash from the city's streets and rivers to prevent yellow fever. Although several observers noted the unusually high number of mosquitoes in the city that summer, scientists attributed the cause of the disease to miasma, or vapors, emitted by rotting garbage. The ruling miasma paradigm convinced people to ignore the mosquitoes and clean up the filth. With hindsight, we know that the cleanup eliminated breeding sites for mosquitoes, the actual cause of the disease. Yet a plaintiff suing a defendant in 1793 for negligently fostering disease-carrying mosquitoes would have lost on summary judgment. No judge using *Daubert* would have rejected the miasma theory held by every doctor of the time. Science had spoken, and mosquitoes would not be relevant to yellow fever for at least another hundred years.

This example and Kuhn's theories suggest that Foster and Huber are overconfident when they assure judges that the science accepted at the core of knowledge is solid enough to hold their weight. Foster and Huber caution about the thin ice on the outer edges, but Kuhn argues that even bedrock beliefs, such as Newtonian optics and Aristotelian dynamics, can crack and collapse.[15] The authors neither address how judges can recognize these shifts nor address how judges can test the "knowledge filter" of their day.[16]

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14. *Id.* at 66.

15. *See id.* at 67.

16. Foster and Huber are uniformly enthusiastic about the scientific method. Their criticism of the plaintiffs' experts in the *Daubert* case suggests that these experts were rogue scientists, if they were scientific at all. The authors seem to place no importance on their own claim that "[s]cientific errors do not usually excite scientists" (p. 90).

Other commentators have noted that the "knowledge filter" of science may become faulty when the science is intended for courtrooms. For example, one critique of forensic hair analysis argues that scientists have not done enough research on the theories to justify admitting statistical evidence into court. *See* Clive A. Stafford Smith & Patrick D. Goodman, *Forensic Hair Comparison Analysis: Nineteenth Century Science or Twentieth Century Snake Oil?*, 27 COLUM. HUM. RTS. L. REV. 227, 279 (1996).

III. AMATEURS' INFLUENCE ON PROFESSIONS

Writing alone in a haughty appendix, Huber castigates the reporters who misunderstood the eventual impact of *Daubert*. The man who suggests that scientific literature is fraught with error seems unnecessarily pleased that reporters, writing on the day of the verdict, erred when they thought the opinion would relax the standards for admissibility of scientific expertise (pp. 263-64). Instead, courts have used *Daubert* to exclude evidence, including the Bendectin evidence when the case returned to the Ninth Circuit.[17] When Huber complains that "[n]one of the reporters who got *Daubert* badly wrong on the first round has ever expressly retracted his or her original story" (p. 266), he shows that he misunderstands journalism as much as lawyers misunderstand science. The Washington-based reporters who cover Supreme Court jurisprudence are not the ones who would write about gradual changes in the legal evidence rules, and newspapers that salivate over Supreme Court opinions probably would find *Daubert's* aftermath to be too arcane for their general-interest audiences.

Huber is not wrong to complain. The public would have been well-served if reporters had predicted the outcome correctly; the public would be better served yet if newspapers would return to the subject and explain the vast impact of *Daubert* on American law. Along with touting Huber's own superiority, the appendix argues for an improvement to journalism, a valid critique offered by a non-journalist.

In the same spirit, non-scientists can have valuable suggestions for scientists, yet Foster and Huber overlook this in their own analysis. Fundamentally, *Judging Science* teaches lawyers to think like scientists in order to evaluate the science that appears in courtrooms. Foster and Huber admit that science is fallible, yet they ignore the real contributions to the debate that could come from lawyers. The evidentiary system could provide an impetus for scientists to accelerate the scientific process — much as the tort system, in its flawed yet powerful way, accelerates product safety design. There can be improvements to the way that science is conducted, especially in the insidious effect of bias that taints work as varied as industry-funded pharmaceutical tests and criminal-defense-supporting psychiatric theories. Although Huber is an amateur when it comes to journalism, reporters would be wrong to dismiss the critique of such an educated, talented amateur. Similarly, perhaps the next book on science and the courts will build on *Judging Science* to suggest how educated, talented non-scientists can help to

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17. *See* Daubert v. Merrell Dow Pharmaceuticals, Inc., 43 F.3d 1311 (9th Cir. 1995).

improve the science that affects law.

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