A Critical Examination of the Post-*Daubert* Scientific Evidence Landscape

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I. INTRODUCTION: SCIENTIFIC EVIDENCE AND JURIES

> *Daubert* puts federal judges in an uncomfortable position.
>
> — Judge Alex Kozinski[1]

> I have gotten involved in a few of these things. It is like somebody hit you between your eyes with a four-by-four.
>
> — Judge Alfred V. Covello[2]

Many judges have expressed discomfort at having to review methodologies and techniques that undergird scientific evidence presented in courts.[3] One look at the range of scientific theories, opinions, and results presented in civil and criminal cases indicates that the concerns of the judiciary regarding scientific evidence are amply justified. In product liability actions, courts are confronted often by plaintiffs' and defendants' experts offering diametrically opposite opinions regarding causation with only a patina of scientific merit to their contentions.[4] Neither the plaintiffs' nor the defendants'

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[1] Daubert v. Merrell Dow Pharm., Inc., 43 F.3d 1311, 1315 (9th Cir.) [hereinafter *Daubert IV*] (discussing Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579 (1993) [hereinafter *Daubert III*]), *cert. denied*, 116 S. Ct. 189 (1995).

[2] *Judicial Panel Discussion on Science and the Law*, 25 CONN. L. REV. 1127, 1144 (1993) (quoting U.S. District Judge Covello of the District of Connecticut, on patent cases typically involving a lot of scientific factual issues).

[3] Many federal judges believe *Daubert* has made their lives more difficult. They are going to have to give a more reasoned statement about why they are letting in evidence. They can't do it on a rubber-stamp basis the way some of them did it in the past . . . . After all, we're not scientists. We're in strange territory, and we want to do the best we can.

Rorie Sherman, *"Junk Science" Rule Used Broadly; Judges Learning Daubert*, NAT'L L.J., Oct. 4, 1993, at 3 (quoting U.S. District Judge Weinstein of the Eastern District of New York); *see also* Craig v. Boren, 429 U.S. 190, 204 (1976) ("It is unrealistic to expect either members of the judiciary or state officials to be well versed in the rigors of experimental or statistical technique."); Ethyl Corp. v. EPA, 541 F.2d 1, 67 (D.C. Cir.) (Bazelon, C.J., concurring) ("[S]ubstantive review of mathematical and scientific evidence by technically illiterate judges is dangerously unreliable. . . ."), *cert. denied*, 426 U.S. 941 (1976); *Judicial Panel Discussion on Science and the Law, supra* note 2, at 1128 ("The reason that judges are in the courtroom is because they didn't want to study science and they had no interest in science and majored in something that had nothing to do with it . . . .")

[4] *See, e.g.*, Wells v. Ortho Pharm. Corp., 615 F. Supp. 262 (N.D. Ga. 1985), *aff'd in part, rev'd in part*, 788 F.2d 741 (11th Cir.), *cert. denied*, 479 U.S. 950 (1986); *see also* Marc S. Klein, *After Daubert: Going Forward with Lessons from the Past*, 15 CARDOZO L. REV. 2219 (1994). For a polemic attack on unreliable scientific expert testimony, see PETER W. HUBER, GALILEO'S REVENGE: JUNK SCIENCE IN THE COURTROOM (1991). Huber offers sensational examples of the abuse of science in the courtroom such as an alleged soothsayer who, "with the backing of expert testimony from a doctor and several police department officials," has won a $1,000,000 jury award due to the loss of her "psychic powers following a CAT scan." *Id.* at 3-4. For a

bar holds a monopoly on experts offering opinions with limited scientific merit.[5] In a society that craves the fruits of modern technology, concerns about the deleterious effects of new products can be expected to continue.[6] For example, cellular telephones and high-voltage electric lines as potential sources of electromagnetic radiation are alleged to affect humans adversely.[7]

Although the veracity of expert testimony is highly controversial,[8] it has been a mainstay of English and American courts for several centuries.[9] Juries in civil and criminal trials, often lacking the training to assess expert scientific testimony on its merits,[10] give overwhelming deference to it. The paradox presented by expert testimony was captured succinctly by Judge Learned Hand:

> The whole object of the expert is to tell the jury, not facts, . . . but general truths derived from his specialized experience. But how can the jury judge between two statements each founded upon an experience confessedly foreign in kind to their own? It is just because they are incompetent for such a task that the expert is necessary at all.[11]

In a nationwide survey of 800 people who served on civil and criminal juries, eighty-nine percent of the jurors reported that paid experts were believable. Among criminal jurors, sixty-eight percent thought experts were very believable and fifty percent of the civil jurors found experts to be very believable.[12] Yet a significant fraction of this expert testimony invites lay jurors to reach conclusions not grounded in any scientific theory or methodology.

A seemingly facile solution to the problems in scientific expert testimony lies in interposing a screening role for the judge between the testifying experts and the jury. In

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vigorous critique of Huber's book, see Kenneth J. Chesebro, *Galileo's Retort: Peter Huber's Junk Scholarship*, 42 AM. U. L. REV. 1637 (1993).

[5] Medical malpractice defendants, while taking the position that they do not have the burden of proof, often raise seriously questionable causation defenses before the jury. *See, e.g.*, Dominguez v. St. John's Hosp., 632 N.E.2d 16 (1993) (Hospital defendants disputed that child's injuries were caused by a perinatal condition and instead claimed the child's brain damage was caused by a genetic condition. A geneticist testified for the defendants that his own tests of the child failed to detect any genetic disease, but justified his position on the basis that genetics is a complex, evolving science and the exact nature of the alleged genetic condition might be determined in the future.). *See also* Terrence J. Lavin, *Seemingly No Side has a Monopoly on Junk Science*, CHI. DAILY L. BULL., Feb. 22, 1994, at 6.

[6] Paul S. Miller & Bert Rein, *The End of Junk Science in the Courtroom?*, LEGAL TIMES, Mar. 29, 1993, at 25.

[7] *Id*.

[8] In a three-city study of judges, jurors, experts, and lawyers in civil and criminal trials, 43% of the lawyers in the study acknowledged they shopped for experts, 65% thought their experts were willing to be coached about their testimony, 39% thought that experts would sway their testimony in favor of the side that was paying them, and 20% thought experts were hired guns who would say almost anything for a large enough fee. Daniel W. Shuman, Elizabeth Whitaker & Anthony Champagne, *An Empirical Examination of the Use of Expert Witnesses in the Courts — Part II: A Three-City Study*, 34 JURIMETRICS J. 193 (1994).

[9] In 1901, Judge Learned Hand outlined a series of cases from the 14th to the 19th century involving expert testimony in areas as diverse as medicine, grammar, paternity, physics, and banking. Learned Hand, *Historical and Practical Considerations Regarding Expert Testimony*, 15 HARV. L. REV. 40, 42-49 (1901).

[10] The ability of expert testimony to unduly influence a jury has been recognized for a long time. *See id.* at 50-52. Expert testimony has a heightened potential to sway a jury "because of its aura of special reliability and trustworthiness." United States v. Amarel, 488 F.2d 1148, 1152 (9th Cir. 1973). Juries often have a diminished capacity to assess the merits of expert testimony. *See* Laurence Tribe, *Trial by Mathematics: Precision and Ritual in the Legal Process*, 71 HARV. L. REV. 1329, 1331 (1971).

[11] Hand, *supra* note 9, at 54.

[12] *Expert Witnesses Found Credible by Most Jurors*, NAT'L L.J., Feb. 22, 1993, at S4.

1993, the Supreme Court offered its first pronouncement on the admissibility of scientific evidence in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*[13] A unanimous Supreme Court held that the seventy-year old *Frye* "general acceptance" test for the admissibility of scientific evidence[14] had been superseded by the *Federal Rules of Evidence*.[15] In *Daubert*, the Court also outlined a gatekeeping role for the trial judge to ensure that an expert's testimony is both reliable and relevant.[16]

Part II of this article discusses the Supreme Court's opinion in *Daubert* and highlights the fundamental compromise at the heart of this decision. Part III presents a temporal model to describe the development of scientific knowledge. This model supplies a framework within which post-*Daubert* decisions can be analyzed and explains the inconsistent landscape of post-*Daubert* decisions. Part III also delineates the weight and admissibility elements in expert scientific testimony by parsing the testimony into four sequential components. These components then are examined in the context of post-*Daubert* cases. Part IV argues that an administrative tribunal, as opposed to generalist trial judges, is more likely to achieve uniform and consistent application of *Daubert* to scientific expert testimony.

II. THE DAUBERT DECISION: A FUNDAMENTAL COMPROMISE

> Whatever knowledge is attainable, must be attained by scientific methods.
> — Bertrand Russell[17]

Daubert had promised to be the case that would decide the "junk science" debate.[18] Twenty-two amicus briefs were filed in this case by individuals and organizations ranging from Nobel Prize winners[19] to the U.S. Chamber of Commerce.[20] In *Daubert*, two children, Jason Daubert and Eric Schuller, along with their parents, sued Merrell Dow Pharmaceuticals, Inc. in California state court alleging that their serious birth defects had been caused by their mothers' prenatal ingestion of Bendectin, a prescription antinausea drug marketed by the defendant. Merrell Dow removed the suits to federal district court on diversity grounds.[21]

Merrell Dow moved for summary judgment, arguing that "Bendectin does not cause birth defects in humans and that petitioners would be unable to come forward with any admissible evidence that it does."[22] The district court, in granting summary judgment, concluded that although the epidemiological[23] evidence presented by Merrell Dow's

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[13] *Daubert III*, 509 U.S. 579.

[14] Frye v. United States, 293 F. 1013 (D.C. Cir. 1923) (requiring that scientific expert testimony may be admitted only if the underlying scientific principle has gained "general acceptance" in the particular field in which it belongs).

[15] *Daubert III*, 509 U.S. at 587.

[16] *Id.* at 589.

[17] BERTRAND A.W. RUSSELL, RELIGION AND SCIENCE 243 (1975).

[18] *See* Marcia Coyle, *Supreme Court to Examine Scientific Proof*, NAT'L L.J., Feb. 1, 1993, at 1; Tony Mauro, *Tort-Reform Week Looms at the Court*, LEGAL TIMES, Mar. 22, 1993, at 12.

[19] Brief Amici Curiae of Nicolaas Bloembergen, et al., in Support of Respondents, *Daubert III*, 509 U.S. 579 (No. 92-102).

[20] Brief Amici Curiae of the Chamber of Commerce of the United States of America in Support of Respondents, *Daubert III*, 509 U.S. 579 (No. 92-102).

[21] *Daubert III*, 509 U.S. at 582.

[22] *Id.*

[23] Epidemiology is a field of public health that studies the incidence, distribution, and etiology of disease in human populations. *See* Linda Bailey, Leon Gordis & Michael Green, *Reference Guide on Epidemiology, in* FEDERAL JUDICIAL CENTER, REFERENCE MANUAL ON SCIENTIFIC EVIDENCE (1994).

expert was admissible, contradictory evidence presented by the expert witnesses for Daubert and Schuller was inadmissible because the evidence failed to meet the *Frye* general acceptance test.[24] The plaintiffs' eight experts had conducted their own studies and concluded that Bendectin could cause birth defects in humans. Their conclusions were based on *in vitro* (test tube) and *in vivo* (live) animal studies that found a link between Bendectin and malformations, pharmacological studies of the chemical structure of Bendectin to show similarities between the structure of the drug and other substances known to cause birth defects, and re-analysis of previously published epidemiological studies.[25] The district court found the plaintiff's experts to be unpersuasive because they did not offer statistically significant epidemiological evidence and because what epidemiological evidence they did present had come from re-analysis of existing data that was neither published nor subjected to peer review.[26]

On appeal the Ninth Circuit Court of Appeals, in a two-page opinion by Judge Kozinski, affirmed the lower court's ruling because the plaintiffs' evidence was not generally accepted in the relevant scientific community. The court of appeals found the unpublished re-analyses studies to be "particularly problematic in light of the massive weight of the original published studies supporting the defendant's position, all of which had undergone full scrutiny from the scientific community."[27] Judge Kozinski also stated that any decision to include or exclude scientific evidence must be reviewed *de novo* on appeal because "the reliability of a scientific technique or process does not vary according to the circumstances of each case [and therefore is not] . . . within each trial judge's individual discretion."[28] The Supreme Court granted certiorari "in light of sharp divisions among the courts regarding the proper standard for the admission of expert testimony."[29]

Justice Blackmun spoke for a unanimous Court when he stated that a "rigid general acceptance requirement would be at odds with the liberal thrust" and "permissive backdrop" of the *Federal Rules of Evidence*. The Court established that the *Frye* test had been superseded by the enactment of the Rules.[30]

On the gatekeeping issue, a majority of the Court[31] set out a two-prong test for the admissibility of scientific evidence based on Rule 702,[32] and assigned a "screening" or "gatekeeping" role to the trial judge.[33] Justifying this gatekeeping role, the Court stated that "under the Rules the trial judge must ensure that any and all scientific testimony or evidence admitted is not only relevant, but reliable."[34]

The Court analyzed the language of Rule 702 to denote a two-prong test for the

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[24] Daubert v. Merrell Dow Pharm., Inc., 727 F. Supp. 570, 571 (S.D. Cal. 1989) [hereinafter *Daubert I*], *aff'd*, 951 F.2d 1128 (9th Cir. 1991) [hereinafter *Daubert II*], *vacated and remanded*, *Daubert III*, 509 U.S. 579, *aff'd*, *Daubert IV*, 43 F.3d 1311 (1995).

[25] *Daubert III*, 509 U.S. at 583.

[26] *See Daubert I*, 727 F. Supp. at 575.

[27] *Daubert II*, 951 F.2d at 1129-30.

[28] *Id.* (quoting Reed v. State, 391 A.2d 364, 367 (Md. 1978)).

[29] *Daubert III*, 509 U.S. at 585.

[30] *Id.* at 587.

[31] Justice Blackmun was joined by Justices White, O'Connor, Scalia, Kennedy, Souter, and Thomas. Chief Justice Rehnquist and Justice Stevens dissented.

[32] Rule 702 states: "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise." FED. R. EVID. 702.

[33] *Daubert III*, 509 U.S. at 596-97.

[34] *Id.* at 589.

admissibility of scientific evidence focusing on 1) the reliability of the evidence, and 2) the helpfulness of the evidence to the jury. First, the Court defined evidentiary reliability by interpreting the words "scientific knowledge" in Rule 702 to refer not to "scientific certainty," but to knowledge that has a basis in the methods of science and is "supported by appropriate validation, i.e., 'good grounds,' based on what is known . . . [T]he requirement that an expert's testimony pertain to 'scientific knowledge' establishes a standard of evidentiary reliability."[35] Therefore, to determine whether the expert's proffered testimony pertains to scientific knowledge, the trial judge must assess "whether the reasoning or methodology underlying the testimony is scientifically valid."[36] The Court emphasized that the "[f]ocus . . . must be solely on principles and methodology, not on the conclusions that they generate."[37]

Second, the Court defined helpfulness of the evidence by relying on the plain language of Rule 702, which requires that the evidence must "assist the trier of fact to understand the evidence or to determine a fact at issue."[38] The helpfulness standard requires that the evidence have "a valid scientific connection to the pertinent inquiry as a precondition to admissibility."[39] The Court characterized the helpfulness prong as essentially being one of "fit" — in other words, whether the nexus between the expert testimony and the facts of the particular case is sufficient to assist in resolving the dispute.

Emphasizing its confidence in federal judges' capacity to conduct such a review, the Court provided a list of illustrative factors that bear on the trial judge's inquiry. The factors mentioned by the Court were 1) whether the theory or technique can be or has been tested (i.e., falsifiability), 2) peer review and publication of the theory or technique, 3) the known or potential rate of error and the existence and maintenance of standards controlling the technique's operation, and 4) general acceptance of the methodology or technique in the scientific community.[40] These factors provide a clear indication that the Court believed the pursuit of science to be an empirical endeavor wherein knowledge about the universe progresses by the development of scientific principles and theories capable of falsification.[41]

Implicitly acknowledging that it did not relish performing a gatekeeping function any more than federal trial judges would, the Court stopped short of applying its new standard to the plaintiff's expert testimony. Although the Court had a substantial record before it, it relinquished the opportunity to illustrate how its new standard would work in practice and instead remanded the case to the lower courts to reconsider their rulings under the new standard. This was unfortunate because the federal courts of appeal in the Bendectin litigation were divided[42] about whether the scientific evidence that Bendectin

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[35] *Id.* at 590.

[36] *Id.* at 592-93.

[37] *Id.* at 595.

[38] FED. R. EVID. 702.

[39] *Daubert III*, 509 U.S. at 592.

[40] *Id.* at 593-95.

[41] *See* INTRODUCTORY READINGS IN THE PHILOSOPHY OF SCIENCE 16-17 (E.D. Klemke, Robert Hollinger & A. David Kline eds. 1988) (describing in a series of steps how scientific knowledge is acquired).

[42] The Fifth Circuit and the Sixth Circuit, both on records similar to *Daubert*, had concluded that the evidence was admissible but insufficient. Turpin v. Merrell Dow Pharm., Inc., 959 F.2d 1349 (6th Cir. 1992); Brock v. Merrell Dow Pharm., Inc., 874 F.2d 307 (5th Cir. 1989). The First Circuit and the D.C. Circuit found the evidence to be inadmissible as opposed to admissible but insufficient. Ealy v. Richardson-Merrell, Inc., 897 F.2d 1159 (D.C. Cir. 1990); Richardson v. Richardson-Merrell, Inc., 857 F.2d 823 (D.C. Cir. 1988); Lynch v. Merrell - National Labs. Div. of Richardson-Merrell, Inc., 830 F.2d 1190 (1st Cir. 1987).

was a teratogen[43] was inadmissible or insufficient.[44]

In *Daubert* the Supreme Court struck a compromise.[45] It did not repose its trust either on legal or scientific institutions entirely.[46] *Daubert* requires judges to undertake independent legal fact-finding and reach judicial conclusions of evidentiary reliability and sufficiency based on the judgments and criticisms passed by scientists through institutional mechanisms, such as peer review, created by the scientific community. The *Daubert* gatekeepers have embraced this responsibility with trepidation.

On one hand, the Court deliberately chose not to assign to the scientific community the responsibility of determining what methodologies or theories satisfy scientific criteria of validity, as manifested by their general or substantial acceptance within the scientific community. Because the Court found evidentiary reliability to require scientific validity,[47] however, why not leave this task to those who are the most qualified individuals to undertake this responsibility — scientists — as the *Frye* general acceptance test did? Such an approach avoids forcing judges review the work product of scientists and scientific experts.

The Court, however, believed that this was an overly "rigid" and strict approach that would hamstring efforts to make informed decisions in court by depriving judges and juries the benefit of the latest scientific developments. It can be argued that the proponents of *Frye* should not be allowed to use the uncertainty of scientific opinion in a particular matter to exclude evidence.

The Court believed "that federal judges possess the capacity to undertake this review."[48] By electing generalist trial judges to perform a scientific review of the proffered testimony, the Court did little to further standardize judicial disposition of scientific evidence. Federal trial judges[49] now simply have to try to learn[50] all they can about modern science and technology.

The Court also did nothing to promote social justice. The plaintiffs had argued that there was no foundational requirement for the admission of expert testimony.[51] The

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[43] A teratogen is a substance capable of causing malformations (i.e., birth defects) in fetuses. *See supra* note 23.

[44] Insufficiency means the evidence, as a threshold matter, is admissible, but the weight of the evidence is insufficient.

[45] Indeed, both sides claimed victory in *Daubert. Compare* Paul M. Barrett, *Justices Rule Against Business,* WALL ST. J., June 29, 1993, at A3; Marcia Coyle, *Supreme Court Eases Admissibility of Experts,* NAT'L L.J., July 12, 1993, at 12; *Supreme Court Says Judges Should Evaluate Scientific Testimony,* 8 LIABILITY WEEK 27 (1993) (arguing *Daubert* was a setback for manufacturers because "junk science" now can get into the courtroom and sway juries) *with* Linda Greenhouse, *Justices Put Judges in Charge of Deciding Reliability of Scientific Testimony,* N.Y. TIMES, June 29, 1993, at A13; Thomas W. Kirby, *Junking Bad Science,* CONN. L. TRIB., Aug. 2, 1993, at 24.

[46] *See generally* Margaret G. Farrell, *Daubert v. Merrell Dow Pharmaceuticals, Inc.: Epistemology and Legal Process,* 15 CARDOZO L. REV. 2183 (1994) (arguing that *Daubert* is an incoherent view that is neither positivist nor constructionist).

[47] *Daubert III*, 509 U.S. at 590 ("In a case involving scientific evidence, evidentiary reliability will be based upon scientific validity.").

[48] *Id.* at 593.

[49] *See supra* notes 1-3 and accompanying text.

[50] The Federal Judicial Center (FJC) has put out a 637-page *Reference Manual on Scientific Evidence* with separate chapters devoted to DNA evidence, epidemiology, toxicology, statistics, and economic damage estimations. *See* FEDERAL JUDICIAL CENTER, REFERENCE MANUAL ON SCIENTIFIC EVIDENCE (1994) [hereinafter REFERENCE MANUAL]. *See also* Sherman, *supra* note 3, at 3 (reporting that the Carnegie Commission on Science, Technology, and Government is putting together a training program with the FJC to help the judiciary cope with scientific evidence after *Daubert).*

[51] Petitioners' Reply Brief at 9, *Daubert III*, 509 U.S. 579 (No. 92-102) (arguing Rule 702 does not contain a foundational reliability threshold).

plaintiff's approach suggested a limited screening role for the trial judge using the relevancy test in Rule 401, the probative value/prejudicial effect balancing test in Rule 403, and a threshold expert qualification requirement.[52] The expert's testimony would be contested through conventional mechanisms in the adversary system in court and be resolved by the jury, not by the judge. The lay jury then could find a causal link between the plaintiff's loss and the defendant's conduct based on a community sense of fairness and the justifiable expectations of the consuming public[53] living in a technological society with imperfect information. An economic justification for such an approach might be the ability of manufacturers to spread the cost of the plaintiffs' losses throughout society by appropriately setting the price of the product or by carrying liability insurance.[54]

Because *Daubert* was played out against the backdrop of the junk science debate, perhaps the Court was concerned that a relevancy-based approach might befuddle juries by exposing them to specious claims about causation that rely on "questionable science" or the temporal sequence of events.[55] Conflicting jury verdicts could undermine the public's confidence in the system of justice. The Court, however, expressed confidence in the capabilities of juries and the adversary system by stating that "[v]igorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence."[56] Nevertheless, it lacked complete confidence in these legal institutional mechanisms because it interposed a threshold scientific validity requirement, the fulfillment of which was to be determined by the gatekeeping trial judge. In the process, the Court ignored notions of community morality as seen through the eyes of juries.

III. THE POST-DAUBERT SCIENTIFIC EVIDENCE LANDSCAPE

A. *A Temporal Epistemological Model to Describe the Development of Scientific Knowledge*

The development of scientific knowledge is an empirical process. John Locke,[57] the first empiricist, believed that all knowledge comprises impressions and ideas that come from human experience, and he rejected the view that ideas are "innate" to the human mind.[58] The early empiricists believed that knowledge with no basis in experience was unjustifiable.[59] Locke's empiricism fit Sir Issac Newton's[60] systematic model

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[52] *Id.*

[53] The consumer expectation test is used to determine defectiveness under strict liability in case of manufacturing defects in product liability actions. W. PAGE KEETON, DAVID G. OWEN, JOHN E. MONTGOMERY & MICHAEL D. GREEN, PRODUCT LIABILITY AND SAFETY — CASES AND MATERIALS 190-205 (2d ed. 1989).

[54] *See id.* at 215.

[55] This is the "post hoc ergo propter hoc" (after which, therefore because of which) fallacy. *See* David E. Bernstein, *The Admissibility of Scientific Evidence After Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 15 CARDOZO L. REV. 2139 (1994) (illustrating post hoc reasoning with an example: If an infant receives a measles vaccination, and then develops a brain tumor shortly thereafter, post hoc reasoning would suggest that the vaccine caused the tumor).

[56] *Daubert III*, 509 U.S. at 596.

[57] John Locke (1632-1704), an English empiricist and moral and political philosopher, is widely regarded to be the father of empirical epistemology. 3 THE ENCYCLOPEDIA OF PHILOSOPHY 22 (Macmillan 1973).

[58] ALBUREY CASTELL, AN INTRODUCTION TO MODERN PHILOSOPHY 202 (1943). The British trio of empiricists — John Locke, George Berkeley (1685-1753), and David Hume (1711-1776) — were united in their opposition to the "doctrine of innate ideas." 3 THE ENCYCLOPEDIA OF PHILOSOPHY 22 (Macmillan 1943).

[59] 3 THE ENCYCLOPEDIA OF PHILOSOPHY, *supra* note 58, at 22-25 (quoting David Hume).

[60] Sir Isaac Newton (1642-1727), an English mathematician and physicist, developed and refined the

of the experimental method in science (i.e., the "scientific method").[61] Newton's *Philosophiae Naturalis Principia Mathematica*[62] embodied the scientific method as the means to attain scientific knowledge. Under the scientific method, a scientist proposes a hypothesis[63] and then engages in experimentation or observation to validate his hypothesis.

In the *Daubert* majority opinion, Justice Blackmun embraced the Newtonian model of the scientific method. He focused on the words "scientific . . . knowledge" in Rule 702 and explained that in order for an inference or assertion "to qualify as 'scientific knowledge,'" it "must be derived by the scientific method."[64]

This section outlines a temporal model to describe how the development of scientific knowledge about a particular phenomenon[65] evolves in practice. This simple model, which assumes that scientific knowledge about the phenomenal world is acquired through application of the scientific method,[66] provides insights into both the merits and the troublesome areas of the *Daubert* decision.

Scientific understanding of a particular phenomenon is not static. When investigating a particular phenomenon, a scientist relies on a body of practices, procedures, and rules derived from fundamental principles in the scientist's discipline. This set of working practices is referred to as a methodology. Using these methodologies, a scientist proposes and tests general rules and theories with predictive or explanatory attributes and capabilities that help society understand and harness the phenomenal world. These rules, if validated, in turn modify or create new methodologies. Thus, scientific understanding of the desirable attributes and intrinsic limitations of a methodology grows with constant testing and refining.[67] As members of an interested scientific community challenge a methodology's theoretical foundations and experimental capabilities, methods and processes previously deemed legitimate are often condemned or redefined. As the Spanish philosopher Jose Ortega y Gasset wrote, "[t]he man who discovers a new scientific truth has previously had to smash to atoms almost everything he had learnt, and arrives at the new truth with hands bloodstained from the slaughter of a thousand platitudes."[68] Over time, as agreement and consensus develops among the community, certain attributes and properties of the methodology become well established.

The development of a particular scientific theory or methodology proceeds through essentially three phases: 1) an embryonic phase, 2) a rapidly evolving phase, and 3) a mature phase. Generally, scientific development (i.e., scientific understanding of a particular theory or methodology) follows an S-shaped curve, as is schematically depicted

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"scientific method" as we know it today. 5 THE ENCYCLOPEDIA OF PHILOSOPHY 489-91 (Macmillan 1973).

[61] Locke's *Essay Concerning Human Understanding* was published in 1689 and Newton's *Philosophiae Naturalis Principia Mathematica* was published in 1687. 4 THE ENCYCLOPEDIA OF PHILOSOPHY 488 (Macmillan 1973); 5 THE ENCYCLOPEDIA OF PHILOSOPHY, *supra* note 60, at 490.

[62] Newton's *Philosophiae Naturalis Principia Mathematica*, more commonly referred to as the *Principia*, was published in 1687 and was immediately and universally acclaimed. 5 THE ENCYCLOPEDIA OF PHILOSOPHY, *supra* note 60, at 490.

[63] Newton used the word "hypothesis" to describe his ideas about the nature of light. *Id*.

[64] *Daubert III*, 509 U.S. at 590.

[65] The word "phenomenon" is used here generally to indicate any occurrence, circumstance, or fact that is perceptible by the senses.

[66] For a detailed discussion of the scientific method, see Bert Black, Francisco J. Ayala & Carol Saffran-Brinks, *Science and the Law in the Wake of Daubert: A New Search for Scientific Knowledge*, 72 TEX. L. REV. 715 (1994); Bert Black, *A Unified Theory of Scientific Evidence*, 56 FORDHAM L. REV. 595 (1988).

[67] This assumes that there is continued interest within the community of scientists who employ that methodology. Because scientific research is a human endeavor, continued interest in a particular area of science is a function of various political, social, and economic factors.

[68] J. ORTEGA Y GASSET, THE REVOLT OF THE MASSES ch. XIV, 157 (1930) (Anon. trans. 1932).

in Figure 1.[69] Figure 1 also demarcates the three phases in this evolutionary cycle.

There are two assumptions implicit in this model. First, the model assumes that there is enough scientific interest in the particular theory or technique to attract multiple workers to the topic. This may not be true in areas that receive limited scientific attention and scrutiny, such as forensic science. Second, the model assumes that the scientific work is published in the open literature so that it can attract broad scientific scrutiny and is not concealed from the public, as in a trade secret.[70] This model is not premised on any philosophical theory about the nature of science (e.g., positivist, constructionist, or relativist). Rather, it delineates the general features in the temporal evolution of scientific progress as it is actually practiced.

In the embryonic stage, scientists propose ideas and make educated guesses about relationships between two or more variables or parameters in a system, based on previously reported theories and experiments. Although scientists typically develop these

[69] The slope of the curve in the three phases follows an S-shaped pattern. Figure 1, however, does not quantitatively represent the rate of scientific progress in any of the three phases and simply illustrates broad trends in scientific development.

[70] Patents are usually not a concern because, after applying for patent protection, the scientific results are published because the priority date given to the invention extends at least as far back as the filing date of the patent application. 35 U.S.C. § 154(a)(2).

educated hunches from previous scientific work, history is replete with examples of how daily routine activities serve as a source for new scientific ideas.[71]

An initial hunch is followed often by experiments or calculations to either support or reject it. At each step, a scientist is aware that other will examine his work. This is a powerful inducement to minimize subjective influences[72] and critically review testing results or calculations. Scientists put forth explanations (i.e., mechanisms) and experimental results to support their hypotheses so that they can be subjected to empirical testing (i.e., replication) and either verified or falsified. In reality, hypotheses are rarely fully falsified. While attempting to relate different phenomena or properties, the scientist infrequently anticipates the full implications of his work. In the embryonic stage progress is often slow and seemingly unrelated experiments are reported by different scientific groups.

In practice, actual replication of the work of others is limited. It is reserved for experiments of unusual import or for experiments that challenge a generally accepted body of work.[73] Most often, scientists seek to advance understanding by building on the results reported by others. Further advancement, going beyond a few isolated reports, generally requires one or two scientific findings that demonstrate the potential for substantial future gain.[74] With the benefit of hindsight, they come to be regarded as significant breakthroughs.

The possibility of broader societal impact draws the attention of other workers in the area, who then scrutinize these results. The initial findings may be rejected thoroughly at this stage. Generally, however, further experimentation identifies shortcomings and errors in the explanations and predictions suggested by the initial findings. Such future work carefully circumscribes previously-advanced propositions, points out their weaknesses, and advances its own solutions. Under the glare of strict scientific scrutiny, a fundamental understanding of the particular phenomenon being studied advances rapidly. The intense skepticism accorded to new findings is important in science. While existing scientific opinion may resist new proposals or dissenting voices, this process ensures that future innovators are provided with a solid foundation on which to build.

In the rapidly evolving phase, repeated attempts to corroborate or disprove the initial findings uncover experimental distortions and oversimplifications. This period may be marked by significant disagreement between different scientific groups. Scientists hotly debate issues such as error rates under different testing conditions and the

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[71] For example, Louis Pasteur was led by chance to what is now a well-known method of immunization. An old bacterial culture was being used to inoculate fowls. The fowls became ill but did not die. Pasteur surmised that perhaps by using bacterial cultures with little virulence and then repeating the injections with cultures of greater virulence, the animals could be made to develop resistance to infection gradually. His theory proved correct. By testing and developing this procedure further, he was able to immunize sheep against anthrax and human beings against rabies. *See* NEW WORLDS OF MODERN SCIENCE 34-35 (Leonard Engel ed. 1956).

In another example, scientists studying the digestive function of the pancreas in dogs noticed a swarm of flies gathered around the urine of these animals, and this observation ultimately resulted in the discovery of insulin. *Id.*

[72] *See* COMMITTEE ON THE CONDUCT OF SCIENCE, NATIONAL ACADEMY OF SCIENCES, ON BEING A SCIENTIST 5 (1989) (noting that scientists have developed methods such as double-blind trials, randomization of experimental subjects, and the proper use of controls to reduce individual subjectivity).

[73] *See id.* at 11 (noting that actual replication is selective and reserved for experiments with unusual importance or for experiments which conflict with an accepted body of work).

[74] Often the broader societal impact from a scientific finding is recognized at this stage. In other cases, the benefits derived from a significant breakthrough might be limited to just the relevant scientific community.

validity of a scientific proposition under another set of conditions. The search to reconcile these disagreements spurs additional scientific inquiry. Scientists formulate or reject various explanations, and publish review papers and reports to pull together and reconcile different findings. Eventually, a substantial agreement about different aspects of the theory or methodology develops. As the level of scientific confidence grows through repeated validation, a broad consensus about the merits and demerits of the theory or methodology may emerge. Once there is a general acceptance among the scientific community, the scientific proposition matures into a well-established theory or methodology.

The pace of progress beyond the embryonic phase depends on the perceived significance of the initial results, the area of science involved, and the number of scientists attracted to the topic. As one distinguished scientist noted, "there are fashions in science."[75] The participation of a large number of scientists in an area that holds the prospect of professional and economic rewards can result in remarkably swift progress. For example, DNA profiling has progressed from the first results in 1985 to general acceptance in less than a decade. The DNA profiling example notwithstanding, forensic tests usually do not receive extensive testing and are subject to limited peer scrutiny because the forensic scientific community is small.[76] Simply put, there is no institutional guarantee in science that hypotheses will be tested or rigorously scrutinized by the scientific community.[77]

General acceptance does not imply that a scientific proposition is valid in every conceivable situation. Even a well-established theory or methodology is valid only to the extent that it has not been falsified or disproved. The consensus within the community may be destroyed by future experimentation or by a revolutionary reformulation of all previous scientific findings. In this sense, a scientific theory is always subject to revision or rejection. Because scientific "truths" are mutable, the concept of finality is alien to science.

This process by which scientific knowledge develops over time can be illustrated by using the example of DNA profiling for individuation.[78] In 1958, James D. Watson and Francis Crick proposed the model of DNA as a double-helix that resembles a spiral

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[75] *Morning Edition: Scientists Spot First Sunspot of New Solar Cycle* (National Public Radio broadcast, Aug. 23, 1995) (quoting Dr. Hal Zearen, professor of astrophysics, California Institute of Technology).

[76] For example, the diphenylamine test (commonly known as the paraffin test) was designed to detect gunshot residue on the hand of a person who recently has fired a weapon. The diphenylamine test for gun powder was introduced and accepted quickly by law enforcement agencies in the 1930s. The test, however, did not draw any serious scientific attention, and no detailed study of the test was performed, until 1967. The 1967 study found the test to be unreliable. Paul C. Giannelli, *The Admissibility of Novel Scientific Evidence: Frye v. United States, a Half-Century Later*, 80 COLUM. L. REV. 1197, 1224-25 (1980).

[77] *See* James A. Martin, *The Proposed "Science Court,"* 75 MICH. L. REV. 1058, 1064 (1977) (noting that nothing in the scientific method guarantees that hypotheses will be tested or when they will be tested).

[78] While only a single example is discussed here, this process of development of scientific knowledge is commonplace through all of science. Two other examples that illustrate the same process are the development of controlled flight in space and the development of penicillin as an antibiotic. S*ee* 1 MCGRAW-HILL ENCYCLOPEDIA OF SCIENCE AND TECHNOLOGY 664, 686-87 (7th ed. 1992); Leonard Engel, *The World of Science, in* NEW WORLDS OF MODERN SCIENCE, *supra* note 71, at 17, 36-37. The history of cold fusion demonstrates that certain "scientific" experiments never will progress beyond the initial few isolated reports, and therefore, never will attain general acceptance. The history of cold fusion also illustrates how a few scientists can be profoundly wrong and cautions to look for repeatability of scientific results as an effective means to reduce individual subjectivity. *See* John Crewdson, *Tempest in a Test Tube: How Two Scientists Created the Brief but Disturbing Cold Fusion Frenzy,* CHI. TRIB., Aug. 15, 1993; GARY TAUBES, BAD SCIENCE: THE SHORT LIFE AND WEIRD TIMES OF COLD FUSION (1993); James Gleick, *A Cold Shoulder to Science*, LOS ANGELES TIMES, Aug. 22, 1993.

staircase.[79] This hypothesis was verified by several key experiments in 1958.[80] Because 99.9% of the three billion base pairs of DNA held within the forty-six human chromosomes are the same,[81] however, DNA profiling as a technique for individuation did not look promising, and much of the initial scientific research focused on its medical applications.

In a pioneering result in 1985, DNA profiling first was proposed as a scientific method for individuation.[82] Soon there was a massive volume of scientific literature analyzing DNA typing.[83] According to this literature, the method of DNA profiling comprised two distinct steps: defining the existence of a match and assessing the probabilistic significance of the match. For the next several years, the scientific community hotly debated the experimental errors in the matching step and the role of population genetics in determining the statistical significance of the match. In one report in 1989, the chance of an alleged match was stated to be 738 quadrillion to one.[84] Once the simplifying assumptions in the population genetics calculations were analyzed and exposed,[85] however, more accurate estimates of the odds of a DNA match arose. In one case, the odds of finding a person with the same genetic profile improved from 7.8 million to one to 78,000 to one.[86] Different scientific groups and testing laboratories conducted coordinated tests of blind samples to identify inaccuracies in the testing process,[87] and the National Research Council (NRC) of the National Academy of Sciences put out a landmark report on DNA technology to identify the common ground among the scientists.[88] At present scientists understand the various sources of error in DNA typing well, and the technique has gained acceptance in the scientific community and in the courts.[89]

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[79] S*ee* JAMES D. WATSON, NANCY H. HOPKINS, JEFFREY W. ROBERTS, JOAN A. STEITZ & ALAN M. WEINER, MOLECULAR BIOLOGY OF THE GENE 74 (4th ed. 1987).

[80] *Id.* at 76.

[81] *See generally*, 2 PAUL C. GIANNELLI & EDWARD J. IMWINKELRIED, SCIENTIFIC EVIDENCE § 18-2 (2d ed. 1993 & Supp. 1994).

[82] Alex J. Jeffreys, Victoria Wilson & Swee Lay Thein, *Hypervariable "Minisatellite" Regions in Human DNA*, 314 NATURE 67 (Mar. 7, 1985) (DNA "fingerprints" will be of general use in human segregation analysis; it can be a powerful method for paternity and maternity testing and can be used in forensic applications).

[83] *See* GIANNELLI & IMWINKELRIED, *supra* note 81, § 18-3 n.6 (listing scientific literature on DNA techniques for forensic applications).

[84] Eric S. Lander, *DNA Fingerprinting on Trial*, 339 NATURE 501 (1989).

[85] Richard C. Lewontin & Daniel L. Hartl, *Population Genetics in Forensic DNA Typing*, 254 SCIENCE 1745, 1749-50 (1991) (listing major problems with the calculations of the odds of obtaining a DNA match).

[86] *All Things Considered: Next Step in Simpson Trial Includes Hearing on DNA* (National Public Radio broadcast, Jan. 2 1995) (quoting Linda F. Robertson, defense attorney in People v. Barney, 8 Cal. App. 4th 798 (1992)).

[87] James E. Starrs, *The Fallibility of Forensic DNA Testing: Of Proficiency in Public and Private Laboratories — Part One*, 15 SCI. SLEUTHING REV. 10 (1990); *see generally* GIANNELLI & IMWINKELRIED, *supra* note 81, § 18-4(A) (describing various DNA typing tests conducted by different laboratories).

[88] NATIONAL RESEARCH COUNCIL, COMMITTEE ON DNA TECHNOLOGY IN FORENSIC SCIENCE, DNA TECHNOLOGY IN FORENSIC SCIENCE (1992). For a critique of the NRC report, see B. Devlin, Neil Risch, Kathryn Roeder, *Statistical Evaluation of DNA Fingerprinting: A Critique of the NRC's Report*, 259 SCIENCE 748 (1993) (arguing that the ceiling principle advocated by the NRC results in extremely conservative estimates of a DNA match).

[89] There is a considerable amount of literature discussing the sources of error in DNA technology. David H. Kaye, *DNA Evidence: Probability, Population Genetics, and the Courts*, 7 HARV. J.L. & TECH. 101 (1993); Jonathan J. Koehler, Audrey Chia & Samuel Lindsey, *The Random Match Probability in DNA Evidence: Irrelevant and Prejudicial?*, 35 JURIMETRICS J. 201 (1995); Kenneth R. Kreiling, *DNA Technology in Forensic Science*, 33 JURIMETRICS J. 449 (1993); Gerald D. Robin, *DNA Evidence in Court*, CRIM. JUST., Fall 1994, at 9 (1994); Barry C. Scheck, *DNA and Daubert*, 15 CARDOZO L. REV. 1959 (1994).

This example illustrates how scientific understanding of a phenomenon grows from the embryonic stage to a mature, well-accepted theory or methodology. It also highlights the simple, broad contours of the model described above. This adumbration of the development of scientific knowledge supplies a framework within which the post-*Daubert* decisions can be analyzed. By examining post-*Daubert* decisions using this model, the strengths and troublesome aspects of *Daubert* are illuminated.

B. *Post-Daubert Decisions: A Uniform Quest for Scientific Knowledge?*

In *Daubert*, the Supreme Court rejected the general acceptance standard for the admissibility of scientific evidence and decided to pursue a more flexible and liberal Rules-based approach.[90] Stepping back from the general acceptance standard, the Court decided that even developing areas in science, which are marked often by genuine disagreements among distinguished scientists,[91] would have a role to play in the courtroom if they satisfied the two prongs of Rule 702. Therefore, under the first prong of *Daubert*, the Court delegated to trial judges the task of arbitrating disputes over the admissibility of evolving scientific methodologies or theories. In this gatekeeping process, the trial judge must assess the state-of-the-art with respect to a scientific claim and decide if the information being debated by well-credentialed scientists both inside the courtroom and in the scientific literature amounts to scientific knowledge. By using an incomplete list of "objective" criteria, the trial judge must determine subjectively if the level of scientific understanding of the methodology employed by the experts in the scientific community is such that it constitutes scientific knowledge. The answer to this threshold question is strictly binary[92] and yet the process by which scientific knowledge develops is capable of characterization only by degrees.

Under *Daubert*, the trial judge may hold an *in limine* hearing to decide if the proffered scientific evidence amounts to scientific knowledge. When such evidence is at the forefront of science, contentious arguments in the scientific arena about the proffered methodology will be directly replicated in the courtroom. The trial judge will be assisted in his inquiry by the four gatekeeper factors outlined in *Daubert*. Certain questions, however, (such as "How much testing is adequate and who should it be done by?" "Is the testing methodology itself suspect?" "What error rate is sufficiently low to qualify as scientific knowledge?" and "Is a single peer-reviewed publication sufficient to satisfy the first prong of *Daubert*?") cannot be answered by fixed standards independent of the particular area of science being considered. This suggests that different trial judges inevitably will review novel scientific evidence and reach conflicting conclusions under the first prong of *Daubert.*

When scientific understanding is still in an embryonic phase, the dangers posed by unreliable or untested science in the courtroom can be significant. Under *Daubert*, hypotheses that are not tested or otherwise reviewed would not be admissible. Therefore, a prescient expert's testimony may not be admitted out of concern that, with the benefit of hindsight, the expert may turn out to be a Tycho Brahe[93] instead of the Galileo[94] he

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[90] *Daubert III*, 509 U.S. at 587-88.

[91] On remand in *Daubert*, Judge Kozinski stated that "scientists often have vigorous and sincere disagreements as to what research methodology is proper . . . [and o]ur responsibility . . . is to resolve [these] disputes among respected, well-credentialed scientists . . . ." *Daubert IV*, 43 F.3d at 1316.

[92] The trial judge decides that it either amounts to scientific knowledge or it does not.

[93] Tycho Brahe (1546-1601), a Danish astronomer and contemporary of Galileo Galilei (1564-1642), built the world's greatest astronomical laboratory of his time. He made reliable records of his celestial observations and determined that the orbit of a comet was elongated (i.e., ellipsoidal) and not circular, as

was predicted to be.[95] As a result, the jury may not learn of "authentic insights and innovations." The Supreme Court stated that "[c]onjectures that [are] probably wrong"[96] would not admissible under *Daubert*, but the Court was silent on how much testing would be needed to satisfy the scientific knowledge requirement of *Daubert*.

When the proffered scientific evidence goes beyond educated speculation but relies on very limited scientific research, it is often difficult to assess if the testimony qualifies as scientific knowledge. In other words, it is unclear at what point in the embryonic stage of scientific development the first prong of *Daubert* satisfied. For example, the question remains whether a single publication or a single test of a methodology is sufficient to meet the scientific knowledge threshold of *Daubert.*

Even if the scientific knowledge threshold is met, however, it may still prove to be insufficient as a matter of law. The Supreme Court in *Daubert* noted that if a "scintilla of evidence" is presented to support a position, it may be "insufficient to allow a reasonable juror to conclude that the position more likely than not is true."[97] In these circumstances, a trial court could direct a judgment under either Rule 50(a) or Rule 56 of the *Federal Rules of Civil Procedure*.[98]

Under *Daubert*'s more liberal admissibility requirements, courts are permitting more scientific evidence in civil and criminal cases. Commentators predicted that scientific evidence would be admitted more easily after *Daubert*,[99] and an examination of post-*Daubert* cases in the past two years clearly supports that conclusion. In many instances, courts have noted that although the proffered evidence does not meet the general acceptance standard, it is nevertheless admissible under *Daubert*. For example, even though the etiology of polymyositis[100] is not generally recognized or accepted by the medical community, the Seventh Circuit held that causation can be proved in a particular case. The court found the expert physician used well-founded methodology to determine the cause of plaintiff's polymyositis, and that his testimony was therefore admissible even though the scientific community recognized that the possible causes of polymyositis were unknown.[101] In another case, in the absence of a "solid body of epidemiological data," the Ninth Circuit sustained admission of expert testimony on silicone's ability to cause autoimmune disorders based on the expert's knowledge of the medical literature and his review of the patient's medical records.[102] The Ninth Circuit

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thought by Aristotle and his contemporaries. He was profoundly wrong, however, in rejecting the heliocentric Copernican view of the universe. ERNEST E. SNYDER, HISTORY OF THE PHYSICAL SCIENCES, 29-30, 112, 114 (1969).

[94] Galileo Galilei was convinced that the Copernican heliocentric view of the universe was correct. In 1633 he was convicted by the Roman Inquisition for his belief that the earth moved and the sun stood still. At the age of 70, Galileo chose to recant his views in order to escape torture. *See id.* at 32.

[95] Psychologists state that people tend to see what they expect to see and often fail to observe what they believe should not be there. This is, of course, true for scientists as well and the risk of self-deception among scientists is a real one. *See* COMMITTEE ON THE CONDUCT OF SCIENCE, *supra* note 72, at 4.

[96] *Daubert III,* 509 U.S. at 597.

[97] *Id*. at 596.

[98] *Id*.

[99] *See, e.g.*, Black, *Science and the Law*, *supra* note 66, at 786-87 (noting that most scientific evidence will survive the admissibility screening process); *see also* David O. Stewart, *Decision Creates Uncertain Future for Admissibility of Expert Testimony,* A.B.A. J., Nov. 1993, at 48-51 (quoting Professor Michael H. Gottesman as saying that *Daubert* "will inevitably make the admission of scientific evidence easier in those circuits that ha[d] adopted the *Frye* rule.")

[100] An inflammatory disorder of the muscles involving both the upper and lower extremities. Cella v. United States, 998 F.2d 418, 420 (7th Cir. 1993).

[101] *Id*. at 425-29.

[102] Hopkins v. Dow Corning Corp., 33 F.3d 1116, 1125 (9th Cir. 1994).

rejected the argument that the expert's methodology was not based on generally accepted scientific principles, because the expert had, in the absence of definitive epidemiological data, used the types of scientific data and techniques relied on by medical experts in determining toxic causation. This trend toward easier admission of scientific evidence is seen in other civil and criminal cases as well.[103]

The most significant impact of *Daubert* has been on cases in which courts have excluded expert testimony that amounted to educated guessing unsubstantiated by any pertinent research. By requiring courts to examine the underlying methodology on which experts rely, *Daubert* has changed irrevocably the judicial microscope with which expert scientific testimony is examined. In criminal cases, courts have excluded mistaken identity testimony by forensic anthropologists[104] and expert testimony regarding police discipline theory[105] as not constituting scientific knowledge under *Daubert*. Medical testimony that radiation-induced cataracts can be identified by mere observation when no such suggestion was found in the medical literature was excluded by the Seventh Circuit under the first prong of *Daubert*.[106] In the absence of other scientific evidence, an expert's "curb side opinion" that ibuprofen caused renal failure was excluded as not being well grounded in the scientific method.[107] Courts also have excluded expert testimony in several other cases as mere opinion testimony lacking any form of scientific support.[108]

Post-*Daubert* decisions suggest that, with the single exception of entirely unsubstantiated opinions, the scientific knowledge prong can be met in most instances. For example, in *McCullock v. H.B. Fuller Co.*,[109] the examining physician's conclusions that the plaintiff's throat polyps were caused by exposure to glue fumes relied on differential etiology, which required listing all possible causes for an illness and eliminating

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[103] Post-traumatic stress disorder evidence has been admitted even if it has only a fair degree of acceptance in the community. Isley v. Capuchin Province, 877 F. Supp. 1055, 1065-66 (E.D. Mich. 1995). Expert testimony linking the drug Provera, a progestin, to birth defects was determined to have satisfied *Daubert* even though general acceptance of the expert's theory was debatable. Grismer v. Upjohn Co., 1995 WL 390053, at *1, *4 (N.D. Ill. June 26, 1995). In a criminal case, the Tenth Circuit affirmed the admission of a forensic chemist's testimony regarding tests he had conducted to determine the presence of cocaine base in a paper sack and noted that general acceptance of the expert's test methods was not a precondition to admissibility under *Daubert*. United States v. Muldrow, 19 F.3d 1332, 1337 (10th Cir. 1994).

[104] United States v. Dorsey, 45 F.3d 809, 812 (4th Cir. 1995) (testimony of two forensic anthropologists about comparisons between surveillance photographs and recent photographs of the defendant and his boots was offered as part of a mistaken identity defense).

[105] Berry v. City of Detroit, 25 F.3d 1342, 1348-53 (6th Cir. 1993) (expert's "discipline theory" was offered to show that the failure to properly discipline police officers was the proximate cause of the victim's shooting death by a police officer).

[106] O'Conner v. Commonwealth Edison Co., 13 F.3d 1090, 1106-07 (7th Cir. 1994).

[107] Porter v. Whitehall Labs., 9 F.3d 607, 614-15 (7th Cir. 1993).

[108] Bradley v. Brown, 42 F.3d 434, 438-39 (7th Cir. 1994) (expert testimony concerning multiple chemical sensitivity disorder excluded as mere opinion testimony); Diaz v. Johnson Matthey, Inc., 1995 WL 455559, at *1, *6, *15-17 (D.N.J. 1995) (expert testimony concerning the development of platinum allergy from exposure to platinum salts excluded as mere opinion testimony); Cavallo v. Star Enter., 1995 WL 410750, at *1, *12 (E.D. Va. 1995) (expert testimony concerning the development of chronic respiratory illnesses from exposure to aviation jet fuel excluded as mere opinion testimony); Chikovsky v. Ortho Pharm. Corp., 832 F. Supp. 341, 346 (S.D. Fla. 1993) (expert testimony concerning the propensity of acne cream Retin-A to cause birth defects excluded as mere opinion testimony); Hayes v. Raytheon Co., 808 F. Supp. 1326, 1330-31 (N.D. Ill. 1992) (expert testimony concerning the emission of cancer-causing radiation from video display terminals excluded as mere opinion testimony) (pre-*Daubert* case where the court's analysis closely follows the methodology-driven focus of *Daubert*). *See also* Eggar v. Burlington N. R.R., 1991 WL 315487 (D. Mont. 1991) (pre-*Daubert* case involving fundamentally unsupported and speculative expert testimony claiming various illnesses as a result of exposure to chemicals).

[109] 1995 WL 447598 (2d Cir. 1995).

all causes but one. The physician based his conclusion on his care and treatment of the plaintiff, the plaintiff's medical history, pathological studies, material safety data sheets, and other references to scientific and medical treatises. Not a single publication, however, stated that glue fumes cause throat polyps. Based on these facts in *McCullock*, the Second Circuit affirmed the district court's ruling that the examining physician's methodology satisfied *Daubert*.[110] A comparison of post-*Daubert* cases in which the proffered testimony is found to be unsubstantiated with other cases relying on limited scientific studies, shows that the quantum of scientific information that must undergird an expert's methodology to render it scientifically valid and admissible under *Daubert* is quite minimal.

When an expert's methodology has been generally accepted in the scientific community for the particular purpose involved in a case, courts have admitted readily the testimony under *Daubert.* For example, when electrophoretic testing of blood stains was admitted on three prior occasions after evidentiary admissibility hearings, the court took judicial notice of these three previous hearings. In the absence of any new scientific data that might challenge the propriety of the findings in these prior hearings, the court admitted the proffered scientific analysis without holding another hearing to address the admissibility of the same methodology.[111] Similarly, once liquid chromatography was well accepted as a testing technique for identifying genetic proteins in cereal grains, it was admitted easily.[112]

General acceptance of a scientific technique for one purpose, however, does not automatically mean that it is generally accepted for an altogether different purpose. In addition, by narrowly defining the relevant field to include only practitioners of a technique, general acceptance can be almost assured. Commentators initially raised these concerns under the *Frye* test,[113] and these problems persist after *Daubert.* For example, in *United States v. Bynum*[114] the Fourth Circuit noted that gas chromatography enjoyed general acceptance in the field of forensic chemistry. Forensic chemistry, however, may be too narrow a field for determining any level of scientific acceptance because the technique always will be deemed reliable and valid if the inquiry is limited to practitioners of the technique. Moreover, the court noted that *Bynum* might be the first case involving chromatograph analysis of cocaine.[115] Even if gas chromatography is well accepted by forensic chemists, it is unclear if gas chromatography was determined by the court to be specifically reliable in analyzing cocaine. Because general acceptance is still part of the relevant inquiry under *Daubert*, it is not surprising that some of the problems associated with the *Frye* general acceptance test persist after *Daubert.*

An examination of post-*Daubert* cases in which the proffered scientific evidence was neither generally accepted nor entirely embryonic reveals a tortured landscape of decisions. When the characteristics of the proffered methodology still are being re-

[110] *Id.* at *5. See also McLain v. Tulane Fleeting Inc., 1995 WL 2272 (E.D. La. 1995), where the courtconcluded that a treating physician's opinion that the plaintiff's development of Guillain-Barre (G-B) Syndrome was caused by a tetanus shot, based on his own tests and observations and his knowledge and training, satisfied *Daubert.* The court reasoned that although no epidemiological study (the court did refer to a single medical publication discussing how the tetanus toxoid vaccine may precipitate the G-B Syndrome in patients who are hypersensitive to the tetanus antigen) linked the triggering of the G-B Syndrome to persons receiving a diphtheria-tetanus shot, *Daubert* did not require that the subject of the scientific testimony be known with certainty.

[111] *See* Smith v. Borg, 1 F.3d 1247 (9th Cir. 1993).

[112] Pioneer Hi-Bred Int'l v. Holden Found. Seeds, Inc., 35 F.3d 1226 (8th Cir. 1993).

[113] Giannelli, *supra* note 76, at 1214 n.118; James E. Starrs, *Frye v. United States Restructured and Revitalized: A Proposal to Amend Federal Evidence Rule 702*, 26 JURIMETRICS 249, 258 (1986).

[114] 3 F.3d 769 (4th Cir. 1993).

[115] *Id.* at 773.

solved in the scientific literature, the analyses and conclusions of courts vary considerably, even when they are faced with the same scientific evidence. Different courts do not employ similar judicial methodologies to review proffers of similar scientific evidence.

The post-*Daubert* cases that deal with polygraph testing supply a good illustration. Rudimentary polygraph testing originated around the turn of the century.[116] Even at the time *Frye* was decided, legal and scientific publications discussed the systolic blood pressure deception test,[117] the precursor to modern polygraph tests.[118] Polygraph testing is based on the detection of physiological responses produced by the psychological stress induced by a fear of deception. Modern polygraph machines can measure accurately and record these physiological responses, but it is the polygraph examiner who must decide whether there is a sufficient indication of deception based on changes in these responses.[119] Polygraph testing has been studied extensively by the scientific and legal communities.[120] At least thirty states regulate polygraphists and have licensing statutes, and the American Polygraph Association accredits polygraph schools and sanctions members who do not follow testing procedures.[121] Nevertheless, the accuracy of polygraph tests is contested seriously and recent accuracy reports range from seventy percent to ninety percent.[122] Experts believe that ten percent of the population can fool even a properly administered polygraph test.[123] Prior to *Daubert*, regardless of the particular admissibility test employed, many courts rejected polygraph testimony.[124] Some federal courts, however, found polygraph evidence to be admissible as early as 1971.[125]

Although there is an extensive body of literature concerning polygraph testing, there is disagreement in the scientific community about its accuracy. Five post-*Daubert* polygraph decisions illustrate how different federal courts, when faced with the same evidence, reach divergent and even opposite conclusions under *Daubert.* In *United States v. Posado*, the Fifth Circuit noted "that tremendous advances have been made in polygraph instrumentation and technique," and held that polygraph evidence would be not be per se inadmissible under *Daubert*.[126] The court viewed polygraph testing favorably and decided to allow polygraph evidence "in certain circumstances."[127]

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[116] *See* Gordon H. Barland, *The Polygraph Test in the USA and Elsewhere, in* THE POLYGRAPH TEST: LIES, TRUTH AND SCIENCE 73 (Anthony Gale ed. 1988) (providing a historical development of the polygraph).

[117] *See* Annotation, *Physiological or Psychological Deception Test*, 34 A.L.R. 147 (1925) (listing several scientific and legal publications between 1917 and 1922 on rudimentary polygraph testing); *see also* Case Note, 37 HARV. L. REV. 1138 (1924).

[118] At the time of *Frye*, the only physiological response detected was blood pressure. Modern polygraph instrumentation, in contrast, detects changes in blood pressure, pulse, thoracic and abdominal respiration, and galvanic skin response.

[119] *See generally* 1 GIANNELLI & IMWINKELREID, *supra* note 81, § 8-2(A) (reviewing polygraph testing).

[120] *See* 22 CHARLES A. WRIGHT & KENNETH W. GRAHAM, FEDERAL PRACTICE AND PROCEDURE § 5169, at 92 n.2, 95 n.7 (1978).

[121] United States v. Posado, 57 F.3d 428, 434 n.9 (5th Cir. 1995); 1 GIANNELLI & IMWINKELREID, *supra* note 81, § 8-2(A).

[122] *Compare* Bennett v. City of Grand Prairie, 883 F.2d 400, 405 (5th Cir. 1989) (stating that polygraph exams by most accounts correctly detect truth or deception 80% to 90% of the time) *with* 1 GIANNELLI & IMWINKELREID, *supra* note 81, § 8-2(C) (quoting a 1983 Office of Technology Assessment study reporting correct guilty detections ranging from 17% to 100%). *Posado*, 57 F.3d at 433 n.7.

[123] *See* Janet Seiberg, *Judge Rejects Requests to Reassess Admissibility of Polygraphs*, CONN. L. TRIB., Dec. 6, 1993, at 7.

[124] *See* Annotation, *Physiological or Psychological Truth and Deception Tests*, 23 A.L.R.2d 1306, 1308 (1952 & Supps. 1982 & 1987).

[125] *See* United States v. Ridling, 350 F. Supp. 90 (E.D. Mich. 1972); United States v. Hart, 344 F. Supp. 522 (E.D.N.Y. 1971); *see also* Giannelli, *supra* note 76, at 1198-99 n.8, 1320 n.258.

[126] *Posado*, 57 F.3d at 434.

[127] *Id.* at 433-36.

Another federal court, however, reached the opposite conclusion regarding polygraph evidence. The Eastern District of New York decided that "polygraph evidence is neither reliable nor admissible" under *Daubert*. The court then concluded that the polygraph evidence offered by the defendant would be inadmissible in either a criminal trial or a pretrial hearing.[128]

In a third case, the Southern District of New York failed to rule on the admissibility of polygraph evidence under *Daubert* and Rule 702, but instead excluded the polygraph evidence as misleading and confusing to the jury under Rule 403.[129] The court stated that in polygraph testing "a[n] examiner must . . . extrapolate a judgement of something not directly measured by the machine."[130] The court also argued that unpredictable variables, such as the skill of the examiner, the kinds of questions asked, natural variations in blood pressure, and how accustomed the subjects are to lying, all make polygraph evidence quite speculative.[131] Therefore, the court bypassed the more difficult scientific knowledge question under *Daubert* and instead chose to exclude the polygraph evidence under the more familiar terms of Rule 403.[132]

The Sixth Circuit took a similar route in another polygraph case and excluded the polygraph test results under Rule 403.[133] The court explicitly declined to address admissibility under Rule 702.[134]

Finally, adopting a middle ground, the U.S. Court of Military Appeals ruled that because the greater weight of authority indicates that polygraph examinations can be a helpful scientific tool, polygraph evidence can neither be accepted nor rejected out of hand.[135] These post-*Daubert* polygraph cases show that even when the basic polygraph methodology is not questioned, because there is significant scientific disagreement about its other attributes, trial judges can perceive the state-of-the-art of polygraph testing quite differently and reach widely disparate conclusions.

The concern about the potential health hazards posed by exposure to electromagnetic fields (EMF) provides another illustration of how scientific uncertainties and conflicting testimony will play a larger role in the courtroom after *Daubert*. The existence of epidemiological studies and publications about the dangers of EMF that do not provide any definitive results can be expected to pose problems for trial judges.[136] As with

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[128] United States v. Black, 831 F. Supp. 120, 123 (E.D.N.Y. 1993). In holding polygraph evidence to be inadmissible under *Daubert*, this court referred to two pre-*Daubert* Second Circuit cases, United States v. Rea, 958 F.2d 1206 (2d Cir. 1991) and United States v. Bortnovsky, 879 F.2d 30 (2d Cir. 1989). Neither of these two Second Circuit cases, however, performed a *Daubert*-like gatekeeping analysis. The two cases did not analyze polygraph testing methodology or even refer to any scientific publications on polygraph testing. Disappointingly, in reaching its conclusions, this court did not hold any *Daubert* hearing or review polygraph testing using any of the *Daubert* gatekeeper factors.

[129] *See* United States v. Lech, 895 F. Supp. 582, 585 (S.D.N.Y. 1995).

[130] *Id*. at 586 (quoting United States v. Williams, 583 F.2d 1194, 1199 n.9 (2d Cir. 1979)).

[131] *Id*.

[132] *Id*. at 585. Expert testimony on eyewitness identification has been similarly excluded, without addressing whether the testimony amounts to scientific knowledge, as not being helpful to the jury under the second prong of *Daubert* (i.e., the helpfulness part of Rule 702). *See* United States v. Benyamen, 39 F.3d 1188 (9th Cir. 1994); United States v. Rincon, 28 F.3d 921 (9th Cir. 1994).

[133] Conti v. Commissioner, 39 F.3d 658, 662 (6th Cir. 1994).

[134] *Id.*

[135] United States v. Rodriguez, 37 M.J. 448, 451-52 (C.M.A. 1993) (remanding for a determination of reliability of polygraph testing under *Daubert*).

[136] The most common claims alleging impact from EMF are personal injury suits, diminution-in-value actions by landowners against utilities, and requests to declare certain facilities nuisances. Substantial scientific work has been conducted and published in the United States and abroad concerning the health hazards posed by occupational and nonoccupational exposure to EMF, and because these studies have reached opposite conclusions, they provide ammunition for parties on both sides. Scandinavian scientists

the post-*Daubert* polygraph cases, different courts in dealing with EMF evidence are likely to reach different conclusions under the first prong of *Daubert*.

Determining when the proffered testimony may satisfy *Daubert* but nonetheless prove insufficient as a matter of law also can be difficult. Courts often rule evidence insufficient when the scientific community is divided on whether specific studies prove a particular result. In *In re Joint Eastern & Southern District Asbestos Litigation*,[137] for example, the scientific community was divided on whether exposure to asbestos significantly increased the risk of contracting colon cancer. Several epidemiological studies were presented to the court, each with differing standardized mortality ratios (SMRs). An SMR of 1.0 is the expected rate of contracting a certain disease *a* in a population not influenced by a causal factor *b*, the causal factor under consideration. An SMR of 2.0 means that *a* was as likely as not caused by *b* and an SMR greater than 2.0 means that *a* was more likely than not caused by *b*. Because many of the epidemiological studies yielded SMRs between 1.14 and 1.47, the district court concluded that the data was statistically insignificant, and therefore the epidemiological evidence was insufficient to support any causal connection between colon cancer and asbestos exposure.[138]

The Second Circuit reversed this finding of insufficiency, pointing to three epidemiological studies yielding SMRs of 1.62, 1.85, and 2.27.[139] The court held that these SMRs were statistically significant and presented a question of causation for the jury.[140] The Second Circuit also noted that the particular causal connection need not be supported by all relevant epidemiological studies and that particular flaws in the epidemiological studies presented classic questions for the jury.[141] Determinations of insufficiency, similar to those of admissibility, are difficult post-*Daubert* decisions for trial judges. With conflicting and inconclusive scientific evidence, it is hard to find a principled distinction for when a judicial finding of insufficiency crosses the line and usurps the role of the jury.

A finding of insufficiency also has been used to exclude scientific evidence without addressing the threshold issue of admissibility under *Daubert*. In *Thomas v. American Cyanamid Co.*,[142] the Sixth Circuit allowed a determination of insufficiency to stand without questioning why the district court never addressed admissibility of the causation evidence. The plaintiff alleged that her brain abnormality had been aggravated permanently by the Tri-Immunol vaccine. The district court had concluded that the "speculative medical evidence" was insufficient without determining its admissibility.[143]

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have found a statistically significant association between leukemia in children and EMF from high-voltage power lines. Interagency reports from the federal government and another study on EMF by a universities consortium found no persuasive evidence of a direct link between EMF exposure and adverse human health effects. *See* Scott H. Strauss, *The Big Uncertainty Over EMF*, CONN. L. TRIB., Dec. 6, 1993, at 20.

Since 1985 over a hundred EMF lawsuits have been filed in the United States. Roland A. Giroux, Note, *Daubert v. Merrell Dow: Is This Just What the EMF Doctor Ordered?*, 12 PACE ENVTL. L. REV. 393 (1994). In 1993, in the first EMF personal injury trial in state court in California, the court admitted the EMF expert testimony over defendant's objection that this data was inadmissible under *Frye*. Zuidema v. San Diego Gas & Elec., No. 638-222 (Super. Ct. San Diego County 1993); San Diego Gas & Elec. v. Superior Court, 36 Cal. App. 4th 1461 (1995). One federal court recently has reviewed EMF expert testimony under *Daubert*. United States v. 0.59 Acres, 1997 U.S. App. LEXIS 6228 (9th Cir. 1997) (excluding *lay* opinion testimony about the effects of EMF under *Daubert*). Nevertheless, EMF testimony is not likely to be excluded under the scientific knowledge prong of *Daubert*.

[137] 52 F.3d 1124 (2d Cir. 1995).

[138] *Id.* at 1128-29.

[139] *Id.* at 1129.

[140] *Id.* at 1134.

[141] *Id.* at 1126-135.

[142] 7 F.3d 235 (6th Cir. 1993).

[143] *Id.* at 235.

This case presents a disturbing procedural concern because an observer can only speculate that the court believed the scientific testimony to be admissible. It also provides no guidance to other courts that may be presented in the future with the same evidence. A finding of insufficiency affords yet another route for a trial court to sidestep the daunting scientific knowledge inquiry under *Daubert.*

In summary, an examination of post-*Daubert* cases reveals mixed results regarding the ability of trial judges to cope with *Daubert*. In a positive trend, *Daubert's* mandate about focusing on the underlying methodology employed by experts is being applied in the lower courts. Expert opinion testimony that is entirely unsubstantiated by relevant scientific research has been excluded as being essentially per se inadmissible by most federal courts. Likewise, when an expert's methodology is generally accepted by the relevant scientific community for a particular purpose, courts have admitted the testimony. When a scientific claim is not unsubstantiated, and there are a few, not-easily-reconcilable scientific studies, the disputes in the scientific literature are replicated in court. Judges thus are forced to apply the gatekeeper factors and review the proffered methodology, and the results of such inquiries are less encouraging. Courts have taken one of two approaches in this situation. Some courts perform a gatekeeper analysis and occasionally reach conflicting conclusions about the admissibility of similar types of evidence. Alternatively, other courts simply avoid the first prong of *Daubert* and exclude the evidence as being unhelpful[144] or insufficient.

The problems encountered by judges, and the inconsistent decisions that have followed, can be traced back to the fundamental compromise in *Daubert.* Arguably, if the Supreme Court had decided that scientific expert testimony would be admissible only if the expert relied on well-established methodologies, the post-*Daubert* decisions may have been more uniform. On the other hand, if the Court had chosen to trust lay juries and their rough sense of justice, decisions would be more justifiable as reflecting the community's notions of fairness. By doing neither and instead choosing to have generalist judges review conflicting scientific studies, the Court has given rise to an unsettled landscape of decisions. In the future, inconsistent jury verdicts that follow the exclusion or inclusion of scientific evidence once again may evoke cries of "junk science" and undermine public confidence in the judicial system.

C. *The Weight/Admissibility and the Methodology/Conclusion Distinctions*

As the Bendectin cases[145] themselves demonstrate, deciding whether the proffered scientific evidence is inadmissible or admissible but insufficient is not always straightforward. When flaws in the execution of an expert's methodology[146] are highlighted, a trial judge must determine whether these flaws render the expert testimony inadmissible or whether they present a question for the jury. For trial judges these decisions have not been easy in a post-*Daubert* world. The Supreme Court in *Daubert* emphasized that "the focus [of the trial judge's inquiry] must be solely on principles and methodology, not on the conclusions that they generate."[147] As Judge Becker pointed

[144] Evidence can be excluded as unhelpful under either the second prong of *Daubert* or Rule 403.

[145] *See supra* notes 42-44 and accompanying text.

[146] The term "methodology" refers to a body of principles, practices, procedures, and rules used in a discipline or an inquiry. A narrower definition of methodology that refers only to the underlying scientific principles in a discipline and not to the procedures employed in a particular case would not be in keeping with the spirit of the scientific validity/reliability inquiry contemplated by *Daubert.*

[147] *Daubert III,* 509 U.S. at 595.

out, however, "[w]hen a judge disagrees with the conclusions of an expert, it will generally be because he or she thinks that there is a mistake at some step in the investigative or reasoning process of that expert."[148] A clear conclusion that can be drawn is that the Court did not want an expert's testimony to be deemed unreliable under *Daubert* simply because he or she disagreed with other experts. After the publication of the Federal Judicial Center's *Reference Manual on Scientific Evidence*,[149] the methodology/conclusion distinction has been hotly debated in the literature.[150] The question that the Supreme Court left unanswered is: Under what circumstances, if any, may an expert's conclusions be excluded under *Daubert?*

In general, expert scientific testimony can be parsed into four steps for expatiating the weight/admissibility distinction. These steps occur sequentially and form the basis for the expert's opinion. They are: 1) the expert's choice of methodology, 2) application of the methodology to the facts of the case, 3) execution of the chosen methodology in the particular case, and 4) the expert's conclusions based on results from the execution of the methodology. Figure 2 identifies the relationship of the four sequential components in an expert's scientific testimony to *Daubert*.

For example, assume that DNA profiling for individuation is the expert's proffered methodology. Application of this technique in a particular case would be relevant only

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[148] *In re* Paoli R.R. Yard PCB Litig., 35 F.3d 717, 746 (3d Cir. 1994), *cert. denied*, 115 S. Ct. 1253 (1995).

[149] *See* REFERENCE MANUAL, *supra* note 50.

[150] *See* Margaret A. Berger, *Evidentiary Framework in* REFERENCE MANUAL, *supra* note 50, at 37. This chapter was designed to "assist judges in structuring inquiries necessary for making rulings on objections to expert evidence." Rorie Sherman, *Judges' Manual Irks Plaintiff Bar,* NAT'L L.J., Aug. 1, 1994, at A6 (quoting Joe S. Cecil, Project Director, FJC Research Division). The Association of Trial Lawyers of America (ATLA) and the plaintiffs' bar criticized the chapter as being biased toward favoring the exclusion of evidence. *See, e.g.*, Eva M. Rodriguez, *The State of Scientific Evidence*, LEGAL TIMES, Dec. 12, 1994, at 6 (reporting criticisms from plaintiffs' bar groups that the FJC's Manual is one-sided and miseducates judges); Thom Weidlich, *Plaintiff's Bar Loses Bid to Sway Science Manual,* NAT'L L.J., Dec. 26, 1994, at A11 (reporting that the FJC's board had considered ATLA's objections and voted to reject them). *See also* Kenneth J. Chesebro, *Taking Daubert's "Focus" Seriously: The Methodology/Conclusion Distinction,* 15 CARDOZO L. REV. 1745 (1994) (arguing that *Daubert* is most coherently understood by concentrating on the methodology/conclusion distinction).

if the identity of an individual in the case (typically the perpetrator) is a contested issue. Execution of DNA testing would involve collection of evidence (e.g., blood and semen samples), perhaps from the scene of a crime and from the suspect, followed by laboratory testing and analysis of the test results. The expert then would draw conclusions based on these test results.

In a civil case, the expert's proffered methodology may involve thoroughly studying the relevant scientific literature, which might include epidemiological and animal studies together with a medical examination of the interested parties. Application of this methodology would be relevant in a particular case only if the associations predicted by the scientific studies correspond to the illnesses actually suffered by the plaintiffs. For example, if exposure to EMF is associated with leukemia in children, the methodology would be relevant only if the plaintiff suffered the same or substantially similar cancer. Execution of the methodology in this case might involve determining the conditions of plaintiff's exposure (e.g., intensity, dosage, and frequency of exposure) to the harm-causing element. The expert then might draw conclusions based on the complete analysis. These four components to an expert's testimony and their relation to the weight/admissibility distinction is discussed further below.

1. *The Expert's Choice of Methodology*

The expert's choice of methodology under the first prong of *Daubert* must amount to scientific knowledge. This is a threshold admissibility consideration.[151]

2. *Application of the Methodology to the Facts of the Case (the "Fit" Requirement)*

Even if the expert's methodology satisfies the first prong of *Daubert*, it still must satisfy the helpfulness/ relevancy requirement under the second prong of *Daubert*. This requirement also is a threshold admissibility issue. For example, a plaintiff's expert testimony that furans and dioxins in polychlorinated biphenyls (PCBs) can cause lung cancer is relevant only if the PCBs that plaintiff was exposed to contained furans and dioxins. In the absence of such evidence, the court in *Joiner v. General Electric Co.* concluded that the expert testimony was inadmissible because it did not fit the facts of the case.[152] There are several other cases in which expert testimony has been excluded as not meeting the fit requirement of the second prong of *Daubert*.[153]

3. *Execution of the Chosen Methodology in the Particular Case*

If the two-prong test of *Daubert* is satisfied, presumably any errors or shortcom-

[151] The effectiveness and manner in which trial judges in post-*Daubert* cases have made this determination has been discussed in the previous section. *See supra* Part III.B.

[152] Joiner v. General Elec. Co., 864 F. Supp. 1310, 1322 (N.D. Ga. 1994).

[153] Habecker v. Clark Equip. Co., 36 F.3d 278, 289 (3d Cir. 1994) (excluding for lack of fit forklift accident simulation that did not replicate lack of an operator or cargo on the forklift, and the height, rearward movement, or velocity of the forklift); Gier v. Educational Serv. Unit No. 16, 845 F. Supp. 1342, 1350-53 (D. Neb. 1994) (excluding for lack of fit expert testimony evaluating nonretarded children by using child behavior checklists designed for mentally retarded children); United States v. Libutti, 1994 WL 774646, *12 (D.N.J. 1994) (excluding for lack of fit testimony about a pathological gambling disorder that did not relate to elements of defendant's life); Richardson v. United States, 835 F. Supp. 1236, 1239-40 (E.D. Wash. 1993) (excluding for lack of fit accident reconstruction experts who did not base their conclusions on on-the-scene measurements of skid marks).

ings in the execution of the methodology should be a question of weight[154] that lies within the province of the jury. There are, however, situations in which the execution of the methodology is so flawed that it either does not amount to scientific knowledge in a particular case or it is simply not helpful to the jury. This may be thought of as a fidelity requirement. In other words, when the execution of the method in a case is so poor that the faithfulness of the execution to the underlying method is seriously in doubt, the evidence may be excluded under either the first or second prong of *Daubert*. As Judge Becker noted in *In re Paoli Railroad Yard PCB Litigation*, "any misapplication of a methodology that is significant enough to render it unreliable is likely to also be significant enough to skew the methodology." [155] Errors in execution are probably one of the most hotly debated issues in the weight/admissibility distinction. For example, the rate of error in DNA profiling, while being generally acceptable, may increase significantly in a particular case due to errors in execution and produce scientifically unreliable test results.

Fidelity in the execution of the methodology is a well-illustrated concept. For example, in *Whiting v. Boston Edison Co.*,[156] the plaintiff's expert, a professor of epidemiology, testified that plaintiff's death from acute lymphotic leukemia was caused by exposure to nuclear radiation during plaintiff's employment at defendant's nuclear power station. According to the court, the expert's methodology was so "replete with factual and mathematical errors" and "riddled with factual inaccuracies and unproven assumptions" that it was unreliable.[157] In this case, the court concluded that the execution of the methodology was so flawed that it either did not amount to scientific knowledge or was unhelpful to any reasonable jury (i.e., it did not meet the fit requirement).

When an expert's opinion relies on data not reasonably relied upon by other experts in the same field (Rule 703),[158] the expert's execution may be fatally flawed under either of the two prongs of *Daubert.* In *McLendon v. Georgia Kaolin Co.*,[159] an economic geologist based his testimony on writings not of the type reasonably relied on by experts in the field of kaolin evaluation.[160] His reliance on those writings raised sufficient doubts about the reliability of his opinion.

Fidelity concerns also are raised in the assessment of results from specialized, diagnostic machinery that incorporate scientific analytical techniques.[161] The concern here is whether the machines are designed, tested, and calibrated to execute the scientific technique faithfully.

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[154] Another common issue that goes to weight relates to the strength of the expert's credentials. *See,e.g.,* McCullock v. H.B. Fuller Co., 61 F.3d 1038 (2d Cir. 1995) (noting that disputes as to the strength of a medical doctor's credentials go to the weight, not the admissibility, of his testimony).

[155] *Paoli R.R. Yard*, 35 F.3d at 745.

[156] 891 F. Supp. 12 (D. Mass. 1995).

[157] *Id.* at 18-19.

[158] Rule 703 plays a diminished role in evaluating expert testimony after *Daubert.* The Court itself paid little attention to Rule 703 in *Daubert.* One central question in Rule 703 remains unanswered: What does "reasonable reliance" mean in the context of Rule 703? Arguably, the reasonable reliance standard in Rule 703 should not interpreted to require scientific consensus or even general acceptance of the data on which the expert is relying. This interpretation would be contrary to the liberal admissibility standard of *Daubert.* In keeping with the spirit of *Daubert,* reasonable reliance in Rule 703 should be interpreted to require a showing that it would be reasonable for another expert similarly situated in the same field to rely on the same data when presented with the same or similar circumstances.

[159] 841 F. Supp. 415 (M.D. Ga. 1994).

[160] *Id*. at 419.

[161] *See, e.g.,* United States v. Lee, 25 F.3d 997, 998 (11th Cir. 1994) (remanding for determination of whether the evidence obtained from two machines incorporating the techniques of gas chromatographic chemiluminescence and ion mobility spectrometry was admissible under *Daubert*).

When the faithfulness of the execution to the chosen methodology is not in serious doubt, questions about execution generally go to weight, and not admissibility, of the evidence.[162]

4. *The Expert's Conclusions Based on Results From the Execution of the Methodology*

Although the Supreme Court did not address whether execution of the methodology is an issue of weight or admissibility, it did briefly caution against excluding an expert's conclusions under *Daubert*.[163] The Court wanted trial judges to focus their attention on the proffered methodology only. Nevertheless, two situations can be posited in which an expert's conclusions may be excluded under *Daubert*. First, the expert's conclusions properly may be excluded when they are simply educated hunches and not based on any methodology that satisfies the *Daubert* test.[164] The second situation, however, is more subtle. When an expert's conclusions are not commensurate with the underlying methodology, they may be properly excluded under *Daubert* because they do not rely on scientific knowledge and thus are unhelpful to the jury. In this situation there is some overreaching by the expert and his conclusions are not commensurate in scope with the methodology employed. In other words, while some conclusions can be reasonably inferred from the methodology employed, others cannot.

It is important to note that the substance of the conclusions should not be questioned by the trial judge. The trial judge only needs to determine whether the scope of the conclusion is in keeping with the methodology employed.

For example, in *Cantrell v. GAF Corp*.,[165] a medical doctor testified regarding the association between asbestos exposure and laryngeal cancer based on epidemiological evidence reported in the medical literature.[166] He then specifically identified a facility where plaintiffs were employed as being the particular plant at which they contracted laryngeal cancer.[167] His first conclusion about causation was well supported and admissible. His second statement about the specific facility being the source of the cancer is a good example of an overreaching conclusion that is not commensurate with the methodology employed because the doctor did not indicate how he could identify the source of the asbestos by examining the plaintiffs.

In *In re Paoli Railroad Yard PCB Litigation*, numerous plaintiffs living near the vicinity of a railyard at which PCBs were used sued to recover damages for a variety of physical ailments. One doctor testified about the ailments suffered by numerous plaintiffs even though she had examined and taken down the medical histories of only two of them. The differential diagnosis methodology she employed required, *inter alia*, a physi-

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[162] *See, e.g., H.B. Fuller Co.*, 61 F.3d at 1044 (holding that specific faults in the use of differential etiology as a methodology goes to weight, not admissibility); *Pioneer Hi-Bred Int'l*, 35 F.3d at 1232-34 (holding that dispute about limitations of electrophoresis and liquid chromatography in determining the parentage of breeds of corn goes to weight, not admissibility); United States v. Chischilly, 30 F.3d 1144, 1154 (9th Cir. 1994) (holding that dispute about improperly conducted laboratory procedures goes to weight, not admissibility); United v. Bonds, 12 F.3d 540, 557, 563 (6th Cir. 1993) (holding that dispute about FBI's DNA testing protocol goes to weight, not admissibility); United States v. Martinez, 3 F.3d 1191, 1198 (8th Cir. 1993) (holding that dispute about improperly conducted laboratory procedures goes to weight, not admissibility).

[163] *Daubert III*, 509 U.S. at 595.

[164] *See supra* note 108 and accompanying text.

[165] 999 F.2d 1007 (6th Cir. 1993).

[166] *Id.* at 1012-14.

[167] *Id.*

cal examination of the patient and a review of the patient's medical records and medical history. The Third Circuit restricted her testimony to only the two plaintiffs she examined.[168] Her conclusions with respect to the plaintiffs she did not examine was unreliable; they were simply not supported by, and not commensurate with, the methodology she employed.

IV. AN ADMINISTRATIVE SOLUTION FOR NOVEL SCIENTIFIC EVIDENCE

In *Daubert*, the Court appointed trial judges as gatekeepers to decide the admissibility of scientific evidence. The post-*Daubert* problems of inconsistency and nonuniformity among the gatekeepers require that we look for other legal mechanisms to address these problems. From specialized science courts[169] to expert magistrate judges at the trial level[170] and scientific appellate/advisory panels,[171] commentators have advanced numerous proposals to improve scientific adjudication. For a variety of reasons, these proposals have not progressed very far.

Another approach to deal with the problems posed by scientific evidence is to rely on the traditional manner in which scientific matters are dealt with in our legal system — in an administrative setting. In such an administrative setting, administrative law judges (ALJs) or administrative judges (AJs), who have specialized expertise and cumulative experience in dealing with novel scientific evidence would rule on whether the type of evidence presented amounts to "scientific, technical, or other specialized knowledge" *vel non* under Rule 702.[172] The helpfulness of the evidence to the fact finder based on the facts in a particular case, i.e., the "fit" requirement under the second prong of Rule 702, could be determined either in the same administrative proceeding or subsequently by a trial judge.

The administrative approach to deal with the scientific evidence is particularly attractive for a number of reasons. First, complex scientific matters are currently handled within administrative agencies such as the Food and Drug Administration, the U.S. Patent and Trademark Office (PTO), the Nuclear Regulatory Commission, the Environmental Protection Agency, the National Science Foundation, and numerous others. Politically speaking, the agencies dealing with scientific matters are well regarded on both sides of the aisle. They are perceived to be competent and capable of providing a dispassionate, nonpartisan analysis of the complex scientific issues that appear before them. We can draw upon the success in dealing with scientific issues in an administrative framework and apply it to resolve the post-*Daubert* problems of scientific expert testimony.

Second, generalist lay judges in federal district courts deal with patent infringement suits involving complex scientific and technical matters *after* an invention has been examined initially in an administrative setting in the PTO, and a patent has been granted for that invention. The metes and bounds of the property right, i.e., the patent,

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[168] *Paoli R.R. Yard*, 35 F.3d at 732, 758, 764-71.

[169] See Proposal to Establish a Science and Justice Program Within the Federal Judicial Center (Aug. 1992) (submission to the Carnegie Foundation); see also Martin, supra note 77.

[170] See Edward V. DiLello, Note, Fighting Fire with Firefighters: A Proposal for Expert Judges at the Trial Level, 93 COLUM. L. REV. 473 (1993) (arguing for appointment of permanent expert magistrate judges who are lawyers specialized in particular scientific and technical fields).

[171] See John W. Osborne, Note, Judicial/Technical Assessment of Novel Scientific Evidence, 1990 U. ILL. L. REV. 497 (recommending institutionalizing scientific and technical expertise in appellate/advisory panel whose function would be limited to reviewing validity of such evidence).

[172] See supra note 32.

based on the invention are carefully outlined in a set of claims that is examined and amended through an administrative process involving technically skilled patent examiners in the PTO. Once the patent has been defined by a set of claims through an administrative process, the federal district courts are presented with a carefully circumscribed property right in a patent infringement case. Lay judges in federal district courts are then capable of dealing with this property right to determine patent infringement and validity.

Experience with patent cases indicates that generalist judges can deal with complex scientific matters after they have been through an administrative process. Similarly, in the case of scientific evidence, once it is determined in an administrative setting that the proffered evidence amounts to scientific or technical knowledge, we are more likely to see uniform and consistent adjudication of scientific evidence issues under *Daubert*.

Finally, in many states, it is common to employ administrative tribunals to deal with complex scientific evidence. For example, in Virginia, medical malpractice review panels arbitrate malpractice claims.[173] The opinions of these panels are admissible in a court of law and the panel members may be called to testify as witnesses by either party.[174] Since the members of the medical malpractice review panels consist of health care providers and impartial attorneys,[175] the panels have specialized medical and legal expertise. In addition, in this administrative setting, the repeated exposure to specialized issues results in accumulation of expertise.

In sum, a traditional administrative framework is an attractive approach to deal with complex admissibility rulings under *Daubert.* Administrative tribunals can bring specialized scientific expertise, and will benefit from the knowledge gained by repeated exposure to scientific matters. As a result, these tribunals are likely to be much more successful than generalist trial judges in achieving uniform and consistent application of *Daubert* to scientific expert testimony.

IV. CONCLUSION

In 1901, Judge Learned Hand remarked, "No one will deny that the law should in some way effectively use expert knowledge wherever it will aid in settling disputes. The only question is as to *how* it can do so best."[176] In *Daubert*, the Supreme Court chose one way to determine how to use expert knowledge. With its overarching emphasis on examining the underlying reasoning employed by an expert, in theory *Daubert* presents an ecumenical approach to determining the validity of expert testimony. The Court seeks to employ trial judges to conduct a validity inquiry.

In *Daubert*, the Court sought a middle ground between reposing its trust entirely in scientific or legal institutions. The Court chose to rely on neither the scientific community nor juries and the adversary system to determine what expert testimony satisfies general criteria of validity. Instead, the Court required generalist judges to conduct a gatekeeping inquiry and reach conclusions on the scientific validity of the expert testimony. The trial judge's inquiry is informed by the application of science-based criteria, including the judgments and criticisms of scientists, through institutional mechanisms created by the scientific community. This middle ground position, however, is fraught

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[173] VA. CODE tit. 8.01, §§ 8.01-581.1 - 8.01-581.20 (Michie 1992 & Supp. 1996).
[174] *Id.* § 8.01-581.8.
[175] *Id.* § 8.01-581.3.
[176] Hand, *supra* note 9, at 40 (emphasis added).

with problems. The Court's belief that trial judges can deal effectively with scientific matters has not borne out.

Post-*Daubert* courts are admitting more scientific evidence in civil and criminal cases. When dealing with scientific evidence about which there is limited agreement in the scientific community, the disputes among scientists are replicated in the courtroom, and the trial judge has had to reconcile these genuine disagreements. The result of these gatekeeping exercises is a tortured landscape of post-*Daubert* decisions, which are non-uniform, inconsistent, and irreconcilable. When different courts are presented with the same scientific methodology, the depth of their scrutiny varies considerably and the gatekeeping factors are not applied uniformly. Not surprisingly, courts reach different and at times conflicting conclusions on admissibility.

Distinguishing between questions of weight and admissibility under *Daubert* poses particular problems for trial judges. Errors in execution of a methodology are taken wrongly to be problems of weight and not admissibility. Courts often do not examine the execution of the proffered methodology to determine the fidelity of the execution to the underlying methodology. In cases in which the execution of the methodology is sufficiently skewed that it casts doubts on the reliability of the results, the evidence should be excluded under the first or second prongs of *Daubert.* In addition, when an expert's conclusions are not commensurate with the scope of the methodology employed, they may be excluded properly under *Daubert.* This is not to question the substance of the conclusions. Rather, it is an inquiry into the scope of the conclusions.

It is amply clear that trial judges do not enjoy their assignments under *Daubert*. Courts employ a gamut of proxies and distinctions to get around the first prong of *Daubert.* Some of these include classifying scientific evidence as not being novel, finding scientific evidence insufficient without addressing admissibility, reclassifying expert testimony as not relating to a science, and declaring proffered expert testimony to be lay opinion. In addition, courts continue to rely on other judicial opinions without ascertaining whether those opinions employed a *Daubert*-like admissibility inquiry.

A traditional administrative setting is an attractive approach to deal with complex scientific evidence under *Daubert*. Administrative tribunals possess specialized scientific expertise, and will benefit from the knowledge gained by repeated exposure to scientific matters. As a result, these tribunals are likely to be more successful than generalist trial judges in achieving uniform and consistent application of *Daubert* to scientific expert testimony.

Theoretically, *Daubert* is an eclectic approach to expert testimony on scientific matters. Practically, however, the Court traded one set of problems for another by replacing *Frye* with *Daubert*. Echoing Judge Hand's sentiments, the court cannot "blunder along" without taking decisive steps to achieve uniform scientific adjudication.[177] Perhaps in the future the court might even decide that *Daubert* is unworkable and revert to a well-defined substantial or general acceptance standard. The present need, however, is greater consistency and guidance in the application of *Daubert.* The dangers of not responding to the problems of *Daubert* at the trial and appellate levels are grave. Inconsistent jury verdicts may further undermine the public's confidence in the justice system, and cries of "junk science" may be heard all over again.

[177] "How long we shall blunder along without the aid of unpartisan and authoritative scientific assistance in the administration of justice, no one knows . . . ." Parke-Davis & Co. v. H.K. Mulford Co., 189 F. 95, 115 (C.C.S.D.N.Y. 1911), *aff'd in part and rev'd in part,* 196 F. 496 (2d Cir. 1912).