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WHEN SCIENCE IS TOO DAUNTING: MULTIPLE CHEMICAL SENSITIVITY, FEDERAL COURTS, AND THE STRUGGLING SPIRIT OF DAUBERT

CARL H. JOHNSON†

I. SCIENCE AS SUBJECTIVE PURSUIT, NOT A BASTION OF OBJECTIVITY

The "experts" have a penchant for being wrong, particularly when it comes to novel scientific theories. Seven years ago, one scientist opined that "research during the last five years has demonstrated that cloning mammals (including humans) is theoretically impossible with today's technology - and with any technology realistically in sight."1 In February of 1997, Dr. Ian Wilmut, a Scottish embryologist, proved that scientist wrong when he announced the birth of a sheep named Dolly, a clone of another sheep.2 Scientific experts in the late nineteenth century considered mechanized flight and missions to the moon mere science fiction. As we progressed through our elementary education, teachers told us that long ago people believed that the world was flat. We are constantly reminded that science is not a bastion of certainty and objectivity,3 but a discipline that "progresses by hunch, vision, and intuition."4 More often than not with science, the lines between fact and theory

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3. See Stephen Jay Gould, The Mismeasurement of Man 21 (1981) (referring to objectivity of science as "myth" that can only become reality "when scientists can shuck the constraints of their culture and view the world as it really is").

4. Id. at 22 (discussing changes in scientific theory over time). Gould emphasizes that the evolution of scientific theories and acts over time can be attributed as much to cultural and societal influences as to advancements in knowledge and understanding. See id. The two are wholly dependent on each other because culture influences the manner in which we perceive and process information. See id. "Theories, moreover, are not inexorable inductions from facts. The most creative theories are often imaginative visions imposed upon facts; the source of imagination is also strongly cultural." See id.

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and therefore between discovery and invention are blurred and indistinct.\(^5\)

Unfortunately, the lack of certainty is not the only weakness that science bares for the world to see. "True science," as touted by those who object to novel scientific theory,\(^6\) also has a history of being used as a political tool. For centuries, the cranial measurements of African Americans and Native Americans were used to "prove" they were more closely related to gorillas and orangutans than to human beings, conveniently justifying slavery and genocide.\(^7\) During World War II, the sciences of anthropology, psychia-


\(^6\) See 3 J. Weinstein & M. Berger ¶ 702[03], at 702-43 (1995) (stating that novel science refers to theories or evidence that have not achieved acceptance by mainstream scientific or judicial communities). See also Gould, supra note 3, at 20 (explaining that some problems associated with science are isolated facts or truths). Gould stated that "[d]eterminists have often invoked the traditional prestige of science as objective knowledge, free from social and political taint. They portray themselves as purveyors of harsh truth and their opponents as sentimentalists, ideologues, and wishful thinkers." Id. Gould's view of science is that society and culture must influence science, and scientists cannot disregard or exclude society's or culture's impact in the pursuit of truth or pure science. In keeping with this sentiment, Gould stated:

[I] do not intend to contrast evil determinists who stray from the path of scientific objectivity with enlightened antideterminists who approach data with an open mind and therefore see truth. Rather, I criticize the myth that science itself is an objective enterprise, done properly only when scientists can shuck the constraints of their culture and view the world as it really is. . . . My message is not that biological determinists were bad scientists or even that they were always wrong. Rather, I believe that science must be understood as a social phenomenon, a gutsy, human enterprise, not the work of robots programmed to collect pure information. I also present this view as an upbeat for science, not as a gloomy epitaph for a noble hope sacrificed on the altar of human limitations. Science, since people must do it, is a socially embedded activity.

Id. at 21.

\(^7\) See id. at 22 (explaining that history of science is necessarily intertwined with social norms of time). Gould notes that questions of science cannot be separated from their social context for two critical reasons:

First, some topics are invested with enormous social importance but blessed with very little reliable information. When the ratio of data to social impact is so low, a history of scientific attitudes may be little more than an oblique record of social change. The history of scientific views on race, for example, serves as a mirror of social improvements. This mirror reflects in good times and bad, in periods of belief in equality and in eras of rampant racism. The death knell of the old eugenics in America was sounded more by Hitler's particular use of once-favored arguments for sterilization and racial purification than by advances in genetic knowledge. Second, many questions are formulated by scientists in such a restricted way that any legitimate answer can only validate a social preference. Much of the debate on racial differences in mental worth, for example, proceeded upon the assumption that intelligence is a thing in the head. Until this notion was swept aside, no amount of data could
try, and clinical psychology joined forces to aid the United States government in justifying both a military and a propaganda war against the Japanese.\textsuperscript{8}

Today, special interest groups are believed to use their financial clout to attack and intimidate scientists and institutions that engage in research unfavorable to industry.\textsuperscript{9} Congress recently attempted to enact legislation that would silence any discussion by the Environmental Protection Agency (EPA) or the Clinton Administration on the effects or existence of global warming.\textsuperscript{10} Time and

\textsuperscript{8}See \textit{John W. Dower, War Without Mercy: Race & Power in the Pacific War} 118-46 (1986). Much of the American military's justification and propaganda surrounding World War II arose out of studies of enemy behavior. \textit{See id.} at 118. The war offered the academic world the opportunity to theorize on various "cultural and personality" studies of the enemy. \textit{See id.} These studies incorporated the disciplines of anthropology, psychology, and psychiatry. \textit{See id.} In this chapter, Dower further explains the impact this propaganda had on academic areas:

The "applied" behavioral and social sciences received unprecedented government support and public attention during the war, offering many academics an exhilarating opportunity to take theory out of the classroom and wed it to causes that seemed simultaneously practical and noble - involving nothing less than understanding the enemy, hastening ending the war, and laying the groundwork for a more tolerant and peaceful postwar world. \textit{Id.} at 118-19.


\textsuperscript{10}See H. Josef Hebert, \textit{Foes Seek to Muzzle Global Warming Talk}, \textit{The Record} (Northern New Jersey), July 7, 1998, at A8 (discussing attempts by House of Representatives to include in EPA appropriations bill prohibition of any education or discussion on global warming by Clinton Administration). \textit{See also Barry Commoner, Making Peace with the Planet} 10 (1990) (discussing that global warming is condition where Earth's atmosphere is heated at unnatural rate, caused mostly by release of various gases into atmosphere, chief among which is carbon dioxide). Many petrochemical manufacturing byproducts and gaseous emissions from internal combustion engines contribute to this process. \textit{See id.} While it is generally accepted in the scientific community that global warming exists, those in the coal and petroleum industries and their supporters in Congress insist that it is a hoax. \textit{See, e.g.,} Hebert, \textit{supra}, at A8 (recording Robert E. Murray, President of American Coal Co., as saying that global warming is hoax); 141 \textit{Cong Rec. E2053} (daily ed. Oct. 26, 1995) (remarks of Rep. Delay) (stating that "despite the public scare campaign by environmental extremists, the reports of destructive global warming have been greatly exaggerated"); \textit{id.} at E2270 (daily ed. Nov. 30, 1995) (remarks of Rep.
time again, science shows us that objectivity is more fantasy than reality.

The subjective and political problems associated with "scientific knowledge" come to a head in courtroom battles over Multiple Chemical Sensitivity (MCS). MCS is a "chronic multisystem disorder, usually polysymptomatic, caused by adverse reactions to environmental incitants, modified by individual susceptibility and specific adaptation."11 Put more simply, MCS is a multi-symptomatic disorder affecting multiple organ systems resulting from exposure to a multitude of chemicals at levels tolerated by the majority of the population.12 Despite the thousands of people affected by this disorder,13 mainstream medical and scientific organizations claim it does not exist.14 The vast majority of practitioners

11. PETER RADETSKY, ALLERGIC TO THE TWENTIETH CENTURY: THE EXPLOSION IN ENVIRONMENTAL ILLNESSES – FROM SICK BUILDINGS TO MULTIPLE CHEMICAL SENSITIVITIES 13 (1997) (noting that environmental incitants are abundant in our habitat). MCS results from an adverse reaction to chemicals that are not only present in our air, food and water but also are present at levels which are considered safe and non-harmful. See id. Reactions usually arise from repeated, long-term exposure to chemicals or from one mass amount. See id. Child birth, a car accident, or an infection are examples of possible MCS initiating occurrences. See id.

12. See Frank v. State of New York, 972 F. Supp. 130, 132 n.2 (N.D.N.Y. 1997) (defining MCS). In Frank, the court stated that the theory behind MCS is that numerous environmental irritants can affect a person's immune system to such a degree that everyday chemicals and naturally occurring substances cause medical problems for that person. See id. at 132. MCS can result from a hypersensitivity to chemical compounds emitted by pesticides, copy machine toners, carpet cleaners, inks, paints, oils, nail polish, perfume, and deodorant. See id.

13. See Studies of the Prevalence of Chemical Sensitivity and MCS (last modified July 4, 1998) <http://www.mcsrr.org/factsheets/mcsprev.html> (citing several studies conducted by clinicians and state agencies regarding prevalence of reported and diagnosed symptoms of MCS in selected states); Charlotte Gray, Waiting list already 7 months long at Toronto's new Environmental Health Clinic, 156 CAN. MED. ASS'N J. 879, 880 (1997) (discussing study of 4,000 patients in Toronto area alone who had health problems related to chemicals or environment).

14. See Sanderson v. International Flavors and Fragrances, Inc., 950 F. Supp. 981, 1001 (C.D. Cal. 1996) (mentioning such "distinguished bodies" as American College of Occupational and Environmental Medicine, American Medical Association, American College of Physicians, American Academy of Allergy and Immunology, and California Medical Association as those which reject the existence of MCS as legitimate disease); Gregory E. Simon et al., Immunologic, Psychological and Neuropsychological Factors in Multiple Chemical Sensitivity: A Controlled Study, 120 AMERICAN COLLEGE OF PHYSICIANS 97, 98 (1993) ("A recent report of the American Medical Association's Council on Scientific Affairs concluded that 'multiple chemical sensitivity should not be considered a recognizable clinical syndrome.'"). This last point once again illustrates how MCS fails to fit into "recognizable" paradigms. That does not mean, however, that it should be considered invalid.
who treat MCS are "clinical ecologists," or doctors of environmental medicine, who have medical and scientific backgrounds. Commentators have derided the methodologies of clinical ecologists as untraditional and unreliable. Throughout the entire scientific debate, it becomes evident that the scientific community's rejection of MCS and clinical ecology goes beyond mere methodology; it can instead be more readily attributed to a selective bias against MCS and a political agenda to keep it out of the courtroom.

Despite its problems, science is an invaluable tool for the toxic tort plaintiff in the courtroom. Unfortunately, the uncertain and

15. In recent years, the scientists formally known among themselves as clinical ecologists have adopted the title "Doctor of Environmental Medicine." As federal courts still recognize and apply the terms "clinical ecology" and "clinical ecologist," this article will use those terms for convenience and consistency.

16. See RADETSKY, supra note 11, at 136-58. If one were to rely on case law and the statements made by Kenneth Foster and Peter Huber, respectively, one would think that only clinical ecologists treat MCS patients or conduct MCS research. This is patently false. The following is a list of some practitioners who conduct MCS research or treat MCS patients who are not clinical ecologists:

Claudia Miller is an allergist-immunologist at the University of Texas Health Science Center in San Antonio, Texas. She was formerly an industrial hygienist for the University of California Medical Center in San Francisco, the Occupational Safety and Health Administration, and finally the United Steelworkers Union. Ms. Miller currently does research in environmental and occupational health in the University of Texas Health Science Center's Department of Family Practice.

Doris Rapp has a background in pediatric allergy medicine.

Al Levin is an immunologist. He is director of an immunology lab and staff physician at the University of California, San Francisco. Mr. Levin has made connections between low T cells in MCS patients and their symptoms with those of early stage cancer patients.

Rebecca Bascom is a pulmonary specialist at the University of Maryland School of Medicine in Baltimore. She has researched possible connections between MCS, the trigeminal nerve, and a naturally-occurring protein called substance P.

Iris R. Bell is a psychiatrist at the University of Arizona. She has conducted research focusing on the limbic portion of the brain, which regulates our mood and emotions, but is also closely connected to the environment through our sense of smell.

John Selner is a Denver allergist and respiratory specialist.

Id.

17. For a further discussion of the bias against MCS, see infra notes 374-81 and accompanying text (emphasizing mainstream medicine's rejection of MCS). Radetsky explains how difficult it is for environmental doctors to get their research published or validated because of traditional medicine's resistance to these new theories and techniques. See RADETSKY, supra note 11, at 13. Despite compelling documentation, studies, and evidence, these non-traditional doctors are considered "quacks" in the respected mainstream medical circles. See id. As a result, medical journals refuse to publish these studies or cite to these doctors. See id.

18. See Jeffrey Trauberman, Statutory Reform of "Toxic Torts": Relieving Legal, Scientific, and Economic Burdens on the Chemical Victim, 7 HARV. ENVT'L L. REV. 177, 197 (1983) (asserting that proving injury causation is paramount barrier that toxic tort plaintiffs need to overcome in courtroom); Richard J. Pierce, Encouraging
subjective nature of science can create complications for its use in the courtroom. Therefore, both the opponents and proponents of scientific evidence need to be cautious. Ample potential for abuse exists by both plaintiffs and defendants regarding admission of expert testimony. Plaintiffs may use "junk science" to promote a tentative claim, while defendants may try to bury legitimate scientific evidence to protect industry from the costs of using chemical substances in the modern world.19

While the Frye20 rule governed such matters in federal courts for most of this century, the Supreme Court changed the equation

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19. See Peter W. Huber, Galileo's Revenge: Junk Science in the Cour- room 3 (1991) (defining "junk science"). Huber said the following about junk science.

On the legal side, junk science is matched by what might be called liability science, a speculative theory that expects lawyers, judges and juries to search for causes at the far fringes of science and beyond . . . . Junk science is impelled through our courts by a mix of opportunity and incentive. "Let-it-all-in" legal theory creates the opportunity. The incentive is money: the prospect that the Midas like touch of a credulous jury will now and again transform scientific dust into gold. Ironically, the law's tolerance for pseudoscientific speculation has been rationalized in the name of science itself. The open-minded traditions of science demand that every claim be taken seriously, or at least that's what many judges have reasoned. A still riper irony is that in aspiring to correct scientific and medical error everywhere else, courts have become steadily more willing to tolerate quackery on the witness stand.

Id.

20. Frye v. United States, 293 F. 1013 (D.C. App. 1923). In Frye, the defendant appealed his murder conviction on the ground that the scientific theory on which the prosecution based its expert testimony was invalid. See id. at 1013-14. The Court held that the test for the admission of scientific evidence was whether the testimony was deduced from a well-recognized principle or discovery. See id. Additionally, the theory from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs. See id. For a further discussion of the Frye rule, see infra notes 153-65 and accompanying text.
with the Daubert21 and Joiner22 decisions.23 At first glance, application of Daubert seems overly prejudicial to plaintiffs. In the vast majority of toxic tort or products liability cases after Daubert and Joiner, plaintiffs have failed to convince the courts to admit vital expert testimony.24 This is especially true in MCS cases where the plaintiff

21. Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579 (1993). This case involved a class action suit brought against Merrell Dow Pharmaceuticals for the marketing of Benedectin, a pregnancy anti-nausea drug, which caused birth defects in the form of limb reduction. See id. The Supreme Court in Daubert held that the general acceptance test established in Frye was not the necessary precondition for the admissibility of scientific evidence under the Federal Rules of Evidence. See id. Rather, the Court held that it is the responsibility of the trial judge to determine whether the expert testimony is rooted in a reliable foundation and is relevant. See id. For a further discussion of the Supreme Court's decision in Daubert, see infra notes 168-232 and accompanying text.

22. General Elec. Co. v. Joiner, 522 U.S. 136 (1997) (holding that abuse of discretion standard does apply to district court's decision to exclude scientific evidence). In Joiner, plaintiff, an electrician who suffered from lung cancer, sued General Electric, the manufacturer of polychlorinated biphenyls (PCBs), electrical transformers, and dielectric fluid. See id. at 136. The Supreme Court held that the district court's admission of expert testimony regarding studies which indicated that infant mice developed cancer after receiving mass doses of PCBs and the exclusion of expert testimony based on epidemiological studies was not an abuse of discretion. See id. For a further discussion of the Supreme Court's decision in Joiner and related material, see infra notes 234-241 and accompanying text.

23. See Edward J. Imwinkelreid, The Methods of Attacking Scientific Evidence 108 (1997) (stating that Daubert and Joiner decisions only have full relevance in federal courts as illustrated by fact that some states have specifically declined to follow Daubert while 20 states have remained steadfast in their dedication to Frye).

attempts to prove that exposure to the defendant’s chemicals or product triggered the onset of MCS symptoms. A closer examination reveals, however, that in many of the cases where the plaintiff’s expert was denied admission, the selection of the experts themselves resulted in losing the Daubert argument. MCS cases are an exception to this rule.

This article seeks to provide guidance on the more subtle issues associated with the Daubert and Joiner cases. One of the primary difficulties associated with the admission of scientific expert testimony is the vastly different lenses through which scientists and


In contrast, a significantly smaller number of plaintiffs have been successful. See, e.g., Zuchowicz v. United States, 140 F.3d 381, 386 (2d Cir. 1998) (stating that decision to admit expert testimony is within broad discretion of trial judge and will be overturned only when manifestly erroneous); Maryland Cas. Co. v. Therm-O-Disc, Inc., 137 F.3d 780, 782 (4th Cir. 1998) (holding that district court properly admitted proffered expert testimony); Kennedy v. Collagen Corp., 161 F.3d 1226, 1228-29 (9th Cir. 1998) (holding medical expert’s testimony that collagen injections caused plaintiff’s atypical systemic lupus erythematosus (SLE) was supported by scientific evidence that would assist trier of fact); Ambrosini v. Labarraque, 101 F.3d 129, 132 (D.C. Cir. 1996) (reversing district court’s decision granting summary judgment after excluding expert testimony); Graham v. Playtex Products, Inc., 993 F. Supp. 127, 133 (N.D.N.Y. 1998) (stating that expert’s conclusions were based on scientific knowledge and therefore admissible under Daubert).

25. See, e.g., Zwillinger, 1998 WL 623589, at *11 (noting that onset of symptoms was triggered by exposure to offgassing of chemical fumes from new synthetic carpet); Coffin, 20 F. Supp. 2d at 109-11 (stating that triggering event was exposure to exterminator’s pesticide in office building); Treadwell v. Dow-United Techs., 970 F. Supp. 974, 980-83 (M.D. Ala. 1997) (noting that triggering event was exposure to epoxy resin in workplace); Bradley v. Brown, 852 F. Supp. 690, 696-98 (N.D. Ind. 1994) (indicating that triggering event was exposure to pesticide through building’s ventilation system).

26. For a further discussion of how plaintiff’s selection of the expert resulted in plaintiff’s losing the Daubert argument, see infra notes 251-67 and accompanying text.

27. See Sanderson v. International Flavors and Fragrances, Inc., 950 F. Supp. 981, 1001-02 (C.D. Cal. 1995) (discovering through courts own research that “every court to rule on this issue” has excluded MCS causation testimony on the grounds that “there is no scientific evidence that such a disease exists”). This exclusion does not stem from poor experts or poor methodology but from the medical and scientific community’s general lack of acceptance of MCS or clinical ecologists. For a further discussion of the medical and scientific community’s rejection of MCS, see infra notes 374-81 and accompanying text.
lawyers see the world. Both cultures differ on what constitutes "proof" and, consequently, who should be considered an "expert."

Section II compares the scientific method with legal deductive methods of evidentiary proof, concluding with examples of how these differences have raised sharp criticism by scientists over the use of expert testimony in the courtroom. Section III introduces Daubert and Joiner and offers a point-by-point discussion of how toxic tort claimants have fared in the wake of Daubert and Joiner. Section IV provides specific examples of what has caused plaintiffs to fail or succeed. Section V introduces the controversy surrounding MCS, with a focus on the scientific community's criticism of the syndrome and clinical ecologists and how MCS plaintiffs have fared in the federal courtroom. Section VI explores how judges should be more comprehensive in their evaluation of novel scientific evidence in the courtroom, focusing on the issues and challenges associated with MCS.

This article concludes that while the application of Daubert and Joiner has answered many of the criticisms over the use of scientific experts in the courtroom, it also has the potential for abuse as a backdoor application of the Frye standard regarding novel scientific theories. Courts can admit novel scientific testimony as long as they stay away from the general acceptance test and concentrate on the Daubert emphasis on the scientific method. Otherwise, judges will continue to take the easy road and hide from their gatekeeping responsibilities, thus allowing the scientific intelligentsia to dictate to the courts what constitutes "science."

II. THE NATURE OF THE EXPERT: UNDERSTANDING THROUGH METHODOLOGY

A. The Scientific and Legal Cultural Clash

A cultural disparity has developed between lawyers and scientists over the last century. Steven Goldberg identified one key dif-

28. For a discussion of the differences between the scientific method and the legal deductive methods of scientific proof, see infra notes 33-167 and accompanying text.

29. For a further discussion of how toxic tort plaintiffs have had difficulty in proving their claims after the Supreme Court's decision in Daubert, see infra notes 168-241 and accompanying text.

30. For a further discussion of how courts differentiate between good and bad experts, see infra notes 242-292 and accompanying text.

31. For a further discussion of MCS, see infra notes 293-364 and accompanying text.

32. For a further discussion of how judges should evaluate scientific evidence in the wake of MCS, see infra notes 365-422 and accompanying text.
ference between the two professions when he stated that the "scientists' emphasis on progress is replaced by the lawyers' emphasis on process." The Supreme Court has even recognized the "important differences between the quest for truth in the courtroom and the quest for truth in the laboratory."34

Despite the differences in culture, science and law share many similarities and both are integral to a functioning modern society. For example, both disciplines share in a belief that behavior must be rule or law-driven.35 Moreover, both seek to justify their authority through claims of establishing rational, objective knowledge.36 Through the process of finding the truth, whether it is scientific or legal, both professions engage in an adversarial process.37 Finally,

33. Steven Goldberg, Culture Clash: Law and Science in America 13 (1994) (noting difference between focus of law and focus of science). Goldberg states: "Does the law, with its focus on the affairs of mankind at large, share anything with the norms of science? Surely the fundamental thrust is in a different direction . . . . Rather than seeking greater knowledge of the natural world, the law seeks the peaceful resolution of human disputes." Id.

34. Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 596-97 (1993) (noting that "scientific conclusions are subject to perpetual revision. Law, on the other hand, must resolve disputes finally and quickly."). See also Goldberg, supra note 42, at 14-15 (discussing difficulty of establishing truth in courtroom). Goldberg wrote:

The legal system and the legal profession are primarily concerned with accommodating the numerous social goals applicable to a particular dispute in a socially acceptable way. The evolution of legal rules in our society is largely the work of appellate judges who write opinions interpreting judicial precedents and the often vague language of statutes and the Constitution. These opinions cannot be tested in a strictly scientific way. Human history does not lend itself to the running of controlled experiments . . . . An additional pressure on the legal system is that whereas ultimate judgments of right or wrong may take decades, particular disputes must be resolved more quickly. The law does not have the luxury of waiting for all the relevant evidence to come in, because with public policy delay is a decision. While we wait an individual is not in jail; a power plant is or is not constructed. Law must stress process in part because it is not in a position to ascertain ultimate truth.

Id.

35. See Expert Evidence: Interpreting Science in the Law 1 (Roger Smith & Brian Wynne, eds. 1989) (hereinafter Expert Evidence) (commenting that both scientific and legal institutions seek reality which can be controlled through observation analysis).

36. See id. at 1 (noting that partial motive of seeking objectivity rationally is public justification of scientific and legal community's respective authorities).

37. See Brian Wynne, Establishing the Rules of Law: Constructing Expert Authority, in Expert Evidence, supra note 35, at 33 (stating that "it has been accepted in the sociology of science that scientific conflicts offer the most fruitful examination of scientific knowledge in-the-making, because the adversarial pressure forces the premises and conventions of each side out in the open").
both develop specialized disciplines grounded in procedures, skills, attitudes, and values unique to the sub-discipline.  

A very simple explanation exists for this love-hate relationship. The professions of law and science employ divergent methodologies and processes designed to find the "truth." A scientific expert presenting an opinion based on "hard" science may hold in contempt another expert whose opinion is merely based upon a legal standard of proof, lacking in the formalities and rigors of the scientific method. Hence, the ability to understand what it means to be an expert in each field lies in the methodologies employed therein.

B. Scientific Proof Through Process and Method – The Expert as Master

A scientist yearns to seek the knowable and constant rules of the universe. The scientific expert is the individual who has meticulously applied the scientific method to theory, tested that theory, and consistently gained respect for adherence to procedure and acceptable methodology. For purposes of this discussion, the "scientific expert" is the scientist in the laboratory, as opposed to the "legal expert" who is the scientist in the courtroom. This scientific expert has pursued such endeavors in a "legitimate" field of science and has been accepted by fields of specialty other than his

38. See Expert Evidence, supra note 35, at 1 (recognizing that both science and law rely on theories to generate rational knowledge).

39. See Moore v. Ashland Chems., Inc., 126 F.3d 679, 685 (5th Cir. 1997) (discussing Supreme Court's Daubert decision as relevant to "hard science" or "Newtonian science," that is, science grounded in scientific method).

40. See Allen v. Pennsylvania Eng'g Corp., 102 F.3d 194, 198 (5th Cir. 1996) (quoting expert as saying, "[t]his is not a scientific study. This is a legal opinion.").

41. See Goldberg, supra note 33, at 19 (stating that "scientists looking for empirically verifiable truth have to believe there is some kind of order in their universe, whether it is expressible in traditional cause-and-effect terms or in probabilistic equations"); see also Sheldon Glashow, Does Ideology Stop at the Laboratory Door? A Debate on Science and the Real World, New York Times, Oct. 22, 1989, at E24. In describing the role of the scientist, Glashow wrote:

We believe that the world is knowable, that there are simple rules governing the behavior of matter and the evolution of the universe. We affirm that there are eternal, objective, extrahistorical, socially neutral, external and universal truths and that the assemblage of these truths is what we call physical science. Natural laws can be discovered that are universal, invariable, inviolate, genderless and verifiable. They may be found by men or by women or by mixed collaborations of any obscene proportions. Any intelligent alien anywhere would have come upon the same logical system as we have to explain the structure of protons and the nature of supernovae.

See id.
or her own. In other words, "science" is what a majority of scientists say it is. The "expert" in the scientific sense is the master of that science.

At the origin of this success lies the valid scientific theory. Karl Popper stated that a truly scientific theory was identified not by its verifiability but by its falsifiability. Each theory that comes to the fore is not necessarily new but built upon the work that has preceded it. Some of these theories can also be viewed as paradigms. Paradigms, such as Newtonian physics or Ptolemaic astronomy, are sufficiently unique to detract a group of scientists from competing modes of scientific activity yet open-ended enough to leave a variety of puzzles for the new group of scientists to resolve. A paradigm is what members of a particular scientific community share and, conversely, a scientific community is a group that shares a particular paradigm. These new paradigms are only successful if they are more capable of solving acute problems than their competitors. As they emerge, these new theories sometimes require such wide-

42. As this discussion will illustrate, scientists who engage in research on non-accepted fields of science, regardless of their adherence to the scientific method, are often not recognized as legitimate.

43. See Kenneth R. Foster & Peter W. Huber, Judging Science: Scientific Knowledge and the Federal Courts 166 (1997) (quoting physicist John Ziman as saying that science "is never one individual... It is a group of individuals, dividing their labor but continuously and jealously checking each other's contributions").

44. See Karl Popper, The Logic Of Scientific Discovery 27 (1968).

45. See Kuhn, supra note 5, at 6-7 (emphasizing connection between ever-evolving theories). Kuhn states:

The invention of other theories regularly, and appropriately, evokes the same response from some of the specialists on whose area of special competence they impinge. For these men the new theory implies a change in the rules governing the prior practice of normal science. Inevitably, therefore, it reflects upon much scientific work they have already successfully completed.

Id. at 7.

46. See id. at 10 (defining paradigms). Kuhn believed that achievements which share two specific characteristics are what he refers to as "paradigms," a term he relates closely to "normal science." See id. Kuhn defined these two characteristics as follows:

They were able to do so because they shared two essential characteristics. Their achievement was sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity. Simultaneously, it was sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve.

Id.

47. See id. at 176 (adding that scientific communities should be isolated without prior access to paradigms).

48. See id. at 25 (noting limits in scope and precision of paradigm at its first appearance). "To be more successful is not, however, to be either completely successful with a single problem or notably successful with any large number. The
spread reevaluation of accepted science as to leave the vast hoards of the scientific community in a state of "profound professional insecurity."49 These new theories emerge, in great part, because the old rules no longer apply.50

In order for a theory to survive beyond its infancy, it must be proven or deemed "valid."51 Several generally accepted principles lie at the heart of a valid theory. Traditionally, the criteria of internal consistency, explanation, prediction, and control have been considered vital elements of a valid theory.52 Internal consistency is essentially the absence of self-contradiction. Without consistency in the theory, it cannot be tested. Therefore, the internal consistency of the theory is the foundation on which validity can be built.53 While all theories must be internally consistent, the degrees of explanation, prediction and control will vary.54

Popper's process of falsification also incorporated some of these points and enumerated a number of ways in which a theory could be tested: (1) by comparing the conclusions that can be deduced from the theory among themselves to see whether they are internally consistent; (2) by investigating the logical form of the theory, to determine "whether it has the character of an empirical or scientific theory, or whether it is, for example, tautological;" (3) by comparing the theory with other theories, "with the aim of determining whether the theory would constitute a scientific advance
should it survive our various tests;" and (4) by "testing of the theory by way of empirical applications of the conclusions which can be derived from it."\textsuperscript{55} Thus, great advances or new paradigms are not made through theory alone but through testability or falsifiability. The problem of validating or invalidating scientific theories lies at the heart of the scientific process.

Just as many lawyers feel that the judicial process of establishing legal "proof" is far from objective,\textsuperscript{56} many scientists also feel similarly about the "scientific method."\textsuperscript{57} Paul Feyerabend insisted that no simple "scientific method" could apply to all disciplines.\textsuperscript{58} Richard Yeo suggests that, in the rhetoric surrounding assumptions about science, the scientific method was seen in "the social relations of science" as accessible, single, and transferable.\textsuperscript{59} It seems, therefore, that scientists can agree to disagree on the exact methodologies to apply to science, depending on what type of science is being studied.

Despite the lack of uniformity in specific methods, certain essential core elements comprise the scientific process. First, a theory is derived through induction from observations of the real world or from previous theories and data from studies.\textsuperscript{60} Next, specific pre-

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\item \textsuperscript{55} Karl Popper, A Survey of Some Fundamental Problems, in \textit{The Logic of Scientific Discovery} 32-33 (1992) (hereinafter \textit{Popper II}).
\item \textsuperscript{56} See generally Benjamin N. Cardozo, \textit{The Nature Of The Judicial Process} (1921) (discussing myth of absolute objectivity in judicial decision making).
\item \textsuperscript{57} See, e.g., Holt, supra note 54, at 1 (referring to process of scientific understanding as "intellectual warfare fought by scientists who are passionate partisans of one theoretical viewpoint or another"); Expert Evidence, \textit{supra} note 35, at 4 ("Scientific knowledge is established, assimilated, and transmitted by social trust and authority, rather than by the radical skeptical testing suggested by science's dominant public image."). But see Clarr v. Burlington Northern Railway Co., 29 F.3d 499, 503 (9th Cir. 1994) (opining that "scientists whose conviction about the ultimate conclusion of their research is so firm that they are willing to aver under oath that it is correct prior to performing the necessary validating tests [may] properly be viewed by the district court as lacking the objectivity that is the hallmark of the scientific method").
\item \textsuperscript{58} Paul Feyerabend, \textit{Killing Time: The Autobiography of Paul Feyerabend} 88 (1995) (commenting on patterns of ad hoc scientific explanations). "How can the circularity be removed? By making sure that what does the explaining is richer in content than the situation to be explained." \textit{See id.}
\item \textsuperscript{59} See Richard R. Yeo, \textit{The Politics And Rhetoric Of Scientific Method} 262 (1986) (describing accessible, single, and transferable as "these three characterizations respectively claimed that the method of science could be understood and practiced by a large number of people; that there was a single method common to all branches of science; and that this method could be extrapolated from natural science to other subjects"). Yeo added that these assumptions, which were derived from the work of Francis Bacon in the early nineteenth century, were later abandoned. \textit{See id.} at 263.
\item \textsuperscript{60} See Holt, \textit{supra} note 54, at 4 (noting that developing theories is creative process, incorporating breadth of scientists' imaginations). The creative process
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dictions are derived from the theory by a logical process of deduction. Then, the scientist obtains "relevant data to test the theory by using some methodology in the investigation of the real world." It is with the application of this methodology that the differences among disciplines arise. Finally, "the data are tested against the predictions of the theory, resulting in support, disconfirmation, or modification of the [original] theory."

Utilizing these essential core functions of the scientific process, the scientist must design a methodology which will legitimately test and eventually prove or disprove the theory. At the heart of all scientific methodologies is the simple premise that the scientist develops a hypothesis and then tests that hypothesis through experimentation. These distinct methodologies differ in their treatment of variables that are encountered in the course of the investigation. A variable in the scientific sense is a deviation or aberration when compared to what is expected. A scientist can address variables by manipulating them, measuring them, keeping them constant, randomizing them out, or simply ignoring them.

Scientists also employ statistical methodology in order to verify or to support the base methodology used to test the theory. Courts have accepted the importance of statistical sampling but only recognize its validity if the sample is unbiased and representa-
tive. Statistics is not only a process of measurement, lending the results to empirical analysis, but also an end in itself. The validity of statistical techniques serves a dual purpose as both (1) the methodology by which a scientist can verify conclusions and (2) the conclusion that must be validated.

The Scientific Process in Focus: A Close Look at Epidemiology and Toxicology

Epidemiology has been defined as "the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control of health problems." It compares control groups of unexposed individuals to groups of individuals exposed to a potential cause of a disease to determine if the exposed individuals bear a greater risk of contracting the disease. Epidemiological studies seek to find statistical associations between exposure to an agent and the occurrence of disease. These studies focus on the general causation of a disease rather than on individual cases or specific causation. Epidemiology is universally considered the best scientific means for proving causation in the courtroom.

68. See, e.g., E.K. Hardison Seed Co. v. Jones, 149 F.2d 252, 256 (6th Cir. 1945) (stating that to be valid "the sample portion should be of such nature as to be fairly representative"); United States Steel Group v. United States, 96 F.3d 1352, 1366 (Fed. Cir. 1996) (noting that to be reliable sample must be representative); Cimino v. Raymark Indus. Inc., 751 F. Supp. 649, 664 (E.D. Tex. 1990) (concluding that sample group must be representative of group as whole).

69. See EDWARD IMWINKELRIED, The Daubert Standard for Validating Scientific Evidence: Linking Us to the Scientific Past in SCIENTIFIC EVIDENCE: LAW, TACTICS, AND SCIENCE 498 (National Practice Institute, Inc. 1996) (explaining that validity of statistical methods must be validated in same way epidemiological techniques must be validated in order to determine incidence of disease).

70. R. BEAGLEHOLE ET. AL., BASIC EPIDEMIOLOGY 3 (World Health Organization 1993).

71. See Hall v. Baxter Healthcare Corp., 947 F. Supp. 1387, 1403 (D. Or. 1996) (explaining that "any difference in risk of getting the disease between the two groups is the exposed individuals' relative risk").

72. See Foster & Huber, supra note 43, at 151.

73. See Linda A. Bailey et al., Reference Guide on Epidemiology, in REFERENCE MANUAL ON SCIENTIFIC EVIDENCE 126 (Federal Judicial Center 1995) (hereinafter "REFERENCE MANUAL") (elucidating differences between general causation and specific causation). For example, one generally attributes an individual's smoking cigarettes as causing one to die from lung cancer. See id. In specific cases of an individual's dying from lung cancer, however, the patient may not necessarily have a history of smoking. See id.

Scientists employ several types of epidemiological studies. Cohort studies, also known as "follow-up" or "incidence" studies, begin with a group of individuals who are free of a disease; these individuals are then classified into subgroups according to exposure to a potential cause of the disease. Starting with the population at large, a group of people without the disease is broken up into two groups, one exposed and one not exposed. Each of these two groups is then further divided into groups of people who have the disease and those who do not. As these groups are studied over a long period of time, the incidence of disease is calculated and compared. The cohort study is considered the best means of determining causation of a disease and for assessing the potential rate of occurrence for a disease. Epidemiological evidence is not, however, required before a hypothesis is considered valid scientific evidence.

The other most common form of study used by epidemiologists is the "case control study." Widely used because of their simplicity, case control studies compare groups of patients that have disease (cases) and groups of individuals that do not have disease (controls) in order to determine if past exposure to disease is greater in cases than in controls, as is expected. When comparing "cohort studies" with "case control groups," the courts consider the latter less reliable. See, e.g., Hall v. Baxter Healthcare Corp., 947 F. Supp. 1387, 1411 (D. Or. 1996) (indicating that "case reports and case studies are universally regarded as an
plicity and economic advantages, case control studies utilize people with a disease and a control group of people unaffected by the disease. The researcher then compares past exposures and experiences between members of the two groups. Typically case-control studies should include study groups that have recently manifested illness in order to avoid the difficulty of isolating the factors that may have contributed to causation in the disease. Based on these comparisons, the researcher will create a "relative risk ratio." A case-control study that can also be carried out prospectively in order to collect exposure data before the development of the disease is called a "nested case-control study." Case studies insufficient scientific basis for a conclusion regarding causation because case reports lack controls"); Muzzey v. Kerr-McGee Chem. Corp., 921 F. Supp. 511, 519 (N.D. Ill. 1996) (stating that case reports "are not reliable bases to form a scientific opinion about a causal link"); In re TMI Litig. Cases Consol. II, 911 F. Supp. 775, 801 (M.D. Pa. 1996) (deciding that expert testimony was excluded because report relied upon by expert in forming conclusion was unreliable and did not "meet the most basic standards of scientific validity"); Grimes v. Hoffman-LaRoche, Inc., 907 F. Supp. 33, 35 n.2 (D.N.H. 1995) (noting that anecdotal reports cannot prove causation alone); Casey v. Ohio Med. Prods., 877 F. Supp. 1380, 1385 (N.D. Cal. 1995) (holding that case reports were unreliable as scientific evidence of causation and stating that "[e]ven if some credibility were given to the study, it does not have the degree of clarity required for a validation of its results on its methodology which is sufficient for objective and independent peer review").

82. See Beaglehole, supra note 70, at 36.
83. See Bailey, supra note 73, at 136 (discussing fact that case-control studies are less effective and therefore reveal weaker associations than cohort studies, particularly in cases where disease is atypical).
84. See Beaglehole, supra note 70, at 37.

A relative risk of "1" is the expected rate of contracting a disease in a population not influenced by the event under investigation. A relative risk of "2" means that the disease occurs among the population subject to the event under investigation twice as frequently as the disease occurs among the population not subject to the event under investigation. Phrased another way, a relative risk of "2" means that, on the average, there is a fifty percent likelihood that a particular case of the disease was caused by the event under investigation and a fifty percent likelihood that the disease was caused by chance alone. A relative risk greater than "2" means that the disease more likely than not was caused by the event.

Id.

86. See Beaglehole, supra note 70, at 37.
are considered to employ valid scientific methodology, but they nevertheless suffer from some methodological flaws.87

Another valuable tool in discerning the cause of an illness is toxicology. Toxicology is "the study of the adverse effects of chemical agents on biological systems."88 Even though the observation of harmful effects of substances on humans predates history, it is considered by some to be a fairly "new" science.89 While many sub-disciplines of toxicology exist, the form most relevant to this discussion is "clinical toxicology," which is a branch of medical science that studies poisoning from xenobiotic90 sources and the chemical means for counteracting the effects from these chemical or natural sources.91

There are three basic tenets of toxicology: (1) all chemicals have the potential to be harmful given the right dosage; (2) many chemical agents have a signature pattern of toxic effects that are used to establish causation; and (3) responses in laboratory animals are useful in determining the potential effects on humans.92 Toxicology generally seeks to identify chemicals that pose a threat to

   Case study populations are frequently small, leaving open the real possibility that the findings are due to chance rather than to exposure to the suspected substance. Another criticism is that the symptoms are often subjective on the part of the patient, susceptible to exaggeration or outright falsity (particularly if litigation is contemplated). Another problem...is potential bias. Doctors who specialize in certain conditions...attract patients with those symptoms.

Id.


89. See Walter J. Decker, Introduction and History, in HANDBOOK OF TOXICOLOGY 1 (Thomas J. Haley & William O. Berndt eds. 1987) (hereinafter "TOXICOLOGY HANDBOOK") (observing harmful effects of chemical substances on living organisms is rooted in prehistoric times and ancient civilizations searched for antidotes to poisons); see also Bernard D. Goldstein & Mary Sue Henifin, Reference Guide on Toxicology, in REFERENCE MANUAL, supra note 73, at 185 (describing toxicology as "an age-old science").

90. See generally John A. McLachlan, Functional Toxicology: A New Approach To Detect Biologically Active Xenobiotics, 101 ENVTL HEALTH PERSP. 386, 387 (Oct. 1993) (noting that xenobiotics is study of "chemicals in the environment with estrogenic activity and other biological functions"). "Xenobiotic" agents are man-made or foreign in origin. See id.

91. See Thomas J. Haley, Clinical Toxicology, in TOXICOLOGY HANDBOOK, supra note 89, at 592 (pointing out that homes present biggest danger of poisoning because of availability of detergents, cleaners, and bleaches and that agricultural chemicals pose dangers in rural areas).

92. See Goldstein & Henifin, supra note 89, at 185 (recognizing that toxicology is continually trying to carve out its own niche distinct from pharmacology, biochemistry, cell biology, and similar fields).
human populations and the risks associated with a chemical exposure at a given dose. Unlike epidemiology, which seeks primarily to establish causation, toxicology seeks primarily to estimate the given risks associated with potential exposure.

Often based on animal experiments, toxicological evidence in the courtroom seeks to establish dose-response relationships, extrapolating data from animals to humans. This extrapolation takes two steps: from animals to humans and from high doses to low doses. Typically, animals receive brief, severely high doses while humans receive lower-level exposures over long periods of time. A direct extrapolation cannot occur without a corresponding human study; otherwise, great potential for a significantly high rate of error exists. Dose-response relationships also consider the intensity of the exposure, the age of the exposure, and any other factors that might affect response, such as lifestyle. Dose-response relationships seek to estimate the dose required to place a population at

93. See id. (noting that foreign agents studied by toxicologists are "all chemicals (including foods) and physical agents in the form of radiation, but not living organisms that cause infectious diseases").

94. See id. (discussing fact that toxicology cannot offer direct evidence that certain chemical caused disease in individual, but toxicology can help determine increased risk of contracting disease because of exposure and eliminate other risk factors for disease).

95. See id. at 188. But see In re Paoli R.R. PCB Yard Litig., 35 F.3d 717, 743 (3d Cir. 1994) (observing that while "animal studies may be methodologically acceptable to show that chemical X increases the risk of cancer in animals ... they may not be methodologically acceptable to show that chemical X increases the risk of cancer in humans").

96. See Goldstein & Henifin, supra note 89, at 191 (clarifying that in "qualitative extrapolation" researchers can rely on fact that element causing effect in one mammal will cause same effect in another mammal).


risk and determine the concentration of a chemical to which humans are likely to be exposed.99

The World Health Organization, the National Academy of Sciences, and numerous United States government agencies have adopted a set methodology for determining the possible effects of a toxin on individuals.100 First, an evaluation is made of the chemicals to which the individual might have been exposed and of the concentrations of these chemicals in air breathed by the individual. The second step involves an evaluation, based on published scientific literature, of the exposures necessary to produce the adverse effects associated with the chemicals to which individuals may be exposed.101 Finally, "[t]hese two evaluations are combined . . . to provide an estimate of the likelihood that any of the harmful properties of any or all of the chemicals might have been expressed in the exposed individual."102 A simple process of establishing toxicological proof regarding causation would include "experimental evidence, the ability to replicate experimental results, and a reasonable mechanism to explain the effect."103

The problems associated with toxicology are well-documented and lamented.104 Standing alone, toxicological data are subject to stricter scrutiny in the courtroom. In conjunction with epidemiological data, however, toxicological data are more useful. The

99. See K.S. Schrader-Frechet, Risk Analysis And Scientific Method 27 (1985) (noting that while risk estimation may be determined by direct measurement, often data are not helpful, and complex models are thus used).

100. See Mancuso v. Consolidated Edison Co. of New York, 967 F. Supp. 1437, 1445 (S.D.N.Y. 1997) (concluding that many courts follow method which adheres to central tenet of toxicology "that the 'dose makes the poison'").


102. Id.

103. Sorensen v. Shaklee Corp., 31 F.3d 638, 644 (8th Cir. 1994) (explaining that expert witness admitted that without experimental evidence, ability to replicate results, and reasonable mechanism to explain effect, she was unable to make conclusive opinion).

104. See Schrader-Frechet, supra note 99, at 26. The criticism of the dependability of toxicology usually revolves around the use of animal studies. See id. Metabolic differences between animals and humans, variations and inconsistencies on how animals and humans react to certain chemicals, and different environmental concerns all contribute to the questionable utility of animal studies. See id. See also Kenneth R. Foster et al., Science and the Toxic Tort, 261 Science 1509, 1509 (1993) (stating that "[h]igh-dose animal studies have questionable relevance to risks to humans from low-dose exposures. Such evidence, presented outside the context of a comprehensive risk assessment, is a gross misuse of scientific data that should be excluded from the courtroom."). But see In re Paoli R.R. Yard PCB Litig., 35 F.3d 717, 734 (3d Cir. 1994) (reversing district court's exclusion of testimony derived from animal studies that were supported by epidemiological data and were used by EPA to conclude that PCBs were probable human carcinogen).
symbiotic relationship between these two fields of expertise is well known.\textsuperscript{105}

The interaction between these two disciplines, that is, understanding the questions they seek to answer, is a vital foundation for appreciating the perspective of the scientific expert on the issue of causation. The cause of a disease is considered to be "an event, condition, characteristic" or combination of these factors which play a role in producing the disease.\textsuperscript{106} A cause is considered "sufficient" when it produces or initiates a disease and is considered "necessary" if a disease cannot develop without it.\textsuperscript{107}

More often than not, a sufficient cause is a combination of several factors. These factors lead to an increased susceptibility to a disease that, when combined with exposure to a contaminant, will produce the physiological response that precipitates the disease.\textsuperscript{108} The four major factors that contribute to the causation of a disease are: (1) predisposing factors, such as age, genetics, and previous illness; (2) enabling factors, such as poor nutrition and insufficient medical care; (3) precipitating factors, such as exposure to a specific disease agent; and (4) reinforcing factors, such as repeated exposure or unduly hard work.\textsuperscript{109}

The process of determining whether observed associations among factors are likely to be causal is called a causal inference.\textsuperscript{110} Before a cause can be established, other factors or "variables,"\textsuperscript{111} such as bias,\textsuperscript{112} chance, or confounding, must be eliminated.\textsuperscript{113}

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\textsuperscript{105} See Goldstein & Henifin, supra note 89, at 194 (asserting that "epidemiology and toxicology have much to offer in elucidating the causal relationship between chemical exposure and disease"). See id. (defining epidemiology as "the study of the incidence and distribution of disease in human populations").

\textsuperscript{106} See Beaglehole, supra note 70, at 71.

\textsuperscript{107} See id.

\textsuperscript{108} See id. at 72-73, figs. 5.1 and 5.2 (illustrating risk factors and mechanisms for tuberculosis and cholera).

\textsuperscript{109} See id. at 74.

\textsuperscript{110} See id.

\textsuperscript{111} For a full discussion of variables, see supra notes 65-66 and accompanying text.

\textsuperscript{112} See R. Christopher Barden, Science Intensive Litigation: The Effective Analysis and Presentation of Complex Scientific Issues In The Legal System 11 (University of Minnesota Law School 1993). "Bias" in scientific evidence testimony can be seen through a variety of indicators: skewed, one-sided report testimony; testimony that summarily dismisses or minimizes unexplained variables; testimony that dramatizes or exaggerates; and testimony that relies upon unreliable or unaccepted testing procedures. See id.

\textsuperscript{113} See Beaglehole, supra note 70, at 74-75.
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This process of elimination involves established criteria for determining causation by objectively testable means.\textsuperscript{114}

The investigating scientist must follow certain criteria in order to prove causation. In epidemiology, the criteria are a temporal relation, plausibility, consistency, strength of association, a noticeable dose-response relationship, and a study designed to test these factors.\textsuperscript{115} The temporal relation is very crucial; the cause must precede the effect.\textsuperscript{116} The potential explanation for causation is plausible if it is consistent with other knowledge. Consistency is shown when several studies produce the same result.\textsuperscript{117} A strong association is demonstrated through the relative risk ratio.\textsuperscript{118} Then, the scientist determines the dose-response relationship by measuring possible cause’s change in level and linking those changes to the prevalence of an effect.\textsuperscript{119} If the removal of a possible cause results in a reduction in disease risk, then the likelihood of a causal relationship is strengthened. Only a well-designed study will produce reliable results.\textsuperscript{120} Finally, the expert must judge the evidence and make a determination as to whether the evidence points to the perceived cause.\textsuperscript{121}

The validity of the theory, adherence to methodology, and dedication to process are all means by which the scientific commu-
nity judges its own experts in the laboratory.\textsuperscript{122} In the courtroom, however, the legal expert is merely one tool to be used in proving injury or illness causation.\textsuperscript{123} In the courtroom, the expert is judged by an entirely different set of rules.\textsuperscript{124}

C. Legal Proof Through Induction and Persuasion – The Expert as a Tool

A legal belief that leads to a decision (unlike a scientific one) is often beyond objective testability.\textsuperscript{125} The law rarely strives to concentrate solely on factual truth, seeking instead to understand a more general truth.\textsuperscript{126} In the courtroom, the expert is not the individual seeking truth, like the scientific "master," but a tool in that search for truth and merely one piece in the inductive puzzle.\textsuperscript{127} While a scientist may use relative risk ratios as persuasion, a lawyer uses the weight of evidence, which sometimes consists of expert tes-

\textsuperscript{122} For a further discussion of the means by which the scientific community judges its own experts in the laboratory, see \textit{supra} notes 33-69 and accompanying text.

\textsuperscript{123} For a discussion of the expert as a tool in proving injury or illness causation, see \textit{infra} notes 125-52 and accompanying text.


\textsuperscript{125} \textit{See Goldberg}, \textit{supra} note 33, at 14 (observing difficulties associated with testing belief that certain types of materials are obscene); \textit{cf.} Jacobellis v. Ohio, 378 U.S. 184, 197 (1964) (Stewart, J., concurring) (referring to types of materials which should be considered obscene). In aspiring to define obscenity, Justice Stewart stated, “I shall not today attempt further to define the kinds of material I understand to be embraced within that shorthand description . . . . But I know it when I see it, and the picture involved in this case is not that." \textit{Id.}

\textsuperscript{126} \textit{See Goldberg}, \textit{supra} note 33, at 16 (observing that in murder case fact finder is less concerned with actual time that victim was murdered than with who murdered that victim).

\textsuperscript{127} \textit{See e.g.}, \textit{In re Paoli R.R. Yard PCB Litig.}, 35 F.3d 717, 741 (3d Cir. 1994) (stating that “we have eschewed imposing overly rigorous requirements of expertise and have been satisfied with more generalized qualifications”). Judges tend to apply a more liberal definition of “expert” than does the scientific community. \textit{See id.} The scientific community, however, possesses a rather poor understanding not only of the expert’s role in the courtroom but also of judicial scrutiny of their testimony. \textit{See e.g.}, Marcia Angell, \textit{Shattuck Lecture – Evaluating the Health Risks of Breast Implants: The Interplay of Medical Science, the Law, and Public Opinion}, 334 \textit{New England J. of Med.} 1513, 1516 (1996):

Witnesses are considered experts on the basis of very broadly defined credentials (for example, pathologists may be permitted to testify about epidemiologic questions), and they needn’t produce evidence from the literature to buttress their opinions, even when there are relevant studies in peer-reviewed journals. In the courtroom, their opinions are the evidence. This is a far cry from the scientific method, which accepts no conclusions, no matter whose they are, without evidence. \textit{Id.} (emphasis in original).
testimony, to persuade by mere argument that the truth, if it is out there, is what the lawyer says it is. While this principle may seem disconcerting to the strictly methodological scientist, it is not the “free-for-all” system that some claim it is.

Lawyers use a variety of time-tested methods to determine the “truth” in a litigious proceeding. Required and standard procedures exist for examining witnesses, introducing exhibits, and making arguments. Rules of procedure and evidence at both the state and federal level govern the methodologies that lawyers use in the courtroom to prove causation through the use of physical evidence, eyewitnesses, expert testimony, and other means at the lawyer’s disposal. Within the guidelines of these rules regarding legal methodology, lawyers also follow certain steps to establish causation through the process of logical inference. In fact, these procedures sometimes generate skeptical pressure on “established science.”

Lawyers must adhere to specific standards in proving causation in the courtroom. Depending on the jurisdiction and the type of case, a lawyer must prove actual causation and proximate causation. First, alleged wrongful or negligent behavior must be the cause-in-fact or actual cause of the harm. This is also known as the sine qua non rule or “but-for” causation. To prove cause-in-fact, a plaintiff’s attorney must show that the defendant’s conduct directly caused the injury sustained by the plaintiff. A defendant

128. See id. (stating that lawyer uses expert opinions as evidence in courtroom to persuade jury that truth is what he says it is).
130. See id. (outlining variety of methods used to determine “truth” in litigation).
131. See Wynne, supra note 37, at 32 (noting that “such procedures sometimes show that ‘established scientific fact’ is riddled with suppositions, unstated limiting conditions, and other qualifications or uncertainties”).
132. For definitions of “but for,” “proximate,” and “probabilistic” types of causation, see infra notes 70-124 and accompanying text. Contrary to the legal understanding, that it is the plaintiff who must prove causation, arising from the agency relationship that exists between the lawyer and his client, it is ultimately up to the lawyer to make a case for his or her client. See id. It is this lawyer who must use his or her knowledge, skill, and command of rules and procedure to prevail in the courtroom. See id.
133. For a definition of causation-in-fact, see infra note 134 and accompanying text.
134. See Prosser & Keaton, Torts, § 41, at 266 (Lawyer’s 5th ed. 1984) (defining “but for” causation as follows: “The defendant’s conduct is a cause of the event if the event would not have occurred but for that conduct; conversely, the defendant’s conduct is not a cause of the event if the event would have occurred without it.”); see also Richard A. Epstein, Cases And Materials On Torts 468 (6th ed. 1995) (defining “but for” causation).
135. See generally Richardson v. Richardson-Merrell, 649 F. Supp. 799 (D.D.C. 1986) (stating that plaintiff must not only prove that Bendectin causes birth defects
can defeat cause-in-fact evidence by showing that the plaintiff suffered the injury in question prior to the occurrence of the defendant's alleged wrongful conduct. 136

Second, a plaintiff's lawyer must prove "proximate" or "legal" causation. 137 More often than not, particularly in toxic tort cases, a long and tenuous chain of events between the defendant's actions and the plaintiff's injuries may exist making proximate causation more difficult to prove. Under the theory of proximate cause, liability is determined if the lawyer can establish a plausible, causal connection with the negligent act and the subsequent injury. 138 The rules of proximate or legal causation limit the defendant's liability to persons and consequences that bear some reasonable relationships to the defendant's alleged tortious conduct. 139 Whether and how proximate cause rules shall be applied is a question of law for the court. 140

Proximate causation presents two problems of proving a connection between the defendant's action and the plaintiff's injury. The first problem is one of "remoteness," that is, the actual harm is either unpredictable with a long chain of intervening causes or an unlikely event or one with severely low probability. 141 The second problem involves an intervening event or action that breaks the chain of causation and potentially relieves the defendant of liability. 142

A third notion of causation, known as probabilistic causation, incorporates probabilistic reasoning as opposed to the causal chains involved in proximate causation. 143 Given the complexity of the issues associated with toxic torts, the new theories emerging, and the frontier science involved, the simple model of showing "yes or no" that a single act definitely did or did not cause an injury is

but also that it caused plaintiff's birth defects); New York Cent. R.R. v. Grimstad, 264 F. 334 (2d Cir. 1920) (stating that plaintiff failed to show that drowning was caused by failure to provide life vest rather than decedent's inability to swim); Stimpson v. Wellington Serv. Corp., 246 N.E.2d 801 (Mass. 1969) (stating that violations of ordinances were in chain of proximate causation). 136. See Epstein, supra note 134, at 467.


138. See id.

139. See Epstein, supra note 134, at 468.

140. See id.

141. See id.

142. See id.

143. See Jack W. Snyder, supra note 121, at 139.
difficult to apply.\textsuperscript{144} Thus, statistical evidence is required to estimate the defendant's contribution to the plaintiff's injury.\textsuperscript{145}

In the process of showing causation, the plaintiff in a tort case bears the burden of proving injury through production of evidence and persuasion on the weight of that evidence.\textsuperscript{146} A plaintiff must meet the burden of production by bringing forth factual evidence to support each element of the claim.\textsuperscript{147} The plaintiff also has a burden of persuasion, meaning that he must convince the jury that his version of events or elements in the chain of causation is "worthy of their collective belief with a minimum level of certainty."\textsuperscript{148}

The most common standards of persuasion used in civil cases are: (1) "clear and convincing evidence,"\textsuperscript{149} and (2) "preponderance of the evidence."\textsuperscript{150} The "preponderance of the evidence" is used primarily in toxic tort, products liability, and occupational disease cases.\textsuperscript{151} Confusion and misunderstanding are exacerbated when the standards of proof differ dependent upon the type of law at question. For example, standards of proof necessary to implement

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\item 144. \textit{See id.} (stating that this third notion of causation is based on probability rather than concrete determinations of whether act was definite cause since complex issues sometimes make it impossible to make determinations of causation with precise certainty).
\item 145. \textit{See id. at 140}.
\item 146. \textit{See id.} (noting that plaintiff bears burden of proof on issue of causation).
\item 147. \textit{See id.} (stating that plaintiff may meet its burden of proof on causation by proving each element of the claim with factual evidence).
\item 148. \textit{See id. at 139}.
\item 149. \textit{See, e.g.,} Raynor v. Merrell Dow Pharm., Inc., 104 F.3d 1371, 1376 (D.C. Cir. 1997) (stating that defendant established by clear and convincing evidence that Bendectin is not human teratogen); Jenson v. Eveleth Taconite Co., 130 F.3d 1287, 1300 (8th Cir. 1997) (stating that punitive damages shall be allowed in civil actions only upon clear and convincing evidence that defendant showed indifference to rights or safety of others); \textit{See, e.g.,} Daubert v. Merrell Dow Pharm., Inc., 43 F.3d 1311, 1321 (9th Cir. 1995) (stating that clear and convincing is most prominently used causation evidence threshold, having been used by 120 federal cases that applied \textit{Daubert} standard); Arnold v. Riddell, Inc., 882 F. Supp. 979, 987 (D. Kan. 1995) (stating that presumption that manufacturer is not liable after product's "useful safe life" has expired may be rebutted only by clear and convincing evidence).
\item 151. \textit{See} Jack W. Snyder, \textit{supra} note 121, at 140 (stating that preponderance of evidence is used primarily in occupational disease, products liability and toxic tort cases).
\end{thebibliography}
regulatory policy differ from those required to resolve legal disputes in the courtroom.\textsuperscript{152}

Given the vast differences in proof required in the laboratory and in the courtroom, it is no surprise that the cultural differences between science and the law would be glaring in cases involving toxic torts, where science is most needed. Congress and the courts have attempted to provide guidance in smoothing-out these wrinkles but not without drawing criticism.

D. Science in the Courtroom – The Critics Speak

Until 1993, the United States Supreme Court had not spoken on how the rules of court should specifically apply to science in the courtroom. Instead, the general rule came from a 1923 D.C. Court of Appeals case, \textit{Frye v. United States}.\textsuperscript{153} In \textit{Frye}, the Court of Appeals for the District of Columbia stated that the origin of a deduction must be “sufficiently established to have gained the general acceptance in the particular field in which it belongs.”\textsuperscript{154} This “general acceptance” test was the dominant standard in this country for over seventy years.\textsuperscript{155} When the Federal Rules of Evidence were enacted, critics found them too liberal in the face of the traditional \textit{Frye} rule.\textsuperscript{156} Those espousing the liberal approach maintained that the Federal Rules were designed to expand the admissibility of scientific expert testimony.\textsuperscript{157}

Critics of the use of scientific evidence in the courtroom found no connection at all between legitimate science and scientific evidence because it is merely the expert opinion itself that constitutes evidence.\textsuperscript{158} In fact, critics feel that anyone claiming to be a scientist need not prove so, for any “self-styled scientist” is welcomed with


\textsuperscript{153} 293 F. 1013 (D.C. Cir. 1923).

\textsuperscript{154} Id. at 1014.

\textsuperscript{155} See Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 585 (1993) (stating that \textit{Frye} “general acceptance” test was untouched until \textit{Daubert} decision).

\textsuperscript{156} See, e.g., HUBER, supra note 19, at 96 (bemoaning “eroding” rules of evidence and “junk science” they permit into courtroom); PHANTOM RISKS, supra note 85, at 38-39 (stating that “[f]or half a century, the \textit{Frye} rule served reasonably well to exclude unreliable or eccentric scientific evidence from the courtroom” and blaming introduction of Federal Rules of Evidence for “avalanche of questionable testimony on scientific issues in the courtroom”).

\textsuperscript{157} See id.

\textsuperscript{158} See Angell, supra note 127, at 1516 (stating that \textit{Frye} distinction is irrelevant because it is expert opinion itself, not legitimacy of scientific evidence, that constitutes evidence).
"open arms" into the courtroom. Conversely, a more gentle view of this behavior is that opportunistic lawyers, representing clients with questionably valid illnesses, seize upon tentative scientific results to further the litigious cause. Such attorneys are not only opportunistic but also driven by the hopes of winning the tort lottery. Supported by the media, politics, fear, or simple outrage, plaintiffs' lawyers take advantage of a legal system that is relatively inept in the face of legitimate science.

Critics believe not only that the system is incapable of handling such matters but also that "ordinary citizens are not equipped to sort out the complex scientific issues" associated with toxic tort litigation. According to critics, some jurors would go so far as to say that the science offered in the courtroom did not matter to them, only their feelings on the issue did. So much for the jury system.

159. See Huber, supra note 19, at 3.
160. See Phantom Risks, supra note 85, at 28; see also Huber, supra note 19, at 2.
2. Huber stated:

Maverick scientists shunned by their reputable colleagues have been embraced by lawyers. Eccentric theories that no respectable government agency would ever fund are rewarded munificently by the courts. Batteries of meaningless, high-tech tests that would amount to medical malpractice or insurance fraud if administered in a clinic for treatment are administered in court with complete impunity by fringe experts hired for litigation. The pursuit of truth, the whole truth, and nothing but the truth has given way to reams of meaningless data, fearful speculation, and fantastic conjecture.

Id.

161. See id. at 35 (stating that attorneys rely on questionable scientific results in order to win large verdicts).
162. See id. at 32-34 (stating that attorneys with weak cases capitalize on legal system which can be manipulated).
163. Id. at 38. See also E. Donald Elliott, Toward Incentive-Based Procedure: Three Approaches for Regulating Scientific Evidence, 69 B.U.L. Rev. 487, 492 n.22 (1989) (stating that "our reliance on lay juries to assess the credibility of technical experts is not a problem, of course, if one is willing to assume that something magical happens in the jury room so that ordinary people can suddenly unravel complex technical and scientific issues that would baffle the rest of us"); Phantom Risks, supra note 85, at 37-38 ("Often baffled by weeks or months of complex scientific testimony, jurors may be left to rely on their instincts, 'common sense,' sense of justice . . . [and] are not equipped to sort out the complex scientific issues that arise in hazardous exposure cases").
164. See Angell, supra note 127, at 1517 (stating that jurors disregard scientific evidence in favor of their personal feelings on issue).
165. For a discussion of flaws in the jury system, see supra note 137 and accompanying text. Once again, herein lies another illustrative opportunity regarding the differences between science and the law. Science seeks to find the "truth." The Law seeks justice. The two are not necessarily complimentary.

Specific examples of such legal crimes against the honor of science abound. Fed by anecdotes, "irrational theories," and mass hysteria, the American tort system permitted thousands of litigants to prevail in the courtroom over the safety of
To best understand how the definition of "expert" has changed since *Daubert* and *Joiner*, one must determine if judges have successfully addressed these criticisms while performing their "gatekeeper" function. Have the proponents of junk science been continually successful, or have they met with resistance in the courtroom? How have federal judges treated experts who fail to support their theories with accepted methodologies? A close analysis of some cases that have applied both the *Daubert* standard of admission and the *Joiner* standard of review shows that courts have been very successful in weeding out "bad" experts.

III. SCIENTIFIC CRITICISM OF THE LAW AS THE LENS FOR VIEWING THE POST-DAUBERT EXPERT: ARE TOXIC TORT LAWYERS STILL MERELY SCHEISTERS PROVIDING A SOAP BOX TO CHARLATANS?

A. *Daubert* on "Scientific Knowledge" – A Matter of Reliability

In *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, the Supreme Court attempted to elucidate how the scientific view of "science" should fit into its use in the legal system. Federal Rule of Evidence 702 states that "scientific knowledge" may be presented in the form of expert opinion if "it will assist the trier of fact" in understanding scientific issues. The Court construed the term "scientific" as implying a "grounding in the methods and procedures of science." silicone-gel-filled breast implants, despite legitimate science to the contrary. See Angell, supra note 127, at 1513-16 (stating that plaintiffs prevailed in breast implant cases despite scientific evidence that implants at issue did not cause injury). While seen by the psychiatric community as being scientifically invalid, psychiatrists in the courtroom are allowed to testify as to the likely future violent behavior of a defendant. See HUBER, supra note 19, at 219-20 (discussing instances where "certain brand of psychiatric soothsaying," that is, ability to use psychiatry to predict "future dangerousness" of criminal defendant, while rejected by American Psychiatric Association, has been accepted by courts). Other examples include litigation over spermicides that might cause birth defects, brain disease resulting from exposure to the whooping cough vaccine, and IUDs that did not contain the nylon multifilament tail that got Robin's Dalkon Shield into so much trouble. See PHANTOM RISKS, supra note 86, at 28-31 (surveying victories by plaintiffs in cases considered scientifically invalid because exposure was far too low to cause injury).

166. See *Daubert v. Merrell Dow Pharm., Inc.*, 509 U.S. 579, 596-97 (1993) (addressing concerns raised by both petitioners and respondents regarding potential for abuse through abandoning *Frye* "general acceptance" test and providing screening role to judges that might stifle or repress scientific ingenuity).

167. For the purpose of this discussion, "bad" refers either to experts who do not support their testimony with acceptable methodology or who perform poorly in presenting their testimony.


169. FED. R. EVID. 702.

It then noted that the word “knowledge” connotes “more than subjective belief or unsupported speculation” but instead describes “any body of known facts or . . . any body of ideas inferred from such facts or accepted as truths on good grounds.”

In interpreting the new Federal Rules of Evidence in the context of the Frye “general acceptance” test, the Court sought to endorse a more objective standard for evaluating scientific expert testimony. In doing so, the Court seemed willing to agree with the conventional scientists’ understanding of what “science” entails. Particularly, the Court agreed with the notion that scientific explanations should be capable of empirical test.

The Court also agreed with Karl Popper’s notion of falsifiability. Thus, the first of the four Daubert principles is whether or not the theory or technique of scientific knowledge has been or is capable of being tested.

Daubert also requires that scientific knowledge has been exposed to peer review and publication.

171. Id. (quoting Webster’s Third New International Dictionary 1252 (1986)).
172. See id. at 587 (holding that Frye test was superceded by Federal Rules of Evidence).
173. Jeffry D. Cutler, Comment, Implications of Strict Scrutiny of Scientific Evidence: Does Daubert Deal a Death Blow to Toxic Tort Plaintiffs?, 10 J. ENVTL. L. & LITIG. 189, 211 n.119 (1995) (arguing that Supreme Court’s description of what constitutes scientific method “seems to be drawn primarily from amicus briefs in case filed by established scientific institutions”). This concession to the scientific establishment’s conservative branch has been criticized as “perpetuat[ing] the judicial system’s close-mindedness towards novel scientific theories.” See id.
174. See Daubert, 509 U.S. at 593 (quoting C. Hempel, Philosophy of Natural Science 49 (1966)). An empirical test is based on generating hypotheses and testing them to see if they can be falsified. see id.
175. See id. (quoting Karl Popper, Conjectures and Refutations: The Growth of Scientific Knowledge 37 (5th ed. 1989) (“[T]he criterion of the scientific status of a theory is its falsifiability, or refutability, or testability”)).
176. Whether a plaintiff’s expert was seeking to testify regarding valid scientific knowledge is only one element of the Daubert decision. The expert’s opinion must also be reliable, relevant, helpful, and “fit” the facts of the case. For a discussion of these requirements, see infra notes 203-47 and accompanying text.
177. See Daubert, 509 U.S. at 593 (stating rationale that exposure to peer review and publication encourages dialogue on issue which may reveal flaws in theory). In order to meet the peer review and publication requirement, it is the underlying theory, not the scientist or doctor, that must be subjected to peer review. See id. It is the theory, not the person, that constitutes “science.” See Kannankeril v. Terminix Int’l, Inc., 128 F.3d 802, 809 (3d Cir. 1997) (observing that since effect of organophosphates on humans was well documented, it was not necessary that plaintiff’s witness himself had published any articles on the theory); see also Pick v. American Med. Sys., 958 F. Supp. 1151, 1158 n.19 (E.D. La. 1997). The Pick court stated:

True peer review means that a scientific hypothesis is subjected to independent evaluation by other scientists in that particular field, typically by
tion did not preclude admissibility, publication did not guarantee admissibility.\textsuperscript{178} The Court even recognized that valid scientific theories might not be published, perhaps because they are too new or of too limited interest to be published, but still be considered valid science for the purposes of scientific expert testimony.\textsuperscript{179} Being submitted to the scrutiny of the scientific community promotes sound science because it increases the likelihood of detecting methodological flaws.\textsuperscript{180} The Court concluded its peer review discussion by stating that publication, while relevant, would not be dispositive in assessing the scientific validity of a technique or methodology.\textsuperscript{181}

The \textit{Daubert} Court also felt a third necessary component of a methodology's validity was a court's ability to consider a known or potential rate of error.\textsuperscript{182} Statistical significance must rise above a level of mere "suggestiveness."\textsuperscript{183} One court has stated that competent testimony must provide evidence that "a reasonable fact-finder independent testing and replication of the results. Pre-publication "editorial peer review," on the other hand, usually consists of sending the proposed article to several outside reviewers who comment on its content and make a recommendation on publication. It is simply not feasible for the editorial staff or the outside reviewers to attempt to replicate the author's findings prior to publishing them. Consequently, just because an article is published in a prestigious journal, or any journal at all, does not mean \textit{per se} that it is scientifically valid.

\textit{Id.} (citation omitted); \textit{but see} Foster & Huber, \textit{supra} note 43, at 157, providing: Some papers are brilliant, others are junk. Most scientific papers, once published, are never cited and are quickly forgotten. The scientific literature is full of inaccurate data, conjectures that turn out to be incorrect, and theories that lead nowhere. Many studies are like fishing expeditions: the scientist tries something to see what happens, planning an experiment on a conjecture or on no theory at all.

\textit{Id.}

\begin{itemize}
  \item \textsuperscript{178} See Daubert, 509 U.S. at 593 (stating that "[p]ublication which is but one element of peer review is not \textit{sine qua non} of admissibility").
  \item \textsuperscript{179} See id. (citing Horrobin, \textit{The Philosophical Basis of Peer Review and the Suppression of Innovation}, 263 J. Am. Med. Ass'n 1438 (1990) (suggesting that "in some instances well-grounded but innovative theories will not have been published").
  \item \textsuperscript{180} See id. (citing J. Ziman, \textit{Reliable Knowledge: An Exploration of the Grounds for Belief in Science} 130-33 (1978)).
  \item \textsuperscript{181} See id. at 593-94 (noting that "[s]ome propositions . . . are too particular, too new, or of too limited interest to be published"); cf. Southland Sod Farms v. Stover Feed Co., 108 F.3d 1134, 1142 (9th Cir. 1997) (adding that "even if the tests were not conducted independently or subjected to peer review, these are only two of the ways Plaintiffs can demonstrate admissibility").
  \item \textsuperscript{182} See Daubert, 509 U.S. at 594 (citing United States v. Smith, 869 F.2d 348, 353-54 (7th Cir. 1989) (surveying studies of error rate of spectrographic voice identification techniques)).
  \item \textsuperscript{183} See Allen v. Pennsylvania Eng'g Corp., 102 F.3d 194, 197 (5th Cir. 1996) (rejecting an expert's testimony where "[s]uggestiveness is not by the expert's own admission statistical significance, nor did the appellants' experts show why and how mere 'suggestiveness' scientifically supported a causal connection").
\end{itemize}
could view as showing a greater than 50% chance of a causal connection” between a defendant’s product and the plaintiff’s illness.\textsuperscript{184}

The \textit{Daubert} decision envisioned science as “an empirical enterprise and emphasizes the need for validation through testing.”\textsuperscript{185} Mathematical accuracy is perhaps the one immutable characteristic of science that is relatively consistent from one member of a scientific community to another in a particular community.\textsuperscript{186} The \textit{Daubert} Court also indicated that reviewing judges should consider the “existence and maintenance of standards controlling the technique’s operation.”\textsuperscript{187} In the absence of a formal study, however, some situations may allow for the use of anecdotal observations to provide sufficient validation.\textsuperscript{188}

Finally, the \textit{Daubert} Court maintained that “general acceptance,” while no longer the sole reviewing criterion, “can yet have bearing on the inquiry.”\textsuperscript{189} In seeking to illustrate what might constitute “general acceptance,” the Court extensively quoted a Third Circuit case, \textit{United States v. Downing}.\textsuperscript{190} The \textit{Downing} case involved

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  \item \textsuperscript{184} McClelland v. Goodyear Tire & Rubber Co., 735 F. Supp. 172, 174 (D. Md. 1990) (precluding plaintiff’s liability claims because greater than 50% chance of causal connection was not shown). Former workers of the Cumberland, Maryland tire plant of Kelly Springfield Tire Company brought actions against the corporate parent of Kelly Springfield and Goodyear Tire and Rubber Company alleging that they suffered from various physical illnesses as a result of exposure to toxic chemicals at their workplace. \textit{See} McClelland, 735 F. Supp. at 173. The court found that the plaintiffs had not shown by a preponderance of the evidence that “any particular, identifiable Goodyear-supplied chemical was a legal cause of their injuries.” \textit{See} id. at 174.
  \item \textsuperscript{185} Margaret A. Berger, \textit{Evidentiary Framework}, in \textit{REFERENCE MANUAL}, \textit{supra} note 73, at 82 (discussing issues regarding expert reasoning and scientific methodology).
  \item \textsuperscript{186} \textit{See} KUHN, \textit{supra} note 5, at 185.
  \item \textsuperscript{187} \textit{Daubert}, 509 U.S. at 595 (quoting United States v. Williams, 583 F.2d 1194, 1198 (2d Cir. 1978) (noting professional organization’s standard regarding spectrographic analysis)). With regard to setting standards for judicial review of expert testimony, the \textit{Daubert} court explained that there is no specific standard for determining the validity of the procedures followed by the experts in making their assessment. \textit{See} \textit{Daubert}, 509 U.S. at 593. Instead, judges should look to the specific organization or field of expertise to determine the proper procedures to be followed by the experts when making their assessment. \textit{See} id.
  \item \textsuperscript{188} \textit{See} Berger, \textit{supra} note 185, at 83 (referring to legal experience with Thalidomide); but see American Academy of Allergy and Immunology, \textit{Position Statement: Clinical Ecology}, 78 J. ALLERGY CLINICAL IMMUNOLOGY 269, 270 (Aug. 1986) (hereinafter “AAAI Position Statement”) (“Anecdotal articles do not constitute sufficient evidence of a cause-and-effect relationship between symptoms and environmental exposure”).
  \item \textsuperscript{189} \textit{Daubert}, 509 U.S. at 594 (distinguishing acceptance and reliability, stating that former supports but is not dispositive of latter).
  \item \textsuperscript{190} 753 F.2d 1224 (3d Cir. 1985).
\end{itemize}
admission of expert testimony on human perception and memory on behalf of a defendant in order to refute the reliability of eyewitness identification.\textsuperscript{191} The Third Circuit undertook a Rule 702 inquiry to determine the admissibility of the expert testimony.\textsuperscript{192}

The \textit{Daubert} Court particularly agreed with how the Third Circuit in \textit{Downing} discussed a “reliability assessment” in deciding whether to admit novel scientific evidence.\textsuperscript{193} The \textit{Downing} court proposed a more flexible approach to assessing reliability, thus specifically contradicting the \textit{Frye} standard.\textsuperscript{194} The court in \textit{Downing} envisioned a reliability assessment that “[did] not require, although it [could] permit, explicit identification of a relevant scientific community and an express determination of a particular degree of acceptance within that community.”\textsuperscript{195} If a particular technique has been able to attract only minimal support within a community, then it may not be deemed reliable.\textsuperscript{196} But if a novel form of scientific expertise has “no established ‘track record’ in litigation, a reviewing court may look to other factors that bear on the admissibility of the proffered evidence.”\textsuperscript{197}

In the end of its discussion on what constitutes scientific knowledge, the Supreme Court said that a Rule 702 inquiry should be a

\textsuperscript{191} See id. (stating that “under certain circumstances expert testimony on the reliability of eyewitness identifications can assist the jury in reaching a correct decision and therefore meet the helpfulness requirement of Rule 702.”).

\textsuperscript{192} See id. at 1226. In United States v. Downing, John Downing (defendant) was indicted and convicted of mail fraud, wire fraud and interstate transportation of stolen property. See id. The case against Downing consisted primarily of testimony given by 12 eyewitnesses identifying Downing as one of the defrauders. See id. Downing contended that the eyewitnesses were mistaken as to the identification of Downing. Downing sought to admit expert evidence that the eyewitnesses’ testimony was unreliable. See id. The district court ruled such evidence was inadmissible because it could never meet the “helpfulness” standard of Rule 702. See id. The Third Circuit disagreed, but ruled that such admission was not automatic but conditional. See id.


\textsuperscript{194} See \textit{Downing}, 753 F.2d at 1238.

\textsuperscript{195} Id. On remand in \textit{Daubert}, the Ninth Circuit added that the methodology must constitute “the scientific method, as it is practiced by (at least) a recognized minority of scientists in their field.” Daubert v. Merrell Dow Pharm., Inc., 43 F.3d 1311, 1319 (9th Cir. 1995).

\textsuperscript{196} See \textit{Downing}, 753 F.2d at 1238. In discussing the reliability of novel scientific evidence and the reliability of its technique, the court in \textit{Downing} “join[ed] a growing number of courts that have focused on reliability as a crucial element of admissibility” under Rule 702. Id. (citing several state cases).

\textsuperscript{197} Id. While this language in the \textit{Downing} decision was not specifically adopted in \textit{Daubert} (unlike the “reliability assessment” language), it is in keeping with the “flexible” approach the \textit{Daubert} decision requires. \textit{Daubert}, 509 U.S. at 594-95.
flexible one. The *Daubert* Court stated that scientific validity would be determined by the principles underlying the submission, focusing "solely on principles and methodology and not on the conclusions that they generate." The notion that methodology determines the validity of a proposed scientific principle is very much in harmony with how the scientific community perceives "valid" science. The theory must be valid, it must be supported by sound methodology, the results must statistically make sense, and the conclusions drawn must comply with the results.

These pointers only suggest how a court might evaluate the reliability of the proffered scientific testimony. How should a reviewing judge apply these scientific notions to decisions regarding the admissibility of scientific evidence? If the allegation is that the methodology is skewed, should the inquiry be a Rule 403 problem, a Rule 702 analysis under *Daubert*, a Rule 703 problem, or a question of sufficiency for the jury?

B. *Daubert* and *Joiner* – Relevance and the Use of Experts

In *Daubert*, the Supreme Court did more than lay the foundation for determining what "scientific knowledge" would be reliable. It also reminded federal judges of their responsibility to consider how other federal rules interact with scientific expert testi-

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198. *See Daubert*, 509 U.S. at 594 (stating that "inquiry we envisioned by Rule 702 is, we emphasize, a flexible one").

199. *Id.* at 594-95; *see also* In re Paoli R.R. Yard PCB Litig., 35 F.3d 717, 744 (3d Cir. 1994) (hereinafter *Paoli II*) (noting that "judge will often think that an expert has good grounds to hold the opinion that he or she does even though the judge thinks that the opinion is incorrect"). The Third Circuit added:

The grounds for the expert’s opinion merely have to be good, *they don’t have to be perfect*. The judge might think that there are good grounds for an expert’s conclusion even if the judge thinks that there are better grounds for some alternative conclusion, and even if the judge thinks that a scientist’s methodology has some flaws such that if they had been corrected, the scientist would have reached a different result.

*Id.* (emphasis added) This conclusion-methodology question is one that has been fiercely debated, but inadequately answered. *See* Jay P. Kesan, *Note, An Autopsy of Scientific Evidence in a Post-Daubert World*, 84 Geo. L.J. 1985, 2019 n.218 (1996) (listing other sources which discuss conclusion-methodology question).


201. *See id.* at 596 (adding that judge can issue directed verdict "in the event the trial court concludes that the scintilla of evidence presented supporting a position is insufficient to allow a reasonable juror to conclude that the position more likely than not is true").


203. *See Daubert*, 509 U.S. at 590 (stating that "in order to qualify as 'scientific knowledge,' an inference or an assertion must be derived by the scientific method").
Furthermore, in General Electric Co. v. Joiner, the Court strengthened the "gatekeeper" role of federal district court judges by holding that their decisions would be overturned only through a showing of "abuse of discretion."

In Daubert, the Supreme Court ruled on the admissibility of evidence linking birth defects and the anti-nausea drug Bendectin. Although questions regarding the connection between Bendectin and birth defects have existed for thirty years, Daubert dealt less with causation than it did with basic questions on the adaptability of the law. The Frye "general acceptance" test was seemingly at odds with the "liberal thrust" of the new Federal Rules of Evidence, particularly Rule 702. In outlining the screening role of the district court judge in light of the new rules, the Court stressed that "under the Rules the trial judge must ensure that any and all scientific testimony or evidence admitted is not only relevant, but reliable."

After determining the reliability of the proffered scientific knowledge, a district court must then examine the knowledge's relevance. The relevance of the proffered testimony, referred to as

204. See id. at 595 (stating that "a judge assessing a proffer of expert scientific testimony under Rule 702 should also be mindful of other applicable rules").


206. See id. at 142-43; see also id. at 147 (concurring, J., Breyer) ("The Court's opinion, which I join emphasizes Daubert's statement that a trial judge, acting as 'gatekeeper,' must 'ensure that any and all scientific testimony or evidence admitted is not only relevant, but reliable."). (quoting Daubert, 509 U.S. at 589).


208. See Daubert, 509 U.S. at 588-89 (stating that admission of expert testimony should be judged in light of "permissive backdrop" of Rule 702). The primary focus of the Daubert decision was the definition of scientific knowledge for purposes of a Rule 702 admissibility inquiry. See id. at 588-94.


210. See Daubert, 509 U.S. at 590. The "reliability" inquiry of the Daubert standard consists of the four elements discussed supra at notes 203-47 and accompanying text. Reliability should not, however, be the ultimate basis for excluding expert testimony. As the Third Circuit indicated in Paoli I, "the reliability requirement must not be used as a tool by which the court excludes all unquestionably reliable evidence." Paoli I, 916 F.2d. at 857. The "ultimate touchstone is helpfulness to the trier of fact, and with regard to reliability, helpfulness turns on whether the expert's 'technique or principle [is] sufficiently reliable so that it will aid the jury in reaching accurate results.'" DeLuca v. Merrell Dow Pharm., Inc., 911 F.2d 941, 956 (3d Cir. 1990) (quoting 3 J. Weinstein & M. Berger, Weinstein's Evidence 702[03], at 702-35 (1988)). A judge frequently should find an expert's methodology helpful "even when the judge thinks that the expert's technique has flaws sufficient to render the conclusions inaccurate." In re Paoli R.R. Yard PCB Litig., 35 F.3d 717, 744-45 (3rd Cir. 1994) (Paoli II).
the Daubert “fit” test, is the second essential inquiry a district judge must make under Rule 702.\textsuperscript{211} Rule 702 requires that the proffered evidence or testimony “assist the trier of fact to understand the evidence or to determine a fact in issue.” This is primarily a question of relevance or of “fit.”\textsuperscript{212} If the expert testimony does not pertain to any issue in the case, it is not relevant.\textsuperscript{213} The Rule 702 “helpfulness” standard requires a legitimate relevance to the core issue as a precondition to admissibility.\textsuperscript{214} On remand, the Ninth Circuit rejected the plaintiff’s expert testimony because it failed to prove a specific causal connection between the defendant’s product and

In Paoli II, the Third Circuit combined the four Daubert reliability factors with the Downing factors to formulate an expanded set of factors:

(1) whether a method consists of a testable hypothesis; (2) whether the method has been subject to peer review; (3) the known or potential rate of error; (4) the existence and maintenance of standards controlling the technique’s operation; (5) whether the method is generally accepted; (6) the relationship of the technique to methods which have been established to be reliable; (7) the qualifications of the expert witness testifying based on the methodology; and (8) the non-judicial uses to which the method has been put.

Paoli II, 35 F.3d at 742 n.8. The Third Circuit incorporated the Downing factors because the Supreme Court’s Daubert decision “specifically refuse[d] to disavow any of the particular factors” listed in Downing. Id. at 742 (citing Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 595 n.12 (1993)). These eight factors have been referred to as “the Daubert-Paoli factors.” Diaz v. Johnson Matthey, Inc., 983 F. Supp. 358, 373 (D.N.J. 1995).

211. See Cutler, supra note 173, at 214-15; see also Jean Macchiaroli Eggen, Toxic Torts, Causation, and Scientific Evidence After Daubert, 55 U. Pitt. L. Rev. 889, 923 (1994) (stating that “[e]xamination of expert’s methodology and reasoning process, as well as ‘fit’ between expert’s opinion and factual issue for which it is proffered, are crucial to proper inquiry”).

One federal district court applying Daubert also conducted a relevancy inquiry under Rule 401. See Pick v. American Med. Sys., Inc., 958 F. Supp. 1151, 1162 (E.D. La. 1997) (“Rule 401 mandates a liberal view of relevancy—evidence having ‘any tendency’ to prove or disprove a fact is admissible”). The “fit test” can be described as “whether [the] expert testimony proffered in the case is sufficiently tied to the facts of the case that it will aid the jury in resolving the factual dispute.” Daubert, 509 U.S. at 591.

212. See Daubert, 509 U.S. at 591-92 (requiring relevancy, or “fit” defined as “a valid scientific connection to the pertinent inquiry”).

213. See id. (quoting 3 J. WEINSTEIN & M. BERGER, WEINSTEIN’S EVIDENCE ¶ 702[02], 702-18). To illustrate how evidence might not be relevant to a case, the Court stated:

The study of the phases of the moon, for example, may provide valid scientific “knowledge” about whether a certain night was dark, and if darkness is a fact in issue, the knowledge will assist the trier of fact. However (absent credible grounds supporting such a link), evidence that the moon was full on a certain night will not assist the trier of fact in determining whether an individual was unusually likely to have behaved irrationally on that night.

Id.

214. See id. at 591-92.
the plaintiff's birth defects. Critics of the relevancy inquiry believe that it inhibits the toxic tort plaintiff's ability for recovery, placing too much control in the hands of judges who fail to appreciate the scientific evidence.

In addition to its analysis of the gatekeeping role under Rule 702, the Daubert Court reminded federal judges to be mindful of other rules affecting admission of expert testimony. Rule 703 was the first among these rules that the Court mentioned. The Court clarified that the second sentence of the rule permitted otherwise inadmissible hearsay to be admitted if the facts or data were "reasonably relied upon" by other experts. "Under Rule 703, a qualified expert may apply his relevant and reliably grounded knowledge and expertise to facts and data in the particular case in order to form and express a pertinent opinion or inference." If they are of a type reasonably relied upon by experts in the field,

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215. See Daubert v. Merrell Dow Pharm., Inc., 43 F.3d 1311, 1320-22 (9th Cir. 1995) (rejecting testimony because experts were unable to prove that defendant's products "actually caused plaintiff's injuries" or, at least, that such exposure "more than doubled" plaintiff's risk of suffering those injuries).

216. See Cutler, supra note 173, at 191 (stating that "the supposed 'liberalization' of the standard for admissibility of evidence actually allows the courts to make recovery less available for toxic tort plaintiffs").

217. See Daubert, 509 U.S. at 589, n.7 (declaring that federal judge must exercise "gatekeeping responsibility" to insure that admitted scientific testimony is both relevant and reliable).

218. See id. at 595. Not discussed in this paper is the Court's reminder to judges of their discretion to procure experts under Rule 706. See id. Some of the critics of courtroom use of scientific expert testimony have urged courts to exercise this discretion more often. See Foster, supra note 104, at 1614 (adding that "European judges routinely summon their own experts").

219. Federal Rule of Evidence 703 states:

The facts or data in the particular case upon which an expert bases an opinion or inference may be those perceived by or made known to the expert at or before the hearing. If of a type reasonably relied upon by the experts in the particular field in forming opinions or inferences upon the subject, the facts or data need not be admissible in evidence.

FED. R. EVID. 703.

220. See Daubert, 509 U.S. at 595. Prior to Daubert, some discrepancies existed as to how a court should determine what is "reasonably relied upon." See Berger, supra note 185, at 107 (explaining standard of "reasonably relied upon" according to Fed. R. Evid. 703). Those who supported a more "liberal" approach to the Federal Rules sought an expanded admissibility of expert testimony, while those who supported a more "conservative" approach advocated a preliminary screening of evidence under Rule 104(a). See id.

221. Moore v. Ashland Chem., Co., 126 F.3d 679, 690 (5th Cir. 1997) (holding that erroneous exclusion of expert's testimony was reversible error). The facts or data may be derived from (1) the first hand observation of facts, data or opinions perceived by the witness before trial; (2) the facts, data or opinions presented at trial; or (3) facts, data or opinions presented to the expert outside of court other than by his direct perception. See FED. R. EVID. 703.
such facts, data, or opinions presented to the expert out of court need not be admitted or even admissible in evidence.\textsuperscript{222}

Rule 703 is designed to bring judicial practices in line with the practice of experts when not in court.\textsuperscript{223} It is believed that Daubert acknowledges that Rule 703 provides an independent authority for excluding expert testimony.\textsuperscript{224} Several courts have acted on this premise and have used Rule 703 to exclude testimony.\textsuperscript{225} This often results in a "back-door resurrection of the Frye 'general acceptance' test."\textsuperscript{226}

The Daubert Court also specifically stated that district court judges "must determine at the outset" under Rule 104(a) whether the expert is seeking to testify to scientific knowledge that will assist the trier of fact in understanding the underlying scientific issues.\textsuperscript{227} Rule 104(a) provides that "[p]reliminary questions concerning the qualification of a person to be a witness, the existence of privilege, or the admissibility of evidence shall be determined by the court . . . ." The Court added that admissibility should be established by a

\begin{itemize}
  \item[222.] See United States v. Harper, 802 F.2d 115, 121 (5th Cir. 1986) (stating that expert may rely on inadmissible facts to form relevant opinion).
  \item[223.] See United States v. Williams, 447 F.2d 1285, 1290 (5th Cir.1971), cert. denied, 405 U.S. 954 (1972), reh'g denied, 405 U.S. 1048 (1972).
  \item[224.] See Berger, supra note 185, at 105 (stating that this approach is consistent with precedent).
  \item[225.] See Claar v. Burlington N. R.R. Co., 29 F.3d 499, 500-01 (9th Cir. 1994) (excluding testimony on causation); In re Breast Implant Litig., 11 F. Supp.2d 1217, 1240 (D. Colo. 1998) (explaining why court excluded expert testimony as unreliable based on Fed. R. Evid. 702 and 703); Kelley v. American Heyer-Schulte Corp., 957 F. Supp. 873, 883 (W.D. Tex. 1997) (explaining why court excluded expert testimony as not having been "reasonably relied" upon, based on Fed. R. Evid. 702 and 703); see also Berger, supra note 185, at 107-11 (identifying four distinct circumstances where court's have excluded testimony under Rule 703: "(1) Expert's failure to consider data that must be taken into account; (2) Expert's reliance on data that should not be taken into account; (3) Expert's reliance upon data that are erroneous; and (4) Expert's opinion does not rest on a foundation that experts would generally find reliable").
  \item[226.] Berger, supra note 185, at 111 (discussing a court's reliance on Rule 703 to exclude an expert opinion). Federal Rule of Evidence 703 allows the court to exclude expert testimony if the procedures used to make an assessment are not generally accepted in that particular field of study. Rule 703 allows courts to look solely to the "general acceptance" principle elucidated in Frye when making determinations regarding the admissibility of expert testimony. Consequently, a court may avoid application of the Daubert "fit test" and make its decision in accordance with the Frye test.
  \item[227.] Daubert, 509 U.S. at 592 (requiring assessment on reasoning and methodology).
\end{itemize}
preponderance of evidence standard. This preliminary assessment of admissibility should be conducted in limine.

Finally, the Daubert Court stated that Rule 403 would also permit the exclusion of otherwise relevant and reliable evidence "if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury." Situations where a court would apply Rule 403 in a Daubert inquiry include presentation of evidence couched in prejudicial terms; evidence that carries with it the "aura of scientific infallibility," and situations where in-court presentation of evidence would be so "vivid and compelling" as to distract jurors from the evidence's actual probative value. In Joiner, the Supreme Court stressed that "when law and science intersect, [the duties of weighing prejudice and probative value] often must be exercised with special care."

Because these are all matters for the trial court judge to consider, this left the question open as to the standard of review. In 1997, the Supreme Court answered that open question with its decision in General Electric Co. v. Joiner. In that case, a district court judge excluded testimony that polychlorinated biphenyls (PCBs) manufactured by defendants caused the plaintiff's cancer. The

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228. Daubert, 509 U.S. at 592 n.10 (citing Bourjaily v. United States, 483 U.S. 171, 175-76 (1987)); see also supra note 150 (citing several cases that applied this standard).

229. See, e.g., Paoli II, 35 F.3d at 738-39 (using in limine hearing testimony of experts to exclude plaintiff's evidence at trial); Bishop v. General Motors Corp., No. Civ-94-286-B, 1995 WL 886817, at *5 (E.D. Okla. Aug. 18, 1995) (denying plaintiff's motion in limine to exclude evidence at trial); Gier v. Educational Serv. Unit No. 16, 845 F. Supp. 1342, 1349-50 (D. Neb. 1994) (conducting in limine hearing to determine admissibility of plaintiff's experts). At the hearing, the defendants submitted affidavits of their own witnesses, that rejected plaintiffs' experts' methodologies and indicated that standards used generally by professional associations across the country were not used by the plaintiffs' experts. See id. The court held that the plaintiffs' witnesses' testimony was admissible. See id.

230. Daubert, 509 U.S. at 595 (quoting Fed. R. Evid. 403). The application of Rule 403 to a Daubert inquiry would not be appropriate, however, in the case of a bench trial. See Gulf State Util. Co. v. Ecodyne Corp., 635 F.2d 517, 519-20 (5th Cir. 1981) (holding that weighing process of Rule 403 "has no logical application to bench trials").

231. See Berger, supra note 185, at 114-17 (discussing admissibility of expert testimony as analogous to nonscientific evidence).


233. For a discussion of the standard of review for decisions regarding admissibility made by lower courts, see infra notes 148-52 and accompanying text.

234. See Joiner, 522 U.S. at 142.

235. See id. at 140 (noting that one reason why trial court granted summary judgment was insufficient expert testimony).
plaintiff had been a smoker for eight years, his parents were smokers, and his family had a history of lung disease, thus indicating that he was "perhaps already at a heightened risk of developing lung cancer eventually." The defendant's experts had criticized the testimony of plaintiff's experts because it was based solely on animal studies without support from epidemiological studies.

Shoring the traditional "abuse of discretion" standard, the Court in *Joiner* disavowed the Eleventh Circuit's application of a "particularly stringent" standard of review. The Court rejected the notion that standards of review should change if there is expert testimony involved. It also rejected an argument that a stricter standard of review should be applied if the result of summary judgment was "outcome determinative." The *Joiner* Court stressed that the expert's analysis must be logical in order to survive scrutiny.

**IV. JUDGES PERFORMING THEIR GATEKEEPING ROLES: SORTING OUT THE GOOD EXPERTS FROM THE BAD**

Scientific expert testimony is crucial to a plaintiff's success in a toxic tort case. Toxic tort cases deal with personal injury or harm resulting from repeated exposure to toxic substances, such as chemicals, radiation, or biological agents. Toxic tort plaintiffs typically experience long-term exposures to chemicals or other substances that may eventually cause illness. The injury is often a terminal disease, such as cancer, or a syndrome caused by an underlying ge-

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236. *Id.* at 139.
237. See *id.* at 143-44 (agreeing with defense, Court held that animal studies were insufficient to support plaintiffs' experts' opinion).
238. See *id.* at 141.
239. See *Joiner*, 522 U.S. at 142 (holding that court of appeals failed to give district court proper deference).
240. See *id.* (stating that proper standard is abuse of discretion).
241. See *id.* at 146 (stating that "nothing in either *Daubert* or the Federal Rules of Evidence requires a district court to admit opinion evidence which is connected to existing data only by the ipse dixit of the expert"). The Court further added, "[a] court may conclude that there is simply too great an analytical gap between the data and the opinion proffered." *Id.*
242. See, e.g., *Joiner*, 522 U.S. at 136 (indicating that one major reason district court granted summary judgment was inadmissibility of expert witness testimony).
244. See Trauberman, *supra* note 18, at 180 (discussing "chronic effects" of long-term exposure to hazardous substances that can be widely separated in time from actual causal agents).
ngetic mutation that manifests itself after a long latency period.\textsuperscript{245} Unfortunately, the long latency periods and low dosages involved make establishing a prima facie case extremely difficult.\textsuperscript{246}

As a result of the complex scientific issues involved, the toxic tort plaintiff must often rely solely upon the strength of his or her expert witness. The performance and strength of the expert, just as much as the science involved, will determine the outcome of a case.\textsuperscript{247} Many plaintiffs who have failed to have evidence introduced in the wake of \textit{Daubert} and \textit{Joiner} have done so because of bad experts.\textsuperscript{248} The outcome of these cases also illustrates how \textit{Daubert} and \textit{Joiner} have succeeded in addressing criticism from the scientific community and, hopefully, changed the perception of “experts” relied upon in the courtroom.

A. Examples that Illustrate \textit{Daubert}'s Success in Weeding-out Bad Experts

While opponents of “junk science” in the courtroom may truly have a grudge against the underlying science itself, they often are more concerned with the “charlatans” promoting the science, using the courtroom to achieve legitimacy.\textsuperscript{249} \textit{Daubert} has been very successful in addressing this criticism by excluding questionable methodologies, practices, and performances of experts in the courtroom,\textsuperscript{250} as the following examples will illustrate.

\textsuperscript{245} See Gold, \textit{supra} note 243, at 376 n.1 (noting well-known effects of toxins, such as vaginal cancer, lung cancer and long-term injuries from Agent Orange exposure during Vietnam War).

\textsuperscript{246} See \textit{id.} at 376-77 (explaining that “[p]roving the cause of injuries that remain latent for years . . . is the ‘central problem’ for toxic tort plaintiffs”).

\textsuperscript{247} For a discussion of poor expert witnesses notwithstanding the validity or strength of the scientific evidence, see \textit{infra} notes 251-67 and accompanying text.

\textsuperscript{248} For a list of post-\textit{Daubert} cases where plaintiffs failed to prevail due to bad experts, see \textit{infra} notes 252-55.

\textsuperscript{249} This is certainly the case with MCS. For a discussion of how MCS does not “fit” with other illnesses, see \textit{infra} notes 325-36 and accompanying text.

\textsuperscript{250} A sublime illustration of the scrutiny that the Supreme Court’s decision in \textit{Daubert} generates can be seen in the Ninth Circuit’s decision in \textit{Daubert} on remand:

Yet something doesn’t become “scientific knowledge” just because it’s uttered by a scientist; nor can an expert’s self-serving assertion that his conclusions were “derived by the scientific method” be deemed conclusive, else the Supreme Court’s opinion could have ended with footnote two . . . \textit{[T]herefore, though we are largely untrained in science and certainly no match for any of the witnesses whose testimony we are reviewing, it is our responsibility to determine whether those experts’ proposed testimony amounts to “scientific knowledge,” constitutes “good science,” and was “derived by the scientific method.”}

\textit{Daubert v. Merrell Dow Pharm., Inc.}, 43 F.3d 1311, 1315-16 (9th Cir. 1995).
1. Failing to Meet the Reliability Requirement of Daubert

While experts are necessary to prove causation in toxic tort cases, a plaintiff should choose his or her experts carefully. Rule 702 mandates a preliminary inquiry into the qualifications of the expert. 251 Surprisingly enough, choosing an expert who lacks the knowledge needed to offer an opinion is a common problem. 252 It may also be detrimental to choose an expert who lacks a certain level of experience. 253 It is certainly damaging to a plaintiff's case to select an expert who is not qualified to testify on the science that pertains to that plaintiff's claim. 254 Finally, judges will exclude an expert who personally discounts the theory behind the claim. 255

Even with a good expert, testimony has been excluded when the expert failed to properly use published research, which is relevant under the Daubert factor governing peer review and publication. 256 Some courts have found it significant that the plaintiff's

251. See Fed. R. Evid. 702. Rule 702 provides, in part, that "a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify" about scientific issues in the form of an opinion. Id.

252. See, e.g., Diaz v. Johnson Matthey, Inc., 893 F. Supp. 358, 372 (D.N.J. 1995) (observing that expert "knew little about" etiology of disease, had only casually studied the literature, even only skimming some of them, and was unable to testify about contents of literature without constantly referring to it); Wade-Greaux v. Whitehall Labs., Inc., 874 F. Supp. 1441, 1476 (D. Vi. 1994), aff'd without opinion, 46 F.3d 1120 (3d Cir. 1994) (stating that expert was unqualified to testify because he had merely reviewed selected articles on relevant subject for purposes of litigation).


254. See National Bank of Commerce v. Associated Milk Producers, Inc., 22 F. Supp.2d 942, 969 (E.D. Ark. 1998) (recalling expert's testimony because he was not qualified to testify to dose response curve necessary to prove causation); Sanderson v. International Flavors and Fragrances, Inc., 950 F. Supp. 981, 994 (C.D. Cal. 1996) (rejecting testimony of neuropsychologist who has no training in medicine, toxicology, or chemistry to testify regarding causation of various maladies that have toxic or chemical trigger).

255. See Pick v. American Med. Sys., Inc., 958 F. Supp. 1151, 1161-62 (E.D. La. 1997) (testifying that linkages plaintiff was suggesting between silicone penile implants and breast implants were "so different that any comparison between the two was illogical and irrelevant").

256. See Sanderson, 950 F. Supp. at 993-94 (discussing that best way for expert to indicate that expert's findings are based on good science is to present "objective, independent validation" of expert's methodology in published works). In Daubert, the Court recognized that the existence, or lack thereof, of a peer reviewed journal to support an expert's particular technique or methodology is a relevant consideration in determining the validity of that expert's opinions. See Daubert, 509 U.S. at 594.
experts could point to no research that supported their position. Courts have also excluded expert testimony when the literature cited specifically disavowed the causal connection a plaintiff was attempting to prove. Judges have been skeptical when the expert makes vague references to scientific literature without providing sources. Despite fears about sophisticated scientists fooling unsophisticated courts, judges have shown that they can identify when an expert is improperly applying published research.

Underlying judicial review of expert testimony is the necessity of ensuring that the methodologies employed were valid. As the Daubert decision mandated, the focus should be on the methodologies used and not the conclusions. Courts have proven very successful in using this focus to eliminate potentially false methodologies. Experts who claim to use methodologies unique to themselves have not been permitted to confuse the courtroom with their haphazard processes. Moreover, courts can recognize when an expert simply did not know how to apply accepted methodology. It has additionally been unacceptable for an expert to apply the incorrect methodology, even if it were valid. Courts have been successful in excluding testimony based on general impressions rather than methodology. Furthermore, courts have re-

257. See, e.g., National Bank of Commerce, 22 F. Supp.2d at 951-52 (E.D. Ark. 1998) ("[T]he Court finds that there is no scientific literature drawing a direct connection between the inhalation of vapors containing AFM . . . and the occurrence of laryngeal cancer in humans"); Sanderson, 950 F. Supp. at 994 (noting that plaintiff's expert could not make showing that published work supported causation theory because no such publication existed).

258. See, e.g., Sanderson, 950 F. Supp. at 997 (citing study that expressly stated that "it is impossible to extrapolate from this study to human exposures").

259. See Aldridge v. Goodyear Tire & Rubber Co., 34 F. Supp.2d 1010, 1023 (D. Md. 1999) (declaring that references to "knowledge of the scientific literature" standing alone do little to satisfy the reliability requirement").

260. See, e.g., Sanderson, 950 F. Supp. at 997 (rejecting expert's reliance on two studies that were done on rats and from which expert could base no conclusions regarding causes of plaintiff's injuries).

261. See Daubert, 509 U.S. at 592-93 (discussing necessity of trial judge's preliminary assessment of reasoning or methodology underlying expert's testimony).

262. See, e.g., Sanderson, 950 F. Supp. at 995 (applying methodology so obscure that, as far as court could tell, expert "simply made it up").

263. See id. at 999-1000 (being unable to articulate statistical probability and admitting that no published statistics would allow expert to quantify his estimate, causing court to conclude, "This is not a 'scientific connection'").

264. See Cavallo v. Star Enter., 892 F. Supp. 756, 771 (E.D. Va. 1995), aff'd in relevant part, 100 F.3d 1150 (4th Cir. 1996) (stating that even if an expert is not a toxicologist, "[t]he expert must nonetheless apply the] principles and methods of toxicology if he is to give an opinion on an issue relating to that specialty").

quired that research on which the expert relies must have been conducted prior to and independent of the litigation.\textsuperscript{266} Finally, courts have excluded testimony if the expert simply provides inadequate exposure proof.\textsuperscript{267} To say that all of these experts applied questionable, dubious, or incorrect methodologies is an understatement. How these district courts have handled the experts illustrates how capable these courts are of fulfilling their gatekeeping functions and ensuring that the science offered is "reliable." In addition, members of the scientific community can take comfort in the \textit{Joiner} standard and its ability to ensure that these decisions will remain undisturbed at the appellate level.

2. \textit{Failing to Meet the Relevance Standard of Daubert}

In order to fulfill their gatekeeping responsibilities, however, courts must ensure that the proffered scientific testimony is relevant to the case.\textsuperscript{268} Critics have claimed that the unsophisticated can be easily misled and that it may be easy for a sophisticated expert to use the wrong scientific methods. As courts which have correctly applied the \textit{Daubert} relevance test have demonstrated, these fears are not well-founded. A proffered scientific study must be applicable to the plaintiff's illness; analogies will not suffice.\textsuperscript{269} Courts will also not permit experts to claim that if a chemical is known to cause one illness, it must be able to cause another.

3. \textit{Generally Poor Trial Strategy or Expert Performance}

Assuming that a plaintiff has a good expert and has science on his or her side, judges may still find other reasons for excluding testimony. First, one may simply have a "bad" plaintiff. For exam-

\begin{itemize}
\item \textsuperscript{266} See id. at 984 (observing that none of plaintiff's experts conducted their research independent of litigation).
\item \textsuperscript{267} See id. at 966 (recognizing that experts failed to identify dosage level that would cause cancer in humans, ignored other potential causes of the illness, and relied solely on temporal connection).
\item \textsuperscript{268} See Mahaney, supra note 152, at 1164 (noting that jury's unfamiliarity with scientific principles may lead to use of expert testimony in order to mislead trier of fact or just to "wear down adversaries").
\item \textsuperscript{269} See, e.g., \textit{National Bank of Commerce}, 965 F. Supp. at 970 (catching expert's attempt to use study to show statistically significant increase in occurrence of disease as result of exposure to defendant's chemical when study applied to disease other than one claimed by plaintiff). The court in \textit{National Bank of Commerce} also refused to allow the expert to claim that risk factors for another disease would be similar to risk factors that could cause the plaintiff's disease because the expert was attempting to analogize two distinctly different illnesses. See id. at 973.
\end{itemize}
ple, courts may not be willing to allow weak causation testimony in the courtroom if it is clear that the plaintiff's lifestyle may have contributed more to his illness than the defendant's product.\textsuperscript{270} Courts have been unsympathetic to plaintiffs who fail to address either the Supreme Court's decision in \textit{Daubert} or the Ninth Circuit's remand decision.\textsuperscript{271} In addition, judges have excluded experts who clearly were uncertain of their own opinions under examination.\textsuperscript{272} Testimony has been excluded when the expert appeared to be altering causation testimony from previous statements made in affidavits.\textsuperscript{273} Experts who cannot even recall the gist of their research have been met with justifiable skepticism.\textsuperscript{274} Furthermore, judges have considered an expert's testimony inadequate if it failed to address the majority of the plaintiff's claims.\textsuperscript{275}

Holding the plaintiff and his or her experts accountable to methodology and relevance has not been an absolute bar to success. The following example illustrates how judges can admit novel scientific evidence with a thorough \textit{Daubert} analysis and good expert performance.

\begin{quote}
\textsuperscript{270} See, e.g., General Elec. Co. v. Joiner, 522 U.S. 136, 139-40 (1997) (re remarking that since plaintiff smoked for eight years, had parents who were smokers, and had history of lung disease in her family, plaintiff was "perhaps already at a heightened risk of developing lung cancer eventually").

\textsuperscript{271} See, e.g., Sanderson, 950 F. Supp. at 995 (stating that "[p]erhaps because she clearly cannot meet its requirements, plaintiff does not even cite \textit{Daubert} on remand or the Supreme Court's decision in \textit{Daubert}"). According to the court, the plaintiff had instead invoked her own "Thrasher" test. \textit{See id.}

\textsuperscript{272} See \textit{id.} at 999 (highlighting that expert first testified that exposure "most likely" caused illnesses but later recanted and admitted that he could not determine what cause of plaintiff's illness was).

\textsuperscript{273} See Aldridge v. Goodyear Tire & Rubber Co., 34 F. Supp. 2d 1010, 1018 (D. Md. 1999) (remarking that plaintiff's expert changed his scientific opinion to meet deficiencies in plaintiff's proof).

\textsuperscript{274} See, e.g., Mancuso v. Consolidated Edison Co. of New York, Inc., 967 F. Supp. 1437, 1443-44 (S.D.N.Y. 1997) (noting that despite expert's testimony that "he had read 40 or 50 articles over the course of fifteen years before authoring his initial opinion, and that he subsequently performed approximately 14-15 hours of library research and review before authoring his supplemental opinion and appearing for his deposition," expert was unable to answer any questions about what level of PCB contamination was hazardous to humans).

\textsuperscript{275} See, e.g., Claar v. Burlington N. R.R. Co., 29 F.3d 499, 502 (9th Cir. 1994) (observing that toxicology sections of affidavit, which discussed literature regarding illnesses caused by certain chemicals, "fail[ed] to discuss the majority of the medical conditions alleged by plaintiffs"); Sanderson, 950 F. Supp. at 996 (relying on \textit{Claar} language to hold similarly that expert's scientific evidence was unreliable).
\end{quote}
D. How Plaintiffs Have Been Successful in Introducing Novel, but “Valid” Science

A few toxic tort or products liability cases have involved a Daubert-Joiner analysis where the plaintiff has been successful in introducing expert testimony. One may view this as either a testament of the courts’ ability to “weed out” successfully “junk science” or as proof of their propensity for treating defendants favorably. After analyzing the previous cases, however, it is clear that proper application of Daubert and Joiner to toxic tort cases usually does not screen out novel scientific theory but only bad experts.

One of the finer examples of a successful toxic tort plaintiff under a Daubert-Joiner application is Zuchowicz v. United States.276 Patricia Zuchowicz initiated a suit277 under the Federal Tort Claims Act,278 claiming to have developed primary pulmonary hypertension (PPH) because of the defendant’s negligence in prescribing an overdose of Danocrine. Both parties in the case agreed as to the injury and the defendant’s complicity in the overdose, but they sharply differed on causation.279 The plaintiff faced two significant barriers: PPH was an extremely rare disease, and few human beings had ever been subjected to the dosage of Danocrine that allegedly caused the plaintiff’s illness and eventual death.280 As a result, the

276. 140 F.3d 381 (2d Cir. 1998) (hereinafter Zuchowicz II).
277. See id. at 383. Ms. Zuchowicz died prior to completion of the suit and her husband, Steven, continued the case on behalf of his wife’s estate. See id.
278. 28 U.S.C. §§ 1346(b), 2671-2680 (1994). Section 1346(b) grants “exclusive jurisdiction of civil actions on claims against the United States . . . for . . . personal injury or death caused by the negligent or wrongful act or omission of any employee of the Government while acting within the scope of his office or employment” for tort claims against the United States. Id., 28 U.S.C. § 1346(b). Sections 2671 through 2680 govern the tort claims procedures in law suits against the United States. See id., 28 U.S.C. §§ 2671-80.

Mrs. Zuchowicz filled a prescription at the Naval Hospital in Groton, Connecticut, which had erroneous instructions. See Zuchowicz II, 140 F.3d at 384. The plaintiffs then brought their lawsuit pursuant to the Federal Torts Claims Act because Section 2671 defines an “[e]mployee of the government” as “officers or employees of any federal agency, members of the military or naval forces of the United States . . . .” FEDERAL TORT CLAIMS ACT, 28 U.S.C. § 2671. Furthermore, Section 2671 defines “[f]ederal agency” as including “the military departments, [and] independent establishments of the United States . . . .” See id.

279. See Zuchowicz II, 140 F.3d at 387 (discussing defendant’s objection to finding by district court that Danocrine caused plaintiff’s illness).
280. See id. at 384. While the FDA approved Danocrine for doses no greater than 800 mg/day, Mrs. Zuchowicz received 1600 mg/day. See id. The plaintiff’s expert conceded that no formal studies on the effects of Danocrine at such high doses had ever been performed and that very few women had ever received doses this high in any setting. See id. at 385.
plaintiff's experts were unable to provide any epidemiological or anecdotal evidence linking PPH to Danocrine overdoses. 281

To overcome these shortcomings, Dr. Matthay established a temporal relationship between the overdose and the beginning of PPH and ruled out other drug-related causes through a differential diagnosis. 282 He compared similarities between the course of Mrs. Zuchowicz's illness and that of accepted cases of drug-induced PPH. 283 Dr. Tackett testified that the overdose of Danocrine caused the PPH by reducing estrogen levels and producing elevated levels of insulin, free testosterone, and progesterone. 284 In concluding that these factors likely caused a dysfunction of the endothelium leading to PPH, Dr. Tackett relied on a variety of published and unpublished studies. 285 Since Danocrine had never before been linked to PPH, the defendant argued that the district court should never have admitted the expert testimony. 286

The Second Circuit disagreed. In reviewing the district court's decision to admit testimony for an "abuse of discretion," 287 the Second Circuit relied upon the four Daubert factors and caselaw to evaluate the scientific methodology. 288 The district court found that each expert "clearly possesse[d] expert scientific knowledge." 289 As

281. See id. at 385.
282. See id.
283. See id. (stating, "[Dr. Matthay's] conclusion was based on the temporal relationship between the overdose and the start of the disease and the differential etiology method of excluding other possible causes").
284. See Zuchowicz II, 140 F.3d at 386 (relying on various studies relating these hormones to endothelial dysfunction which leads to PPH).
285. See id.
286. See id. at 387.
287. See id. at 386 (holding that proper review of district court's decision regarding admission of expert testimony is "highly deferential abuse of discretion standard"). See also General Elec. Co. v. Joiner, 522 U.S. 136, 142 (1997) (holding that proper standard of review is abuse of discretion standard). The abuse of discretion standard of review is not a stringent review, and the lower courts have a great deal of discretion. See id. The appellate court will not reverse unless the lower court's ruling is "manifestly erroneous." See id. (quoting Spring Co. v. Edgar, 99 U.S. 645, 658 (1878)).
288. See Zuchowicz II, 140 F.3d at 387.
289. Zuchowicz II, 140 F.3d at 385-86; see also Zuchowicz v. United States, 870 F. Supp. 15, 18 (D. Conn. 1994) (hereinafter Zuchowicz I). The Second Circuit impliedly agreed with the district court's assessment of each expert's qualifications by merely reciting them without further discussion. See Zuchowicz II, 140 F.3d at 385-86. The Second Circuit's account of the expert's qualifications is as follows: Dr. Richard Matthay is a full professor of medicine at Yale and Associate Director and Training Director of Yale's Pulmonary and Critical Care Section. He is a nationally recognized expert in the field of pulmonary medicine, with extensive experience in the area of drug-induced pulmonary diseases . . . Dr. Randall Tackett is a tenured, full professor of pharmacology and former department chair from the University of Geor-
to the methodology employed by the experts, the Second Circuit stressed the flexible nature of the *Daubert* inquiry.\(^{290}\) The Second Circuit concluded that the district court properly fulfilled its gatekeeping role, thus admitting the testimony of well-credentialed experts relying on scientific methodology.\(^{291}\) It also agreed with the district court's conclusion that the experts "based their opinions on methods reasonably relied upon by experts in their particular fields."\(^{292}\)

While the system remains far from perfect, as does the scientific process itself, examination of post-*Daubert* and post-*Joiner* cases show that courts have addressed many of the scientific community's criticisms. Proper application of the *Daubert* standards, coupled with the "abuse of discretion" standard of review reaffirmed by *Joiner*, may lead to a reduction in the admission of experts, and, in turn, to an increase in the quality and reliability of expert testimony. While few lawyers would say it outright, the legal system seeks justice, but it also seeks credibility. Establishing credibility of the process is a fundamental goal of the Federal Rules of Evidence. Increased quality of experts in the courtroom contributes to both. The end result does not need to be fewer experts but instead better ones. It should also lead plaintiff's attorneys to pause and think before accepting a case; merely because someone is ill does not necessarily mean that he or she has a cause of action. Some cases cry for justice but, in the end, there may be nothing we can do.

The *Zuchowicz* case illustrates how judges can admit novel scientific expert testimony in a post-*Daubert*, post-*Joiner* court. Well-credentialed experts, internally consistent theories, and valid methods relied upon by other members of an expertise provide judges

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\(^{290}\) See id. at 386-87 ("The [Supreme Court in *Daubert*] emphasized, however, that [the four factors] were not an exclusive or dispositive list of what should be considered, and that the trial court's inquiry should be a flexible one" (quoting *Daubert* v. Merrell Dow Pharm., Inc., 509 U.S. 579, 594 (1993)). The *Zuchowicz II* court also found a similarly flexible approach in the Second Circuit's *McCullock* decision. The *Zuchowicz II* court stated:

With regard to the doctor's testimony [in *McCullock*], we noted that the doctor based his opinion on a range of factors, including his care and treatment of [the plaintiff]; her medical history . . .; pathological studies; . . . his training and experience; use of scientific analysis known as differential etiology (which requires listing possible causes, then eliminating all causes but one); and reference to various scientific and medical treatises. *Zuchowicz II*, 140 F.3d at 387 (quoting *McCullock*, 61 F.3d at 1044).

\(^{291}\) See id. (affirming district court's admission of expert testimony).

\(^{292}\) Id.
with sufficient justification for admitting novel scientific evidence. But what if the science is so novel that it does not fit into these conventional models? Should courtrooms be forever closed to such claims? Do courts need to adjust their paradigms to meet these new theories? These questions are addressed in the following discussion on Multiple Chemical Sensitivity.

V. WITCH DOCTORS AND NEUROTICS WITH IMAGINARY ILLNESSES: THE CONTROVERSY OF "MULTIPLE CHEMICAL SENSITIVITY"

Holding yourself out as a clinical ecologist to members of some of the "legitimate" scientific fields is analogous to identifying yourself proudly as an "ambulance chaser" in a room full of state supreme court justices. Sneers, loathing, and upturned noses are sure to follow. Such a response results because clinical ecologists promote the "junk science" known as Multiple Chemical Sensitivity or MCS. According to opponents of MCS, clinical ecologists not only promote their pet illness but also invented the hysteria. Some scientists even feel threatened by the field of clinical ecology itself. Opponents of MCS consider it a "Cheshire fact," that is, something "solemnly recorded, earnestly explained, vehemently defended, and then never seen again." According to opponents of the science, MCS and its underlying theories are considered "absurd and irrationally pseudoscientific assertions."

293. Cf. Huber, supra note 19, at 104 (opining that "clinical ecology is medical fantasy, not fact").

294. Compare American Council on Science and Health, MCS: Multiple Chemical Sensitivity 27 (concluding that multiple chemical sensitivity is scientifically unsupported, unrecognized by mainstream medical community and largely based on "junk" science), and Huber, supra note 19, at 2, with William J. Rea, Chemical Sensitivity: Principles and Mechanisms (1992) (providing detailed model supporting theory of multiple chemical sensitivity), and Linda Lee Davidoff, Multiple Chemical Sensitivities, Amicus J., Fall 1989, at 12 (discussing possibility that multiple chemical sensitivity is widely prevalent).

295. See Suzanne Orofino Galbato, Note, Multiple Chemical Sensitivities: Does Daubert v. Merrell Dow Pharmaceuticals, Inc. Warrant Another Look at Clinical Ecology?, 48 Syracuse L. Rev. 261, 282 (1998) (claiming that clinical ecologists invented MCS, which is "more a belief system than a scientific study").

296. See Ephraim Kahn & Gideon Letz, Clinical Ecology: Environmental Medicine or Unsubstantiated Theory, 111 Annals of Internal Med. 104, 105 (July 15, 1989) (warning that "the practice of 'environmental medicine' cannot be considered harmless").

297. Huber, supra note 19, at 25 (defining "Chesire fact" also as "pathological science" or "the science of things that aren't so").

298. Mainstream "normal" science advocates are historically intolerant of new theories proposed by others, see Kuhn, supra note 5, at 24, but this skepticism rarely translates into such virulent disgust. Others offer a more optimistic view of main-
WHEN SCIENCE IS TOO DAUNTING

MCS patients also share the scorn of legitimate science. Persons claiming affliction via MCS are referred to as neurotic or "very seriously nuts." At the very least, some consider them social deviants. This perception of the environmentally afflicted leads more to marginalization than to treatment.

stream science than that proposed by Thomas Kuhn. See, e.g., Patricia E. Lin, Note, Opening the Gates to Scientific Evidence in Toxic Exposure Cases: Medical Monitoring and Daubert, 17 REV. LITIG. 551, 570 (1998). Lin stated:

The scientific community simultaneously seeks to encourage innovative thinking and to assure that new ideas are subjected to rigorous review. On the one hand, science is a creative process, in which advances occur only if researchers are encouraged to develop and test innovative ideas . . . On the other hand, because science is a cumulative endeavor in which each scientist must build on the work of others, the scientific community needs to weed out false ideas.

Id. (footnote omitted).

Compare A. R. Rees & H. J. Purcell, Disease and the Environment 141 (1982) (citing common attributes assigned to MCS patients, such as "neurotic," "pochondriac," "overanxious," "obsessional," "paranoid," and that illness is all in patients' minds), with Dower, supra note 8, at 134-35 (observing that terms "neurosis" or "compulsive neurosis" were commonly associated with describing Japanese psyche and that it was generally believed Japanese were "collectively ill in a clinical sense"). As the comparison with the Japanese propaganda war illustrates, these are not terms associated with objective science but a deep-seeded hatred for the targets of such language. Great strides have been made in "proving" the psychological nature of MCS, see, e.g., Carroll M. Brodsky, "Allergic to Everything": A Medical Subculture, 24 PSYCHOSOMATICS 731 (1983), but few efforts have been made to sort out the anecdotes from the science, to determine if the psychoses preceded the illness or resulted from prolonged association with the illness. One case study suggested that psychological stress did not predate the onset of MCS symptoms. See Gregory E. Simon et al., Immunologic, Psychological and Neuropsychological Factors in Multiple Chemical Sensitivity: A Controlled Study, 19 AMERICAN COLLEGE OF PHYSICIANS 97, 100 (1993). The study, however, has been greatly criticized for its questionable methodology, its inherent biases, and its funding from the Boeing Company. See generally Controversy Over Multiple Chemical Sensitivities, 120 ANNALS OF INTERNAL MED. 249 (1994) (publishing several editorials by various practitioners).

Northern Exposure: Blowing Bubbles (CBS television broadcast, Nov. 2, 1992). In this particular episode, Dr. Joel Fleischman, a "virtually Board-certified physician," ridicules MCS patient Mike Monroe, the "Bubble Man," who has moved into a geodesic dome in order to protect himself from the toxicity of the environment. Id.; Cf. Michael I. Luster et al., Chemical Pollutants and "Multiple Chemical Sensitivities," in Phantom Risks, supra note 85, at 389 (suggesting that many symptoms associated with MCS can be treated with psychotherapy).

See Rees & Purcell, supra note 299, at 137, 141 (observing that those who suffer maladies resulting from adverse reaction to environment suffer condition that may "contribute to, or constitute, a form of social deviance" and citing several examples where MCS sufferers were referred to as "antisocial, naughty, badly behaved, unsocial, drunk").

See id. at 138-43. In addition, most physicians are inadequately trained to recognize properly environmental or occupational illnesses in general, let alone something as controversial and complicated as MCS. See Scott Deitchman, Occupational and Environmental Medicine, 271 J. AM. MED. ASS'N 1691, 1691 (1994). This lack of training only exacerbates the difficulties that MCS patients face when they seek medical help.
Yet thousands of people in the United States and Canada claim to be afflicted with this illness or syndrome. Clinics have been established to treat the MCS infirmed. Professional organizations have been established which publish journals and establish treatments for MCS. This section discusses the scientific quandary that is MCS and how courts have addressed the controversy through Daubert review.

A. The Nature of MCS – Theories, Symptoms, and Treatments

One author has suggested that the perceived illness of MCS originated with the publication of two books in 1962: Rachel Carson’s *Silent Spring* and Dr. Theron G. Randolph’s *Human Ecology and Susceptibility to the Chemical Environment*. Multiple chemical sensitivity is known by many names, most of them associated with the perceived cause of the particular illness. Some of the more common names include “environmental illness,” “total allergy syndrome,” and “twentieth-century disease.” The clinical definition for MCS is similar to that of “sick building syndrome.”

The fundamental theory behind MCS is that various types of environmental “insults” may overload a person’s immune system to the point that the exposed person becomes hypersensitive to chem-

303. See id. (noting that there are 6,345,700 cases of work related illnesses among 90 million Americans working in private industry and stating that there are no comprehensive estimates on prevalence of environmental illness).

304. See, e.g., Gray, supra note 13, at 879 (discussing newly-opened Toronto clinic); Bradley v. Brown, 852 F. Supp. 690, 698 (N.D. Ind. 1994) (mentioning Environmental Health Care Center in Dallas, Texas); Radetsky, supra note 11, at 86 (discussing Environmental Allergy Center in Buffalo, New York).

305. See id. at 79. The American Academy of Environmental Medicine (AAEM), founded in 1965, boasts nearly six hundred members, almost one-third of all practicing environmental physicians. See id.

306. See Huber, supra note 19, at 93.

307. See id.; Radetsky, supra note 11, at 4.


- Symptoms are reproducible upon exposure.
- The condition is chronic.
- Symptoms occur following low level exposure.
- Removal of precipitating exposures results in resolution or improvement of symptoms.
- Multiple often unrelated chemicals may produce symptoms.
- The condition is acquired.
- There is an acute inciting event, followed by a chronic component.
- There are no accepted objective tests to adequately explain the symptoms.

Id.
icals, odors, or other naturally occurring substances.\textsuperscript{309} MCS has also been compared with classic Pavlovian conditioning and with psychophysiological models of conditioning theory.\textsuperscript{310} Underlying these theories is a belief that each person suffering from the illness will develop a syndrome unique to his or her respective situation.\textsuperscript{311}

The symptoms associated with MCS are numerous. At one Toronto clinic, patients complained of sensitivity to odors, neurological symptoms, allergies to food, or medication and breathing problems.\textsuperscript{312} Specific symptoms cited number over one hundred, including swelling or pain in joints, nasal or sinus difficulties, hypersensitivity to sounds and smells, abnormalities in breathing and pulse rate, fatigue, skin irritation, nausea, and various gastrointestinal disorders.\textsuperscript{313} This myriad of symptoms tend to originate from several bodily systems, including the nervous, muscular, respiratory, gastrointestinal, and cardiovascular systems.\textsuperscript{314} According to the American Academy of Allergy and Immunology, however, no evidence demonstrates that these symptoms are caused by anything at all.\textsuperscript{315}

Despite these assertions, commentators have suggested several triggers for the illness. Organic solvents, bacteria or fungus, pesticides, perfumes, petrochemicals, and many other unrelated chemicals are believed to trigger the onset of the illness, which is usually

\begin{itemize}
\item \textsuperscript{309} See Berger, \textit{supra} note 185, at 73 (discussing clinical ecology as untestable science).
\item \textsuperscript{310} See Martin Hahn & Herbert L. Bonkovsky, \textit{Multiple Chemical Sensitivity Syndrome and Porphyria: A Note of Caution and Concern}, 157 \textsc{Archives Internal Med.} 281, 282 (1997).
\item \textsuperscript{311} See Berger, \textit{supra} note 185, at 73.
\item \textsuperscript{312} See Gray, \textit{supra} note 13, at 880. Dr. Frank Foley, a family physician who serves as the clinic director, indicates that excessive sensitivity to smells is the most common symptom. \textit{See id.}
\item \textsuperscript{313} See Nicholas A. Ashford & Claudia S. Miller, \textit{Chemical Exposures: Low Levels and High Stakes} 76-77 (1991) (describing symptoms of MCS patients).
\item \textsuperscript{314} See Hahn & Bonkovsky, \textit{supra} note 310, at 282. The symptoms and systems affected, such as memory loss and brain damage with related emotional and functional disruption from exposure to chemicals is well known in other contexts. \textit{See N. Fledler et al., Evaluation of Chemically Sensitive Patients, 34 \textsc{J. Occupational Med.} 529-38 (1992); L.A. Morrow et al., \textit{PET and Neurobehavioral Evidence of Tribromoethane Encephalopathy, 2 \textsc{J. Neuropsychiatry Clinical Neuroscience} 431-35 (1990).}
\item \textsuperscript{315} See AAAI Position Statement, \textit{supra} note 188, at 270. The AAAI stated: There is no clear evidence that many of the symptoms noted above are related to allergy, sensitivity, toxicity, or any other type of reaction from foods, water, chemicals, pollutants, viruses, and bacteria in the context presented. \textit{Id.}
transmitted via the olfactory systems. At least one article concluded that certain stimuli do not cause MCS. Adding to the confusion, no one has been able to determine why some chemicals trigger MCS and some do not.

Because multiple symptoms and theories of causation are associated with the illness, it should not be surprising that medical practitioners apply a variety of methods to treat MCS patients. The two general types of treatment that MCS patients undergo are (1) those that are self-enforced and (2) those that are practiced by the physicians treating MCS patients. Most common among the self-imposed treatments are avoidance regimens, where patients attempt to avoid the chemicals or substances they believe have contributed to their condition. The most well-known of the clinical treatments for MCS is a process known as the “provocation-neutralization” method.

There is also no consistency in the types of people who are afflicted with MCS. Studies have shown that those affected by MCS include industrial workers, those who work in airtight buildings, people exposed to chemicals in consumer products, chemical accident victims, people who live in areas with higher concentrations of water and air pollution, and people living near toxic waste sites. MCS studies, however, consistently show that MCS patients are predominantly females in their forties.

316. See Hahn & Bonkovsky, supra note 310, at 282.
317. See id. at 284 (concluding that “there is no satisfactory evidence that decreased activity of coproporphyrinogen oxidase (leading to coproporphyrinuria) is a cause for multiple chemical sensitivity”).
318. See Wendi J. Berkowitz, Multiple Chemical Sensibility in the Courtroom: Is there Life After Daubert?, 63 DEF. COUNS. J. 483, 483 (1996) (stating that “proponents of MCS are not meeting the standards established by Daubert and their testimony is being rejected”)
319. See Rees & Purcell, supra note 299, at 143-44; Radetsky, supra note 11, at 6 (quoting one patient as saying, “[a]s long as I work at home, avoid rush-hour driving, stay away from people wearing perfume in close spaces, avoid buildings where the indoor air problem is obvious when I enter it, then I am able to function well enough to do my job”).
320. See id. at 88. Under this method, the treating physician intradermally injects a strong dose of an allergen, which provokes a reaction, then administers a “neutralizing” dose of the allergen through progressing dilutions of strong to weak. See id. Other treatments also include nutritional therapy and “heat therapy,” which involves literally sweating the toxins out of one’s system. See id. at 83.
322. See Simon et al., supra note 14, at 99; Gray, supra note 13, at 880; Radetsky, supra note 11, at 14-15.
According to the opponents of MCS and studies cited in federal case law, every "recognized" medical organization denies the existence of MCS as a physiological illness. Reports on MCS have been criticized on technical grounds because the studies reflect individual reports of patients rather than controlled clinical or epidemiological studies. Federal courts consistently agree to concede to defendants' use of outdated statements from these professional organizations. With all deference to federal courts, however, the scientific issues associated with MCS are considerably complex.

B. How MCS Doesn't Fit in With the Other Illnesses: "Which One of These Does Not Belong?"

One of the "problems" with MCS is that it does not conform to any widely accepted concept of illness. It is not accepted in the "normal science" community because it does not fit into any "relatively inflexible box" of existing immunological, epidemiological, or toxicological paradigms. It is the very nature of science that some theories stubbornly refuse to be assimilated into existing paradigms. While this pattern gives rise to new theories, which, in turn, advance science, something about MCS brings the "true" scientist's blood to a boil and causes the defending attorney to return to a primordial, bestial state.

Another problem is that the etiology for MCS is not known. Several immunologic, neurotoxic, and psychiatric causes...
have been proposed.\textsuperscript{329} Some common triggers include personal stress, surgery, and reaction to a new building.\textsuperscript{330} For the most part, although, the onset of MCS is not accompanied by a single isolating event; it is not a "signature" illness.\textsuperscript{331} Therefore, a simple model based on isolating singular cause-and-effect relationships is useless in trying to explain the occurrence of an illness that is caused by several factors.\textsuperscript{332}

MCS sufferers also display a vast array of symptoms, far too many for those in traditional scientific or medical practices to accept.\textsuperscript{333} But MCS is not the only recent illness to suffer this defect. The thousands of women who have experienced illness from exposure to silicone gel implants have also displayed a vast array of symptoms.\textsuperscript{334} Veterans from the Gulf War have experienced as many as six distinct and documented syndromes, each with unique symptoms and all under the commonly known heading of "Gulf War Syndrome."\textsuperscript{335} The types of symptoms associated with MCS also place the illness outside of conventional paradigms.\textsuperscript{336} The complexity of the issues and the diversity of symptoms and theories has led to unfavorable results for plaintiffs in federal court. The following discussion recounts how federal courts have applied the Daubert

\textsuperscript{329} See Simon, supra note 14, at 97.
\textsuperscript{330} See Gray, supra note 13, at 880.
\textsuperscript{331} A "signature" disease is an illness known to be caused by one specific agent; for example, mesothelioma is caused specifically be exposure to asbestos. See In re Joint E. & S. Dist. Asbestos Litig., 827 F. Supp. 1014, 1026 (S.D.N.Y. 1993).
\textsuperscript{333} See Radetsky, supra note 11, at 15 (citing multitude of symptoms as one of primary reasons that American Medical Association has rejected MCS as "recognized clinical entity," adding that "[a]n old saw in medical circles is that the more numerous the symptoms, the less credible the patient").
\textsuperscript{334} See In re Breast Implant Cases, 942 F. Supp. 958, 961 (E.& S.D.N.Y. 1996) (indicating that "there are hundreds of symptoms associated with the undifferentiated" silicone-induced autoimmune disease).
\textsuperscript{335} See Robert W. Haley et al., Is There a Gulf War Syndrome? Searching for Syndromes by Factor Analysis of Symptoms, 277 J. AM. MED. ASS'N 215, 218-19 (1997) (listing approximately fifty distinct reported symptoms associated with illness and identifying characteristics of each of six syndromes); Technology Assessment Workshop Panel, The Persian Gulf Experience and Health, 272 J. AM. MED. ASS'N 391, 391 (1994) (listing several symptoms that "do not fit traditional diagnostic categories").
\textsuperscript{336} See Gray, supra note 13, at 880 (quoting Dr. Frank Foley, director of the Toronto Environmental Health Clinic). Excessive sensitivity to smell, common among MCS patients, is a symptom that "traditional medicine cannot explain," states one MCS clinic doctor. See id.
test to the admissibility of MCS causation evidence and, in so doing, ignored the spirit of *Daubert* and recent scientific developments.

C. Success of the MCS Plaintiff – An Unhappy Day in Court

Not a single district court has admitted causation testimony regarding MCS, and only one circuit court has reviewed the evidence under the *Joiner* standard of review.\(^3\)\(^3\)\(^7\) The mere allegation that a plaintiff is claiming to suffer from MCS is enough for a district court to dismiss the case, regardless of what an expert might have to say.\(^3\)\(^3\)\(^8\) Courts reviewing MCS causation testimony have excluded it for essentially two reasons: the etiology of MCS is unknown, and the existence of the illness and the practice of clinical ecology are not "generally accepted" in the medical or scientific community. Only one court has conducted a thorough analysis of all four *Daubert* reliability factors and the relevancy test.\(^3\)\(^3\)\(^9\)

The lack of acceptance of both MCS and clinical ecologists by the scientific and medical community seems to be the foremost justification for denying the admissibility of causation testimony. To support a belief that MCS and its progenitors, the clinical ecologists, are not generally accepted in the scientific community, courts have cited to Kenneth R. Foster and Peter W. Huber’s *Judging Science: Scientific Knowledge in the Federal Courts*, which states, “Chemical ecologists have failed to provide criteria that allow a doctor to decide when somebody does not suffer from MCS which is one of the main reasons why MSC is regarded skeptically by mainstream medicine.”\(^3\)\(^4\)\(^0\) The Federal Judicial Center has voiced similar con-


\(^\text{338.}^\) See *Summers*, 132 F.3d at 603 (saying that if plaintiff is actually claiming to suffer from MCS, then "defendant prevails because MCS is a controversial diagnosis that has been excluded under *Daubert* as unsupported by sound scientific reasoning or methodology") (citing Bradley v. Brown, 42 F.3d 434, 438-39 (7th Cir. 1994); Foster & Huber, *supra* note 43, at 50). This author finds it interesting that the Tenth Circuit would cite the Foster & Huber book, given the obvious bias that the authors hold against any novel scientific theory, particularly the use of such theory in the courtroom.


cerns, also well taken by the courts, regarding the reliability of clinical ecologists and their methods. "Clinical ecologists have not been recognized by traditional professional organizations within the medical community . . . . The leading professional societies in the fields of allergy and immunology have rejected clinical ecology 'as an unproven methodology lacking any scientific basis in either fact or theory.'" 341

Oddly enough, the cases that cite to this passage from the Reference Manual exclude the textual references to studies that support the claims of clinical ecologists. 342

The selected reading from the Reference Manual is not the only miscue in the federal courts regarding the legitimacy of the science of MCS. Twenty-five federal entities, including the U.S. Agency for Toxic Substances & Disease Registry (ATSDR), 343 the Social Security Administration, 344 the U.S. Department of Housing and Urban Development (HUD), 345 and numerous state authorities have recognized that MCS is either a legitimate illness or a phenomenon that demands research and study. State worker's compensation boards have also held that MCS is a legitimate illness. 346 Several state court cases have recognized the legitimacy of MCS, permitting


342. See Berger, supra note 185, at 74 (observing that "recent studies may provide some support for their claims" and that "numerous other professional organizations and societies . . . have not discredited completely the potential usefulness of clinical ecology").

343. In conjunction with the National Academy of Sciences and the Association of Occupational and Environmental Clinics, the ATSDR sponsored three national medical conferences on MCS from 1991-94. The proceedings of these conferences are reprinted in MULTIPLE CHEMICAL SENSITIVITY: A SCIENTIFIC OVERVIEW (Frank Mitchell ed., 1995).

344. The Social Security Administration's Program Operations Manual System (POMS) includes a section on the "Medical Evaluation of Specific Issues - Environmental Illness," stating that "evaluation should be made on an individual basis to determine if the impairment prevents substantial gainful activity." SSA Pub. 68-0424500, Part 04, Ch. 245, § 24515.065, transmittal #12, 1988.

345. "MCS [is recognized] as a disability entitling those with chemical sensitivities to reasonable accommodations under Section 504 of the Rehabilitation Act of 1973." Letter from Timothy Coyle, HUD Assistant Secretary, to Frank Lautenberg, U.S. Senator (October 26, 1996).

346. See, e.g., Elizanne Shcakle v. State of Delaware, Hearing No. 967713, Delaware Industrial Accident Board in and for New Castle County, Dec. 1993 (awarding total temporary disability benefits and attorney's fees based on its finding that the claimant's work exposure had "caused her present respiratory symptoms" and that this has "sensitized her to other odors"); McDonnel v. Honeywell, Hearing No. 95-5670, Wash. State Board of Industrial Appeals (Oct. 22, 1996) (recognizing
claims ranging from negligence/toxic tort, housing discrimination, and employment discrimination.

Statements cited in federal cases by the American Medical Association and various other professional organizations regarding the perceived illegitimacy of MCS and clinical ecology have also been afforded great weight by courts reviewing MCS causation evidence under Daubert. These statements are taken out of context and predate recent developments in the recognition of MCS among various organizations, including the AMA. Yet in some federal cases, this perceived lack of general acceptance alone was sufficient justification for not allowing the evidence into the courtroom. One court even declined to conduct its own independent review of clinical ecology and the science of MCS, citing a lack of general acceptance as reason enough to exclude causation testimony.

"toxic encephalopathy" as acceptable diagnosis for MCS-induced permanent partial disability).


348. See, e.g., Lincoln Realty Management Co. v. Pennsylvania Human Rights Comm'n, 598 A.2d 594 (Pa. 1991) (recognizing housing discrimination when reasonable accommodations were not made for handicapped tenant with chemical sensitivities).


351. In a book published jointly by the Consumer Protection Safety Commission, the Environmental Protection Agency, the American Lung Association, and the American Medical Association, these organizations state that "[t]he current consensus is that in cases of claimed or suspected MCS, complaints should not be dismissed as psychogenic, and a thorough workup is essential." INDOOR AIR POLLUTION: AN INTRODUCTION FOR HEALTH PROFESSIONALS (Government Printing Office, 1994).

352. See Sanderson, 950 F. Supp. at 1001-02 (repeating defendant's argument that expert opinion as to MCS should be excluded because various medical organizations do not believe that illness exists and that any testimony about MCS would be unreliable for that reason). The court then added that its research "has revealed that every court to rule on this issue has agreed with defendant's argument." Id. at 1001. The court later added that it had "discovered no case in which MCS was recognized as a legitimate medical condition." Id. at 1002. This assertion is in direct contradiction, however, to the cases mentioned above. In another case, the court cited "serious doubts as to the scientific validity of the multiple chemical sensitivities syndrome" and would exclude the plaintiff's expert testimony even if it were scientifically valid. See Carlin, 1995 WL 760739, at *4.

The unknown etiology of the disease is the second most prominent reason for denying admission of MCS causation testimony. Bradley v. Brown\textsuperscript{354} provides an example of exclusion on this basis. Without specifically applying the four Daubert standards and conducting a general discussion on the "speculative" nature of MCS, the Bradley court stated that "the 'science' of MCS's etiology has not progressed from the plausible, that is, the hypothetical, to knowledge capable of assisting a fact-finder, jury or judge."\textsuperscript{355} In order to support this conclusion, the Bradley court discussed the various suspected theories behind the etiology, sources that indicated a need for further study on the etiology, other sources that indicated the controversial and speculative stage of the science of MCS at this time, and the experts' own testimony.\textsuperscript{356}

In only one case, Zwillinger v. Garfield Slope Housing Corp,\textsuperscript{357} has a court taken the extra steps to look beyond general acceptance and the uncertain etiology of MCS. In Zwillinger, the district court conducted a full analysis of the Daubert admissibility standards. For the first prong, whether the expert's theory has been empirically tested, the court focused on studies relating to the toxic effects on mice of chemical outgassing, particularly the substance 4-PC, from new synthetic carpets.\textsuperscript{358} The court concluded that the studies and conclusions of the Bradley and Summer courts, concluding that MCS etiology and the practice of clinical ecology were scientifically unreliable. Id. at 982.


356. See Bradley, 852 F. Supp. at 698 (citing testifying expert's book on MCS as indicating that thirteen percent of his patients "relate the onset of their sensitivity to a sever acute [chemical] exposure" and some nine percent who "identified childbirth as the triggering event" and stating, "[W]e do not know at this time the initial mechanism by which good health gives way to chemical sensitivity").


358. Zwillinger, 1998 WL 623589, at *10–16. Despite the court's acknowledgment of the controversial nature of MCS and how MCS has not been accepted by any federal court, the court still conducted an in depth review. See id. at *11.
cited by the plaintiff's expert not only failed to support the outgassing theory but in fact refuted it.\(^{359}\) The court also examined a study currently in progress by the plaintiff's expert and concluded that it was not reliable because it did not use a control group and because it failed to utilize an animal study to test exposure levels and toxicity.\(^{360}\)

Due to its extended analysis of the underlying methodology, the court spent considerably less time on the remaining Daubert factors. Under the peer review analysis, the Zwillinge\(\text{r}\) court acknowledged the publication of various studies regarding the effects of carpet emissions on mice but that the expert's own study had not yet been subjected to publication or peer review.\(^{361}\) With respect to the third prong of the Daubert analysis, the court concluded not only that a known rate of error for the study did not exist but also that the likelihood was very high that the error rate would be substantial.\(^{362}\) In applying the fourth Daubert reliability prong, the court determined that the expert's theories were not generally accepted in the relevant scientific community.\(^{363}\) Finally, the court

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\(^{359}\) See id. at *12 (citing study that stated, "[w]ith regard to the issue of multiple chemical sensitivity (MCS), . . . evidence of an association with 4-PC is lacking"). The plaintiff also submitted forty-five other scientific studies "comprising several hundred pages" but failed to cite the specific pages within those studies that supported her position. See id. The court noted that the responsibility to locate the specific pages was the plaintiff's burden, not the courts, for "[d]istrict judges are not archaeologists. They need not excavate masses of papers in search of revealing tidbits." Id. (quoting Northwestern Nat'l Ins. Co. v. Baltes, 15 F.3d 660, 662 (7th Cir. 1994)). The court did, however, conduct a cursory review of the cited animal studies and concluded that they provided no valid basis for being extrapolated to humans. See id. at *13. One particular study heated a carpet sample in an aquarium to a temperature slightly above room temperature, then exposed the mice, in an adjacent chamber, to the heated air containing emissions from the carpet. See id. The court failed to see how the reactions of mice to heated carpeting could be analogized to humans being exposed to carpet at room temperature. See id.

\(^{360}\) See id. at *15. The plaintiff's expert was conducting a study, which he planned to have published in the Archives of Environmental Health, that consisted of a case-control study of eighty-nine of his current MCS patients with symptoms and triggers similar to the plaintiff's. See id.

\(^{361}\) See id. at *17; but see Kannankeril v. Terminix Int'l, Inc., 128 F.3d 802, 809 (3d Cir. 1997) (observing that since effects of organophosphates on humans was well documented, it was not necessary that plaintiff's witness himself had published any articles on theory).

\(^{362}\) See Zwillinge\(\text{r}\), 1998 WL 623589, at *18 (citing lack of objective test for determining cause of elevated antibody levels in patients' blood, reliance on self-reported patient histories, and lack of control group).

\(^{363}\) See id. at *21-23. The court concluded that, although the plaintiff's expert tried to avoid the MCS controversy and lack of general acceptance by calling it "immunotoxicity" or "toxic encephalopathy," the hypothesis that exposure to gases given off by carpeting may cause MCS is not generally accepted in the scientific community. See id.
also found that the expert's testimony did not "fit" the facts of the case because he did not apply the proper methodologies required for general and specific causation. The evidence, therefore, failed the relevancy requirement.

While federal courts have generally used the Daubert and Joiner standards to keep "bad experts" out of the courtroom with respect to MCS, these courts have also used the same factors to exclude evidence of the science itself. This result has clearly come from an overemphasis on etiology and on general acceptance. In this regard, federal courts have failed abysmally in their application of Daubert. The following section illustrates how judges could allow the admission of some, but not all, MCS expert testimony while still remaining true to Daubert.

**VI. ADMITTING NOVEL SCIENTIFIC THEORY – A DAUBERT ROADMAP**

The fact that MCS does not fit into any accepted paradigms of illness should not bar admitting causation testimony. This section discusses matters of science and an application of Daubert that would allow a court to admit novel scientific evidence into the courtroom. While the focus of this discussion remains on MCS, these standards could easily apply to other novel scientific theories. This is not to say that it is the lawyer's job to prove or disprove a

364. See id. at *19-20.
365. See, e.g., In re Breast Implant Cases, 942 F. Supp. 958, 960 (E.& S.D.N.Y. 1996). In In re Breast Implant, the district court stated:

The hundreds of symptoms associated with this undifferentiated disease, the lack of any acceptable agreed upon definition, the inadequacy of any satisfactory supporting epidemiological or animal studies, the lack of a scientifically acceptable showing of medical plausibility, and the questionable nature of the clinical conclusions of the treating doctors, all point to a failure of proof in making a prima facie case that silicone implants cause any of the syndromes claimed except for local disease.

*Id.* Having taken the time to say all of that, the district court still denied summary judgment for the defendants. See id. The court deferred rendering summary judgment pending the outcome of a national study; "It is possible that further information will in time support the plaintiffs' general systemic claims sufficiently to permit a jury trial." *Id.* at 961.

366. This is a limited scope of inquiry. Due to the complex nature of MCS, the diversity of persons claiming to suffer from MCS, the multiplicity of suspected triggers, and the vast number of displayed symptoms, it would be impractical and implausible to conduct a discussion on how to prove either general or specific causation. The purpose of this discussion is to isolate the weaknesses in judicial analysis of the "scientific knowledge" associated with MCS and to indicate how judges should be able to admit causation testimony with a proper application of the spirit and the letter of Daubert.
phenomenon. Such matters should be left to the scientists. But lawyers are required to find quick, final solutions and help their clients to the best of their abilities with available law and science.

As the MCS cases illustrate, it is all too easy for federal courts to fall into a de facto application of the Frye general acceptance test in the face of novel scientific theory. Judges should review with greater skepticism a proclaimed lack of general acceptance and determine if the underlying methodologies are “grounded in the scientific method,” regardless of whether these methodologies are “traditional.” Fulfilling these two elements covers at least three of the four prongs of the Daubert reliability assessment and the relevance assessment. An application of these arguments to the review of MCS evidence by federal courts will help illustrate the best way to prevent the exclusion of novel scientific theory.

A. General Acceptance within the Relevant Scientific or Medical Community

The Supreme Court in Daubert held that general acceptance, while still relevant, is not an absolute test of the reliability of the proffered testimony. If courts are to bring judicial practice in line with the practice of experts outside of the courtroom, then courts should give less weight to general acceptance and peer-review.

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367. See Underwagner v. Salter, 22 F.3d 730, 736 (7th Cir. 1994) (“Scientific controversies must be settled by the methods of science rather than by the methods of litigation”).


The law is usually in much more of a hurry to decide than science is. Ironically, however, law's findings, although less reliable and tested than those of science, are treated as more final and authoritative. Law operates under pressure to resolve particular disputes speedily and conclusively . . . [Scientific] consensus often takes a long time to assemble, yet even then it is conditional, always open to revision on the basis of new data or theories.

Id.

369. Most courts that hold a methodology to be unreliable also conclude that the proffered testimony fails to “fit” the facts of the case, or be deemed relevant. See, e.g., Zwillinger v. Garfield Slope Housing Corp., No. CV 94-4009 (SMG), 1998 WL 623589 (E.D.N.Y. Aug. 17, 1998). Courts that view a scientific theory to be not generally accepted will also likely hold that the science has not been subjected to peer review. See id. The remaining two components, subject to empirical testing and error rate, are more case specific and harder to illustrate for purposes of this exercise.

370. See Daubert, 509 U.S. at 589 (rejecting “generally accepted” standard as “austere” and “absent from and incompatible with the Federal Rules of Evidence”).
This conclusion is logical because most objective evaluations of the scientific method do not include either factor as a basis for valid methodology. General acceptance may even be inappropriate to evaluate as a matter of admissibility because it goes more to the credibility of the expert's science.

Despite this assertion, federal courts have almost consistently treated the lack of general acceptance of MCS as an absolute bar. Several reasons exist as to why MCS and clinical ecologists are not "generally accepted" in the scientific community. These reasons are directly tied to the lack of peer review or published studies in "reputable" journals which strongly support the science of MCS. First of all, clinical ecologists and other scientists and practitioners who believe in the existence of MCS employ practices and procedures that are not traditional. They utilize tests with different names like "provocation-neutralization" and "SPECT" that are not traditional testing methods. While based on traditional allergist models, clinical ecologists utilize a method of skin testing that varies slightly from the norm. Second, the traditional medical and scientific communities have a bias against anything that has the label of clinical ecology, regardless of scientific validity. The bias

371. See United States v. Williams, 447 F.2d 1285, 1290 (5th Cir. 1971), cert. denied, 405 U.S. 954 (1972), reh'g denied, 405 U.S. 1048 (1972) (arguing that Federal Rule of Evidence 703 is designed to perform this function).

372. Any discussion of peer review or general acceptance is notably absent from Karl Popper's validity assessment, see supra note 44, Carl Sagan's "baloney detection kit," see infra note 400, and the "Koch-Henle Postulates," see infra note 401. It would seem that the scientific community is only deeply concerned about peer review and general acceptance when litigation is involved.

373. See McCullock v. H.B. Fuller Co., 61 F.3d 1038, 1042 (2d Cir. 1995) (holding that peer review and publication or general acceptance of expert's theory goes to weight of testimony rather than its admissibility).

374. For a further discussion of the weight given to the use of non-traditional practices and procedures in MCS causation testimony, see supra notes 376-78, 385-97 and accompanying text.

375. See Treadwell v. Dow-United Tech., 970 F. Supp. 974, 981 (M.D. Ala. 1997) (quoting statement on MCS by American College of Occupational and Environmental Medicine as finding that "[t]he scientific foundation for managing patients with this syndrome has yet to be established by traditional investigative activities that withstand critical peer review").

376. For a discussion of the provocation-neutralization method, see infra notes 404-05.

377. Single Photon Emission Tomography. Similar to CAT and PET scans, SPECT tracks the flow of blood to the brain and the brain's ability to utilize that blood. Clinical ecologists and other practitioners who treat MCS use this technique to measure neurophysical reactions to toxic exposures. See Radetsky, supra note 11, at 107.

378. See id. at 87.

379. Doris Rapp conducted a double-blind study on the provocation neutralization method, but was rejected by the traditional medical journals in the United
of the mainstream scientific community is particularly directed against Dr. William J. Rea, director of the Environmental Health Center in Dallas, Texas.380

Although peer review on the subject of MCS is not lacking, courts continue to succumb readily to contrary assertions. In reality, hundreds of articles have been published addressing a variety of topics that involve MCS, including viewpoints or data that MCS is an organic illness, that it is a psychogenic illness, or that it is a mixture of both.381 The difficult aspect of wading through the peer review is determining which articles favor MCS as a legitimate illness, which studies support or refute theories behind MCS, and which studies originate from the appropriate scientific community.

A lack of understanding of what constitutes the relevant scientific community leads to confusion in the courts. No cases, particularly not MCS cases, have discussed which community is “relevant” for Daubert purposes. Criticism of MCS and clinical ecology comes from toxicologists, epidemiologists and immunologists. None of these critics, however, are members of the clinical ecology or environmental medicine communities.

If courts focus upon clinical ecologists and other practitioners who treat MCS patients, then the relevant organization would be the American Academy of Environmental Medicine (AAEM) and not the American Medical Association (AMA). This result would be consistent with the Ninth Circuit’s Daubert remand decision.382 Thus, in limiting the scope of the community, a court is more likely

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States. She eventually published in the Medical Journal of Australia. Claudia Miller has suggested that the standards expected by mainstream scientific and medical journals is higher for MCS than other subjects: “The standards for MCS papers are much more exacting, scrutiny is much more intense, because many scientists don’t believe it exists.” Id. at 142-44.

380. William J. Rea was previously a cardiovascular surgeon who started making connections between blood clotting and artificial lungs and hearts. After conducting extensive research and study on the matter, he wrote a paper and submitted it to the Journal of the American Medical Association. He recalls their response: “This is a novel concept. Nobody on the reviewing panel has ever heard of such a thing. Therefore, we’re gonna reject it.” Id. at 82. Since then, the mere mention of William Rea’s name in an article will guarantee rejection. See id. at 142 (recounting experience of academic physician, not clinical ecologist, who tried to publish article in one of leading medical journals but was told by editorial staff, “If you expect to publish in this journal you will not cite any work by Bill Rea”) (emphasis in original).

381. Journals publishing articles on MCS include Annals of Allergy, Archives of Environmental Health, Archives of Internal Medicine, Journal of Occupational Medicine, Journal of the American Medical Association, and Toxicology & Industrial Health.

382. Daubert v. Merrell Dow Pharm., Inc., 43 F.3d 1311, 1319 (9th Cir. 1995) (adding that methodology must constitute “the scientific method, as it is practiced by (at least) a recognized minority of scientists in their field” (emphasis added)).
to find that the methodologies are employed by "members of the relevant community." This would further aid the courts in determining the appropriate level of "general acceptance" and the appropriate journals to consider as authority for peer review purposes.

Courts have paid particular attention to the perceived "bias" and "subjectivity" of MCS diagnoses, but they have failed to recognize the inherent bias that MCS opponents have against the disease and how that bias affects the extent to which MCS has been "recognized" by the "scientific community." This bias illustrates the inherent difficulty and potential for abuse associated with giving the "general acceptance" test such weight. It also provides a good foundation for arguing for a different understanding of the definition of "relevant scientific community," particularly in light of the Daubert and Downing rationalizations of the concept.

B. The Science Behind MCS – Theories Grounded in Known Scientific Fact

One of the fundamental barriers to acceptance of MCS is the seeming ridiculousness of its fundamental premise: that life in industrial society can simply overload the body's immune system or create a hyper-allergic state. The concept of MCS is not the grand leap from already "accepted" medical and scientific knowledge that the AMA would have federal courts believe. MCS claimants certainly do not allege that their illnesses are being caused by extraterrestrial implants.

An evaluating court should remember the purpose behind Rule 703, which is to ensure that scientific fact, not fiction, finds its way into the courtroom. Many of the fundamental theories and principles behind MCS are already accepted scientific fact, yet

384. See, e.g., Viterbo v. Dow Chem. Co., 826 F.2d 420, 421 (5th Cir. 1987) (stating that plaintiff's expert "brought to court little more than his credentials and a subjective opinion"); Buckley & Haake, supra note 85, at 10293 (suggesting that "so-called experts" are "well paid" for their "unsupported opinions").
385. Of course, it is easy to ridicule the theory if you work for the industries contributing to the toxicity of the environment. For a discussion of the influence of industry upon "objective" scientific study, see supra note 9. A useful analogy to articulating a sensible theory might be found in death by exsanguination. It takes no stretch of imagination to believe that a deep cut across the carotid artery would cause quick and certain blood loss, and eventually death, absent adequate medical attention. It is harder to accept a theory that death was caused by a scratch, unless that scratch was one of a thousand over a short period of time, and the victim was a hemophiliac. This scratch analogy most aptly fits the primary theories over what causes MCS.
courts continue to reject MCS. First, it is well known that the vast majority of diseases are caused by environmental factors. Four groups of environmental factors may adversely affect health: (1) psychological factors, such as stress in the workplace or in human relationships; (2) accident factors, such as speed and the influence of alcohol or drugs; (3) biological factors, such as bacteria, viruses, or parasites; and (4) physical factors, such as noise, climate, radiation, and ergonomics. The effects of exposure can range from subtle physiological conditions to severe illness or death.

Second, immunologists have also identified several kinds of toxic effects of chemicals on the immune system. Some of the identified toxic effects include immunosuppression, which is a change or suppression in immunological functions following exposure to chemicals; and hypersensitivity to chemicals or therapeutic drugs, which can result either in allergies or in attacks by the immune system against the body’s own cells (autoimmunity).

Third, science has also proven that some people are more sensitive, even to common chemicals, than others. Three lines of indirect evidence provide support for the links between chemical exposure and human disease resulting from immune system suppression. Similar evidence suggests possible links between chemical exposure and autoimmune disorders.

Fourth, the lack of known etiology is not the litmus test of unscientific knowledge as MCS opponents and courts suggest. If that were truly the case, then no federal court would allow causation

386. See Beaglehole, supra note 70, at 117. For example, 80 percent of all cancers are caused by environmental factors. See id.
387. See id. at 118, fig. 9.1.
388. See id. at 125.
389. See Luster et al., supra note 300, at 379-81 (discussing scientific studies and adding that “these immune system problems are well established and accepted by the medical community”).
390. See, e.g., Needleman, supra note 332, at 266 (discussing increased vulnerability of children to pesticides in food products).
391. See Luster et al., supra note 300, at 383 (discussing studies and providing details). These three “lines of evidence” include (1) the use of powerful drugs for cancer treatment or to suppress the immune system of patients following organ transplants, (2) several occupational or inadvertent exposures to chemicals that have resulted in immunologic changes, and (3) “scattered studies” that report both immune suppression and “clinically apparent health defects” in people following occupational or accidental exposure to chemicals. See id.
392. See id. at 385. In addition, the National Academy of Sciences has suggested that fifteen percent of all Americans may experience “increased allergic sensitivity” to chemicals. See Radeisky, supra note 11, at 12. Furthermore, a 1991 survey by the Environmental Protection Agency found that approximately one-third of inhabitants of sealed buildings reported sensitivity to one or more common chemicals. See id.
testimony on cancer. A close look at cancer also provides some parallels to the criticism against MCS as an illness. Cancer victims undergo varying treatments, their bodies are affected differently and they manifest a variety of symptoms. Cancer patients particularly may show psychological symptoms due to prolonged illness. Thus, it is possible for theories behind an illness to be based on scientific fact, even when all of the answers are not known.

C. Methodologies of MCS are Grounded in the Scientific Method

A plaintiff must make a prima facie showing, typically under Rule 104(a), that a methodology is “reliable.” The chosen methodology will be rejected if its application is so flawed that it does not constitute scientific knowledge. In this sense, the Daubert Court asserted that such knowledge must be grounded in the scientific method. As previously stated, scientific disciplines differ greatly on what methodologies should be applied. Scientists agree that at the heart of every methodology exists a sound theory, a hypothesis, and some means of testing that hypothesis. As previously mentioned, scientists still have much to learn about cancer's etiology. Despite knowledge about substances that are likely to cause cancer, scientists still have much to learn about cancer's etiology. See, e.g., Suzanne V. Cocca, Who's Monitoring the Quality of Mammograms? The Mammography Quality Standards Act of 1992 Could Finally Provide the Answer, 19 Am. J.L. & Med. 313, 313 (1993) (asserting that little is known about etiology and prevention of breast cancer); Charles Nesson, Agent Orange Meets the Blue Bus: Factfinding at the Frontier of Knowledge, 66 B.U.L. Rev. 521, 526 (1986) (stating that “the etiology of cancer is not yet known; scientists cannot explain at a cellular level the mechanism of causation”).

394. Rita Linggood et al., A Blueprint for Linking Academic Oncology and the Community, 23 J. Health Pol'y Pol'y & L. 973, 982 (1998) (listing some treatments as “combined modality therapy with chemotherapy plus radiation, radiation sensitizers, hyperthermia, brachy-therapy, physical dose-localization approaches” and others).


396. See id. Cancer symptoms will reflect the organ or system being attacked. See id.


399. This has been suggested by one author to be a “fidelity” requirement. See Kesan, supra note 199, at 2021.

400. CARL SAGAN, THE DEMON-HAUNTED WORLD: SCIENCE AS A CANDLE IN THE DARK 210-11 (1995). Carl Sagan, well-known for his popularization of the field of astronomy, combined some of the traditional elements of proper methodology with a few of his own to build a criteria for establishing sound theory he referred to as a “baloney-detection kit”: 
it is accepted scientific knowledge that toxic chemicals adversely impact the immune system.

One possible source of confusion for courts is deciding which methodology should be used for determining causation. A good defense attorney should argue that if the methodology does not fit into readily accepted criteria, then the methodology does not belong in the courtroom. Unfortunately, many of the “hard sci-

What’s in the kit? Tools for skeptical thinking.
What skeptical thinking boils down to is the means to construct, and to understand, a reasoned argument and – especially important – to recognize a fallacious or fraudulent argument. The question is not whether we like the conclusion that emerges out of a train of reasoning, but whether the conclusion follows from the premise or starting point and whether that premise is true.
Among the tools:
• Wherever possible there must be independent confirmation of the “facts.”
• Encourage substantive debate on the evidence by knowledgeable proponents of all points of view.
• Arguments from authority carry little weight – “authorities” have made mistakes in the past. They will do so again in the future . . .
• Spin more than one hypothesis . . . What survives, the hypothesis resists disproof in this Darwinian selection among “multiple working hypotheses,” has a much better chance of being the right answer than if you simply run with the first idea that caught your fancy.
• Try not to get overly attached to a hypothesis just because it’s yours . . .
• Quantify. If whatever it is you’re explaining has some measure, some numerical quantity attached to it, you'll be much better able to discriminate among competing hypotheses. What is vague and qualitative is open to many explanations . . .
• If there’s a chain of argument, every link in the chain must work (including the premise) – not just most of them.
• Occam’s Razor. This convenient rule-of-thumb urges us when faced with two hypotheses that explain the data equally well to choose the simpler.
• Always ask whether the hypothesis can be, at least in principle, falsified. Propositions that are untestable, unfalsifiable are not worth much . . .

Id. (emphasis original).

The Bradford-Hill criteria are as follows:
strength of association (epidemiological evidence); consistency of association (are the epidemiological studies consistent?); specificity of association (are one or more diseases implicated with exposure to agent?); biological gradient (does the exposure produce a dose-response?); biological plausibility; coherence (are the data consistent?); experiment (does the effect disappear in experimental animals when the suspected agent is removed?); and analogies (do analogies suggest causal inferences?).

Id. (citing no authority for criteria, but stating that it was “originally proposed in 1965 in an interpretive framework for analyzing whether an association existed between cigarette smoking and lung cancer”); see also National Bank of Commerce v. Associated Milk Producers, Inc., 22 F. Supp. 2d 942, 972 (E.D. Ark. 1998) (discussing similar process previously known as “Koch’s Postulates” then later known
ence'' methodologies are not readily adaptable to MCS. Those methodologies usually assume a linear relationship between exposure and illness. This means that the expert must isolate single independent variables, relate them to dependent variables, control for bias, and apply these principles to predict future results.\textsuperscript{402} Causation theories for MCS are more nonlinear. Therefore, they do not easily fit into this limited paradigm. Perhaps observational epidemiological studies would be useful to MCS claims since they rely less on statistical linear relationships and allow the expert to draw inferences from observation.\textsuperscript{403}

Because clinical ecologists come from a variety of backgrounds, it is difficult to determine the proper methodology to be used in presenting causation evidence. The easy question to answer is what methodology an expert should not utilize, at least presently. That methodology is the provocation neutralization method. Regardless of what some scientists and organizations think of the method, courts have not accepted it.\textsuperscript{404} Clinical ecologists themselves dispute its validity.\textsuperscript{405} While there may be some valid scientific merit to the procedure, enough controversy exists at this time to question its usefulness in the courts.

Many judges will not accept any methodology other than toxicology when it comes to admitting causation evidence for toxic tort cases. This practice is based on a misconception. Contrary to what some commentators claim, toxicology is not the only useful methodology for proving illness causation.\textsuperscript{406} Allergy and immunology as "Koch-Henle Postulates"); PHANTOM RISKS, supra note 85, at 7 (discussing "Henle-Koch-Evans (HKE) Postulates"); Alfred S. Evans, Causation and Disease: The Henle-Koch Postulates Revisited, 175 YALE J. OF BIOLOGY & MED. 49 (1976) (identifying ten principles of the Henle-Koch Postulates).

402. See Needleman, supra note 332, at 265.

403. See Bailey, supra note 73, at 133 (stating that observational studies "allow the researcher to draw stronger inferences about associations between risk factors and disease").

404. See, e.g., Treadwell v. Dow-United Tech., 970 F. Supp. 974, 982 (M.D. Ala. 1997) (noting that parties had "failed to make it clear" that provocation-neutralization method is scientifically valid and supported by sound methodology).

405. See, e.g., Don L. Jewitt et al., A Double Blind Study of Symptom Provocation to Determine Food Sensitivity, 323 N. ENG. J. MED. 429 (1990) (concluding that provocation-neutralization method "appears to lack scientific validity"); ASHFORD & MILLER, supra note 313, at 133 (arguing that even if they were able to validate provocation-neutralization method, "extension of this technique from inhalants and foods to chemicals such as formaldehyde, automobile exhaust, phenol, and tobacco smoke is a major leap of faith that needs much further investigation").

406. See Goldstein & Henifin, supra note 89, at 197 (noting that with toxic torts "[a] proposed expert should be able to demonstrate an understanding of the discipline of toxicology, including statistics, toxicological research methods, and disease processes").
methodologies are also helpful in understanding illness causation, and courts have admitted these methodologies.\footnote{407} 

Courts might find it useful instead to focus on a strictly clinical approach, thereby permitting the expert to apply a differential diagnosis.\footnote{408} Differential diagnosis is a "patient-specific process of elimination that medical practitioners use to identify the 'most likely' cause of a set of signs and symptoms from a list of probable causes."\footnote{409} The expert presenting this evidence must be a physician who has considered the history of the patient's symptoms, reviewed outside records, conducted a physical examination and laboratory testing, evaluated all the potential causes for the condition, and ultimately selected a diagnosis that best fits the findings.\footnote{410} While ruling out potential causes of an illness, an expert must include known possible causes.\footnote{411} Several courts have held that differential diagnosis passes Daubert muster.\footnote{412} The Second, Third, and Fourth Cir-
cuits have held that a clinical physician may express an opinion that is based on clinical medical methodology generally accepted in that discipline, without hard scientific support, and still remain consistent with Daubert. Furthermore, standards of general acceptance do not apply to differential diagnosis.

Finally, the methodologies employed by clinical ecologists are not as entirely unscientific as courts have been led to believe. Clinical ecologists consider exhaustive patient histories and not entirely self-reported histories. They take complete physical exams of their patients as well as comprehensive laboratory testing of blood samples. The SPECT and skin testing utilized by clinical ecologists, though unconventional, are examples of methodologies that are testable and repeatable, going beyond mere subjective speculation.

D. Experts and the Balancing of Extremes

One question that courts evaluating MCS have not confronted is whether a plaintiff has presented a suitable expert. Tech-

413. See Zuchowicz v. United States, 140 F.3d 381 (2d Cir. 1998); Benedi, 66 F.3d 1378; In re Paoli, 35 F.3d 717.
414. See In re Paoli R.R. Yard Litig., 35 F.3d 717, 758-59 (3d Cir. 1994). In In re Paoli, the court stated:
[Although differential diagnosis is a generally accepted technique, no particular combination of techniques chosen by a doctor to assess an individual patient is likely to have been generally accepted. But unlike a methodology used in conducting a scientific study, lack of general acceptance is not a sign of unreliability, it is merely a result of the fact that the medical community will rarely have considered the reliability of a particular process of differential diagnosis used in an individual case. Nor is it likely that the particular combination will have been published and subject to peer review, because a particular version of differential diagnosis will rarely be of general interest to the medical community. However, to the extent that a doctor utilizes standard diagnostic techniques in gathering this information, the more likely we are to find that the doctor's methodology is reliable.]

Id.
415. See Ashford & Miller, supra note 313, at 30 (characterizing diagnostic and therapeutic modalities used by Alfred Johnson and William Rea as "comprehensive environmental control with the use of an environmental unit" as "the gold standard").
416. See Radetsky, supra note 11, at 84.
417. See id. at 85.
419. Even Alfred Johnson and William J. Rea, the two experts most utilized in MCS cases and most despised by the scientific community, have been considered qualified to appear as experts. See, e.g., Bradley v. Brown, 852 F. Supp. 690, 697 (N.D. Ind. 1994) (noting that defendant did not even question the qualifications of Doctor Johnson and Doctor Rea). For suggestions on a line of questions to ask
niques employed by courts in order to determine the qualifications of the expert will depend on the type of expert the plaintiff seeks to use in her case.\textsuperscript{420} Regardless of the field, each expert should possess an advanced degree, research or practical experience specifically related to the field, certification to practice in the field by a specialized board, membership in a professional organization related to the field, and other indications of expertise, such as selection for national advisory panels relating to the subject.

Courts should be reminded that the balancing of extremes in admitting or denying scientific evidence into the courtroom was the primary objective behind the Supreme Court's decision in \textit{Daubert}. For those who argued against abandoning the \textit{Frye} "general acceptance" test, the \textit{Daubert} Court stated that traditional trial techniques of cross-examination, introduction of contrary evidence and proper jury instructions were more than adequate to filter out invalid scientific testimony.\textsuperscript{421} For those who feared that the screening role of the judge would stifle scientific ingenuity, the Court was less comforting. While recognizing the differences in the scientific and legal search for the truth, the \textit{Daubert} Court admitted that sometimes a court would deny a jury access to "authentic insights and innovations," but that is just how it goes sometimes in the name of fairness and justice.\textsuperscript{422} To continue on the present course and categorically deny MCS plaintiffs admission into the courtroom violates the balance sought by \textit{Daubert}.

\textbf{VII. JUDICIAL AND LAWYERLY OBLIGATIONS IN PROMOTING CONSTRUCTIVE USE OF SCIENCE IN THE COURTROOM}

Lawyers should never leave it solely up to scientific experts to educate the court on science. Education should begin with each plaintiff's lawyer during consultation. Lawyers should seek out partners who are knowledgeable about scientific processes or should an expert in order to establish qualifications, see Merilyn Brown, \textit{Establishing a Prima Facie Case Involving Multiple Chemical Sensitivity: A Threshold Approach}, 29 \textit{J. Marshall L. Rev.} 441, 449-453 (1996).

\textsuperscript{420} For example, there are specific questions a judge might ask a toxicology expert, such as: Does the expert have an advanced degree in toxicology, pharmacology, or a related field? Has the proposed expert been certified by the American Board of Toxicology, or does he or she belong to a professional organization? See Goldstein & Henifin, \textit{supra} note 89, at 198.

\textsuperscript{421} \textit{See Daubert}, 509 U.S. at 596.

\textsuperscript{422} \textit{See id.} at 596-97.
educate themselves on the issues.\textsuperscript{423} Lawyers as well as judges should become more familiar with the scientific issues regarding risk assessment.\textsuperscript{424} More importantly, judges who frequently deal with these issues should themselves become more acquainted with scientific issues and processes.\textsuperscript{425} The haphazard review of scientific evidence in MCS cases, coupled with the obvious bias of the scientific and medical community against the disease, has shown that perhaps judges should become amateur scientists, at least to the extent they can recognize independently what constitutes a scientific method.\textsuperscript{426}

That no federal judge has sanctioned a plaintiff's attorney for bringing a frivolous claim illustrates that courts are not opposed to admitting MCS causation evidence; they simply believe that the science does not support it at this time. While waiting for the science to "catch up" with the needs of MCS clients,\textsuperscript{427} plaintiffs' attorneys may simply have to do what they can for their clients. District courts have not admitted expert causation testimony under Daubert, but they have permitted experts to testify regarding the effects of

\begin{itemize}
  \item \textsuperscript{423} See generally James Podgers, \textit{Science Wizards}, ABA Journal, Feb. 1999, at 34 (featuring several attorneys who, in addition to law, specialize in fields ranging from intellectual property to engineering). Susan R. Poulter, a professor at the University of Utah College of Law in Salt Lake City, suggests that attorneys should attend ABA-sponsored courses on environmental science for lawyers and should read up on articles in scientific and technical journals. \textit{See id.} at 38. She adds that such self-education may be a good start to understanding science but should never replace a good expert. \textit{See id.} By understanding the methodologies of science, perhaps lawyers will do a better job of communicating scientific concepts of causation. \textit{See} Jack W. Snyder, \textit{supra} note 121, at 131 (remarking on changing nature in scientific causation, that is, being modified to allow for probability, while being poorly articulated in legal discussions on causation).
  \item \textsuperscript{424} \textit{See} Foster et al., \textit{supra} note 104, at 1509 (opining that "[m]uch of the scientific evidence that has been presented in toxic tort suits has questionable relevance to public health," mentioning high-dose animal studies as example).
  \item \textsuperscript{425} \textit{See} David L. Faigman, \textit{Mapping the Labyrinth of Scientific Evidence}, 46 Hastings L.J. 555, 556 (1995) (suggesting that judges should become "sophisticated consumers of science").
  \item \textsuperscript{426} Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 600-01 (1993) (Rehnquist, C.J., concurring). In his concurring opinion, Chief Justice Rehnquist stated that he did not think the gatekeeping function imposed on judges either the obligation or authority "to become amateur scientists in order to perform that role." \textit{See id.}
  \item \textsuperscript{427} \textit{See} Needleman, \textit{supra} note 332, at 266 ("It may be many years before scientific understanding catches up with the possibilities suggested by recent research" into environmentally related illnesses); \textit{but see} Moore v. Ashland Chem. Co., 151 F.3d 269, 276 (5th Cir. 1998) ("[T]he law cannot wait for future scientific investigation and research. We must resolve cases in our courts on the basis of scientific knowledge that is currently available"). For a criticism of the \textit{Moore} decision, \textit{see generally} Thomas M. Reavley & Daniel A. Petalas, \textit{A Plea for Return to Evidence Rule 702}, 77 Tex. L. Rev. 493, 493 (1998) (stating that \textit{Moore} decision is "an abuse of Rule 702 and a distortion of the Supreme Court's opinion in \textit{Daubert}").
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MCS cases involving Fair Housing Act discrimination.\textsuperscript{428} While some employers have made accommodations for MCS sufferers,\textsuperscript{429} plaintiffs have met with less success in using the ADA to compel employers to provide those accommodations.\textsuperscript{430}

While one should not use the courtroom as a forum to prove "junk science" theories,\textsuperscript{431} the courtroom should also not cater to the whims of the scientific intelligentsia. A misapplication of Daubert and a de facto resurrection of Frye merely permits the scientific community to dictate legal causation in the courtroom. Just because a scientific theory does not bear the AMA stamp of approval does not mean it cannot be "helpful" to the trier of fact.\textsuperscript{432} It is the responsibility of lawyers and judges, as ambassadors of the law, to preserve scientific theory and their professional reputations. The law is not served by defendants' attorneys who are openly hostile to toxic tort claimants\textsuperscript{433} any more than it is by plaintiffs' attorneys who bring questionable claims.\textsuperscript{434}

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  \item \textsuperscript{428} See generally Brown, supra note 419, at 444-49 (discussing elements of FHA claim and relevant case law).
  \item \textsuperscript{429} See, e.g., Internal Guidelines regarding Multiple Chemical Sensitivity/Environmental Illness (MCS/EI) for Disability Services at the University of Minnesota, <http:www.disserv.stu.umn.edu/TC/Admin/MCS-Guidelines.html> (last visited Feb. 17, 1999) (noting that many employers establish procedures and guidelines for addressing MCS illness); but see Eric Nelson & Mark Worth, Boeing to Ill Workers: "It's All In Your Head," WASH. FREE PRESS, Feb./Mar. 1994 (discussing pattern of harassment directed against employees who claimed to have MCS).
  \item \textsuperscript{431} See, e.g., Dick Thornburgh, Junk Science: The Lawyer's Ethical Responsibilities, 25 FORDHAM URBAN L.J. 449, 449 (1998). Thornburgh stated:
    Broadly speaking, I hold that "junk science" in the courtroom emanates from testimony by expert witnesses hired not for their scientific expertise, but for their willingness, for a price, to say whatever is needed to make the client's case. Put simply, I believe that it is unethical lawyers who are largely to blame for introducing, or, in settlement negotiations, threatening to introduce this so-called "expert" testimony.
    \textit{Id.}
  \item \textsuperscript{432} Judges must also be mindful, as cited numerous times in this article, that science is inherently subjective, easily manipulated, and hostile to dramatically new theories, regardless of their scientific validity. New theories, or paradigms, will always require widespread reevaluation of science, particularly when the old rules no longer fit new developments.
  \item \textsuperscript{433} See generally Berkowitz, supra note 318 (displaying not only disdain for "fad disease" of twentieth century, but obvious lack of compassion for so-called "victims" of MCS); cf. generally Parker, supra note 401 (offering suggestions on how to protect courtroom against illegitimate science).
  \item \textsuperscript{434} One of the "dark times" for the credibility of scientific testimony was the period in American Tort Jurisprudence when courts readily admitted plaintiffs' scientific evidence that "proved" a blunt-trauma injury later caused cancer in the same location. See, e.g., White v. Valley Land Co., 322 P. 707 (N.M. 1958) (holding
The application of *Joiner* adds one additional quandary for the toxic tort plaintiff. Very rarely has a circuit court held that a district court abused its discretion under *Joiner* for excluding causation evidence relating to a toxic tort or products liability claim. One court, however, held that a district court abused its discretion for admitting such evidence. With that in mind, the importance of a strong showing during a motion *in limine* becomes even more apparent. *Joiner* provides additional incentive to succeed at the district court level or not to succeed at all.

In closing, the conflict over the use of environmental experts in the courtroom is one that will not be resolved any time soon. Scientific and legal differences over standards of proof and the use of science in the courtroom lie at the heart of this controversy. The *Daubert* and *Joiner* cases have significantly answered many of the criticisms levied against the courtroom by scientists, reinforcing a vision of the environmental expert as one grounded in the methods of science. As a result, the road ahead for the plaintiff trying to admit novel scientific theories into the courtroom is long and hard. While *Daubert* stressed a more liberal standard than the traditional “general acceptance” test, courts have consistently applied the *Frye* rule, albeit under the guise of *Daubert*, against MCS claimants. If judges will not seek to conduct thorough reviews of the science, it is up to the plaintiff’s lawyer and experts to properly educate the court on matters of science.

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that plaintiff’s bone cancer was caused by injury to leg suffered while doing some heavy lifting); Emma v. A. D. Julliard & Co., 63 A.2d 786 (R.I. 1949) (deciding that woman’s breast cancer was caused by large can of orange juice hitting her in chest); Traders & General Ins. Co. v. Turner, 149 S.W.2d 593 (Tex. Civ. App. 1941) (concluding that two severe blows to man’s testicles caused his cancer); Winchester Milling Corp. v. Sencindiver, 138 S.E. 479 (Va. 1927) (finding that plaintiff’s cancer of rib was caused by five-foot fall from elevator); Baetz v. City of Melrose, 193 N.W. 691 (Minn. 1923) (determining that police officer’s abdominal cancer was caused by assault on his person); Canon Reliance Coal Co. v. Industrial Comm’n, 211 P. 868 (Colo. 1922) (finding that miner’s cancer was caused by blow to face by piece of coal).

435. The Third Circuit in 1997 reversed a district court for abusing its discretion by denying admission of expert testimony, but that court was not applying *Joiner* and the case seems to be an anomaly in light of the vast majority of decisions that affirm district court determinations of admissibility. See Kannankeril v. Terminix Int’l, Inc., 128 F.3d 802 (3d Cir. 1997).

436. See Robertson v. Norton Co., 148 F.3d 905, 907-08 (8th Cir. 1998) (holding that district court abused its discretion by allowing ceramics expert to testify that warnings on grinding wheel were inadequate).