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Scientific Evidence After the Death of Frye
Daubert and Its Implications for Toxic Tort, Pharmaceutical, and Product Liability Cases

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CHECK YOUR CRYSTAL BALL AT THE COURTHOUSE DOOR, PLEASE: EXPLORING THE PAST, UNDERSTANDING THE PRESENT, AND WORRYING ABOUT THE FUTURE OF SCIENTIFIC EVIDENCE

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*1800 Introduction

Since the earliest days of the use of expert witnesses,[1] judges (and more recently legislatures) have struggled to design the juridical intersection where law and science cross paths.[2] The effort has not met with notable success.[3] This situation could be changing, however. ***1801** Last term, in Daubert v. Merrell Dow Pharmaceuticals, Inc.,[4] the Supreme Court adopted a novel approach to the age-old problem of scientific evidence. The Court determined that the Federal Rules of Evidence require scientific evidence to be scientifically valid before it enters the courtroom. The Court has served notice that experts should trade in their crystal balls for electron microscopes. But the success of this move into the twentieth century largely depends on the law's proper understanding of the crossroads at which law and science meet. Becoming scientifically literate should prove to be a continuing challenge to the law.

The trial process seeks out expert testimony because the expert, by definition, possesses knowledge that the judge and jury lack. With the benefit of the expert's knowledge, the fact-finder's uncertainty about facts at issue in a case might be reduced and decisions reached more easily and accurately. But precisely because the expert's knowledge is beyond the ken of the judge and jury, they are in a weak position to evaluate whether what an expert is offering is genuine, valid, and helpful. Case law is replete with examples of shady science and shoddy scientists. This has made courts, at best, ambivalent about their relationship with science. This ambivalence has led to profound misunderstanding and great inconsistency in how the courts evaluate scientific opinion.

The essential difficulty, courts well realize, is that they confront a fundamental dilemma in this area. A court must not admit invalid evidence, for to do so violates the fundamental principle of evidence law that only relevant evidence may be admitted. Testimony that is not valid is not relevant. At the same time, a court may not exclude valid information, for to do so would violate the equally fundamental principle that all relevant evidence is admissible.[5] The challenge to the law, the one it has been struggling to meet, is to devise a test of admissibility for scientific evidence that will present a green light to genuine expert testimony and a red light to false or distorted offerings.

Of course, no filter will be free of error. Whatever rule is imposed, wherever the line is drawn, some good evidence will be excluded and some poor evidence will be admitted. Some tests will produce more of the first type of error; other tests will produce more ***1802** of the second type. A more refined goal, therefore, is to devise a test that strikes the proper balance between erroneous admission and erroneous exclusion.

Solving the fundamental dilemma does not eliminate the difficulties. A further problem is somehow to employ sufficient expertise or procedural assistance on behalf of the fact-finder so that good use can be made of valid scientific knowledge when it is received. Moreover, one may ask if the difficulties are growing or whether they are remaining proportional to the volume of cases. Although virtually everyone seems to assume that more knowledge, more fields of expertise, more client resources, and smarter lawyers must add up to more scien- tific evidence offerings, more complexity, and more problems, no one knows this for certain.[6]

This Article seeks to improve the choice and application of a legal test by illuminating the nature of scientific knowledge. We believe that the law can best manage and use scientific expertise by accommodating itself to the nature of the beast, an approach

that has rarely been pursued. Historically, courts have not taken the time to examine, in all its complexity, the scientific enterprise. This Article offers a glimpse into that enterprise and argues for a legal test of admissibility that fully accounts for its complexity.

We begin with a sketch of the history of the law of admissibility of scientific evidence, from the days before the much discussed and, we believe, misunderstood Frye test[7] to the adoption of the Federal Rules of Evidence (Part I). Then we discuss the issues confronted in Daubert,[8] the Supreme Court's only attempt to interpret the test of admissibility embodied in the Federal Rules (Part II). We then offer a conceptual analysis of the nature of both scientific knowledge and the legal process in order to see where the overlooked connections might be and to try to discern whether and how the intersection of law and science might be further improved, so that both the admission and exclusion of evidence will involve fewer errors (Part III).

*1803 I. The Admission of Scientific Evidence in American Law

A. The Test Before Frye : Acceptance in the Commercial Marketplace

Modern discussions of the test for admitting scientific evidence almost always begin with Frye v. United States--the "general acceptance" test--decided in 1923.[9] But science--good, bad, and pseudo--began long before 1923, as did the testimony of good, bad, and pseudoexperts. The courts before 1923 must have had some ideas about when such experts were to be permitted to testify. Moreover, like most law, the Frye test can be understood best in the light of what existed before it. For these reasons we begin our brief history well before Frye v. United States. From at least the middle of the nineteenth century until Frye--perhaps, indeed, until the adoption of the Federal Rules of Evidence in 1975--the general rule for the admissibility of expert testimony remained fairly stable.

The basic test consisted of the determination whether an expert was "qualified" before the expert's testimony could be admitted. If the witness was an expert, then his or her opinion testimony was "entitled" to be admitted as evidence (given, of course, its apparent relevance to the issues to be determined at trial).[10] A more sophisticated version of this pre- Frye test focused first on the nature of the subject matter at issue and whether that subject matter was beyond the range of knowledge of the average juror. If so, a qualified expert's opinion was considered to be helpful, if not essential, to the jury's determination of facts at issue.[11] As stated by one commentator in 1880:

The practice of the courts is to admit the testimony of a class of witnesses who are not supposed to have personal knowledge of any facts or circumstances bearing upon a pending case, but on the assumption that they are able from their special training and experience to apply scientific tests and present to the court and jury the import and value of such evidence as may appear, which laymen could not be expected to comprehend and properly estimate.[12]

***1804** Expertise was implied from the expert's success in an occupation or profession which embraced that knowledge. If a person could make a living selling his knowledge in the marketplace, then presumably expertise existed.[13] Although courts sometimes spoke of an expert's "greater study respecting certain subjects" or having "made the subject upon which he gives his opinion a matter of particular study,"[14] it seems clear that a modicum of prosperity in the practice of the occupation or profession possessing that knowledge almost always accompanied the expertise. In effect, the marketplace deter- mined whether valid knowledge existed by endowing it with commercial value. This is not a point that courts made explicitly, but it seems to be implicit in the courts' determinations of who was "qualified."[15]

On the one hand, this seems practical enough. What better crucible for testing expertise than the everyday world of life's activities, with stakes as great or greater than those at issue in trials, and decisions reflected in consumers' hard-earned dollars? Buyers with practical needs would have ample opportunity to assess and compare the knowledge that was for hire, and they would choose what was valid and useful and reject what was not. Knowledge that proved valuable ***1805** under such a test could hardly be without worth in a courtroom. What was good enough for the marketplace was good enough for the courtroom.

But though it might be practical and easily administered, the test of commercial value is a poor one. Its major weaknesses are perhaps more obvious today than they were a century or two ago. The market not only selects for validity, it selects also for entertainment, desire, wishful thinking, hope, sometimes even desperation. These are not without their value, but they are not good proxies for what courts are looking for in expert testimony. If the marketplace approves, as it does, of astrologers, sellers of phony cancer cures, and guides to new age vortexes, are those therefore good enough to provide guidance in a courtroom? The marketplace test is incapable of distinguishing astrophysics from astrology.[16]

A second problem is that some fields have little or no life in any commercial marketplace. Indeed, in the past century, some fields have come into being that have no function outside of their possible courtroom utility.[17] The courtroom is their marketplace.

Finally, the marketplace test entirely conflates the expert and the expertise.[18] Before the twentieth century, courts apparently never considered the question of whether a body of asserted knowledge existed, and could be validated, separate from the "qualified expert" who "possessed" it. The expert and the knowledge were treated as one. If an expert were "qualified," then an expertise existed.[19] But being a "qualified expert" presupposes that an expertise exists in which one may have become expert.

These last two problems are the ones that demanded of the Frye court at least a slightly new solution.

B. The Frye Corollary: Acceptance in the Intellectual Marketplace

The defendant in Frye v. United States, James Alphonso Frye, proffered the results from an early form of polygraph testing, the "systolic blood pressure deception test," as evidence in support of his plea of innocence to a charge of murder.

This was an unfamiliar problem for the court. How was the validity ***1806** of such asserted expertise to be assessed and a judgment made as to its admissibility as evidence? The technique was new. Perhaps it was valid, perhaps not. There were, as yet, no polygraphers and no developed market for their services. There might never be, if the only place that had any use for them was the courtroom, and if the only way to get into the courtroom was to gain prior marketplace acceptance.[20] An intelligent and fair-minded judge would realize that a novel scientific question presented itself, and that in this case, the conventional test offered no ready solution.[21] The asserted expertise offered in Frye demanded of the court a different test than the one that had served the law for so long.

Like most good common law judges, however, Judge Van Orsdel found a solution that departed as little as possible from prior law. The whole of the Frye opinion took up only two pages of the Federal Reporter. The critical words are these:

Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.[22]

In one sense, this is nothing more than the familiar market test relocated into a different marketplace. Where there is no commercial market, and may never be one, the evaluation of the asserted expertise can be performed in the "field's" marketplace by those who trade there. The intellectual or professional marketplace was simply a proxy for the commercial marketplace. The test is still a marketplace ***1807** test, the real evaluation still is conducted outside of the court or the law, and it still is incapable of distinguishing astrology from astro- physics.

Yet the Frye corollary did some new things. First, it separated the expertise from the expert, thereby creating legal accommodation to the notion that a body of asserted knowledge has an existence separate from any individual, no matter how brilliant, well educated, or experienced that person might be, and that the body of asserted knowledge had to be evaluated apart from any and every individual who might seek to bring it to court. Second, of course, the alternative marketplace--the

intellectual marketplace--allows more knowledge to be assessed, even if the knowledge is too new to be marketed commercially or if there is no hope of ever marketing it commercially.

Third--and most remarkable-- Frye replaced buyers with sellers as assessors of the validity of what was being offered.[23] The commercial marketplace test, even with its serious weaknesses, had the virtue of allowing buyers in the marketplace to be the authority on whether something was valuable and, "therefore," valid. Under the Frye variation, that control was passed to the people who produced the knowledge and offered it (and, in a sense, offered themselves) to the courts.[24]

***1808** But in the main, the Frye test was a minor adaptation of a major theme. The major theme was so nearly universal, so long established, so much a part of the courts' woodwork, that it did not even need a name. It simply was what the courts did. For most kinds of expertise in most circumstances, the larger doctrine and the special situation would lead to the same result. So unimportant was the Frye corollary that it went unnoticed for decades. No contemporary law review articles were written about it, commentators ignored it, and other courts did not cite it.[25] In fact, Frye only became "trendy" in the 1970s as an argument arose over the admissibility of scientific evidence, perhaps in anticipation of the new Federal Rules.[26]

Though of little importance at the time it was decided, and barely noticed for decades afterwards, the Frye test eventually became the icon for one of the dominant notions of the proper criterion for the admissibility of scientific evidence--general acceptance within its field. The larger theme of marketplace acceptance was swallowed by its corollary.

Frye may have become the icon for several reasons. Foremost, perhaps, it was easy to apply and required little scientific sophistication on the part of judges. Moreover, the controversial cases were from the subset of scientific evidence cases that Frye was designed to deal with: asserted new knowledge that lacked an established clientele. To established fields of endeavor--to old "knowledge"--the courts implicitly applied the old marketplace notions: if one were a card-carrying member of a recognized occupation or profession, one's proffered expert testimony was admitted and the validity of the underlying knowledge was assumed.[27] Finally, by the middle of the twentieth ***1809** century, the distinction between experts and expertise had grown more apparent, even to courts. Not only did new fields or new specializations arise, but old fields acquired and offered distinct new knowledge. New knowledge was sometimes put before courts in a form more abstracted and isolated from the people who presented it. Frye had been designed to fit just these kinds of situations.[28]

C. The Federal Rules

In 1975, the Federal Rules of Evidence offered another major test for the admissibility of expert testimony, and most states made the Federal Rules their own. Under the Federal Rules, in order to be admissible, scientific expert testimony, like any evidence, first had to be relevant.[29] In addition, it had to satisfy Rule 702:

If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise.[30]

By its terms, the Federal Rules test,[31] and the Advisory Committee's comment on it, give no hint of the Frye criterion;[32] instead, the rule appears to call for some sort of heightened relevancy test. The increased threshold is set by the condition that to be admissible, the judge must be persuaded that the testimony "will assist the trier of fact."

Nevertheless, a majority of federal circuits and most states imported the Frye concept into the Federal Rules test.[33] The situation ***1810** provided an interesting paradox. The rules were widely regarded as having been intended to open the courthouse door to scientific expert witnesses somewhat wider than Frye had.[34] Yet, a majority of jurisdictions held that general acceptance still was required.

The conventional view[35] that Frye sets a higher threshold for admissibility is an erroneous one. Whether Frye or the Federal Rules constitute the more rigorous test of admissibility depends on certain features of the proffered knowledge. For example,

Frye likely would be a trustworthy filter when the asserted knowledge is relatively new and the field or fields that provide the knowledge have traditions of vigorous research, testing, and debate. Scientific issues that might be in this category would include the toxicity of substances, the psychology of memory, and the identification of chemicals. This is not to say that the Federal Rules test would necessarily be less rigorous, but the responsibility would be on the court to evaluate the validity of the knowledge, and a considerable burden that is. It is no surprise that many judges would prefer to rely on the expert's field to do it for them.

On the other hand, the Frye test is much weaker than the Federal Rules test when the knowledge is provided by fields that lack traditions of vigorous research, testing, and debate. Scientific issues that might be in this category would include most psychological syndromes[36] and most of the forensic identification sciences.

If a field or fields external to courts are to decide the validity of various propositions, the success of the enterprise is going to depend on how well equipped those fields are to subject the issue to rigorous ***1811** examination and whether they have in fact subjected the question to rigorous examination. Even rigorous fields cannot test everything, and a lot of their knowledge slips into general acceptance without careful examination. This is especially likely to be true of knowledge that has been widely accepted for a considerable time.[37] Thus, the Frye test will only be effective sometimes. Courts that wish to rely on Frye should first satisfy themselves that the field to which they are deferring is capable of doing, and has in fact done, the necessary evaluation. Otherwise, such courts would be deceiving themselves.

The current popular view is that a growing and unprecedented mass of "junk science" is being admitted into evidence. This view has been most exuberantly and popularly expressed through numerous anecdotes by Peter Huber in his book, Galileo's Revenge.[38] Various commissions, committees, task forces, and educational programs for judges have been formed, rule changes proposed, and litigation undertaken aiming to modify or reinforce stronger rules to hold back the tides of junk. It was in this environment that the Supreme Court agreed at last to interpret the Federal Rules in Daubert.

II. The Issues Raised by Daubert v. Merrell Dow

The most recent step in the design and redesign of the courts' ***1812** law-science intersection occurred on June 28, 1993, when the United States Supreme Court announced its decision in Daubert v. Merrell Dow Pharmaceuticals, Inc.,[39] and for the first time interpreted the test of the Federal Rules for the admission of scientific expert testimony.

A. Frye 's Demise

The first question the Daubert Court addressed was whether the general acceptance test of Frye had survived the enactment of the Federal Rules. On this seemingly basic question the Rules and their history are silent. The Advisory Committee's Notes,[40] the congressional committee reports,[41] and the hearings on the Federal Rules[42] do not address the issue. Judge Weinstein has stated that the "silence of the rules and its drafters may arguably be regarded as tantamount to an abandonment of the general acceptance standard."[43] He further argues that the "elimination of the Frye test is consistent with the underlying policies of Article VII."[44]

Some commentators disagree with Judge Weinstein's view.[45] Although Professors Louisell, Mueller, and Graham criticize the Frye standard, they conclude that it survived enactment of the Rules. It was the only standard in common use and the Rules invite (if not require) some standard. Furthermore, it has been argued that imposition of the Frye test provides a method by which courts can assess the validity of novel scientific information and safeguards the jury against possibly specious expert testimony.[46]

When interpreting the Federal Rules, the Court has steadfastly refused to consult, at least explicitly, the common law prior to their ***1813** enactment. Instead, the Court employs the plain-meaning standard in its construction of the Rules. This standard "requires courts to enforce a statute's literal language unless the legislative history . . . intended another meaning."[47] The Daubert

Court read the "plain" language of Rule 702 and its statutory history to mean that the Frye test is not incorporated in the Rules. Neither the Frye test nor the concept of "general acceptance" appears in the text of Article VII. Although nearly twenty years had passed since the adoption of the Federal Rules of Evidence, and most circuit courts somehow had "found" Frye in those Rules, the Supreme Court in Daubert found that nothing in the language or history of the Federal Rules gives any suggestion that Frye or the general acceptance concept had become part of the Federal Rules, and since the Rules occupy the field, the Court held that the Frye test was superseded by them.[48] Justice Blackmun buried Frye succinctly: "The assertion that the Rules somehow assimilated Frye is unconvincing."[49]

B. The Standard for Admissibility Under the Federal Rules

Although the standard for admissibility of scientific evidence under Article VII of the Federal Rules is often described as a "relevancy test," such a limited characterization constitutes a mere redundancy. Rule 401 already requires, as a threshold matter, that all evidence be relevant to be admitted. Rule 702 focuses the relevancy requirement on the scientific merit of the evidence and expressly mandates that the scientific information "assist the trier of fact."[50] In gen- eral, under the Rules all relevant evidence is admitted and the opponent of the evidence bears the burden to provide a good reason to ***1814** exclude it.[51] In some instances, however, as with hearsay, more is needed to admit the evidence. "Multiple ways exist to interpret what more is needed under Article VII."[52]

1. The Expert's Qualifications

Rule 702 plainly requires that the proffered expert be "qualified." As discussed above, the qualifications test has long been a favorite of judges, and many continue to employ this test up to the present.[53] But Article VII plainly demands more.[54] Judges who merely check qualifications defer to whatever the witness thinks is valid science[55] or to the professional guilds to decide what scientific evidence to admit. Admissibility of scientific evidence thus becomes a guild issue resolved not by legal principle, nor on the basis of the accuracy of the information, but instead by the internal politics of professional organizations.[56] But failure to query more than qualifications at the courthouse door leads inevitably to the admission of invalid science.

The Court in Daubert paid no explicit attention to the possibility that an expert's qualifications alone might provide the additional assurance of validity called for by Rule 702, though the opinion refers several times to the credentials of the experts who testified at trial in ***1815** the case.[57] Contrary to the practices of the most liberal courts as well as to some state statutes,[58] the opinion gives every indication that such a view is not worth discussing because it is beyond the pale. Given the test the Court does find in Rule 702,[59] admissibility conditioned on a witness's credentials alone would have to be viewed as an absurdity.

2. General Acceptance

The Daubert Court banished the general acceptance test[60] from the Federal Rules with the same language it used to spurn Frye. Despite this repudiation, lower courts might turn to general acceptance in order to fulfill their responsibilities under the validity test of Daubert.[61] Unconditional reliance on the general acceptance test, however, is inadvisable, especially given the severe criticism it has received from courts and commentators.[62]

The vagueness of the general acceptance test renders it susceptible to manipulation and tends to obscure the relevant inquiry.[63] Since the test serves as a proxy for determining the validity[64] of the scientific method, technique, or opinion in question, its utility must be evaluated on the basis of its success in this capacity.

***1816** The general acceptance test suffers from several fundamental weaknesses. It often is criticized as overly conservative, for it imposes a protracted waiting period that valid scientific evidence and techniques must endure before gaining legal acceptance.[65] Another weak- ness of the general acceptance test concerns the problem of ascertaining when a scientific

proposition has been generally accepted.[66] There are no standards defining the "pertinent field" to be consulted and nothing in the test to establish what proportion of experts constitutes "general acceptance."[67]

Courts have had considerable difficulty defining the "pertinent field" in which to assess the scientific information because it often extends into more than one academic or professional discipline.[68] Compounding this problem is that each field may contain one or more subspecialties.[69] Although general acceptance often is thought to be the most conservative test of admissibility, in practice it often results in the most liberal standards for admission.[70] The more narrowly a court defines the pertinent field, the more agreement it is likely to find.[71] Even tea leaf reading is generally accepted if the pertinent field consists of practicing tea leaf readers. The general acceptance test thus degenerates into a process of counting noses.[72] Depending on how the court defines the pertinent field, the count ends up being overinclusive or underinclusive. Because the pertinent field can be so readily manipulated, the test by itself provides little bulwark against shoddy science.

***1817 3. Preliminary Judicial Evaluation of Proffered Scientific Evidence Under Rule 104(a)**

After rejecting a qualifications test and the general acceptance standard, the Daubert Court went on to spell out the standard by which federal courts should evaluate scientific evidence under Rule 702. The Court selected Rule 104(a) to describe the judge's responsibility as a gatekeeper to review the proffered science.[73] Under Rule 104(a) the judge must be convinced, by a preponderance of the evidence, that the scientific evidence is valid.[74] In adopting this standard, the Court joined the chorus of voices calling for science to be judged on the basis of scientific principles.[75]

The selection of Rule 104(a) might, at first, not seem a radical departure from usual practice under the Rules. Rule 104(a) ordinarily applies when a fact is a prerequisite to the application of a Rule. Under the hearsay exception for dying declarations, for example, the judge must independently find by a preponderance of the evidence that the statement was made under a belief of impending death. Therefore, under the Daubert Court's view of Rule 702, scientific validity is a preliminary fact upon which the proponent of the evidence bears the burden of proof before the judge.[76]

Rule 104(a), however, was not the only standard the Court might have adopted to set the threshold for admissibility. Subsection (b) of Rule 104 establishes a somewhat more liberal standard for reviewing facts upon which the relevance of testimony depends. Rule 104(b) limits the judge's threshold examination to finding that a reasonable trier of fact could find the fact to be true.[77] McCormick's excellent discussion of the distinctions in application between Rules 104(a) and (b) points out that under 104(a), "the trial judge decides with finality those preliminary questions of fact upon which depends the admissibility of an item of evidence that is objected to under an exclusionary rule of evidence."[78] Rule 104(b), in contrast, applies in those situations "in which the relevancy, i.e. probative value, of a fact offeredin ***1818** evidence depends on the existence of another, and preliminary, fact."[79]

The Court's choice of Rule 104(a) over 104(b) is extremely significant in several respects. Foremost, it reflects the Court's recognition that jurors are not presumed to be capable of doing the mental gymnastics necessary to assess both admissibility and weight; jurors who determine that evidence is not admissible are thought, nonetheless, to put some weight on what they have heard.[80] The more strin- gent 104(a) standard ordinarily applies to the application of exclusionary rules under circumstances when the jury cannot be expected to make both the preliminary and ultimate findings of fact. Rule 702 presents such an instance. Jurors obligated to conduct the initial validity assessment are not able to resist the dubious message of the invalid science.[81] Moreover, many have voiced the concern that jurors will be overwhelmed by the aura of infallibility of scientific evidence,[82] and thus jurors are not expected to conduct such a preliminary assessment very well. For these reasons, it is the judge who should guard the courthouse door to ensure that only valid science is admitted.[83]

The Court's selection of 104(a) also suggests an answer to a debate that very quickly emerged after Daubert was announced. Court ***1819** observers have sharply disagreed whether Daubert stands for a liberal standard of admissibility or a conservative one.[84] The opinion, it seems, has language enough to satisfy everyone. On balance, however, it appears that Daubert 's validity test is some distance from the most liberal rule the Court could have adopted. Rule 104(b) would have provided a much more generous reception to expert witnesses.

To be sure, a more conservative rule could be envisioned. An entire section of Daubert is devoted to recognizing the generally liberal thrust of the Rules. Of course, the Daubert Court's statements regarding the general competency of the jury are like statements favoring motherhood and apple pie; they are not controversial and add little to our understanding of the outcome. In the end, the Court situated Rule 702 along with Article VIII of the Rules (Hearsay), and thus selected the most conservative standard that the Rules contemplate. Rule 104(a) provides the strongest judicial check on the vagaries of scientific practice and the best safeguard against jurors being overwhelmed by those practices.

The focus of the inquiry under Rule 104(a) is to be on the core of the knowledge--the underlying assumptions, methods, data, and inferences of the proffered expert testimony--and not on the periphery where so much of the evaluation of expert witnesses has taken place over many years (e.g., credentials or the views of other experts in the same field):

The subject of an expert's testimony must be "scientific . . . knowledge." The adjective "scientific" implies a grounding in the methods and procedures of science. Similarly, the word "knowledge" connotes more than subjective belief or unsupported speculation. The term "applies to any body of known facts or to any body of ideas inferred from such facts or accepted as truths on good grounds." Of course, it would be unreasonable to conclude that the subject of scientific testimony must be "known" to a certainty; arguably, there are no certainties in science. But, in order to qualify as "scientific knowledge," an inference or assertion must be derived by the scientific method. Proposed testimony must be ***1820** supported by appropriate validation . . . .[85] Rule 702 thus is seen to bring about a fundamental, if belated, departure from some of the most familiar ways that courts have evaluated and admitted asserted scientific expert testimony over a great many years.[86] In a sense, the Supreme Court has shifted control of the key admissibility judgment from the "sellers" to an agent (the trial judge) acting on behalf of the specific group of "buyers" who seek the knowledge for the law's purposes.

4. Appellate Review of Asserted Scientific Evidence

If it is the responsibility of trial courts to make preliminary determinations concerning the validity of asserted science under Rule 104(a), what part is to be played by appellate courts? The Daubert Court did not specify the standard appellate courts should use when reviewing a trial court's conclusions about the validity of proffered science. Is a determination about the validity of scientific evidence within a trial court's discretion, or is the trial court bound by an appellate court's findings on the subject?[87]

The Ninth Circuit in Daubert[88] held that the question of the validity of scientific information

is reviewed de novo by an appellate court, for "the answer to the question about the reliability of a scientific technique or process does not vary according to the circumstances of each case. It is therefore inappropriate to view this threshold question of reliability as a matter within each trial judge's individual discretion."[89]

Although trial courts are invested with wide discretion when applying the Rules,[90] significant reasons support limiting their discretion regarding validity assessments. First, a substantial component of the "relevance" determination under Rule 702 is legal in character.[91] ***1821** Moreover, the factual component of the determination is not the traditional case-specific adjudicative fact to which an appellate court defers to the trial court's findings.[92] Trial courts are no better situated to assess the validity of scientific methods.[93] Such determinations do not, for instance, depend on assessing the credibility of witnesses or knowledge of local conditions. Indeed, judicial assessment of validity might be better conducted through written briefs rather than oral testimony.

Scientific methods ordinarily operate at two fact levels of the trial process. Scientific information both transcends individual disputes and is specific to particular disputes.[94] The de novo standard should apply to scientific information that transcends a particular dispute.[95] Such facts resemble legislative facts much more than adjudicative facts, and appellate courts generally review legislative facts on a de novo standard.[96]

An illustrative example of the law-science connection is research on the effects of cigarette smoking on health used in litigation against cigarette producers. A substantial body of research indicates that cigarette smoking significantly increases a person's risk for lung cancer. This research transcends particular disputes and ought to be subjected to de novo review; there is no reason to allow different courts to decide this matter differently.[97]

In addition, the plaintiff probably will offer an expert to testify ***1822** that the plaintiff 's particular lung cancer was caused by cigarette smoking.[98] Such testimony has two components.[99] First, it is premised upon the transcendent scientific conclusion that experts in general can accurately draw such inferences. This scientific premise should also be subject to a de novo standard of review. Second, it is premised upon the conclusion that the particular witness is competent to make such a judgment; this assessment is case specific and should be overturned only if the trial judge abused his or her discretion in admitting it.[100]

Application of less than a de novo standard of review to scientific information that transcends individual cases invariably leads to inconsistent treatment of similarly situated claims. The validity of scientific knowledge does not change from court to court; assessments of that knowledge also should not change from court to court.

It would follow, then, that if scientific knowledge that transcends particular disputes has been reviewed under Rule 702 as a matter of law, trial courts must follow the precedent established on the issue. If it is a matter of first impression, of course, the trial court must exercise its independent legal judgment.

III. Fitting the Legal Process to the Scientific Process

The principal alternatives for evaluating the admissibility of scientific expert testimony may not so much be effective and workable solutions as they are statements of the dilemma that courts face. The general acceptance test provides judges the option of delegating to others the making of decisions that most judges feel ill-equipped to make. The Daubert test places the responsibility squarely on judges to determine whether the evidence they are admitting into trials is ***1823** valid.[101] The former seems to surrender fundamental judicial responsibilities. The latter, if pursued with any rigor, seems to place on judges a burden that few human beings can be expected to carry.

The principal failing in the legal system's approach to scientific evidence has been courts' unwillingness to grapple with the basics of the scientific method. Daubert is a good first step in the right direction in that it calls upon federal judges to apply the standards of science to evaluate evidence. This is no easy assignment and it remains to be seen how many states will follow the federal lead. Judges will need substantial assistance and should expect to invest substantial time if they are to successfully complete the task. At first, especially, judges applying the validity test are likely to look to proxies for validity in making the necessary preliminary judgments. Factors such as general acceptance, therefore, are likely to creep back into daily practice. Indeed, in some instances, proxies such as general acceptance, publication in a peer-reviewed journal, reputation of the scientist-expert, and so on will be entirely appropriate to rely upon; scientists themselves would do so. But not always. Ultimately, judges must come to appreciate the complexity of scientific inquiry. They must come to understand those questions scientists can answer and those they cannot. This section explores the different sorts of questions scientists address and suggests ways in which judges might come to distinguish good science from bad science.

A. The Intersection of Law and Science

Several legal scholars have attempted to bring greater coherence to scientific evidence by describing the structure of scientific investigations and then tailoring evidence law to that structure. The two most notable offerings are Professor Imwinkelried's description of the syllogistic structure of science[102] and Professors Monahan and Walker's description of the scientific structure inherent in the empirical questions asked by legal decision makers.[103] A brief detour to consider ***1824** these ideas should be fruitful.

Professor Imwinkelried describes two levels of science that enter the courtroom and must be assessed by legal decision makers.

Imwinkelried distinguishes between the general research and theories of science (the major premise), and the case-specific information that informs the expert's particular opinion (the minor premise).[104] Although written before Daubert, Imwinkelried's approach to the admissibility determination for these two premises is instructive. He argues that courts should scrutinize the minor premise under Rule 703, but should defer to the expert's better judgment regarding the accuracy of the major premise pursuant to Rule 702.[105] Imwinkelried explains that the reason for this deference is that the greater complexity of the major premise compels deference to the expert's knowledge.[106]

Professors Monahan and Walker approach the problem of scientific evidence with a sophisticated model that incorporates the nature of the legal question asked with the nature of the scientific answer.[107] The first level of convergence between science and law, social authority, does not implicate the rules of evidence. It refers to research that is relevant to the determination of legislative facts and the resulting formulation of legal rules.[108] At a second level of the Monahan-Walker model, what they term social facts, scientific research might be relevant to adjudicative facts.[109] According to the model, the research methods used in the investigation would be reviewable by the judge and any results obtained from a valid methodology would be presented to the jury through expert testimony. Finally, the third level pertains to cases where scientific research might have relevance as a combination of social authority and social fact; they label this aspect of the model social frameworks.[110] In a social framework, some issue in the particular dispute is claimed to be an instance of a ***1825** general scientific finding or theory.[111] The judge, under the model, would consider and instruct the jury on the verity of the general claim, but the jury would also hear expert testimony on the theory's applicability to the case before it.

Neither the Imwinkelried nor the Monahan-Walker conception of the scientific enterprise provides a straightforward solution to the complexities of scientific evidence under Daubert. First, Imwinkelried's description of the syllogistic structure of science, though generally accurate, oversimplifies the assessment process that the law must bring to scientific research. Inherent in the social framework and social fact components of the Monahan-Walker model are at least three levels of the scientific enterprise--not two--that are of relevance to legal decision makers. The Monahan-Walker model, while truly an innovative vision, gives little guidance under the Daubert standard. Foremost, judges are unlikely to assume the full range of responsibilities that are created by the social framework and social fact components of the model. Moreover, the model offers no guidance regarding the threshold standard that divides responsibility between the judge and jury for evaluating scientific evidence.

Nonetheless, whatever the shortcomings or limitations of the Imwinkelried and Monahan-Walker approaches, their basic insights are essential to any viable strategy for evaluating scientific evidence. The structure of the next section's analysis rests on much of this path-breaking work.

B. The Structure of Science

Three levels of scientific thinking must be considered in assessing the validity of any scientific expert opinion.[112] First, at the top of the abstraction hierarchy, is "the theory or principle that provides authority for the conclusions that are drawn from the data."[113] This "theory or principle" is the most abstract of the concepts in the hierarchy of validation of scientific evidence, and is, as a consequence, often the most difficult level for the nonscientist to understand. It is ***1826** likely that this level was the one on which the court in Frye was dealing, and for this reason, deferred to "general acceptance" in establishing the standard.[114] One example of "theories or principles" at this level is the notion that the physical characteristics of all living things are determined by DNA and that each person's DNA is unique and uniquely defines that individual.[115] Another example is the belief that a person's truthfulness is reflected in his breathing rate, temperature, and blood pressure.[116]

That these theories be well established is vital to the validity of the ultimate data presented in a particular court. Because this level is the most abstract and difficult, however, its admissibility has often been left to the "experts" or ignored altogether.

The second level is "the general technique or procedure that produces the data."[117] This level is often confused with the more abstract "theory" level. Indeed, the legal test intended for the "theory" level of our hierarchy has most often been used to determine the admissibility of the "general technique" instead. Examples of general techniques or procedures include the laboratory procedure developed to extract and study DNA and the actual polygraph technique of measuring a person's blood

pressure, temperature, and so on while he is being questioned.

It is essential to differentiate this middle level of science from the other two. It is possible, for instance, that an underlying theory is based on sound scientific testing, but that the technique used to produce the data is not reliable or produces invalid results. For instance, even though the theory that DNA is unique to an individual may be scientifically valid, the technique presented for admission into court may not accurately or reproducibly separate DNA into "bands" by which it can be compared from one individual to another. Conversely, the technique used may be reliable, but because the underlying theory is invalid, results from the technique would also be invalid. This is illustrated by the handwriting identification test sponsored by the Forensic Sciences Foundation.[118] In a proficiency test, all of the "experts" agreed on an identification, indicating that the technique they were using resulted in reproducible and, therefore, reliable results. However, all of them were incorrect, possibly because the underlying ***1827** theory, that a person's handwriting is unique and cannot be disguised, is not scientifically valid.

Further, the general technique or procedure must be distinguished from the procedure that was actually performed to produce the data that are to be introduced into evidence. A general technique can be "proven"--that is, many laboratories may have used it, demonstrating that reproducible results are possible. This is not to say, however, that the laboratory or the technician that produced the data in the specific case at bar is reliable. Thus, the second level, although less abstract than the first, is still more abstract than the third.

The third and most concrete level is "the specific practices used to obtain the data."[119] As noted above, this level does not involve whether a technique, in the abstract, can produce reliable and valid data, but whether it produced reliable and valid data in this case. Thus, even though the scientific theory underlying a technique may be valid, and the technique can and does produce reliable and valid results when used by experienced and knowledgeable technicians, the actual data produced in the specific case may be unreliable. This might happen in a variety of ways. The "technician" might have been poorly trained or not trained at all. An equipment failure, or failure of the technician to properly calibrate the instrument, could result in invalid results. In addition, even if the equipment works perfectly, the technician or scientist in a specific case may misinterpret the results. Even where reliable and valid results are possible and previously have been relied on, the circumstances surrounding production of those data in the particular case at bar may render those data invalid and thus inadmissible.

The first two levels have received considerable, though somewhat confused, attention in cases and commentaries.[120] The third has received virtually none. The first two levels transcend particular cases, are analogous to law, and seem to lend themselves to appellate or legislative control; the third more closely resembles case-specific findings of fact.[121] All three levels must be found valid in order for the testimony to be valid. If any level is not valid, the end product likely will lack validity. The standard for admissibility should account for all three levels in order that the testimony be relevant, authentic, and helpful.

Look again at the language of the Frye test:

While courts will go a long way in admitting expert testimony ***1828** deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.[122] The language of this passage suggests that the court was referring to the first of the three levels, the basic scientific principles on which the technique was based. However, most cases and commentaries refer to the Frye test as applying to a scientific technique.[123] But application is really the second, more concrete, level. The validity of the scientific theory often is assumed or lumped together with the general technique or process; or, alternatively, the second level is simply assumed to be met when an expert offers an opinion at the case-specific level.

Frequently, science answers only a part of the pertinent question well enough to assist the trier of fact. Part of the court's preliminary responsibility in deciding admissibility, therefore, is to determine the specific question that the data answer. The availability of data at one level of the pertinent legal category should not operate as a blank check that permits the expert to offer any opinion she is paid to conclude. However, once the court has divided the scientific question into its component parts--general theory, general application, and specific application--the tools it uses to assess these parts might very well differ.

1. The Underlying Theory

The first question, then, is how a court is to assess the underlying scientific theory. Is this the level of evaluation where a general acceptance test could be most effectively and workably applied? A major problem overlooked in the courts' application of Frye has been that they have confused the first and second levels described above.[124] As noted, the language of the Frye opinion suggests that the court intended the test to apply to the underlying scientific theory, not to a technique applying that theory. A general acceptance test might be useful, but only to evaluate the scientific theory that underlies the technique that underlies the testimony.[125]

***1829** Determining the validity of a scientific theory, as previously mentioned, is perhaps the most difficult task for a court. Daubert requires the judge to independently evaluate the validity of proffered scientific evidence. The first step should be, therefore, to determine the validity of the scientific theory--the first level.

The Daubert Court mentioned several factors to assess the validity of scientific evidence, including the possible use of a general acceptance test.[126] It is our contention that the general acceptance test is most appropriately used at this most abstract level; other factors mentioned by the Court could be helpful as well.

Evaluation of a theory's validity should be informed by the largest and widest array of empirical and theoretical literature, and from a relatively broad array of disciplines.[127] A sincere attempt to evaluate a serious scientific theory, if not a career, is at least the work of a graduate program. The "relevant scientific community" which must accept the theory should be a large and diverse group.[128] In order to insure that the scientific data admitted by the court have sufficient corroboration to be considered valid, great care should be taken that this community not be comprised only of persons who have applied the theory and developed the technology, or who serve primarily as laboratory technicians and expert witnesses.

A general acceptance test that requires a truly relevant scientific community will render evidence regarding some of the most common forensic techniques suspect. Many of these "forensic sciences," such as handwriting analysis, toolmarks, and even the study of the scratches left from rifling on bullets, are generally accepted only by workers whose livelihoods and careers depend on the technique. In order to be generally accepted, in our view, the theory underlying such a technique must be accepted by those who have less of a stake in the outcome. One way to accomplish this would be to subject the theory to rigorous testing by those outside the immediate field.

Another indication, although not an entirely reliable one, is whether the theory has been subjected to peer review and publication. As pointed out by the Daubert Court, publication does not necessarily correspond with reliability. However, although the presence of peer review does not guarantee valid science, the absence of peer review is a definite warning sign to the user. Of course, theories that have little ***1830** support can in turn provide little support. Well-refuted theories can provide no support.

Not all expert testimony, however, is based on a technique, a technology, or a belief that is based on a well-developed and well-tested scientific theory. While the toxic relationship between some substances and human illness is well understood in terms of their chemistry and biology,[129] others are far less so.[130] Some techniques are frankly "empirical."[131] Others seem to stand on the flimsiest of theoretical scaffolding.[132]

The lack of theory need not be disqualifying, but in the eyes of most scientists, less understanding of the nature of a phenomenon translates to less confidence in the phenomenon. Courts should exercise similar caution. The lack of theory should increase doubt. Especially strong evidence of the validity of the technique or the empirical relationships would be needed to make up for the lack of theoretical supports.

2. General Application of the Theory

The second level of evaluation is the general technique, procedure, relationship, or other application that follows from the

theoretical knowledge. As discussed above, the Frye test has traditionally, and incorrectly, been used to assess the validity of this level of inquiry. It is our contention that elements from the Federal Rules of Evidence, as well as factors discussed in Daubert, give a judge the proper tools to evaluate a technique at this level.

Even if the theory that underlies a technique is found to be valid, any given application from that theory may not be. Moreover, it is likely that fewer people from a smaller variety of fields will have scrutinized the technique. Here the court can have even less trust in general acceptance, and a greater need to scrutinize the technique. At the ***1831** same time, the task is made more manageable because less information exists for the court to review than would exist if it were trying to evaluate a well and widely established theory.

In what is likely to become controversial language, the Daubert Court asserted that the test of admissibility queried the methodology and reasoning of the research, not its conclusions.[133] The meaning of this statement is unclear. Scientists do not distinguish so precisely between methodology and conclusion; the latter is an integral function of the former. Conclusions are accepted because a sound methodology was employed. They are not matters of "truth" or "falsity." As the Court itself pointed out, science is a continual process of testing and attempting to falsify hypotheses.[134] Scientists accept a hypothesis (i.e., find it corroborated), because their attempts to falsify it have failed. The conclusion, acceptance, or rejection of the hypothesis of interest is intertwined, inextricably, with the methods and reasoning.

Alternatively, the Court might have meant that the "conclusion" to be left to the trier of fact refers to the application of the theory in the particular case. Yet, as already noted, there are two levels of application that must be distinguished. For example, in Daubert itself, the principal issue involved the relationship between Bendectin and birth defects. This issue, as we have seen, divides into three levels of scientific inquiry. The first level concerns the general theoretical connection between Bendectin and birth defects. The second, more concrete issue, concerns whether, as a general matter, doctors can identify when specific birth defects are traceable to Bendectin. And, finally, the most concrete issue concerns the correctness of the diagnosis that the plaintiffs' birth defects were caused by the drug.

Arguably, both the general application and specific application levels might be swept into the Court's "conclusion" category. This would be unfortunate. The helpfulness of a particular expert's testimony depends not merely on a valid general theory, but on research demonstrating that it is possible to apply this theory to concrete cases. An example from the social sciences illustrates why this is so.

Social scientists have invested substantial research time studying eyewitness identification and have uncovered a host of factors that interfere with accurate eyewitness identifications. Despite this considerable work, researchers are not able, and do not pretend to be able, to determine whether a particular witness's identification was accurate. ***1832** Such an opinion is beyond their expertise. Sometimes, scientists cannot answer all of the scientific questions the law poses.

Inevitably, when the law asks scientific questions, there is no shortage of "experts" available to offer an answer. Indeed, in a wide range of cases, "scientific" opinions are offered into evidence with little or no empirical research data behind them. In many areas of psychology, psychiatry, medicine, and the sundry forensic sciences, experts offer opinions about case-specific facts that are based on little more than a general study of the phenomenon, an interview with the subject (maybe), and an educated guess. These "clinical judgments" do not qualify as science in the absence of empirical evidence which generally indicates the practitioners have the ability to make the particular sorts of judgments in which they claim an expertise. In most cases, these judgments could be tested for their accuracy, but the requisite data simply are not yet available.

Given the Daubert Court's insistence that trial judges examine the data upon which an expert bases an opinion, experts offering clinical judgments have two approaches available to them. First, they could collect data that would validate their ability to draw the particular conclusion they seek to offer. Alternatively, they could redescribe their enterprise as nonscientific and claim a right to testify as "specialists," because Daubert speaks to only part of Rule 702--experts offering scientific knowledge. Rule 702 also permits expert opinion on "technical or other specialized knowledge."

Courts should not permit this form of revisionism. The issue that courts must resolve in determining whether an expert falls

within Daubert is whether the "expert" knowledge upon which the witness is relying is testable. Thus, for instance, expert opinion about the market value of a painting is testable, whereas expert opinion about the artistic value of a painting is not. The former expert must show that an empirical basis supports her opinion. The latter might have to demonstrate only a particular educational background.

Judges' failure to query the empirical basis for clinical judgments would eviscerate the Daubert rule. All pseudoscience can be redescribed as specialized knowledge; expert opinion based on the research of Steven King will be as welcome as that based on the research of Stephen Hawking. Daubert establishes a principled standard by which to measure the probative value of scientific opinion. The challenge now before the courts is to apply that standard to produce the most reliable result.

***1833 3. Case-Specific Application**

The Daubert Court's statement that the methodology and reasoning is the correct focus, not "the conclusions that they generate," appears to be directed at the case-specific application of science.[135] Under Daubert, therefore, a trial court must assess the validity of the general theory as well as the capability to draw specific conclusions. If the data support these first two levels of science, the validity of the specific conclusion drawn in the particular case will be for the trier of fact to determine. This does not mean, however, that judges have no role in supervising experts' case-specific conclusions.[136] Although Rule 104(a) does not apply to these determinations, other evidentiary rules continue to play an important role in regulating the admission of such evidence, most notably, Rule 403.

The evaluation at the case-specific level should be guided, of course, by the relevancy rules, with special attention paid to Rule 403. Traditionally, courts have commended scientific data to the jury with the holding that any question about validity of the specific data "goes to weight, not admissibility."[137] While seemingly accurate, this total abdication is unacceptable under basic conceptions of relevance. If data are invalid, they will not assist the trier of fact, although data presented by a scientist with impressive-sounding credentials have the potential to be believed simply because of those credentials. We therefore suggest that this level of inquiry lends itself to analysis under Rule 403.

Rule 403 involves balancing the probative value of the evidence against the danger of unfair prejudice, of confusion of the issues, or of misleading the jury. These factors are exactly those that present themselves when an apparently eminent scientist presents faulty data. The jury, generally unsophisticated in science, is in danger of being swayed by the credentials or impressiveness of the witness rather than the true worth of the data. The judge must step in to ensure that the specific data are sufficiently valid that their probative value is not substantially outweighed by unfair prejudice.

The specific inquiry undertaken by the judge on this level of analysis can include a wide range of factors. Assuming, of course, that the first two levels of analysis indicate that a tested scientific theory exists, and that the general technique utilized is considered potentially reliable, ***1834** the specifics of the actual data produced for admission in court must be examined. We suggest that the factors to be considered in this examination include the following:

(1) The credentials and experience of the technician performing the actual procedure used to produce the data. An inexperienced or poorly-trained technician should alert the court to the possibility of flaws in the data. In addition, the court should look to the technician's understanding of the underlying process. Any technician who does not understand how or why the process works produces inherently suspect data.

(2) The specifics of data collection for the data set presented. An examination of lab notebooks or other evidence should show that equipment was properly maintained, properly calibrated, and properly used. Factors that might affect the result (e.g., temperature or concentration of the solution) should be consistent, and any variation in one of these factors should indicate a possible problem.

(3) The general reputation and track record of the laboratory that produced the data. Ideally, labs should submit themselves to periodic "blind" testing by impartial agencies. If the lab in question has not been so tested, it may be required to receive "blind"

samples for analysis to demonstrate the lab's ability to produce reliable data. Any finding that a lab has a significant error rate should render the lab's data suspect.

(4) The specifics of collection of any samples that were used to produce the data. Again, lab or field notebooks can be examined to determine whether any contamination of the samples occurred, or whether the chain of custody subsequently allowed tampering or contamination to occur.

(5) The extent to which the technique relies on the interpretation of an "expert." Interpretive data should be highly suspect if the expert has a vested interest in the outcome, or has been shown to have made mistakes in other cases. This is another area in which "blind" submission of samples is very useful in determining whether a given expert can produce reliable and valid results.

Any indication that the specific data may be unreliable should weigh against admissibility under a 403 analysis.

Conclusion

The analysis in Daubert, together with the suggested analysis here, will render the consideration of scientific data rather daunting to many judges. It is, however, vitally important that a rigorous and thorough analysis of scientific data be undertaken before those data are admitted into court. This task is made difficult because of the ***1835** general lack of scientific literacy among Americans, including lawyers and judges.

When a case becomes especially difficult or complex, the court may need to employ an independent expert or special master to evaluate the science on any or all of the three levels indicated in this Article. It should be emphasized that it is not always necessary for the judge to become an expert in the particular field; it is only necessary that the judge be convinced that the data presented are sufficiently valid to pass muster under the Federal Rules of Evidence.

Footnotes

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[1] Throughout this Article, the phrase "expert witness" should be understood to refer to expert witnesses offering testimony purportedly based on scientific knowledge, rather than the many other sorts of expert witnesses that are possible. At the same time, it is important to note that our discussion applies to all expert testimony premised upon purportedly scientific methods. For example, California courts draw a distinction between expert testimony and scientific evidence, see, e.g., People v. McDonald, 690 P.2d 709, 723-24 (Cal. 1984), as well as between social science and natural science, see, e.g., People v. Stoll, 783 P.2d 698, 712-13 (Cal. 1989). Such distinctions are unsound as a matter of logic and practice. Moreover, neither the Frye test, see Frye v. United States, 293 F. 1013 (D.C. Cir. 1923), as interpreted by most federal courts, nor the plain language of Article VII of the Federal Rules of Evidence, draws these distinctions. Testimony derived from or premised upon purportedly scientific methods should be assessed by the standards and principles of science. See David L. Faigman, To Have and Have Not: Assessing the Value of Social Science to the Law as Science and Policy, 38 Emory L.J. 1005, 1024-25 (1989).

[2] Before the sixteenth century, experts usually were part of the jury. Once expert witnesses became witnesses, it is not clear whether they were called by the parties or the court. See John Basten, The Court Expert in Civil Trials--A Comparative Appraisal, 40 Mod. L. Rev. 174 (1977). The first clear reference to an expert witness called by and on behalf of a party appears in the case of Folkes v. Chadd, 99 Eng. Rep. 589 (1782). See generally Learned Hand, Historical and Practical Considerations Regarding Expert Testimony,

15 Harv. L. Rev. 40 (1901) (discussing the development of the use of expert witnesses).

3 Nearly a century ago, one observer summed up the state of expert testimony as it had arrived to that point in history:
The position of an expert on the witness stand, who does not testify either to what he has observed or knows as fact but expresses merely his opinion as to a situation or on facts which have been established by other witnesses, is anomalous in Anglo-Saxon law. It was to be expected that former generations of judges and lawyers trained in older precedents and practices who recognized the appearance in the courts of an expert witness as an innovation would look with suspicion and doubt on such testimony. While the principles on which such evidence is introduced have come to be well recognized and while the profession no longer has any reservation in approving theoretically of the use of expert testimony, yet, on the other hand, there is a constant complaining and mistrust on the part of judges, juries and lawyers of the expert witness.Lee M. Friedman, Expert Testimony, Its Abuse and Reformation, 19 Yale L.J. 247, 247 (1910). Others, writing in still earlier generations, have been less restrained. For example:
Many judges have expressed their thorough dissatisfaction with the prevalent method ... of making use of the services of experts in the conduct of judicial inquiries .... No judge has, in recent times, said aught in praise of the system, so far as the writer has been able to observe. Law writers are equally condemnatory of the system, and severe in their reflections upon the product of that system--the expert.Clemens Herschel, Services of Experts in the Conduct of Judicial Inquiries, 21 Am. L. Rev. 571, 571-72 (1887);
We think expert testimony should not be much encouraged and should be received only in cases of necessity.... The expert witnesses' views cannot fail generally to be warped by a desire to promote the cause in which they are enlisted.Ferguson v. Hubbel, 97 N.Y. 507, 514 (1884) (emphasis added); and
Medical expert witnesses come with such a bias on their minds to support the cause in which they are embarked, that hardly any weight should be given to their evidence. Id. at 514 (citing The Tracy Peerage, 10 Cl. & Fin. 154, 191 (1843)).

4 113 S. Ct. 2786 (1993).

5 Unless a specific reason exists for excluding it.

6 And this has long been the view:
It has been said, with truth, that "the scientific expert is a product of an advanced and rapidly advancing civilization; that he has acquired an immensely increased importance, and a much wider field, and a far greater frequency of employment by the recent marvellous advances in the applications of science,-- applications which have increased the sphere of things to be litigated about." William L. Foster, Expert Testimony,--Prevalent Complaints and Proposed Remedies, 11 Harv. L. Rev. 169, 176 (1897-98) (quoting an unidentified source).

7 Frye v. United States, 293 F. 1013 (D.C. Cir. 1923).

8 113 S. Ct. at 2786.

9 See infra notes 21-25 and accompanying text for a discussion of the Frye test.

10 Albert S. Osborn, Reasons and Reasoning in Expert Testimony, Law & Contemp. Probs. , Oct. 1935, at 488, 489. Conditioning the admission of expert testimony on nothing more than the expert's "qualifications" went on before Frye, after Frye, after the Federal Rules, and perhaps will continue after Daubert. See generally Paul C. Giannelli, The Admissibility of Novel Scientific Evidence: Frye v. United States , a Half-Century Later, 80 Colum. L. Rev. 1197, 1210 (1980).

11 The "helpfulness" element of admissibility is still present today in the Federal Rules of Evidence. See, e.g. , Fed. R. Evid. 702 (expert can testify if it "will assist the trier of fact") (emphasis added).

12 John B. Chapin, Experts and Expert Testimony, 22 Alb. L.J. 365, 365 (1880).

[13] The Authors, therefore, refer to this as the "commercial marketplace test."

[14] Jones v. Tucker, 41 N.H. 546, 548 (1860).

[15] Consider three examples from the middle of the nineteenth century. Chief Justice Lemuel Shaw, writing in New England Glass Co. v. Lovell, 61 Mass. (7 Cush.) 319 (1851), stated:
It is not because a man has a reputation for superior sagacity, and judgment, and power of reasoning, that his opinion is admissible; if so, such men might be called in all cases, to advise the jury, and it would change the mode of trial. But it is because a man's professional pursuits, his peculiar skill and knowledge in some department of science, not common to men in general, enable him to draw an inference, where men of common experience, after all the facts proved, would be left in doubt. Id. at 321.
Chief Justice Ames, writing in Buffum v. Harris, 5 R.I. 243 (1858), affirming a lower court decision to admit the opinions of two civil engineers, a well digger, a farmer, and a gardener in an action on the case to recover damages for interference with the flow of water from a natural spring on plaintiff's property said:
Indeed, knowledge of any kind, gained for and in the course of one's business as pertaining thereto, is precisely that which entitles one to be considered an expert, so as to render his opinion, founded on such knowledge, admissible in evidence. Id. at 251.
Or, as stated by the Supreme Court of Maine in Clark v. Rockland Water Power Co., 52 Me. 68 (1860):
The foundation on which expert testimony rests, is the supposed superior knowledge or experience of the expert in relation to the subject matter upon which he is permitted to give an opinion as evidence. This knowledge must be such as is peculiar to persons of skill and experience in some particular branch of business, or department of science, which is the subject of investigation, and not of such a character as to be open and common to all persons. Id. at 77.

[16] The Frye test also cannot distinguish between science and pseudoscience; after all, astrological forecasts are "generally accepted" in the "pertinent field" of astrology.

[17] Some of these have been appropriately gathered under the heading of forensic sciences, and they include the identification of firearms, handwriting, tiremarks, fibers, toolmarks, and so on.

[18] So have many courts right up to the present time. See, e.g., Giannelli, supra note 10.

[19] See Osborn, supra note 10, at 489.

[20] Although courts today rarely admit polygraph expert testimony, and then only upon stipulation of the parties, polygraph testing has found commercial value in police investigation, pre-employment screening, aperiodic testing, and national security protective work. It remains controversial. Office of Technology Assessment , OTA-TM-H-15 , Scientific Validity of Polygraph Testing: A Research Review and Evaluation (1983).

[21] The court in Frye may have had a second problem. Suppose it wanted to exclude the lie detection results, then and thereafter, even if some day such examiners did attain a commercial market and qualified polygraphers were plentiful. (The most obvious reason a court might feel this way is that polygraph testing could become a major vehicle by which at least some defendants could make a jury feel there is reasonable doubt about guilt.) Such exclusion would not be easy in a legal world which, despite "constant complaining and mistrust" of experts, routinely admitted them--so long as they were "qualified." And William Marston, Frye's expert witness, was well qualified by conventional standards (if he actually had an expertise in the subject at issue). Marston was an attorney and research psychologist who had done a considerable amount of empirical research on the physiological correlates of lying. See William M. Marston, Systolic Blood Pressure Symptoms of Deception, 2 J. Exp. Psych. 117 (1917).

[22] Frye , 293 F. at 1014.

[23] The courts' placing themselves, now, at the mercy of the sellers of knowledge has another implication. While buyers may have more or less constant standards, or adjust their standards to their needs, different fields have widely varying standards. Some fields have a tradition of vigorous debate, data gathering, hypothesis testing, an ethos consistent with the scientific enterprise. In these fields, an idea does not become generally accepted until it passes a rigorous gauntlet of testing. Other fields lack these traditions of research, empirical testing, and debate, and accept ideas into their catalog of generally accepted knowledge with far less scrutiny. (Important examples of the latter fields are many of the forensic identification sciences.) See, e.g., D. Michael Risinger et al., Exorcism of Ignorance as a Proxy for Rational Knowledge: The Lessons of Handwriting Identification "Expertise," 137 U. Pa. L. Rev. 731 (1989); Michael J. Saks & Jonathan J. Koehler, What DNA "Fingerprinting" Can Teach the Law About the Rest of Forensic Science, 13 Cardozo L. Rev. 361 (1991); I.W. Evett, Criminalistics: The Future of Expertise, 33 J. Forensic Sci. Soc'y 173 (1993). The courts have difficulty telling one of these fields from another. Indeed, and especially ironically for courts, they may mistake vigorous research and debate over the meaning of the findings for lack of agreement (rather than the process of reaching trustworthy findings) and the lack of research and debate as a sign of consensus (rather than a sign of an immature or retarded science).
In any event, under the Frye variant, because the courts have to rely on the standards set within each field, by definition they will find themselves accepting more readily the offerings of less rigorous fields and less readily accepting the offerings of the more rigorous fields. Fields that set higher thresholds will place a smaller proportion of their knowledge over the threshold.

[24] While this might strike some readers as an odd or even dangerous relocation of the power to make important judgments, it was entirely consistent with one of the defining notions of professionalism that was alive in that period and for some time thereafter: to be a profession is to hold a monopoly of judgment over what constitutes your field's expertise, and in many respects the courts have been deferential to the claims of other professions. See generally Samuel Haber , The Quest for Authority and Honor in the American Professions, 1750-1900 (1991); Ronald M. Pavalko , Sociology of Occupations and Professions (2d ed. 1988).

[25] Frye was not cited by a single other court, federal or state, for a decade. During the first quarter century after its publication, Frye was cited in eight federal cases and five state cases. During its second quarter century, it was cited fifty-four times in federal cases and twenty-nine times in state cases. By the 1980s, it was being cited as much each year as it had been in its first fifty years added together. What seems apparent from counting case citations is that judicial interest in the Frye test did not pick up until a few years before the promulgation of the Federal Rules of Evidence and thereafter, no doubt stimulated by the drafting and adoption of the Federal Rules themselves.

[26] See Paul C. Giannelli, Frye v. United States --Background Paper Prepared for the National Conference of Lawyers and Scientists, 99 F.R.D. 189, 191 (1983); J.E. Starrs, "A Still-Life Watercolor": Frye v. United States, 27 J. Forensic Sci. 684, 685 (1982).

[27] Yet, some portion of the "knowledge" of established fields is invalid. For example, many accepted medical techniques have been found, after finally being subjected to rigorous empirical testing, to be no better than or worse than less well-accepted treatments or no treatment at all. See John P. Gilbert et al., Progress in Surgery and Anesthesia: Benefits and Risks of Innovative Therapy, in Costs, Risks, and Benefits of Surgery 124 (John P. Bunker et al. eds., 1977).

[28] For further discussion of the strengths and weaknesses of the Frye test, see infra part II.B.2.

[29] See Fed. R. Evid. 401, 402.

[30] Fed. R. Evid. 702.

[31] By which we mean the test embodied in Rule 702.

[32] See Rules of Evidence for United States Courts and Magistrates , 56 F.R.D. 183, 282 (1973) hereinafter Rules .

[33] At least seven circuits have held that judicial use of Frye is allowable under the Federal Rules of Evidence. See Christophersen v. Allied-Signal Corp., 939 F.2d 1106, 1115-16 (5th Cir. 1991) (per curiam) (expert testimony failed to meet Frye test), cert. denied, 112 S. Ct. 1280 (1992); United States v. Two Bulls, 918 F.2d 56, 60 & n.7 (8th Cir. 1990) (refusing to reject use of Frye in evaluating "the admissibility of any questionable opinion evidence"), reh'g granted, vacated (en banc), and remanded, 925 F.2d 1127 (8th Cir. 1991); United States v. Smith, 869 F.2d 348, 351 (7th Cir. 1989) ("This Circuit has continued to affirm (and to apply) the Frye standard."); Kropinski v. World Plan Executive Council--U.S., 853 F.2d 948, 956 (D.C. Cir. 1988) ("We have recently held that ' Frye is still the law in this Circuit.' ") (citing United States v. Shorter, 809 F.2d 54, 59-61 (D.C. Cir.), cert. denied, 484 U.S. 817 (1987)); United States v. Gillespie, 852 F.2d 475, 481-82 (9th Cir. 1988) (therapist testimony did not satisfy Frye standard); United States v. Metzger, 778 F.2d 1195, 1203 (6th Cir. 1985) (" 'This circuit still predicates the admission of scientific evidence on general acceptance in the community.' ") (quoting 3 Jack B. Weinstein & Margaret A. Berger, Weinstein's Evidence P 70203, at 702-17 to 702-18 (1985) (footnotes and citations omitted)), cert. denied, 477 U.S. 906 (1986); Ellis v. International Playtex, Inc., 745 F.2d 292, 304 n.15 (4th Cir. 1984) (continuing to recognize the validity of Frye test but limiting its use under certain circumstances).
In contrast, two other circuits have held that the Frye test is incompatible with the expert testimony provisions. See United States v. Jakobetz, 955 F.2d 786, 794-97 (2d Cir.) (rejecting any use of Frye), cert. denied, 113 S. Ct. 104 (1992); United States v. Downing, 753 F.2d 1224, 1232-37 (3d Cir. 1985) (concluding that Frye "should be rejected as an independent controlling standard of admissibility").

[34] Though a widely shared perception, the reading of Frye as more restrictive than the Federal Rules is overly simplistic, as we show infra notes 35-37 and accompanying text.

[35] See, e.g., United States v. Bonds, 12 F.3d 540 (6th Cir. 1993) (describing Frye test as "austere" and the Federal Rules of Evidence test as "liberal" regarding the admissibility of scientific evidence); People v. Kelly, 549 P.2d 1240 (Cal. 1976); Peter W. Huber, Galileo's Revenge: Junk Science in the Courtroom (1991); Kenneth J. Chesebro, Galileo's Retort: Peter Huber's Junk Scholarship, 42 Am. U. L. Rev. 1637 (1993).

[36] See, e.g., David L. Faigman, Note, The Battered Woman Syndrome and Self-Defense: A Legal and Empirical Dissent, 72 Va. L. Rev. 619 (1986).

[37] Philip H. Abelson, The Need for Skepticism , 138 Science 75 (1962) (noting the long-held myth that noble gases did not combine).

[38] Huber , supra note 35. Huber's entertaining book may be right or it may be wrong about the alleged upsurge of unreliable scientific testimony. Unfortunately, he does not advance our knowledge on the question because his own methodology is a form of junk social science (that is, he uses no systematic empirical evidence or analysis, merely anecdotes). See generally Chesebro, supra note 35.
On some important matters, Huber simply is incorrect. First, the problem is by no means a new one. Rather than being, as he calls it, a "landmark ruling," Huber , supra note 35, at 14, the Frye test, supra notes 21-25 and accompanying text, was a minor variation on long-established evidentiary doctrine governing the admission of scientific evidence. Nor is it true that following the decision in Frye, "federal courts, widely copied by the states, were bound by the Frye rule." Huber , supra note 35, at 14. Frye was not followed in droves but was long ignored, perhaps because it was Frye that was following what courts, for the most part, already did. Moreover, as a matter of elementary jurisprudence, only a single court was "bound" by Frye, and that was the United States District Court for the District of Columbia. Finally, Huber attributes the problem of junk science to the demise of Frye in the wake of the Federal Rules. Id. at 15-16. He gives no evidence beyond his assertion. His causal attribution may be doubted if only because judges and lawyers had bemoaned the real or supposed problem of junk science loudly and clearly for at least a century--before and after Frye, and before and after the Federal Rules--and because most courts, state and federal, treated the Federal Rules as if they embodied a general acceptance test. (The Supreme Court has now made clear that they do not. See infra notes 40-49 and accompanying text.) Huber also does not explain why Frye is supposedly better than the Federal Rules, or how theories become "generally accepted." His underlying thesis seems to be that when "conventional" scientists say a theory is valid, it must be valid. This does not get the law much beyond question-begging.

[39] 113 S. Ct. 2786 (1993).

[40] The Committee's Notes appear throughout the Federal Rules. See Rules , supra note 32, at 183.

[41] H.R. Conf. Rep. No. 1597, 93d Cong., 2d Sess. (1974), reprinted in 1974 U.S.C.C.A.N. 7098; S. Rep. No. 1277, 93d Cong., 2d Sess. (1974), reprinted in 1974 U.S.C.C.A.N. 7051; H.R. Rep. No. 650, 93d Cong., 2d Sess. (1974), reprinted in 1974 U.S.C.C.A.N. 7075.

[42] Proposed Rules of Evidence: Hearings Before the Special Subcomm. on Reform of Federal Criminal Laws of the House Comm. on the Judiciary, 93d Cong., 1st Sess. (1973); Federal Rules of Evidence: Hearings on H.R. 5463 Before the Senate Comm. on the Judiciary, 93d Cong., 2d Sess. (1974).

[43] 3 Jack B. Weinstein & Margaret A. Berger , Weinstein's Evidence P 70203, at 702-36 (1993).

[44] Id.; see also 22 Charles A. Wright & Kenneth W. Graham, Jr. , Federal Practice and Procedure s 5169 (1978 & Supp. 1993) (concluding that Frye was repealed by the Federal Rules).

[45] See, e.g., Michael H. Graham , Handbook of Federal Evidence s 703.2 (3d ed. 1991); 1 David W. Louisell & Christopher B. Mueller , Federal Evidence s 105, at 818 (1977).

[46] United States v. Downing, 753 F.2d 1224, 1235 (3d Cir. 1985).

[47] Randolph N. Jonakait, The Supreme Court, Plain Meaning, and the Changed Rules of Evidence, 68 Tex. L. Rev. 745, 746 (1990). In several recent cases the Court has adhered strictly to a plain-meaning approach to interpreting the Rules. See Huddleston v. United States, 485 U.S. 681, 687 (1988); Bourjaily v. United States, 483 U.S. 171, 179-81 (1987). But see Green v. Bock Laundry Mach. Co., 490 U.S. 504, 527 (1989) (Scalia, J., concurring) (stating that the Court will go beyond the plain meaning when "a statute which, if interpreted literally, produces an absurd, and perhaps unconstitutional, result"); see also Glen Weissenberger, The Supreme Court and the Interpretation of the Federal Rules of Evidence, 53 Ohio St. L.J. 1307 (1992) (arguing that application of legislative intent is misplaced in the interpretation of the Federal Rules of Evidence).

[48] Daubert, 113 S. Ct. at 2794.

[49] Id.

[50] Of course, Rule 702 is not limited to the scientific context, for it also applies to "technical or other specialized knowledge." The present discussion is limited to the scientific context because that is the nature of the expertise offered here. Nonscientific expertise presents many similar problems, as well as many special ones, that space does not allow us to consider. See generally Charles T. McCormick et al. , McCormick on Evidence s 13 (Edward W. Cleary ed., 3d ed. 1984).

[51] This is the lesson of Rule 403 which mandates that relevant evidence is excluded under the rule only if its probative value is substantially outweighed by its prejudicial effect.

[52] Brief for a Group of American Law Professors as Amicus Curiae in Support of Neither Party, Daubert (No. 92-102). In their petition for certiorari, the Daubert petitioners raised "the issue of the power of lower federal courts under Rule 402's mandate that all relevant evidence is admissible unless excluded pursuant to another rule. We do not disagree with the proposition that Rule 402 was intended

to restrict the federal courts' common law making power over the rules of evidence." Id. ; see 22 Wright & Graham , supra note 44, s 5192. However, regarding the interpretation of Rule 702, the principal question of concern here, Rule 402 provides little guidance. Rule 702, after all, is one of those "other rules" that restricts the admission of "relevant evidence." See United States v. Downing, 753 F.2d 1224, 1235 (3d Cir. 1985) ("The notes of the advisory committee make clear that Rule 402 is limited by Fed. R. Evid. 403 and by the rules contained in Article VII ... including Rule 702.").

53 See supra note 33 and accompanying text; see also Giannelli, supra note 10, at 1210; John W. Strong, Questions Affecting the Admissibility of Scientific Evidence, 1970 U. Ill. L.F. 1, 9 ("Essentially the only obstacle to the admission of general propositions through the medium of 'expert testimony' is the requirement that the qualifications of the expert be established, i.e., that the expert be shown to be one.").

54 See Edward J. Imwinkelried, The "Bases" of Expert Testimony: The Syllogistic Structure of Scientific Testimony, 67 N.C. L. Rev. 1, 14 (1988).

55 The situation gets even worse in cases where minimally-trained technicians or police officers are admitted as "experts" on using sophisticated scientific techniques of which they have little or no understanding. E.g., City of Abilene v. Hall, 451 P.2d 188 (Kan. 1969) (testimony based on gas chromatography allowed even though "expert" who conducted the test conceded lacking knowledge of why or how the machine and technique worked).

56 See Faigman, supra note 1, at 1086; Comment, The Psychologist as Expert Witness, 38 Md. L. Rev. 539, 563-64 (1979).

57 Daubert, 113 S. Ct. at 2791.

58 Iowa Code Ann. s 691.2 (West 1993) (making the testimony of the state's forensic scientists automatically admissible based on the mere fact that they are employees of the state's bureau of criminal identification).

59 See infra part II.B.3 and accompanying text.

60 The general acceptance standard, as employed by most courts claiming to be following Frye, is applied to the scientific methodology used rather than the specific conclusions derived from that methodology. But see infra notes 119-23 and accompanying text. As the court in Ibn-Tamas v. United States emphasized, the relevant inquiry concerns "the general acceptance of a particular methodology in the field, not ... on the subject matter studied." 407 A.2d 626, 638 (D.C. 1979). Even so, the admitting court, of course, still must check that the generally accepted method was actually employed to obtain the proffered results.

61 The usual justification for the general acceptance test is that "those most qualified to assess the general validity of a scientific method will have the determinative voice." United States v. Addison, 498 F.2d 741, 743-44 (D.C. Cir. 1974). In People v. Barbara, the relevant scientific community was described as a "technical jury" which passes on the scientific validity of a procedure before it is admitted. 255 N.W.2d 171, 194 (Mich. 1977).

62 See generally United States v. Downing, 753 F.2d 1224, 1235-37 (3d Cir. 1985).

63 Id. at 1236; see also supra notes 35-37 and accompanying text.

64 Courts use the term "reliability" to refer loosely to what scientists separate into validity and reliability. Unfortunately, the use of different terms injects unnecessary confusion into the debate. We use the standard scientific definition of validity so as to create

some consistency across the law and science frontiers; this area of the law would be substantially assisted if lawyers and scientists began using the same vocabulary. Given these precise and well-settled terms of art in science, we believe the law's usage should conform to them.
"Validity" refers to the ability of a scientific test to measure what it purports to measure; "reliability" refers to the ability of a scientific test to obtain consistent results. See Giannelli, supra note 10, at 1201 n.20. The pertinent question for admissibility is validity, as emphasized in Daubert. ("In a case involving scientific evidence, evidentiary reliability will be based upon scientific validity ." 113 S. Ct. at 2795 n.9.)
Consider the example of handwriting identification. In a proficiency test sponsored by the Forensic Sciences Foundation, handwriting experts unanimously agreed on the solution to a handwriting identification problem (100% reliability), but all of them reached an incorrect result (0% validity). See Risinger et al., supra note 23, at 737.

65 See 1 Louisell & Mueller , supra note 45, at 821-22; Giannelli, supra note 10, at 1223; see also Addison, 498 F.2d at 743.

66 See Strong, supra note 53, at 10-11.

67 See, e.g., United States v. Williams, 583 F.2d 1194, 1198 (2d Cir. 1978), cert. denied, 439 U.S. 1117 (1979).

68 Giannelli, supra note 10, at 1208.

69 Id. at 1209.

70 In addition to what follows, see the discussion supra notes 35-37 and accompanying text.

71 See Williams, 583 F.2d at 1198 (noting that "selection of the 'relevant scientific community,' appears to influence the result"); see also National Academy of Sciences, On the Theory and Practice of Voice Identification (1979) (in which a group composed of acoustical engineers, physiologists, statisticians, and others gave a less favorable assessment of the technique than the narrower range of developers of the technique).

72 DeLuca v. Merrell Dow Pharmaceuticals, Inc., 911 F.2d 941, 955 (3d Cir. 1990), cert. denied , 114 S. Ct. 691 (1994).

73 Daubert, 113 S. Ct. at 2796.

74 Id. at 2796 n.10 (footnote on distinction between reliability and validity).

75 See 1 Paul C. Giannelli & Edward J. Imwinkelried , Scientific Evidence s 1-6(A) (2d ed. 1993) ("The probative value of scientific evidence depends on its reliability."); Faigman, supra note 1, at 1081 ("The legal relevance of social science research simply cannot be divorced from its scientific credibility."); Jonakait, supra note 47, at 767 ("Testimony based on the scientific test aids the jury if it is relevant; it is relevant only if the test is reliable.").

76 Daubert, 113 S. Ct. at 2796 n.10.

77 Huddleston v. United States, 485 U.S. 681 (1988).

[78] McCormick et al. , supra note 50, s 53, at 137. Thus, for example, Rule 104(a) requires judges independently to find under Rule 804(b)(2) that a dying declaration was made under a belief of impending death before permitting the jury to consider the hearsay statement.

[79] Id. Two recent decisions of the Supreme Court adhere to and exemplify the distinct provisions of Rule 104. In Bourjaily v. United States, the Court applied the 104(a) standard to the preliminary question whether a conspiracy existed under the hearsay exclusion for the statements of coconspirators. 483 U.S. 171, 171 (1987) (applying Rule 104(a) to Federal Rule of Evidence 801(d)(2)(E)). Consistent with the traditional standard for preliminary fact review for exclusionary rules of evidence, Bourjaily required judges independently to find the existence of a conspiracy by a preponderance of the evidence. In Huddleston v. United States, however, the Court did not apply the 104(a) standard to extrinsic act evidence under 404(b). The Court found that Congress's principal concern in enacting Rule 404(b) was not exclusion, but rather "ensuring that restrictions would not be placed on the admission of such evidence." 485 U.S. at 689. Thus, the Court read 404(b) as a rule of inclusion and applied Rule 104(b). Id. at 687 ("Generally, ... Rules 404 through 412 do not flatly prohibit the introduction of such evidence but instead limit the purpose for which it may be introduced.").

[80] See John Kaplan, Of Mabrus and Zorgs--An Essay in Honor of David Louisell, 66 Cal. L. Rev. 987, 997-99 (1978) (criticizing the California rule for giving these sorts of fact questions to jurors and praising the Federal Rules for treating them as preliminary facts to be decided by judges).

[81] As stated in Downing, "Novel scientific evidence carries with it concerns over trustworthiness and reliability akin to those raised by offers of hearsay evidence." United States v. Downing, 753 F.2d 1224, 1240 n.21 (3d Cir. 1985). See generally Peter Tillers & David Schum, Hearsay Logic, 76 Minn. L. Rev. 813 (1992) (discussing the necessity of having a theory about behavioral characteristics relevant to assessment of hearsay and in-court testimonial evidence).

[82] Barefoot v. Estelle, 463 U.S. 880, 926 (1983) (Blackmun, J., dissenting); United States v. Amaral, 488 F.2d 1148, 1152 (9th Cir. 1973).

[83] See United States v. Tranowski, 659 F.2d 750, 755 (7th Cir. 1981) (applying Rule 104(a) to assess the validity of the data upon which the expert relied); cf. Kelly v. State, 824 S.W.2d 568, 573 (Tex. Crim. App. 1992).

[84] Compare Kenneth J. Chesebro, Taking Daubert 's "Focus" Seriously: The Methodology/Conclusion Distinction , 15 Cardozo L. Rev. 1745 (1994) and Anthony Z. Roisman, Conflict Resolution in the Courts: The Role of Science , 15 Cardozo L. Rev. 1945 (1994) (liberal standard) with Bert Black, The Supreme Court's View of Science: Has Daubert Exorcised the Certainty Demon? , 15 Cardozo L. Rev. 2129 (1994) and Clifton T. Hutchinson & Danny S. Ashby, Daubert v. Merrell Dow Pharmaceuticals, Inc. : Redefining the Bases for Admissibility of Expert Scientific Testimony , 15 Cardozo L. Rev. 1875 (1994) (conservative standard). See also Bert Black & John A. Singer, From Frye to Daubert : A New Test for Scientific Evidence, 1 Shepard's Expert & Sci. Evidence Q. 19 (1993); Barry J. Nace, Reaction to Daubert, 1 Shepard's Expert & Sci. Evidence Q. 51 (1993).

[85] Daubert, 113 S. Ct. at 2795 (footnotes and citations omitted) (first ellipsis in original).

[86] For example, it is hard to imagine how a conscientious federal court could now admit testimony by certain types of forensic scientists, until there is a more satisfactory showing than has been available to date. See Randolph N. Jonakait, Forensic Science: The Need for Regulation, 4 Harv. J.L. & Tech. 109 (1991); Risinger et al., supra note 23; Saks & Koehler, supra note 23, at 361.

[87] See generally Michael J. Saks, Judicial Attention to the Way the World Works, 75 Iowa L. Rev. 1011 (1990) (providing an integrative summary of Monahan and Walker's tripartite theory of facts, authority, and frameworks, including analysis of when lower courts are bound by the factual findings of higher courts).

[88] Daubert v. Merrell Dow Pharmaceuticals, Inc., 951 F.2d 1128 (9th Cir. 1991).

[89] Id. at 1130 (quoting Reed v. State, 391 A.2d 364, 367 (Md. 1978)); see also United States v. Williams, 583 F.2d 1194, 1197-1201 (2d Cir. 1978), cert. denied, 439 U.S. 1117 (1979).

[90] Hamling v. United States, 418 U.S. 87, 108 (1974).

[91] "The Court has long noted the difficulty of distinguishing between legal and factual issues." Cooter & Gell v. Hartmarx Corp., 496 U.S. 384, 401 (1990); see Mark McCormick, Scientific Evidence: Defining a New Approach to Admissibility, 67 Iowa L. Rev. 879, 908 (1982) (describing the question of the admissibility of novel scientific evidence as "a mixed question of fact and law").

[92] Compare Kenneth C. Davis, An Approach to Problems of Evidence in the Administrative Process, 55 Harv. L. Rev. 364, 402-03 (1942) (describing and contrasting adjudicative facts and legislative facts) with Laurens Walker & John Monahan, Social Frameworks: A New Use of Social Science in Law, 73 Va. L. Rev. 559, 563-70 (1987) (modifying and expanding the concept of adjudicative facts) hereinafter Walker & Monahan (1987).

[93] See McCormick, supra note 91, at 909.

[94] See John Monahan & Laurens Walker, Social Authority: Obtaining, Evaluating, and Establishing Social Science in Law, 134 U. Pa. L. Rev. 477, 490-91 (1986) hereinafter Monahan & Walker (1986); see also Imwinkelried, supra note 54, at 24-25.

[95] See Dunagin v. City of Oxford, Miss., 718 F.2d 738, 748-49 n.8 (5th Cir. 1983), cert. denied, 467 U.S. 1259 (1984).

[96] See, e.g., Barefoot v. Estelle, 463 U.S. 880, 900-01 n.7 (1983) (validity of predictions of dangerousness); New York v. Ferber, 458 U.S. 747, 758 n.9 (1982) (the effect on children of being a subject in pornographic materials); Ballew v. Georgia, 435 U.S. 223, 231 n.10 (1978) (the effect of jury size on deliberations); Gregg v. Georgia, 428 U.S. 153, 184 n.31 (1976) (the deterrent effect of capital punishment); Paris Adult Theatre I v. Slaton, 413 U.S. 49, 58 n.8 (1973) (the relationship between obscenity and crime). See generally David L. Faigman, "Normative Constitutional Fact-Finding": Exploring the Empirical Component of Constitutional Interpretation, 139 U. Pa. L. Rev. 541, 552-56 (1991) (reviewing the role of judicial fact-finding in the cases cited, and the role of fact-finding in judicial lawmaking).

[97] Cf. United States v. Jakobetz, 955 F.2d 786, 799 (2d Cir.) (taking judicial notice of the general acceptance of the theory underlying DNA profiling and the general techniques used to identify profiles), cert. denied, 113 S. Ct. 104 (1992).

[98] Not all scientific information is described at the case-specific level at trial. For example, experts who testify on the unreliability of eyewitness identifications present only general research findings indicating the factors related to errors in witnesses' perceptions. The jury is left to draw inferences from the expert's testimony to the case before it. See, e.g., State v. Chapple, 660 P.2d 1208, 1219 (Ariz. 1983) (concluding that the fact that the expert "would testify to general factors which were applicable to this case ... but would not express any opinion with regard to the accuracy of the specific identification" favored admissibility). See generally John Monahan & Laurens Walker , Social Science in Law: Cases and Materials 346-448 (2d ed. 1990).

[99] See Walker & Monahan (1987), supra note 92, at 584; see also Robert P. Mosteller, Legal Doctrines Governing the Admissibility of Expert Testimony Concerning Social Framework Evidence, Law & Contemp. Probs. , Autumn 1989, at 85.

[100] See Jakobetz, 955 F.2d at 799 (leaving the reliability of the specific DNA profile used in the case for the jury to determine).

101 One of the authors has seen the dilemma "in the flesh," so to speak, during numerous summers of teaching scientific research methods and statistics to judges working on their LL.M. degrees. For most of the semester they complained of and criticized the expert witnesses who appeared in the cases we read and cases which they had decided. In the final week of the semester we would turn to a body of scholarship that argued that in many circumstances no experts were needed, but rather judges should be making the decisions themselves. The suggestion seemed to panic many or most of the judges, and they began to insist, as it were, on the return of the experts to help them.

102 Imwinkelried, supra note 54, at 1.

103 Monahan & Walker (1986), supra note 94, at 477; Laurens Walker & John Monahan, Social Facts: Scientific Methodology as Legal Precedent, 76 Cal. L. Rev. 877 (1988) hereinafter Walker & Monahan (1988); Walker & Monahan (1987), supra note 92, at 559.

104 Imwinkelried, supra note 54, at 2-3.

105 Id. at 14-19.

106 Id. at 9-10. For an argument refuting this insight, see David L. Faigman, Struggling to Stop the Flood of Unreliable Expert Testimony, 76 Minn. L. Rev. 877, 886-89 (1992).

107 Walker & Monahan (1988), supra note 103, at 886-87.

108 Monahan & Walker (1986), supra note 94, at 490-91. According to their proposal, scientific authority is analogous to legal authority. Judges should consider such scientific "precedent" (i.e., past research) as presented in briefs and arguments, and sua sponte. The information found to be relevant and valid would then be incorporated into the judge's conclusions of law. Id. at 495-98.

109 Walker & Monahan (1988), supra note 103, at 881; see, e.g., Zippo Mfg. Co. v. Rogers Imports, Inc., 216 F. Supp. 670, 690-91 (S.D.N.Y. 1963) (utilizing a consumer survey to determine the degree of public confusion in recognizing cigarette lighters manufactured by the plaintiff and defendant).

110 Walker & Monahan (1987), supra note 92, at 568-71.

111 Id.

112 William A. Thomas, Some Observations by a Scientist, 115 F.R.D. 142, 144 (1986).

113 Id. at 144. A scientific theory is the result of the scientific method; that is, it is a hypothesis that has undergone testing numerous times and by numerous methods and has, so far, not been completely falsified. A hypothesis (and the resulting theory) is a model or mental picture of how and why a certain natural system or process works. A theory is therefore not a "fact" in the sense that it is an absolute truth; instead, it is a well-established and respected model for the true system. See Ernest Nagel, The Structure of Science: Problems in the Logic of Scientific Explanation 15-46 (1961); Karl R. Popper, The Logic of Scientific Discovery (rev. ed. 1968).

114 See Thomas, supra note 112, at 142.

115 See, e.g., United States v. Jakobetz, 955 F.2d 786 (2d Cir.), cert. denied, 113 S. Ct. 104 (1992).

116 John E. Reid & Fred E. Inbau , Truth and Deception: The Polygraph ("Lie-Detector") Technique 1-3 (1966).

117 Thomas, supra note 112, at 144.

118 See generally National Academy of Sciences, supra note 71.

119 Id.

120 See Thomas, supra note 112, at 144.

121 Cf. Imwinkelried, supra note 54; Walker & Monahan (1987), supra note 92.

122 Frye v. United States, 293 F. 1013 (D.C. Cir. 1923) (emphasis added).

123 See, e.g., Giannelli, supra note 26, at 189.

124 The National Academy of Sciences pointed this out in its report on voice spectrography. See National Academy of Sciences, supra note 71, at 41.

125 Harking back to our marketplace metaphor, where general acceptance may place a legal judgment at the control of those selling what is being judged, applying general acceptance to basic theoretical knowledge, instead of technique, lessens this risk. This lower risk (to continue the metaphor) results from the probability that many different sellers' guilds, often with competing intellectual and professional interests, will have studied a theory. Agreement among competitors should increase the courts' confidence.

126 Daubert, 113 S. Ct. at 2796-97.

127 At least broader than will be the case for any given technique.

128 Such as that commissioned by the National Academy of Sciences to study voice spectrography. See National Academy of Sciences , supra note 71.

129 E.g., atropine, cyanide, and nicotine.

130 Fire coral, sea urchin, and stonefish, for example, are known to be toxic, but the mechanisms are not understood. New compounds, including pharmaceuticals, must be tested to determine their safety or toxicity.

131 For example, a biomedical test may have been proven capable of predicting the likelihood of acquiring a certain disease, or a psychological test may have been shown to be a reliable predictor of who will be able to perform certain tasks, but no theory has

been developed and tested to make deeper sense of the empirical findings.

132 For example, all forensic identification sciences (handwriting, toolmarks, fingerprints, etc.) rest on the "theory" that "nature never repeats"; that is, that no two objects, natural or manufactured, ever occur that are so similar they are indistinguishable. This theory is based on little more than the faith of those who subscribe to it. Michael J. Saks, Implications of the Daubert Test for Forensic Identification Science, 1 Shepard's Expert & Sci. Evidence Q. 427 (1994).

133 Daubert, 113 S. Ct. at 2797 ("The focus, of course, must be solely on principles and methodology, not on the conclusions that they generate.").

134 Id. at 2796.

135 Id. at 2797. The third level of evaluation of scientific validity is the most neglected by the courts.

136 Id. at 2796-97.

137 United States v. Bonds, 12 F.3d 540, 559 (6th Cir. 1993); United States v. Smith, 776 F.2d 892, 898 (10th Cir. 1985).

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