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Dumping Daubert, Popping Popper and Falsifying Falsifiability: A Re-Assessment of First Principles

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Abstract:
The Daubert mantra demands that judges, acting as gatekeepers, prevent para, pseudo or bad science from infiltrating the courtroom. To do so, the Judges must first determine what is ‘science’ and what is ‘good science.’

It is submitted that Daubert is deeply polluted with the notions of Karl Popper who sets ‘falsifiability’ and ‘falsification’ as the demarcation line for that determination. This philosophy has intractably infected case law, leading to bad decisions immortalized as *stare decisis*, and an unworkable system of decision-making, which negatively impacts litigant expectations. Among other problems is the intolerance of Popper’s system for multiple causation, a key component of toxic tort law. Thus, the objective of this work is to sanitize the gatekeeping mindset from the philosophy of Popper, the first step in creating a new gatekeeping paradigm.

I first show that Popper’s philosophy derived from and is applicable only to the world of quantum physics and is irrelevant to the science of the courtroom: biology, chemistry and Newtonian physics. Next, I falsify Popper’s ‘falsifiability’ using scientific examples; to my knowledge the first attempt to use this approach in a systematic fashion. Third, I demonstrate, both by scientific and legal example that Popper’s falsification system is inapt for forensic use. Finally, with the assistance of works of the philosopher Paul Hoyningen-Huene and the scientist George Gore, I recraft the definitions of ‘science’ and ‘good science’ highlighting the importance of *verifiability* and performance of *verified* experiments that produce valid and reliable results.
Dumping Daubert, Popping Popper, and Falsifying Falsifiability

A Re-Assessment of First Principles

Barbara Pfeffer Billauer

“I will begin this book, which it is my intention to write, with an exposition of the reason why men, in their search for Truth, become involved in errors, and how these errors can be removed so that the objects of their investigations may be fully attained; moreover, why some of these errors have such a powerful hold on some people that they affirm them as the truth, deluding themselves that they know something....” Saadia Gaon in Emunot V’Daot

I. Introduction: Immortalized Error

A little over two decades ago, the United States Supreme Court handed down a decision that would profoundly change the face of scientific evidence in American courts. As it turned out, the decision would also influence legal decisions and judicial reasoning throughout the world. The case of Daubert v. Merrell Dow Pharmaceuticals concerned the admissibility of certain scientific (medical and epidemiological) evidence to establish causation in a civil case.

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2 Chris Miller, Causation in personal injury: legal or epidemiological common sense? 26 LEGAL STUDIES, No 4, (December, 2006) at 544-569, summarizing the effects of Daubert under the British Canadian and Australian legal systems.

3 In 2005, the United Kingdom House of Commons Science and Technology Committee recommended creation of a Forensic Science Advisory Council to regulate forensic evidence along the lines of Daubert, see also FORENSIC SCIENCE ON TRIAL, London: The Stationery Office Limited, HC96-I (2005), para.173.


although some say the most profound effects of Daubert concerned the use (or misuse) of scientific evidence in the criminal courts.\footnote{STRENGTHENTING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD, The National Research Council of the National Academies Press, Washington D.C. (2009), www.nap.edu.} \footnote{The National Research Council’s publication runs 254 pages and catalogues no less than a dozen problems related to criminal cases.}

The actual consequence of Daubert was to confer upon judges the roles of ‘gatekeepers’ of scientific evidence.\footnote{“Faced with a proffer of expert scientific testimony under Rule 702, the trial judge, pursuant to Rule 104(a), must make a preliminary assessment of whether the testimony’s underlying reasoning or methodology is scientifically valid and properly can be applied to the facts at issue.” Daubert, \textit{supra}.} The newly empowered judges were now charged with preventing pseudo or parascientific evidence (junk-science”)\footnote{I define ‘Junk Science’ using product liability parameters describing a defective product: i.e., “Dangerous and unfit for the use intended.” Steven J. Milloy in JUNK SCIENCE JUDO, Cato Institute, Washington, D.C. (2001) at1, says: “What exactly is junk science? In a word, fraud. In a sentence, it’s faulty scientific data and analysis used to advance a special interest.” Plaintiff’s attorney, Mark Bower sums up the present state of understanding as: “By definition, a theory that even its proponents admit, has not and cannot be tested or proved or disproved, is junk science according to the legal definition. An unprovable/un-disprovable hypothesis cannot serve as “proof” of facts in a courtroom setting. It is mere speculation, not “proof”. The rules of evidence require that a theory be testable, verifiable, and refutable. The “natural forces of labor theory” does not fulfill these basic criteria.” Mark, Bower, \textit{Erb’s Palsy Junk Science Debunked by NY Appellate Court: Defendants Get Their Comeuppance}, (2012). http://www.newyorkpersonalinjuryattorneyblog.com/2012/02/junk-science-debunked-by-ny-appellate-court-defendants-get-their-comeuppance.html} \footnote{Gary Edmond and David Mercer, \textit{Trashing Junk Science}, 3 STANDFORD TECH. L. REV. (1998), https://journals.law.stanford.edu/sites/default/files/stanford-technology-law-review-stlr/online/edmund-mercer-trashing-junk-science.pdf.} from infiltrating the courtroom and tainting legal decisions. Thus, much like the guards to the palace visited by the fictional Jonathan Bing,\footnote{“Jonathan Bing,” by Beatrice Curtis Brown, see Appendix.} judges are now tasked with keeping riffraff and other unsuitable prospective (evidentiary) candidates from presentation at court. However, unlike the palace guards vetting Mr. Bing -- who had at least had some objective (albeit superficial) criteria to evaluate his
suitability -- Daubert leaves Judges who are generally unversed in,\textsuperscript{13} and even antithetical to, the sciences\textsuperscript{14} without clear guidance or ample criteria upon which to predicate their decisions.

After commanding the judiciary to vet scientific evidence according to a litany of vague precepts, the \textit{Daubert} court remanded the case back to the Ninth Circuit to fulfill this directive. Skittish over their ability to carry out their assigned task, the Circuit Judges intrepidly proceed, but not before issuing an alert:

“As we read the Supreme Court's teaching in Daubert, therefore, though we are largely untrained in science and certainly no match for any of the witnesses whose testimony we are reviewing…. our responsibility, then, … is to resolve disputes among respected, well-credentialed scientists … in areas where there is no scientific consensus as to what is and what is not "good science,…. Mindful of our position in the hierarchy of the federal judiciary, we take a deep breath and proceed with this heady task.”\textsuperscript{15}

Even in the face of their acknowledged limitations, however, the Ninth Circuit judges were remarkably clear on what they were expected to do, noting that: “First, we must determine nothing less than whether the experts' testimony reflects [a]"\textit{scientific knowledge} … \textit{derived by the scientific method}." and [c] whether their \textit{work product amounts to} "\textit{good science}".\textsuperscript{16} [emphasis supplied]. It's just \textit{how} they were to make this decision that flummoxed them. To be sure, some \textit{ad hoc} admissibility tests are suggested by the Supreme Court\textsuperscript{17} Critics, however,

\textsuperscript{13} Today's judges seem more antithetical to science than their peers 100 years ago when Louis Brandeis submitted a one hundred page brief to the Supreme Court that (with the exception of two pages) predicated entirely on scientific evidence, Muller v. Oregon, 208 U.S. 412 (1908).
\textsuperscript{16} Daubert, 113 S. Ct. at 2795, 2797, repeated in Daubert on remand, 43 F.3d 1311.
\textsuperscript{17} “Many considerations will bear on the inquiry, including whether the theory or technique in question can be (and has been) tested, whether it has been subjected to peer review and
complain these “appearance” tests are no more useful arbiters of admissibility than Mr. Bing’s outfits, a point seconded by philosophers\textsuperscript{18} and scientists alike:

“As in the past, our beliefs have been largely founded on appearances, and many of them have been reversed by deeper knowledge, so may we reasonably expect, in accordance with the principles of uniformity of nature that the same process will continue to operate in the future, and that even some of our most attractive beliefs (excepting those which are logically absolute which or demonstrative in science) will have a similar fate.”\textsuperscript{19}

Thus, “when agreement about what constitutes scientific knowledge can range so widely that even long-held ideas are challenged, it is not easy to come up with a workable alternative to the Frye test\textsuperscript{20}, which requires the judge to be an arbiter of the views of practicing scientists. Trying to decide which expert is reasoning properly seems a rather difficult task for a court, when even scientists often disagree on how to do it.”\textsuperscript{21}

To redress the problem, a surfeit of law review articles purporting to understand how science is practiced or what science is have been offered -- establishing only more disagreement and error. A quick Lexis search of law review articles and commentary yielded 999 entries, while a Google search produced 127,000 hits\textsuperscript{22} with over 800 published Appellate Court publication, its known or potential error rate and the existence and maintenance of standards controlling its operation, and whether it has attracted widespread acceptance within a relevant scientific community. The inquiry is a flexible one, and its focus must be solely on principles and methodology, not on the conclusions that they generate. Throughout, the judge should also be mindful of other applicable rules.” Ibid.

\textsuperscript{18} “G. Gore, infra, p. 102. (infra).

\textsuperscript{19} See also, Bertrand Russell, The Problems of Philosophy, Gutenberg files, 1912 (chapter 1) http://www.gutenberg.org/files/5827/5827-h/5827-h.htm

\textsuperscript{20} Frye v. United States, 293 F. 1013 (D.C. Cir. 1923).


\textsuperscript{22} Twerski and Sapir found 3929 results in the Westlaw database for "Daubert v. Merrell Dow Pharmaceuticals" with the search limited to "Secondary Sources, Law Reviews and Journals/" Aaron D Twerski, Sufficiency of the Evidence Does Not Meet Daubert Standards: A Critique of
Dumping Daubert, Popping Popper and Falsifying Falsifiability

decisions.\textsuperscript{23} The prolix of legal commentary is mostly an unenlightened reiteration of Daubert precepts\textsuperscript{24} without critical analysis or useful and practical tools.\textsuperscript{25} So bereft of guidance are the judges and so perplexing has the issue become that the latest law review article appearing as of the date of this writing suggested turning the question over to computers.\textsuperscript{26}

In addition to the problems of making \textit{Daubert} work, we also have a proliferation of diametrically opposite opinions over its effect: some claiming Daubert has overly excluded evidence and others claiming Daubert relaxed standards of admissibility.\textsuperscript{27} Both sides are adamant.\textsuperscript{28} However, any bias, if it does exist,\textsuperscript{29} could be due to factors other than \textit{Daubert}'s direct precedential value,\textsuperscript{30} such as more judges taking judicial training courses or availing

\textsuperscript{23} www.daubertontheweb.com


\textsuperscript{25}

\textsuperscript{26} Thus, if a positive finding exists, it may not be due to Daubert \textit{per se}, but to other confounding factors, e.g. political biases of the decision-makers which is likely similar to those of the President who appointed her/him. See, Adam Liptak, \textit{Why judges tilt to the right}, Jerusalem Post, February 8, 2015, p. 8, reprinted from the N.Y. Times commenting on a study by Maya Sen, and a treatise by Lee Epstein, William M. Landes and Judge Richard Posner, “The Behavior of Federal Judges,” (2013); see also Erik C. Nisbet, Kathryn E. Cooper, and R. Kelly Garrett, \textit{The Partisan Brain: How Dissonant Science Messages Lead Conservatives and Liberals to (Dis)Trust Science}, 658\textit{THE ANNALS OF THE AMERICAL ACADEMY OF POLITICAL AND SOCIAL SCIENCE} (March 2015) at 36-66, doi:10.1177/0002716214555474.

A 2001 Rand study found that 90\% of the courtroom uses of \textit{Frye} and \textit{Daubert} was anti-plaintiff. Lloyd Dixon, Brian Gill, \textit{CHANGES IN THE STANDARDS FOR ADMITTING EXPERT EVIDENCE IN FEDERAL CIVIL CASES SINCE THE DAUBERT DECISION}, Rand Institute for Civil Justice, California (2001).

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Anecdotal experience leads me to conclude that Judge’s decisions on admissibility turn on the Judge’s innate phobia or interest in science; those interested being more likely to hold Daubert
Dumping Daubert, Popping Popper and Falsifying Falsifiability

themselves to greater educational or expert resources. It is also possible that Daubert is only indirectly influencing admissibility as a consequence of scientific misunderstandings that have crept into case law over the years, now embedded as binding precedent.31

Some academics who claim the decision “has led to the exclusion of experts in hundreds, perhaps thousands of cases,” have proposed solutions to remedy this claimed over-exclusion. Michael Green and Joseph Sanders postulate substituting a ‘sufficiency’ standard 32 focused on the totality of evidence submitted by plaintiff, instead of the reliability of the expert’s methodology enunciated in Daubert which purportedly subjects each individual proffer of proof to scrutiny on its own merits.33

This interpretation has been vigorously refuted and publically debated. 34 Green and Sander’s opponents, including Aaron Twerski and Lior Sapir, advocate strict adherence to Daubert, concerned that substituting an amalgamated approach (i.e., sufficiency) for the formal hearings; those being science-averse being more likely to let the jury (who in all probability is far less science-averse than the Judge, anyway) decide.

33 “Reliability of method” is a scientific malapropism. The accurate terminology would be the ‘validity of method.’
structure set forth in the *Daubert* trilogy has the potential to eviscerate *Daubert*. Even changing the name of the standard bothers Twerski and Sapir, concerned that nomenclature influences thought. Twerski and Sapir make a compelling case that junk science has found its way into court (citing the Parlodel controversy). But rather than focusing on refining a methodology to preempt such practice, they claim that preserving strict adherence to Daubert as it stands will preclude continuing abuses.

It is beyond doubt that *Daubert* is broken. I submit, however, that merely substituting one fuzzy and composite test (sufficiency) for a hodge-podge based on uninformed science-speak (e.g., the enumerated *Daubert* tests) only confounds and compounds the problem. Thus, rather than arbitrarily weakening the standard, as Green and Sanders suggest, or maintaining the *Daubert* status quo as Twerski and Lior Sapir argue, I suggest that a different approach is called for--a simplified, cohesive method predicated on relevant science (i.e. the science of the courtroom), and how it is practiced by scientists -- and not philosophers. Moreover, rather than adopting alien words with particular terms of art, (e.g., reliability and validity) and bastardizing

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38 Barbara P Billauer, Patent, Method and system for providing interactive legal training, Issued: March 1, 2007, Application number 20070048720.
them, I suggest casting the scientific method in familiar legal language such as competency and materiality\textsuperscript{39} should help produce a paradigm more readily embraced by the judiciary.\textsuperscript{40}

**The Errors Daubert Wrought**

Before attempting to create a judicial gatekeeping paradigm, we must first agree that the science of the courtroom arises from biology, chemistry and Newtonian physics.\textsuperscript{41}

Considerations of the rarified world of Quantum physics—which may explain how Universe was born and functions--are inapplicable to matters directly relating to human activity. This may seem rudimentary. However, one conclusion of this paper is that the root of the Daubert-dilemmas derives from misappropriation of philosophies associated with cosmological constants, constraints and considerations irrelevant to the world of courtroom evidence.

Next, we identify the issues Daubert presents, the first two of which will be addressed in this paper:

1. What is science (and scientific knowledge)?

2. What is good science?


\textsuperscript{40} I take note the following comment from the NRC report: “[S]o long as we have our adversarial system in much its present form, we are inevitably going to be stuck with approaches to expert evidence that are imperfect, conceptually unsatisfying, and awkward. It may well be that the real lesson is this: those who believe that we might ever fully resolve—rather than imperfectly manage—the deep structural tensions surrounding both partisanship and epistemic competence that permeate the use of scientific evidence within our legal system are almost certainly destined for disappointment,” citing 73 BROOK L. REV. 1009, 1033(2008).

\textsuperscript{41} It is the trajectories of bullets and the torque of a screw, which fall under the rubric of Newtonian physics, that find themselves litigated. While many scientists believe Newtonian physics is ‘wrong,’ the errors are quantitative (i.e. that the results are not reliable or precise) -- about $10^{14}$ I suggest that for court use we can safely say they are ‘reliable or precise enough’. This appears to be the view of Justice Breyer, who wrote that “a courtroom is not a scientific laboratory, and hence the objective of the judge must be “to seek decisions that fall within the boundaries of scientifically sound knowledge and \textbf{approximately} reflect the scientific state of the art,” [emphasis supplied], Stephen Breyer, “The Interdependence of Science and law,” 280 SCIENCE 237 (24 April, 1998). This view would not, however, satisfy Popper.
3. What is the scientific method? Is there a difference between reliability and validity?

4. What constitutes adequate scientific proof? What are standards and burdens of proof?
   How do we prove scientific causation in light of Joiner,\textsuperscript{42} which requires courts to vet evidence on methodology grounds by evaluating the nexus of opinion and results (i.e. permissible inferences)?

5. What ‘novel science’ is sufficiently ‘scientific’ to pass evidentiary muster?

B. The five errors in the ‘Daubert Postulates’:

And finally, we dissect out the five errors that Daubert establishes:

Simply stated, Daubert says or implies that:

1. Science is theories that can be falsified (tested and proven false).

2. Good science is science which has been tested and not falsified; (at least not yet).

3. The scientific method is based on deductive reasoning.

4. Validity and reliability “are no different from a hen’s kick.”\textsuperscript{43}

5. Unquestioned reliance on peer review is an acceptable method to evaluate novel science.

I submit these conclusions are plain wrong. I further argue that these five flawed conclusions have negatively impacted the state of the law, causing significant scientific errors to be enshrined under the guise of precedent\textsuperscript{44} and generating such bizarre holdings\textsuperscript{45} that relying on \textit{Daubert} has itself perpetuated junk science\textsuperscript{46} self-replicated in the form of \textit{stare decisis}.\textsuperscript{47}

\textsuperscript{43} Daubert, supra fn. 9
\textsuperscript{44} “Courts often ‘affirm admissibility citing earlier decisions rather than facts established at a hearing…. Much forensic evidence—including, for example, bite marks and firearm and tool mark identifications—is introduced in criminal trials without any meaningful scientific validation, determination of error rates, or reliability testing to explain the limits of the discipline.’” \textbf{NATIONAL SCIENCE COUNCIL REPORT}, 82-284 at 45.
Thus, by way of example, in *United States v. Green,* Judge Gertner acknowledged that tool-mark identification testimony ought not be considered admissible under Daubert. But the judge pointed out that “the problem for the defense is that every single court post-Daubert has admitted this testimony, sometimes without any searching review, much less a hearing.”

C. Objectives

I demonstrate, here, that the theoretical underpinnings of Daubert are flawed, although I am hardly the first to do so. What is new and different about this paper is the systematic use of scientific example to debunk Popper’s understanding (philosophy) of science, rendering its use inapposite for the courtroom:

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45 See Manko v. United States, 636 F. Supp. 1419 (W.D. Mo. 1986), holding that a relative risk of 2 is equivalent to ‘more probable than not’ causation. Eventually, later courts produced a policy-based rationale for its continued use: “The use of scientifically reliable epidemiological studies and the requirement of more than a doubling of the risk strikes a balance between the needs of the legal system and the limits of science,” Merrell-Dow Pharmaceuticals Inc. v Havner, 53 S.W.2d 706 (Tex.1997).


47 Judge Gernter (in United States v. Green, *supra*) specifically admitted that, “I reluctantly [admit the evidence] because of my confidence that any other decision will be rejected by appellate courts, in light of precedents across the country, regardless of the findings I have made,” NATIONAL SCIENCE COUNCIL REPORT, at page 45.


50 Nicholas Dyke reaches this conclusion, in *Tangled Web of Guesess; A Critical Assessment of the Philosophy of Karl Popper,* London: Libertarian Alliance, (1996) relying on P.A. Schilpp and Anthony O’Hear for support. Dykes notes that “When *The Logic of Scientific Discovery* first appeared, Popper's contemporary, Hans Reichenbach, asserted bluntly: "The results of this book appear to me completely untenable... I cannot understand how Popper could possibly believe that with respect to the problem of induction his investigations mean even the slightest advance.”

51 *Debunking Popper* was previously published in 24 REASON PAPERS, A JOURNAL OF INTERDISCIPLINARY NORMATIVE STUDIES, Tibor R. Machan, Ed. (Fall, 1999) at 5-25.
First I show that the foundation-stone of Daubert: mis-reliance on Karl Popper’s views of science and especially his insistence on falsification and falsifiability is patently incompatible with scientific practice; second, I demonstrate that Popper’s view of science is incompatible with legal theories, such as joint or multi-causation, substantial causation, the burden of proof and situations where identifying the causal actor is impossible, and third, I propose an alternative view of what science is and what good science is.

Regardless of its flaws, one must acknowledge the noble intentions of the Daubert Court. With the sophisticated science relevant to today’s litigation, e.g., genetic engineering, cloning technology and birth defect causation, for which we are wanting in understanding, ‘pseudo-scientific or para-scientific explanations (testimony) may easily be confused with the ‘real thing.’ And while pseudo-sciences have contributed to societal advance, even promoting our

54 “For the most part, we don’t know how birth defects come about,” Daubert on remand.
55 “Daubert’s general acceptance factor does not “help show that an expert’s testimony is reliable where the discipline itself lacks reliability, as for example, theories grounded in any so-called generally accepted principles of astrology or necromancy.” STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD, Committee on Identifying the Needs of the Forensic Science Community of the National Research Council, National Academies Press, Washington, D.C., (2009) at 45, citing commentary to Federal Rules of Evidence 700, 702.
understanding of the universe, we must guard against the temptation to consider intriguing, but unsubstantiated, research as ‘science’ even if produced by reputable scientists, ever-mindful of the fact that gatekeepers without rudimentary schooling in science and technology are especially vulnerable to persuasion by the superficial: fancy titles, alphabet strings of degrees or distinguished grey-beards. We begin our mission, then, by examining what ‘science’ is according to Popper as relied on by Daubert:

II. Falsifying Falsifiability

A. Science 101 according to Daubert-93:

57 The practice of astrology added valuable insights into astronomy and navigation; alchemists developed basic laboratory techniques, theory, terminology, and experimental methods still used today, faith-healers introduced the mind-body connection into modern medicine, Shamanism brought knowledge of the placebo effect and Chinese medicine has become mainstreamed from ‘alternative’ medicine to covered insurance expenses. Notable scientists, such as Paracelsus, Jābir ibn Hayyān, (often called the father of chemistry), Robert Boyle (the father of modern chemistry) and Sir Isaac Newton were either alchemists or influenced by alchemy. Rabbi Abraham Zacuto, Court Astronomer to King John II of Portugal and inventor of the astrolabe was also an astrologer and Johannes Kepler was an accomplished astrologer who made his living as a fortune-teller! (Gore, infra.)


61 “The judicial system is encumbered by, among other things, judges and lawyers who generally lack the scientific expertise necessary to comprehend and evaluate forensic evidence in an informed manner….” STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD, supra.
‘Science’, according to the ancients, simply means ‘knowledge.’”

But the Daubert Court has a different take. They begin by telling us that "scientific" implies grounding in the methods and procedure of science, and that "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." [emphasis supplied]. But then the court reverses itself, saying that "science is not an encyclopedic body of knowledge about the universe. Instead, it represents a process for proposing and refining theoretical explanations about the world that are subject to further testing and refinement. Indeed, scientists do not assert that they know what is immutably `true'--they are committed to searching for new, temporary theories to explain, as best they can, phenomena." [emphasis supplied].

Getting itself further bolloxed up, the Daubert court reformulates its view of ‘science’ based on the beliefs of Karl Popper (1902-1994) as represented by Michael Green. Popper also tells us that “we must not look upon science as a ‘body of knowledge,’ but rather a system of hypotheses; that is to say, as a system of guesses or anticipations, which in principle cannot be

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62 Cohen and Nagel. Infra, P.191. “The German Wissenschaft is still used to mean both knowledge and science,” at note 1; The words for knowledge in Hebrew “Yedah” and science “Madah” derive from the same root.
63 Daubert, supra.
64 Susan Haack, Federal Philosophy of Science: A Deconstruction – and A Reconstruction, pp.122-155, reprinted in Susan Haack, EVIDENCE MATTERS: SCIENCE, PROOF AND TRUTH IN THE LAW, Cambridge University Press (2014). Professor Haack not only accuses Green of misunderstanding Popper, but also alludes to the possibility that Green never actually read Popper in the original, only summarized in an article by David Faigman Haack at p. 139 n. 76. This means that the current legal view of science is based on triple hearsay: the court relied on Green who relied on Faigman who relied on Popper.
65 citing Michael D. Green, Expert Witnesses and Sufficiency of Evidence in Toxic Substance Litigation: The Legacy of Agent Orange and Bendectin Litigation, 8 NORTHWESTERN UNIVERSITY LAW REVIEW, no 3 (1991-2) at/643-99,644
Dumping Daubert, Popping Popper and Falsifying Falsifiability

justified … but which we work as long as they stand up to tests, and of which we are never justified in saying that we know that they are ‘true’ or ‘more or less certain,’ or even ‘probable.’”

66 (!) The court rejects the notion of speculative statements as science before embracing Popper - whose very notion of science is that it only includes speculative hypotheses or conjectures and these cannot even be considered “probable.” Taken to its logical conclusion, Popperism would mean that a scientific statement proffered by a plaintiff cannot sustain a civil verdict – which is based on only ‘probable certainty.”

We next learn that according to the view of Popper as embraced by the Daubert court:
"the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability."

Citing Popper’s Conjectures and Refutations: The Growth of Scientific Knowledge, 67, 68 the Court tells us that "Scientific methodology today is based on generating hypotheses and testing them to see if they can be falsified; indeed, this methodology is what distinguishes science from other fields of human inquiry…. [T]he criterion of the scientific status of a theory is its falsifiability, or refutability, or testability.”

An amicus brief from the American Association of the Advancement of Science confirms this view: “Scientists conduct rigorous experimental testing in an attempt to falsify

66 Popper’s description would apply to Ptolemaic astronomy and alchemy.
68 Popper’s seminal work on the subject THE LOGIC OF SCIENTIFIC DISCOVERY,” Routledge Press (2002 edition), first published in German in 1934 before being translated to English in 1959 was written 60 years before Daubert and thirty years before the cited ‘Conjectures’.
69 Daubert-93 supra citing Michael Green; Moore v. Ashland Chem. Inc., 126 F. 2d. 679. 685 (5th Circ., 1997), See also Haack, supra at124.
hypotheses, its channeling Popper, who notes that science is dependent on “falsifiability, falsification, deductive reasoning and temporality of its work-product (which may or may not be knowledge) i.e. the ethereal nature of ‘truth.’”

By falsifiability, Popper means first that the proposed precept is capable of being tested, If so, Popper then asks, has it been falsified? Popper’s initial view is that the two concepts are inseparable: In the testing phase we are looking to disprove an assertion, not verify it.

Hypotheses that withstand falsifiability are presumed true until proven otherwise, meaning we allow it to remain in our arsenal of ‘scientific knowledge’ on a temporary basis, since we ‘know’ all ‘science’ is capable of being disproved. To restate Popper’s view, he means that the proffered hypothesis is testable -by showing it is wrong. If, however, it hasn’t been proven wrong (no matter how many times we test it), Popper asserts that the information is regarded as true – but only provisionally – that is until proven otherwise, i.e. until another test comes along and falsifies the prior results, which can never be considered reliable because science is ever-changing.

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70 Haack supra at 137.
71 Popper recognized there might be deficiencies and limitations in his proposal: “I admit that my criterion of falsifiability does not lead to unambiguous classification. (p. 61); “In section 6, I tried to define empirical science with the help of the criterion of falsifiability; but I was obliged to admit the justice [‘justification’ in 1959edn] of certain objections.” P.32; I promised a methodological support to my definition...empirical science may be defined by means of its empirical rules.... A supreme rule is laid down. It is the rule which says that other rules of scientific procedure must be designed in such a way that they do not protect any statement in science against falsifiability. (1959 ed at 54.), “The Logic of Scientific Discovery (1934, 2002 edn.).
72 Fifty years later Popper backtracks. (See “Realism and the Aims of Science, from the Postscripts to The Logic of Scientific Discovery pp. xx-xxiii). No one bothered to tell the Supreme Court that they were relying on ‘outdated Popperisms.’
73 Popper, SELECTIONS, supra at 12.
74 “Reliable,” means “consistently good in quality or performance; able to be trusted.”
75 His view of pre-science (i.e. scientific statements that cannot as yet be tested), is that they are considered as metaphysical precepts. Should they be later shown wrong, (accidentally or otherwise), they now become falsified science. Thus like Schrodinger’s cat, they are either
Popper, via Daubert, thus tells us *falsifiability* is the *sine-qua-non* of science, “These considerations suggest that not the *verifiability* but the *falsifiability* of a system is to be taken as a criterion of demarcation.” [emphasis in original]  

Thus we find one Popper apologist rhetorically asking, “But then what then do scientists do, if they don’t [affirmatively] prove things?” before supplying the Popperian response: “The most important action scientists take is to find errors…. Science is above all its method—essentially the critical method of searching for errors. In the process, they filter error from theories and methodology, but they do not prove that the surviving methodologies—those that are left standing or those that are changed to correct errors—are valid.” In a sentence, this author claims: “Scientists *disprove* things…..”

In sum, the Popperian view immortalized in Daubert, asserts that “an explanation or hypothesis that cannot be subject to the possibility of rejection based on observation or experiment cannot be regarded as scientific.” The mantra is now well entrenched in case law. Thus in *Moore v. Ashland Chemical*, the court held, “theoretically...hypotheses are not metaphysics or wrong science, depending on the time of viewing. “For the transition between metaphysics and science is not a sharp one: what was a metaphysical idea yesterday can become a testable scientific theory tomorrow.” Popper Selections, op cit.ch 8, “The Problems of Demarcation,” (1974) at 123, see also, THE LOGIC OF SCIENTIFIC DISCOVERY, where Popper excludes from the purview of ‘what is scientific,” experiments which cannot be replicated, at 24.

77 Jan Beya and Daniel Berger, *Scientific Misconceptions Among Daubert Gatekeepers: The Need for Reform Expert Review Procedures,* DUKE LAW REVIEW http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1221&context=lcp; One of the authors is a physicist; the other a lawyer. The comments on epidemiology should be read with extreme care.
affirmatively proved only falsified. Of course, if a hypothesis repeatedly withstands falsification, one may tend to accept it … [as] true.”

In vetting scientific evidence, per Popper, Judges, merely need to ask if the evidence can be and has been falsified. Even assuming, arguendo, Popper is correct, the legal literature reveals that the courts aren’t playing by Popper’s rules! The ‘temporary’ scientific findings have become entrenched in law with all the power of *stare decisis*— but without the constant attempts at falsification Popper demands. Since judges are far more comfortable relying on legal precedent than subjecting a scientific ‘non-truism’ to review each time it comes to court, we could hardly expect otherwise.

It must be noted that important philosophers, both contemporaries of Popper and of Daubert, reject Popper’s views. Paul Feyeraband, once a student of Popper’s, in a scathingly acid attack contends that “Popper’s theory is a contribution to confirmation theory and has nothing to do with science.” In her exhaustive treatment, Susan Haack demonstrates the flaws

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80 Morris Cohen and Ernest Nagel, criticized “falsification” as erroneous and assert that scientific proof is based on inductive verifiability,” supra, (2002 edn) at 383.
of Daubert’s reliance on Popper from a philosophical\(^{84}\) or epistemological perspective, concluding that “to Popper all scientific theories are in effect ‘speculative hypothesis,’”\(^{85}\) which therefore would be of little use to a jury (as not being reliable) and hence outlawed from court. Other scholars concurred\(^{86}\) and “objected to these passages [outing falsification] as philosophically naive, unhelpful,\(^{87}\) or out of date. As one noted epistemologist quipped, the Court was guilty of “mixing up its Hoppers and its Pempels.”\(^{88}\) [sic]

Chief Justice Rehnquist gave a clear warning regarding the dangers of using falsifiability as the definer of ‘science,’ in his Daubert dissent.\(^{89}\) “I defer to no one in my confidence in federal judges; but I am at a loss to know what is meant when it is said that the scientific status of a theory depends on its "falsifiability," and I suspect some of them will be, too.”\(^{90}\)


\(^{86}\) the physicist, Professor David Goodstein, says in “How Science Works” “I know of no example of a Nobel Prize awarded to a scientist for falsifying his or her own theory.” http://www.its.caltech.edu/~dg/HowScien.pdf

\(^{87}\) It appears judges are less than clear on the meaning of falsifiability. In telephone interviews with written follow-up, only 5% of 400 state trial court judges gave answers that indicated a clear understanding of the notion. Sophia Godowsky et al., "Asking the Gatekeepers: A National Survey of Judges on Judging Expert Evidence in a Post-Daubert World", 25 LAW & HUM. BEHAV. 433, 433 (2001).


\(^{89}\) Justice Rehnquist appears to be focusing on the incomprehensibility of the concept as it applies in real life, however his view also respects the notion of judicial minimalism as enunciated by Cass Sunstein, “who proposed that judges should generally avoid broad rules and abstract theories and attempt to focus their attention only on what is necessary to resolve particular disputes.” See “Originalism v. Minimalism,” CATO POLICY REPORT, November/December 2014 at 9-11.

These objections have not infiltrated legal thinking, however, and we continue to find the oft-repeated sentiment that ‘falsifiability’ is the most important characteristic separating science from other forms of knowledge. In fact, Popper’s falsifiability has been so entrenched\(^{91}\) that even stinging criticism from the scientific community has been unable to dislodge it:\(^{92}\) Sheila Jasanoff, the Director of the Program of Science and Technology at Harvard University sharply attacked the otherwise well received piece (at least by the legal community) of Francisco Ayala of the American Association for the Advancement of Science and Bert Black, and early and prolific Daubert commentator, for their mindless repetition of the Daubert mantra: “In their insistence on a unitary model of ‘good’ scientific practice and their unquestioning acceptance of ‘testability’ and “falsifiability” Ayala and Black display almost complete disregard for findings in contemporary historical, political, and sociological studies of science.”\(^{93}\)

**B. The Consequences of Falsifiability:**

What confounds matters further is Popper’s unfortunate choice of two similar terms to predicate his delineation of science vs. non-science, i.e., ‘falsifiability’ (i.e. the capacity to test a theory and disprove it or the capability of a theorem to be so tested) and falsification (the actual disproof of a scientific assertion, i.e. when a hypothesis is falsified). He acknowledges that it is important to “clearly distinguish between the terms [with]… falsification being a criterion for the

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\(^{91}\) As electro-chemist George Gore noted in 1878, “attractive errors have a most tenacious existence” and “false notions have a propensity to linger in the literature,” see “The Art of Science,” infra.


empirical character of a system of statements.”\textsuperscript{94} and it has been said that according to Popper, “it is falsification, and not falsifiability, that matters.”\textsuperscript{95} In this regard, “Daubert’s parenthetical phrase, ‘has been tested,’ is far more significant than the hypothetical, ‘can be tested,’ and the blurring of these matters in Justice Blackmun’s opinion … has permitted obvious mis-applications of the demand for testing.”\textsuperscript{96}

Popper, however, never seems to have actually said this. In fact, he seems to state the contrary: “I do not demand that every scientific statement \textit{must have in fact been tested} before it is accepted. I only demand that every such statement must be \textit{capable of} being tested;” \[emphasis in original]\textsuperscript{97} Hence, it is not clear whether the legal standard for defining science is ‘falsifiability’ or actual attempts at ‘falsification.’ \(\text{It must be noted, however, that Popper disdained definitions as unnecessary and confusing;}\textsuperscript{98} \text{he even “assails the undeservedly widespread dogma that definitions, and the precision fondly imagined to spring from them, are essential to any logical articulation of our thoughts, and even to plain clear thinking.”}\textsuperscript{99} And

\begin{footnotesize}
\begin{enumerate}
\item Popper, THE LOGIC OF SCIENTIFIC DISCOVERY, (2002 edn) at 66.
\item Daubert, supra. “Ordinarily, a key question to be answered in determining whether a theory or technique is scientific knowledge … will be whether it can be (and has been) tested, at 593, 600.
\item Popper, THE LOGIC OF SCIENTIFIC DISCOVERY, (2002 edn.), at 26. He pointedly adds: “In other words, I refuse to accept the view that there are statements in science which we have, resignedly, to accept as true merely because it does not seem possible, for logical reasons, not to test them.”
\item “Definitions do not play any very important part in science…. Our ‘scientific knowledge’… remains entirely unaffected if we eliminate all definitions…. Definitions never give any factual knowledge about ‘nature’ or about the ‘nature of things’…Definitions… are never really needed, and rarely of any use” [RASC xxxvi]” See Nicholas Dykes, “Debunking Popper: A Critique of Karl Popper’s Critical Rationalism http://www.libertarian.co.uk/lapubs/philn/philn065.htm.
\item Popper, \textit{supra}, 1959 p.16. See also POPPER SELECTIONS, ed. David Miller at. 15. Miller also notes that Popper utilizes “no organized or systematized method for analysis … for deciding what science is, or how it is done (inductive v. deductive) or how it is proven or established (the scientific method). “I do not care what methods a philosopher (or anybody else) may use so long as he has an interesting problem, and so long as he is sincerely trying to solve it… [perhaps with
\end{enumerate}
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finally, where necessary he redefines his terms, giving falsifiable and falsifiability two different meanings, thereby further increasing confusion. So perhaps at the end of the day Popper wouldn’t have cared much whether the key criteria is falsification or merely falsifiability, as long as we recognize the criticality of disproof as part of the scientific method.

Popper does care, however, about the impact of a falsified result, recognizing that a falsified result which eliminates a theorem from our arsenal of scientific knowledge was bound to elicit confusion. Popper’s key position appears sacrosanct, however: once a theory has been falsified, the approach should be entirely rejected without sentimental attachment to keeping the theory on life-support by ad hoc explanations. “Science proceeds on the assumption that contradictions are impermissible and avoidable ... once a contradiction is admitted, all science must collapse.” Sadly for Popper (and Daubert) – this approach does not work in biology and chemistry, as we shall see, thereby rendering Popper’s philosophy unsuitable for forensic use. Eventually, Popper ‘himself’ comes to realize the infirmities of his position, because later he “stresses, as he [himself] has pointed out,” that every empirical falsification should not be taken too seriously.” However, it’s too late. This postscript never made its way to the legal case

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100 See Karl Popper, REALISM AND THE AIM OF SCIENCE: FROM THE POSTSCRIPTS TO THE LOGIC OF SCIENTIFIC DISCOVERY, Routledge Press (1992), at xx-xxiii, where he gives one meaning as “logical-technical,” and the other it seems means “demonstrable.”

101 As he says, “an entire literature rests on the failure to observe this distinction.” Ibid.

102 Popper constantly proposes new definitions only to retract or qualify them later. See Popper, THE LOGIC OF SCIENTIFIC DISCOVERY (2002 edn.) at 251.

103 Ibid (1959 edn.) at 86.


105 Nicholas Dykes, DEBUNKING POPPER; A CRITIQUE OF KAR POPPER’S CRITICAL RATIONALISM, Philosophical Notes No., 65 Libertarian Alliance (2003).

106 Popper, REALISM AND THE AIM OF SCIENCE, op. cit. at xxiii.
books and we are stuck with Popper’s initial statements as proffered by the legal philosophers who offered him to the Court.

C. Popper’s Past as Prologue: Quantum Obsession and Skewed Motivation

1. The Source-point of Popper’s Knowledge

Popper’s overall view of science is rather amorphous, hardly as pristine or exact as we would expect. Thus, he says: “what is to be called a ‘science’ and who is to be called a ‘scientist must always remain a matter of convention or derision,”107 and at one point he lumps biological phenomenon108 with sociological phenomenon.109 Nevertheless, he unabashedly tell us that to him, “all science is cosmology,”110 111 His focus on falsifiability apparently derives from this obsession with quantum physics, and Popper tells us that “in modern theoretical physics, I and others see the most complete realization to date of what I call ‘empirical science.’”112 [emphasis supplied]. Popper was not alone in this belief; it was a conviction Ernest Rutherford113 (of the “All science is physics or stamp collecting” school) would have applauded.114

108 HaCohen says that biological science was of interest to Popper, especially the biological basis of thought. Whether this is in fact the case, Popper’s language speaks for itself.
109 Karl Popper, THE LOGIC OF SCIENTIFIC DISCOVERY, (1934, 2002 edn.) at 81: In regards to the biological or sociological phenomenon he looks at science as a “tool, or an instrument, comparable perhaps to some of our industrial machinery.”
111 According to NASA, cosmology refers to “the scientific study of the large scale properties of the universe as a whole, in other words ‘the Big Bang.’ http://map.gsfc.nasa.gov/universe/
113 Ernest Rutherford, the “father of nuclear physics,” was the 1908 Nobel Laureate in Physics.
114 J.B. Birks, RUTHERORD AT MANCHESTER, Heywood and Co., London (1962); some attribute the quote to Lord Kelvin.
Chauvinistic in his views of physics, Popper has strong opponents in the scientific community. JD Bernal says quantum physics is ‘a world of its own,’ As far back as 1878 George Gore, the chemist who worked with phosphorus (and invented matches), noted that biology was far more complex than (classical) physics or chemistry. Modern day theorists such as Richard Lewontin and Nancy Cartwright would agree, holding that at the very least, the biological sciences are inherently different from physics.

“Traditionally, philosophers of science have focused on physical laws, which were taken to be at least true, universal statements that support counterfactual claims. But, although this claim about laws might be true with respect to physics, laws in the special sciences (such as biology, psychology, economics etc.) appear to have—maybe not surprisingly—different features than the laws of physics. … [and] with the success especially of the biological sciences it became clear that there is genuine scientific knowledge that does not conform to the paradigm of physics.”

115 Karl Popper, CONJECTURES AND REFUTATIONS; THE GROWTH OF SCIENTIFIC KNOWLEDGE (1989) at. 84.
116 X-Ray crystallographer and science historian, J.D. Bernal thought that “physics is an unusual science, being the combination of experiment and self- contained theory. There is undoubtedly a view now that the experiment is really a kind of unfair physics and that if we only thought hard enough we would have all the answers without bothering to experiment.” See JD Bernal op cit. at page 302.”

117 G. Gore, THE ART OF SCIENTIFIC DISCOVERY, infra at 143,146.
119 Cartwright notes that until very recently all sciences except physics were thought of special sciences. “That means that their laws hold at best only ceteris paribus,” meaning they hold only so long as nothing from outside the domain of the theory interferes.” Thus biology and chemistry requires a greater degree of flexibility in assessment than evidence from physics, which is believed to be a closed system. Roger Penrose, THE LARGE, THE SMALL AND THE HUMAN MIND, Cambridge University Press (1997) at 23,p 166.
Nevertheless, Popper rigidly applies his system of falsification and falsifiability across the board of sciences, even though, as we will see in this paper, they have no place in biology, chemistry, or the Newtonian physics of the court docket.

2. A Brief Chronology of Popper’s Philosophy

Before demonstrating the inaptitude of Popper’s philosophy to the quotidian science of the courtroom, it might be useful to consider its derivation. It is commonly believed that Popper’s antithesis to questionable science derived from his opposition to Freud and Adler’s claim that psychotherapy was a bone fide science and his objections to Marxism. This is undoubtedly true, but it is merely a manifestation of Popper’s ever-changing mindset throughout the 1920s, crystallized in the thirties as a hard core reaction to developments in modern physics. Popper, himself, fosters the notion that his dissatisfaction with Marxism and psychoanalysis precipitated his thoughts on science, but his revisionist history in “Conjectures and Refutations,” has been seriously criticized. It appears Popper continued his ties to the

121 Ceteris Paribus Laws, Stanford Encyclopedia of Philosophy, Mar 14, 2011, e.g., “Mendel's Laws—are usually taken to “have exceptions”, to be “non-universal” or “to be ceteris paribus laws”. Whether the laws of physics and the special sciences differ is one of the crucial questions motivating the debate on ceteris paribus laws.” ceteris paribus comes from the Latin “all other things being equal.” http://plato.stanford.edu/entries/ceteris-paribus/
122 As Popper tells us in CONJECTURES AND REFUTATIONS, supra.
124 Karl Popper, CONJECTURES AND REFUTATIONS, supra (2002 edn,) at 43, see generally chapter 1.
125 In KARL POPPER-THE FORMATIVE YEARS 1902-1945: POLITICS AND PHILOSOPHY, HaCohen notes that Popper’s autobiographical rendition of the timing of his discoveries “must be radically revised.”
Dumping Daubert, Popping Popper and Falsifying Falsifiability

Socialist movement as late as 1931 and may not have actually read some of Marx’s key works until 1932 at the earliest.

Thus, in 1919, the year Popper gives for his epiphany, (he says began to “feel more and more dissatisfied with …the Marxist theory of history, psychoanalysis and individual psychology; and I began to feel dubious about their claims to scientific status”), Popper was seventeen years old. His philosophy of science was conceived after hearing Einstein lecture (in 1919) and immediately on reading an article of Einstein’s in December of that year. Not surprisingly, Popper was ‘overwhelmed’ although apparently didn’t understand much at the time. 1919 was also the year Einstein’s relativity predictions were confirmed by Arthur Eddington, which decidedly had a major impact on the young man. And 1919 was also the year that Popper met Adler. Popper’s attacks on Freud and Adler, where he contrasted their work with Einstein and Eddington, however, didn’t surface until years later.

126 Malachi Haim Hacohen in, KAR POPPER THE FORMATIVE YEARS 1902-1945 at 168 indicates Popper was contributor to the Association of Socialist Students magazines as late as 1931.

127 Phil Parvi, KARL POPPER, Bloomsbery Academic Press ( ) at 100, notes that Marx’s works on Economics weren’t translated into German until 1932 and the Gundrisse didn’t come out in German until 1939.


131 Don Grant and Edwin Harari, Psychoanalysis, Science and the seductive theory of Karl Popper,” supra.


133 Eddington’s work sought to prove Einstein’s theories, not to falsify or disprove them.

134 Don Grant and Edwin Harari, supra “Psychoanalysis, Science and the seductive theory of Karl Popper,” 39 Australia and New Zealand Journal of Psychiatry 446-452, (2005),
http://www.glerl.noaa.gov/seagrant/ClimateChangeWhiteboard/Resources/Uncertainty/Mac1/grant05PR.pdf
Popper says he came up with the falsification concept in 1920 (when he was 18) at the time he was studying music and performing as a musician, and in 1923 when he became interested in the problem of induction - he was working as a cabinetmaker.\textsuperscript{135} Thereafter, he became qualified first as a primary school teacher, and then in 1929 as a secondary school teacher. One biographer, W.W. Bartley, ascribes Popper’s philosophy of science originating, not in his opposition to Marxism and psychoanalysis, but to his experience as a primary school teacher in the mid to late 1920s.\textsuperscript{136}

A few years later, (Popper claims “it must have been in 1928 or 1929“)\textsuperscript{137} Popper proposed his conception of demarcation and formalized the falsification idea. This timeline puts him squarely in the midst writing his doctoral dissertation -- on gestalt psychology, which he did right after writing his thesis for his teacher training certificate in 1927 – also on gestalt psychotherapy.\textsuperscript{138} In point of fact, Malachi Haim Hacohen dates Popper’s transformation to 1929-1932, and notes that falsification did not become Popper’s criterion for demarcation until 1932, before which time Popper was a follower of the inductivist school.\textsuperscript{139}

Since Popper had no formal training in the natural sciences (his degrees were in in psychology and economics),\textsuperscript{140} the exciting discoveries of the new science, quantum mechanics, compelled him to educate himself – especially as he began his stint as a secondary school

\textsuperscript{135} Malachi Haim HaCohen, op cit.
\textsuperscript{136} WW Bartley III. says Popper’s “methodology .. bears a close resemblance on many points with the work of Piaget.” And Popper's view of conjecture and refutation … is also close to Piaget.”

\textsuperscript{137} Popper, CONJECTURES AND REFUTATIONS, (2002 ed.) at. 47, 51.
\textsuperscript{138} WW Bartley, op cit.
\textsuperscript{139} Popper claims he became interested in the problem of induction in 1923 but did not fully appreciate the connection with demarcation until 1928. (CONJECTURES AND REFULATIONS, p. 55.)
\textsuperscript{140} He chose psychology and the History of Music as the subject matter for his doctoral examination.
physics teacher in 1930: Popper explains: “At the time (1930) … I began writing my book, modern physics was in turmoil…. from the very beginning there was dissension and confusion. The two greatest physicists, Einstein and Bohr, perhaps the two greatest thinkers of the twentieth century, disagreed with one another.”

Somehow Popper became embroiled in a debate about the work of Neils Bohr, which Popper understood to mean that uncertainty relations must be viewed subjectively. About this time, Albert Einstein, Boris Podolsky and Nathan Rosen (of the Technion) wrote an article discussing whether Quantum Mechanical descriptions can ever be considered complete. They argue in the negative. Soon after its publication, the article was criticized by Bohr. And here is where Popper jumped into the fray - claiming Bohr’s views supported subjectivity in science and abandoned scientific realism, a notion that horrified him, motivating him to insert himself in a dispute he refused to let go of.

Popper’s view, that “the basic predictions of quantum mechanics should continue to be tested, with an eye towards falsification rather than merely adding of decimal places to confirmatory experiments,” drove him to propose his own experimental method. But Popper’s experiment was a failure, trounced not only by Bohr but by Einstein, who demonstrated that Popper’s proof didn’t prove (or disprove) anything. At least having some integrity on this

141 William M. Shields,” Karl Popper’s Quantum Ghost,” Department of Science and Technology Studies, Virginia Tech, Falls Church, Virginia. highc.king@verizon.net http://www.tvsfpe.org/_images/popperquantum.pdf.
144 William M. Shields, KARL POPPER’S QUANTUM GHOST, Department of Science and Technology Studies, Virginia Tech, Falls Church, Virginia, P. 68 and 71.
145 The dispute came to a head at a scientific conference in Italy, per Shields, but Popper and Einstein were in correspondence for months thereafter, correspondence in which Einstein rejects
point, Popper conceded that his experiment “has been shown to be in principle impossible (from the quantum –theoretical point of view).” 146 Nevertheless, the public humiliation of his failed experiment had a deep impact. William Shields of Virginia Tech tells us that for the next fifty years Popper worked on reestablishing his credibility in the field of quantum mechanics, continually trying to refine an appropriate experiment - and in the process entrenching his falsification ideas.

In fact, Popper’s antagonism to Bohr’s viewpoint (if not to Bohr himself) bordered on the emotional, likely triggered by Bohr’s suggestion that “mere knowledge” of things had an observable physical effect. “To Popper this was nearing something like belief in the paranormal.”147 Shields claims that to Popper, the issue was not the difference between science and non-science, (as we lawyers might have hoped and as Daubert purports to represent) but between the physical reality of things and human knowledge of those things.148

Popper’s proposed experiment, While Popper eventually resigns himself to this failure (at least for the time) conceding that “the letter from Albert Einstein …briefly and decisively disposes of my imaginary experiment,” he takes issue with Einstein over determinism, and refuses to budge: Regarding “the problem of subjective probabilities, and of drawing conclusions from nescience [lack of knowledge or ignorance], in this, I still disagree with Einstein.” [emphasis supplied].Appendix, xii. “A letter from Albert Einstein, 1935 (2002 ed.) at 481].

147 William M. Shields, Karl Popper’s Quantum Ghost, Department of Science and Technology Studies, Virginia Tech, Falls Church, Virginia, 68 and 71.

148 After getting hopelessly bollixed up in now differentiating between a third, hybrid concept of falsifiable as distinct from falsifiability and falsification, Popper complains that none of these definitional issues would make any difference, “but for the fact that it has led some people to abandon rationalism in the theory of science, and to tumble into irrationalism. For if science does not advance rationally and critically, how can we hope that rational decisions will be made anywhere else? A flippant attack on a misunderstood logical-technical term has thus led some people to far-reaching and disastrous philosophical and even political conclusions.” Karl Popper, REALISM AND THE AIMS OF SCIENCE: FROM THE POSTSCRIPT TO THE LOGIC OF SCIENTIFIC DISCOVERY, at xxiii. [emphasis supplied].
Shields recounts that “Popper tells us in the opening pages of Schism that the ‘strongest reason for my own opposition … lies in its claim to finality and completeness,’ [thus the requirement to continued re-testing]. Popper designed and promoted “his experiment” not so much to prove quantum mechanics wrong, but to restore the “conjectures and refutations” attitude in quantum theory.” 149

Popper’s relentless response may have been an over-reaction to a prevalent mindset of the day: mindless and uncritical acceptance of a popular philosophy. Alternatively, it might have been a relic of Popper’s disenchantment with the Marxism he flirted with in his teens. It might have been further stoked by the unchecked spread of fascism. Or possibly it was the annexation of Austria by the German Reich, resulting in Popper’s exile150 to New Zealand in 1937151, coupled with Popper’s failed mind-experiment. Or it might have been the compilation of all these forces that generated his dogmatic152 anti-dogma-polemic against totalitarian thought, his insistence on continued testing and an obsessive need to attempt to falsify current knowledge.

Popper himself notes the emotional impact: “I could not get over my mistaken thought experiment,” until sometime in 1948 or 1949… “I took this blunder very much to heart…I thought that my blunder proved my incompetence…. I felt defeated… I was unable to resist the tremendous impact of Bohr’s personality.”153

149 Ibid.
150 Haack, op cit. at 125.
152 “Popper acknowledges the’ value of a dogmatic attitude,’ (mostly, it seemed when used to support one of his own maxims) “Somebody [has] to defend a theory against criticism,” (1945, revised ed., Princeton University Press, 1950) at. 374.
At any rate, following the failed experiment Popper began to persistently publicize his new philosophy of science. Whether this was done to deflect attention from his public failure -- or to enable him to regain some stature in the scientific world, or as a subterfuge to attack rigid dogmatic thinking of the social activists of the day, we shall never know. (According to Asher Peres\textsuperscript{154} of the Technion who called Popper’s work ‘absurd,’ Popper totally misunderstood Bohr,\textsuperscript{155} so his opposition was meaningless.’) Nevertheless, no doubt as a consequence of Popper’s persistent writings, the philosophy of falsifiability became entrenched as the delineation of ‘the scientific’ and earned Popper the appellation of one of the greatest minds of the 20\textsuperscript{th} century.\textsuperscript{156}

(Ironically, as much as Popper tried to refine his anti-Bohr and pro Einstein quantum experiment, it never worked. Never, that is, until 2000 when two scientists at the University of Maryland physicists, Yanhua Shih and Yoon-Ho Kim reported the results of a “realization of Popper’s experiment.” Ironically, their results were not consistent with affirming Popper’s hypothesis.\textsuperscript{157}

Over the next decades Popper eventually comes to believe that Bohr’s concept of ‘understanding’ was different from his – and, according to Popper, much narrower. Bohr’s understanding and thought processes, Popper concluded, were “based on visual models of picture and models; his own being an understanding of the logical force of a theory, its explanatory


\textsuperscript{155} Asher Peres. \textit{Karl Popper and the Copenhagen Interpretation} Department of Physics, Technion|Israel Institute of Technology, Haifa, Israel http://cds.cern.ch/record/404139/files/9910078.pdf


\textsuperscript{157} Shields, op cit.
power, its relation to other relevant problems and other theories.”\textsuperscript{158} It is no wonder that Popper came to oppose the empirical nature of science and concentrated on its logic – for that is the area he felt he bested Bohr. But Popper’s unrepentant stance in opposing Bohr – and even fighting with Einstein over determinism and probability\textsuperscript{159} should have exposed Popper’s true colors, for in his obstinate opposition to their positions, he contradicts his own basic views of science: “The wrong view of science betrays itself in the craving to be right; for it is not his possession of knowledge, or irrefutable truth that makes the man of science, but his persistent and recklessly critical quest for truth.”\textsuperscript{160}

With this background in mind, it should not be surprising that the philosophical, epistemological and theoretical approaches of Popper which arose from his difficulties in the realm of quantum physics, would not have enabled us to produce the desired Gatekeeper paradigm to resolve human disputes. (In fairness to Popper, Haack advises that “[n]o philosophy of science could . . . supply the hoped-for crisp criterion to discriminate the scientific, and hence reliable, from the unscientific, and hence unreliable.”\textsuperscript{161} [emphasis supplied]

Nevertheless, we must deal with the fact that falsification has infiltrated the law and survived attacks by philosophers, lawyers and logicians. To finally slay the Daubert-dragon, we

\textsuperscript{158} Popper: UNENDED QUEST op cit.
\textsuperscript{159} i.e., “ the problem of subjective probabilities and of drawing statistical conclusions from nescience,” [ignorence].
\textsuperscript{161} Susan Haack, DEFENDING SCIENCE supra note 7, at 251 (criticizing the “court’s preoccupation with specifying the method of inquiry that distinguishes the scientific and reliable from the non-scientific and unreliable” because “[t]here is no such method”); See Haack, Trials and Tribulations, supra note 7, at 59. Susan Haack, An Epistemologist in the Bramble-Bush: At the Supreme Court with Mr. Joiner, 26 J. HEALTH POLITICS, POLICY AND LAW 217, 232 (2001), contending that neither Hempel’s nor Popper’s philosophy of science can “help a judge decide either whether evidence preferred is really scientific or how reliable it is”; cf. Michael A. Mason, Comment, The Scientific Evidence Problem: A Philosophical Approach, 33 ARIZ. ST. L.J. 887, 902 (2001) arguing that “Popperian uncertainty is not necessarily the appropriate view for courts to take in determining the admissibility of scientific evidence.”
therefore look to science - proposing to show by scientific examples that ‘Popper just doesn’t pop’ and that we must re-craft judicial understanding of the meaning of science, good science and the scientific method in light of relevant science, i.e., biology, chemistry and Newtonian physics. What we propose to do is to bring down Popper by falsifying falsification, i.e. hoisting Popper on his own petard.

As noted earlier, there were great thinkers who opposed Popper’s views (although, somehow, almost magically, Popper seems to have erased them from the legal community’s memory banks). Among these was Francis Bacon (1561-1626), who was trained as a lawyer and ultimately became Attorney General and Lord Chancellor of England. Bacon’s prodigious
accomplishments included formulation of the scientific method. Out of Bacon’s vision and insistence on testing and empirical verification came William Harvey’s map of the circulation of the human blood system in 1628 (around the same time and place as Galileo).\textsuperscript{162} To whet our appetite as to the inapplicability of Popper to biology, we start by examining William Harvey’s work. We discover that Harvey’s findings are falsifiable – but they cannot be falsified, for if we allow for the possibility of a humanoid whose arteries are carrying oxygenated blood \textit{to the heart} instead of \textit{away} from it -- and, per Popper, we cannot rule this out -- we find we are dealing with either a defective human or a non-humanoid.

In other words, the knowledge that human arteries carry oxygenated (bright red) blood away from the heart is final, as Harvey’s finding cannot be falsified without torpedoing our entire notion of human biology. Of course, Popper eventually realizes this. Thus, to deal with admittedly scientific statements (knowledge) that are impossible to falsify, Popper either excludes them from his purview or uses them as a metaphysical (and metaphorical) teaching devices.\textsuperscript{163} Since they cannot abide his rigid falsification system, these statements become ‘extra-scientific.” Popper must create several classes of “extra-scientific” knowledge which torment his formulation of falsifiability, to preserve it.\textsuperscript{164} But by 1963 it appears Popper feels he needs a stronger ‘out’ than the extra-scientific definitional classes. Now he defends himself by noting that “most dissectors of the heart before Harvey observed the wrong things –those which

\textsuperscript{163} “From a methodological point of view, the possibility of falsifying a corroborated law is by no means without significance. It helps us to find out what we demand and expect from natural laws.” Popper, THE LOGIC OF SCIENTIFIC DISCOVERY (2002 edn.) at 251.
\textsuperscript{164} Amongst these classes of ‘extra-scientific endeavor” are “strictly existential statements,” (also called non-empirical since they are not falsifiable), “axioms”, “equations” and “definitions”. These fall into the pit of metaphysics. See Popper, ibid, at. 48-50, 53,54.
they expected to see.”

It appears Popper is claiming that errors committed prior to Harvey’s work justify the need to continue to try to falsify Harvey’s discovery long after they are conclusively proven.

To be sure, knowing when an observation is completely safe or conclusively proven may be an unknown. It may be after thousands of repeated necropsies have yielded the same results, or millions of doctors over time and throughout the world see only red blooded humans – or it may take the development of new instruments, such as MRIs and cardiac catheterization to map blood flow (much as it took the telescope to prove Copernicus right). Even after new technology emerges, different standards or different manufacturing techniques might prevent reproducible findings, as happened to Anton Von Leeuwenhoek, whose microscope lenses were so superior to his contemporaries that his findings could not be replicated for years after his death. Nevertheless, it is one thing to say it may take decades or centuries to fully verify an idea, and another to say “there can never be anything like a completely safe observation free from the dangers of misinterpretation,” or that “valid induction is not even metaphysical: it simply does not exist.”

We certainly know of scientific truths that cannot stand falsification – i.e. they will always be true, (the Earth is round, it rotates around the sun, etc. Yet we still must fashion an effective disproof of Popper. We do so here by determining if the notion of “falsifiability” of science can itself be falsified.

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165 Popper, CONJECTURES AND REFUTATIONS (2002 edn.) at55.
167 Popper, CONJECTURES AND REFUTATIONS at 55, 70. For someone who eschews dogma, it is interesting to catch Popper in the act of the dog-matic.
168 Although we are not sure how it happens, Mendel’s genetics have been falsified in findings of brown eyed children with blue-eyed parents. How Blue Eyed Parents Can Have Brown Eyed Children, Sanford at the Tech Museum of Innovation. http://genetics.thetech.org/how-blue-eyed-parents-can-have-brown-eyed-children.
E. Popper and Biology: Once Upon a Popper There Were (Only) White Swans: 169

Let us begin our formal effort to falsify Popper’s scheme by evaluating one of his few examples: 170 He starts by examining the hypothesis “all swans are white;” 171 a statement that cannot be verified, he says, because ‘induction is logically invalid [and therefore] no matter how many instances of white swans we may have observed, this does not justify the conclusion that

169 But see Karl Popper, REALISIM AND THE AIM OF SCIENCE; FROM THE POSTSCRIPT TO THE LOGIC OF SCIENTIFIC DISCOVERY, Routlege Press, (1992) at xx-xxiii. where he backtracks and says that the hypothesis can be salvaged by being reformulated to include at least some potential falsifiers (i.e. conditions), the form any competent scientist would have used to begin with. As an altered hypothesis, he now says that the statement is, “of course falsifiable.”

170 POPPER SELECTIONS, Introduction, p. 15.

171 Karl Popper, THE LOGIC OF SCIENTIFIC DISCOVERY, Ch. 1: “A Survey of Some Fundamental Problems,” Section I: The Problem of Induction, at 27. In the 1959 edition, ravens were added as an example (at 68).
all swans are white,” and because it is logically possible to falsify it by observing a single black swan. Here, we see Popper evaluating his straw-man statement masquerading as a hypothesis (all swans are white) with all the philosophical rigor he can muster, confusing the science of epistemology with the epistemology of science:

The problems with Popper’s swan example – from a scientific perspective – are manifold. First, a scientist would not offer the statement “all swans are white” as a fact or even a hypothesis because it is not predicated on the practice of science, i.e., it is not ‘scientific’: a. it does not derive from a systematized classification system with recognized criteria and evolutionary rationale, b. nor is it a conclusion (logical inference) derived from a (controlled) and replicated experiment and c. there is no biological basis for the assertion. In fact, “all swans are white” is nothing more than an opinion, of which only a four year old could be proud, since no scientist would presume to contend they have evaluated every swan in existence.

But Popper has more problems; and luckily for us, testing Popper requires that we disprove (falsify) Popper only once to disprove his entire premise.

172 POPPER SELECTIONS op cit. Ch. 7“The Problem with Induction,” (1953,1974) at. 110.
173 The term falsifiability is sometimes synonymous to testability, albeit only in a negative sense, since Popper eschews the use of ‘verifiability’ which might be considered positive testing.
174 The philosophical problem with this example, the so-called ‘raven paradox’ has been amply set forth by others. See John N.W. Watkins (1984), Science and Skepticism, p. 319
175 While direct observation is considered a key element of admissible legal testimony (along with other sensory information) such that secondary information (hearsay) is frowned on in a court of law, and while observation is a key requirement for the scientist, Popper views observation as a tool of receiving information and knowledge with something short of contempt. POPPER SELECTIONS, edited by David Miller, Princeton University Press, New Jersey, 1985 at pages 46-49. Compare Plotkin who say that “all science is built, in the first instance, on observation.”
176 As George Gore (see infra) said in 1878: “No proposition can be proved to be true by means of experience alone, because experience is finite.” G. Gore, “The Art of Scientific Discovery, Longman, Green and Co, London (1878) p. 88.” Thus, no scientist would make such a statement, which can only be ‘true’ based on the proponent’s limited experience.
Assuming, *arguendo*, the scientist had only observed white swans, the scientist might say ‘all birds that have long necks, etc. and are white are called ‘swans,’ leaving open the possibility that we might find something that otherwise looked like a swan but was black, in which case it might be called a ‘blawn’ without disrupting the classification scheme.

Should further investigation yield varieties of different coloration, such as Swan Geese thereby ‘falsifying’ the initial premise, the biologist, simply ‘invents’ a new sub-species to demonstrate the scientific advance. Popperians (and perhaps quantum physicists), however, would void the classification scheme and opt for a new one. As Popper states: “We decide that if our system is threatened, we will never save it by any kind of conventionalist stratagem.” [emphasis supplied].

By 1974 Popper realizes there is a simple, practical solution to the white swan/black swan dichotomy -- furnishing a new name for the new entity, i.e. the conventionalist stratagem - -is workable. Popper, however, doesn’t like this approach: Yes, he says, the biologist can escape the refutation by creating a new *species* in the classification system (in Popper’s slovenly

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177 “The swan goose (*Anser cygnoides*) … is large and long-necked for its genus, with upper parts that are greyish-brown, with thin light fringes to the larger feathers and a maroon hind neck and cap (reaching just below the eye)... In flight, the wings appear dark, with no conspicuous pattern. Uniquely among its genus, the long, heavy bill is completely black; the legs and feet, on the other hand, are orange as in most of its relatives. The eyes’ irises are maroon. Juveniles are duller than adult birds, and lack the white bill base and dark streaks on the underside.” Carboneras, Carles (1992). del Hoyo, Joseph; Elliott, Andrew; Sargatal, Jordi, ed. Handbook of Birds of the World. Volume 1: Ostrich to Ducks. Barcelona: Lynx Editions. p. 581. ISBN 84-87334-10-5.


179 At page 87 of Logic of Scientific Discovery (1959 edn) Popper says “If basic accepted statements [explained on P. 88 as an ‘occurrence’ or ‘event’] contradict a theory, then we take them as providing sufficient grounds for its falsification only if they corroborate a falsifying hypothesis at the same time.” On page 91 Popper says: “the class of …potential falsifiers is identical with that of all possible basic statements [occurrences or events]: it is falsified by any statement whatsoever.”
(unschooled?) biology, he says “the black swans would be considered a new ‘kind’ of bird”), but Popper dogmatically tells us, “I think that he is likely to learn more if he admits that he was wrong.”

Let us revisit the circulatory system in light of the white swan experiment. Would Popper venture that the statement ‘all human (mammalian) blood is red’ is not scientific? According to Popperians we must consider this as a real possibility - and we must be prepared to be able to falsify it – and if so falsified, reject its truth forthwith, as he says: “scientists…should make bold, highly falsifiable conjectures [hypotheses?]… and, should they be falsified when they are tested, drop them and start again rather than making ad hoc adjustments to save them.”

The scientist who did much work on the role of hemoglobin, the iron-containing molecule that transports oxygenated blood, Claude Bernard, would have agreed with Popper. And in fact, Bernard’s version of falsifiability, posed about 70 years before Popper’s, is remarkably similar and hence far more original. Nevertheless, Bernard’s other views were slightly different: For starters Bernard did not eschew induction as a means of pursuing scientific discovery, believing that experimental science is a constant interchange between induction and deduction; secondly Bernard validated ‘verification’ as a conceptual mode of discovery; and most importantly he ratified the notion of cause and effect on which he says, “The scientist tries to determine the relation of cause and effect. This is true for all sciences: the goal is to connect a "natural phenomenon" with its "immediate cause". We formulate hypotheses elucidating, as we see it, the relation of cause and effect for particular phenomena.”
It is this acknowledgement of the connection between cause and effect that allows Bernard to succeed where Popper fails, for in searching for causes we are forced to consider the mechanism of causation, and it is Popper’s refusal to consider causal mechanism that denies him the option of making reliable future predictions. To wit, he contends, we cannot predict the sun will rise tomorrow based on our past experience. However, it is not past experience that enables the future predictions, but our understanding of the mechanisms responsible for these events. Thus Popper confidently says (where no one else would dare):

“Let us suppose that the sun will not rise tomorrow (and that we shall nevertheless continue to live, and also to pursue our scientific interests). Should such a thing occur, science would have to try to explain it, i.e. to derive it from laws.” From this entirely irrational, absurd and impossibly flawed statement, Popper builds his philosophy. But, because he is not concerned with mechanics of causation, Popper can also claim it is impossible to say the sun will rise tomorrow because we can’t predict future events from past ones. He gives us examples here and I will give two others: Malthusians population dynamics or Paul Ehrlich’s predictions of the environmental apocalypse where history has shown the predictions were quite wrong. But

182 Claude Bernard, AN INTRODUCTION TO THE STUDY OF EXPERIMENTAL MEDICINE (1865) reprinted by the Courier Corporation: “Theories are only hypotheses, verified by more or less numerous facts. [emphasis supplied].

183 Popper, THE LOGIC OF SCIENTIFIC DISCOVERY, (2002 edn.) at 250-251” the ‘principle of the uniformity of nature’ can again be regarded as a metaphysical interpretation of a methodological rule – like its near relative, the ‘law of causality.’

184 “Existing theories would presumably require to be drastically revised. But the revised theories would not merely have to account for the new state of affairs: our older experiences would have to be derivable from them. From the methodological point of view one sees that the principle of uniformity of nature is here replaced by the invariance of natural laws.” Popper, ibid, at. 251.


186 Paul Ehrlich (the populist-entymologist, not to be confused with Paul Ehrlich the biologist Nobel Prize winner) in THE POPULATION BOMB, Sierra Press (1969)
these predictions are based on experience – and not on causal mechanism, and indeed past experience alone cannot predict future events.

However, where we do know the mechanism responsible for causing the event in question: i.e., the earth rotates around the sun, we most certainly can predict that this event will happen tomorrow – for if it doesn’t, the only explanation would be that a. there is no more sun or b. that the Earth has stopped rotating. Should either of these eventualities occur, life of the human will also cease to exist – and none of this will matter.

Popper’s refusal to respect the ‘why’ of science, (i.e. the mechanics of scientific discovery and causal connections) enables him to build thought-castles in the sky where he ensconces his mythical principality of science, to which Daubert remains tethered. As causation (and hence causal mechanisms) is rejected from Popper’s considerations\(^\text{187}\) it remains to us to incorporate the notion of ‘scientific plausibility’ (or validity of causal inference) into our courtroom considerations. And this test, it is argued, supersedes ‘falsifiability’ as a determinant of court-relevant science.

Let us now return to investigating why human blood color differs from Popper’s swan colors. If we believe that color is a whimsical decision by the Chief Artisan of the Universe, Popper is correct – we may well find a magenta swan, for what difference does it make to the swan’s existentiality? Similarly, if Creator-color-preference were involved, we could entertain the notion of finding a green-blooded human – and falsifying our initial premise: that ‘all human blood is red’– because it doesn’t matter to the existence of the human from a physiologic or evolutionary biological perspective. However, where color has a scientific significance or

biologic importance, such as the plume color of a peacock, statements regarding its fungibility cannot be so easily jettisoned.

Scientific knowledge teaches that the color of human (or mammalian) red blood cells derives from its iron (heme) mediated functionality (oxygen-carrying capacity); the red comes from iron with its rust-like color. Should we find a humanoid with, let’s say, green blood, we can conclude (from our knowledge of chemistry) that that entity’s oxygen-carrying physiology is not mediated by iron (i.e. that person would not be human) – or that the humanoid has a particular medical problem. Rather than regarding our finding of a green-blooded human as a falsification of our initial premise as Popper would have us do, this finding propels further investigation into the cause of our ‘aberrant’ green-blooded humanoid.

Since we accept the immutability of the statement that all human blood is red except for those who are diseased, we first investigate whether disease is involved in our green-blooded specimen, in which case we may find a medical cause, for example, the unusual green color can arise from an excessive dose of a particular drug. (!) ¹⁸⁸

Should we fail to find a medical explanation, we must determine that green-blooded humanoid is not really human. Let us call him ‘Vulcan’. Since we know that human blood is red due to the iron color of the oxygen-mediating component of human blood, we are now able to validly hypothesize why the Vulcan’s blood is green. Indeed, further investigation reveals that the Vulcan’s creator (Gene Roddenberry) chose Mr Spock’s blood color, not because of Roddenberry’s verdi-philic aesthetics, but because the physiology determinant of the Vulcan

¹⁸⁸ Alana Flexman, M; Del Vicario, Giuseppe; Schwarz, Stephan KW. "Dark Green Blood in the Operating Theatre" The Lancet Volume 369 Issue: 9577 (June 9 - 15 2007) p. 1972, where the green-colored blood of the patient was caused by massive ingestion of the migraine drug, sumatriptan which caused a rare condition, sulfhaemoglobinemia, where sulfur is incorporated into the oxygen-carrying compound hemoglobin in red blood cells.
blood color is the copper - which renders blood color as green.\textsuperscript{189} \textit{Thus, it is the negation of falsification that allows us to propel our research forward in productive directions.}

\textbf{F. Popper and Chemistry: Elemental Obstacles}

Let us now look to the world of chemistry. The science of Chemistry holds all Carbon atoms have six electrons.\textsuperscript{190} Upon this conviction (and convention) the entire field of organic chemistry is based.\textsuperscript{191} (Whether this is actually falsifiable is a subject of debate, since at some level it is a definitional issue). Nevertheless, should we suddenly encounter something that looks like, smells like, tastes like and behaves like a Carbon atom -- but has five electrons, we have varying choices: The Organic Chemist would search for a reason for the existence of this ‘bizzaro’ particle, giving the new entity a new name to differentiate it from ‘classical carbon’. The Popperian might set about to rebuild a new system of chemistry, (demolishing Mendeleevian classification of the elements on the way and wreaking havoc with how chemistry is practiced on the way), Popper deals with the matter by removing the science of identifying chemicals by atomic numbers from his purview of science entirely. He considers this type of statement extra-scientific or “existential” and hence decides that it does not require falsification and falls into the category of non-empirical (even though we can certainly observe or examine the molecule) or \textit{metaphysical}.\textsuperscript{192}

\textsuperscript{189} http://en.memory-alpha.org/wiki/Vulcan
\textsuperscript{190} In 1803 John Dalton, an English chemist, meteorologist and physicist, discovered that all atoms of a given element are identical in size, mass, and other properties His first set of discoveries included Carbon.
\textsuperscript{191} It was once believed that a property of Carbon was that it had also six protons and six neutrons. When it was found that atoms could have a varying amount of neutrons, the concept of ‘isotopes’ was devised to describe this phenomenon.
\textsuperscript{192} Popper, \textit{THE LOGIC OF SCIENTIFIC DISCOVERY} (2002 edn) at. 48, where he calls typing of chemicals by atomic structure, ‘physics’. 
That the existence of a Carbon atom with a variant morphology could be contemplated, requiring reformulation of the periodic table of elements is ludicrous, for this finding would not only crumble the science of Organic chemistry, but polymer chemistry as well. Indeed the discovery of Benzene by Faraday in 1825 (which led to the coal-tar industry and formulation of dye-stuffs)\textsuperscript{193} could only have been predicated on a surety of Carbon’s atomic makeup. 

Let us take this thought further by selecting two elements to make a compound whose ‘recipe’ is predicated on the atomic number of each element. For example, by combining two molecules of hydrogen with one molecule of oxygen, we can make water. Let us presume this experiment has been repeated by every inorganic chemistry student since Henry Cavendish first compounded water in 1784\textsuperscript{194} over 200 years ago, generating perhaps one hundred million repetitions of the experiments – all trying and succeeding in \textit{proving} that H\textsubscript{2}O is water.

The Popperian, who eschews certainty in science, is fully ready to accept that tomorrow, in some small town, call it Chelm, the experiment will go awry – and everyone in Chelm now requires two hydrogen molecules and two oxygen molecules to make water (the recipe for a different compound, elsewhere called hydrogen peroxide). The Popperian would start at once to reevaluate the notion of chemistry; the chemist would hypothesize that atmospheric conditions in Chelm have been altered (from climate change, electromagnetic radiation, sun spots, etc.) such that the laws of nature for our universe no longer apply to that locality. The Homeland Security expert, however, would infer that Chelm is under attack by terrorists who have the power to change the way Chelmites think -- or that the enemy is playing havoc with the natural laws of the Universe – or both. This example is not made facetiously; rather it demonstrates how different scientists with different approaches can infer different causal mechanisms to explain the

\textsuperscript{193} Martin, op. cit. p. 31
\textsuperscript{194} Philip Cane, “Giants of Science,” Grosset and Dunlap, New York (1959) p. 64.
same phenomena\(^{195}\) and the very real conundrum of how three different experts\(^{196}\) can reach
different conclusions in the same tort case,\(^{197}\) leaving it to the hapless judge to sift out the
competing viewpoints.\(^{198}\)

**F. Popper and Religion: Popper’s Alchemical Science**

1. **We can Falsify Religion > Therefore, Per Popper, It’s Science**

   We have just demonstrated that it is impossible to falsify some very valid scientific
   statements, especially in biology and chemistry. This alone, should invalidate Popper. But we
   will go further. Next we will use the converse approach, we will falsify religious statements.

   The Popperian system discards notions that religion is scientific, claiming that what props
   up this ideology is merely belief\(^{199}\) and not objective proof.\(^{200}\) Under the rubric of falsifiability
   Popper claims he can distinguish religion from ‘science,’ because religion cannot be falsified,
   (i.e. tested and disproved). We shall now falsify Popper’s view that religion cannot be falsified
   using Popper’s falsification method (not to disprove the scientific status of the religion asserted,
   but to disprove the viability of the falsification method itself).

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\(^{195}\) Thus chemist would consider a single atom of Helium to also be a molecule, while to a
physicist it would not. Kuhn, op cit. p 50.

\(^{196}\) Soldo v Sandoz Pharmaceuticals Corp, 244 FSupp2d 434 (WD Pa 2003).

\(^{197}\) Joe Cecil, *Ten Years of Judicial Gatekeeping Under Daubert* Supplement 1, 2005, Vol. 95,
No. S1 | AMERICAN JOURNAL OF PUBLIC HEALTH Cecil | Peer Reviewed | Public Health
Matters | S75

\(^{198}\) Morris R. Cohen and Ernest Nagel, *AN INTRODUCTION TO LOGIC AND THE
SCIENTIFIC METHOD*, Harcourt, Brace and World, Inc., New York (1934) at 5. Cohen and
Nagels’ book was published the same year as Popper’s first edition of “The Logic of Scientific
Discovery.

\(^{199}\) Wolfgang Pauli commenting on Paul Dirac’s early, unequivocal and passionate atheism
compared it to religion. See Helge Kragh. *THE PUREST SOUL: DIRAC: A SCIENTIFIC

\(^{200}\) Anthony Flew is credited with being the originator of this approach. James Franklin Harris,
*ANALYTIC PHILOSOPHY OF RELIGION*, Springer Science & Business Media, May 31,
The Popperian rejection of religion makes no distinction between religions. Since all religions are the object of Popper’s wrath, we can pick any to disprove. Let’s examine the religion of ‘idolatry,” with adherents believing that pagan images were all-powerful. As most students of the Old Testament know, Abraham’s father was an idol-maker and merchant of graven images named Terach. One day, so the story goes, Terach asked his son to mind the store. When he returned it was in shambles – all the idols, save one, the largest, were smattered into smithereens. When Terach asked his son what happened, Abraham pointed to the largest idol, now ‘holding’ a large ax, and said, “He did it -” a conclusion which Terach rejected, along with the notion that the idol had any power at all, even to stop the idol-massacre.

2. Faith-based Science

We will now proceed to learn (to Popper’s horror) that the notion of faith (or conviction) has a welcome home in science! We start by noting that science changes and new discoveries supplant older theories. At what point along the continuum the new entirely replaces the old as the ‘prevailing; wisdom’ is the subject Thomas Kuhn’s work. Commenting on the ripe time for a scientific paradigm shift (which he calls a revolution), Kuhn notes that in “the beginning of this revolution to commitment to a scientific ‘truth, ... a decision of alternate ways of practicing science is called for, and in the circumstances...a decision of that kind can only be based on faith...,[To be sure] there must also be a basis, though it need be neither rational nor ultimately correct, for [that] faith ....Something must make at least a few scientists feel that the new

201 Daubert-93 at 483.
202 Ibid.
Dumping Daubert, Popping Popper and Falsifying Falsifiability

proposal is on the right track, and sometimes it is only personal and inarticulate aesthetic considerations that can do that.”203 [emphasis supplied].

There is vaguely complicated about Kuhn’s notion; knowledge always changes. The problem with Popper is that he believes all knowledge changes and that we can never be sure when.204 In other words, per Popper, we can only ‘believe’ something in science is true until it is proven otherwise. “The old scientific idea of episteme – of absolutely certain, demonstrable knowledge – has proved to be an idol. The demand for scientific objectivity makes it inevitable that every scientific statement must remain tentative for ever.[sic] …. Only in our subjective experiences of conviction, in our subjective faith, can we be absolutely certain.” [emphasis in original.]205 How this ultimately differs from religion is not precisely clear, other than perhaps by formulating science as rebuttable presumptions. (To the jurist this is a non-issue:, we must begin with some basic premises in which we trust. Popper would probably be outraged to realize that in most courtrooms, the first principle of trust is in God).206

Science, Certainty and Subjectivity

The net impact of Popper’s work, then, changed the prevailing notion associated with science, that of [objective]‘certainty,’ into one of continuous uncertainty. 207 Popper’s own

204 “There are no certainties in science. See, e. g., Brief for Nicolaas Bloembergen et al. as Amici Curiae 9,” Daubert.
206 Indeed, while the Judges in Kitzmiller (Tammy Kitzmiller, et al. v. Dover Area School District, et al. 400 F. Supp. 2d 707 ((M.D. Pa. 2005), rejected the notion of any scientific underpinnings to Intelligent Design, some elements of Darwinian Evolution defy falsifiability –. Thus, we have no mechanism to explain how life arose from non-life, although this is a cornerstone of the doctrine. See R.C.Lewontin, Facts and Factitious in Natural Sciences, in Chandler, et al’s QUESTIONS OF EVIDENCE, supra.
207 Bryan Magee, op cit. at.220.
conviction in the tentative nature of science causes him to sound anything but scientific, even waxing poetic: “Science does not rest on solid bedrock. The bold structure of its theories rises, as it were, above a swamp. It is like a building erected on piles. The piles are driven down from above into the swamp, but not down into any natural or ‘given’ base; and if we stop driving the piles deeper, it is not because we have reached firm ground. We simply stop when we are satisfied that the piles are firm enough to carry the structure, at least for the time being.” Since Popper furnishes us with no objective standard to determine when this state of satisfaction is reached, we are forced to use subjective assessments. Yet, Popper tells us that “the word ‘subjective’ as applied (by Kant) to our feelings of conviction is not science, and without objective statements we trespass on what we call ‘religion.’

Popper, therefore leaves the gatekeeper in a multiple conundrum which no gatekeeper rules can assist: Where are the objective criteria to determine when the evidence is scientifically solid enough to furnish firm ground for a jury to deliberate? Perhaps we can rely on the gatekeeper to apply these rules, but who will set them? The judge? The majority of scientists? The experts on either side? And on what basis does the judge decide if the standards are met? Is it a quantitative test? (how much proof) or a qualitative one? (how solid or convincing the proof).

Popper’s view of provisional truth in science, therefore, leads us to the untenable conclusion that scientific knowledge can only be believed to be true, since there is always the possibility that tomorrow will bring about evidence of its falsity. The differential between Popper’s science and religion is that religion requires eternal belief in its veracity, while science only demands temporary loyalty.

H. Finality in Law and Science

208 Popper, THE LOGIC OF SCIENTIFIC DISCOVERY (2002 edn) at 94.
This viewpoint has been taken to support the false notion that science and law differ in their desire or need for finality. Thus the Court in Daubert opines:

“Yet there are important differences between the quest for truth in the courtroom and the quest for truth in the laboratory. Scientific conclusions are subject to perpetual revision. Law, on the other hand, must resolve disputes finally and quickly. 209

This sentence, which sounds – at first blush- like a simple, uncontestable truism, presents yet another example of the willing suspension of disbelief lawyers employ when evaluating Daubert: The court used a scientifically flawed method of analysis: When comparing temporal differences between law and science, the Court compares two different aspects of the process. Instead, we should be compare the body of law with the body of science and individual cases with individual experiments.

Thus, over swatches of time, both law and science change: The reasonable man has become the reasonable person and Workman’s Compensation is now Worker’s Compensation, but under normal conditions, do not we see revision within a pending case or single experiment or individual treatment.210 This can be illustrated by diagnostic tests used in the practice of medicine. We require prompt finality when seeking a diagnosis or treating a patient - although researchers may be continually working on refining diagnostic methods.

Furthermore, contrary to what Popper would have us believe - in the courtroom – while things move quickly, the ‘final’ verdict may well be temporary! And - subject to revision. Finality does not accrue until all appellate relief is exhausted (which may take years) and the

209 Daubert, supra.
law, itself, may be changed at any point in time. In fact, one might say that the legal appellate
procedure invites revision more quickly and systematically than does science.

In concluding this section, it must be said that while the Popperian approach may have
worked in physics (or at least ‘modern’ non-Newtonian physics) its run may be at an end.
Even in the world of cosmology ‘falsifiability’ is coming into disrepute. Although once almost
‘magical’ in its ability to generate falsifiable results, mathematics is longer able to resolve all the
disputes in the realm of theoretical physics. “We are now faced with the untenable conclusion
that – using falsifiability - we can reject neither of two prevalent theories: relativity and quantum
theory, and that we are no closer to resolving the dilemma than when it was first posed by Bohr
and Einstein nearly one hundred years ago.” As Criton Zoakos notes, the current (and
unprecedented) controversy of superstring theory exists because we cannot even formulate
testable predictions even after forty years of effort. “This has caused some particle physics
practitioners to argue for a nearly infinite number of potential universes, a “multiverse”, leading
to the conclusion that physics must now abandon the test of falsifiability…. Leonard Susskind,
director of the Stanford Institute for Theoretical Physics and a “father” of string theory, was led

211 In Basso v. Miller, (Basso v. Ice Cave Mountain) 40 N.Y.2d 233, 352 N.E.2d 868, 386
N.Y.S.2d 564 (1976) the requirements for notice in a premises liability negligence were changed
based on differing societal expectations, as a matter of policy.

212 Copernicus’ heliocentric theory was falsified and should not have been further considered, per
Popper, because it could not predict planetary motions as accurately as the traditional Ptolemaic
system. Similarly, Newton's theory was arguably falsified in the mid-19th century, when certain
anomalies were noted in the orbit of Mercury. But it would have been irresponsible to have
discarded Newtonian mechanics because of its overwhelming success in explaining a vast array
to characterize the situation as a “war”, even accusing his opponents of practicing “faith-based science.”  

In sum, whatever Popper’s rationale for pushing ‘falsifiability’ three facts emerge: 1.) Enough opponents to Popper exist from various perspectives: legal, epistemological, philosophical, to render his approach questionable; 2. I have falsified (and hence invalidated) Popper’s views on falsifiability by scientific examples; and 3.) the science from which Popper’s philosophy derived and was directed (quantum and Einsteinian physics), is not relevant to the courtroom- which primarily addresses questions of Newtonian physics and the special sciences, biology, chemistry.

PART III: So Falsifiability is Falsified: Who cares?

Attempts to vivify a moribund method of vetting scientific evidence have buried us deeper into the quagmire, generating contortions, confusion and contentiousness.  

Before attempting to create another approach, we discuss the consequences of the previously enumerated flaws.

We submit we have falsified Popper’s ‘falsifiability’ and hence disqualified it as the rubric to determine what is considered ‘science.’ But the question remains: so what? Since we can easily use a search term and replace ‘falsify’ with ‘verify’ or some other paradigm – ‘what difference does it make now’ to expose this false premise twenty years after it was planted in

213 Criton Zoakos, Time for Big Question, December 22, 2014, “Several prominent scientists have recently expressed concern about whether it is prudent to continue pursuing string theory, given that practitioners have not yet been able to derive empirically testable consequences even after 25 years of effort.”

214 Haack, op cit. p 139.

215 U.S. v. Hines, 55 F. Supp. 62, 65 (D. Mass. 1999) n. 7, noting that “Daubert has been accused of taking the definition of science from Karl Popper, a definition that others have criticized as deriving from a culturally defined, time-bound paradigm.” Also cited in Haack, op cit at page 141.

216 DH Kaye, supra. On Falsification and Falsifiability: The First DAUBERT Factor and the Philosophy of Science.
case law and the judicial mindset? Here we identify and address problems Popper created arising from his notions of deductivism, falsification and falsifiability.

A. Popperism is Incompatible with Legalism

The Popperian emphasis on disproof unnecessarily distances science from law which pivots on proof. Rarely, if ever, would plaintiffs or prosecutors enter a court-room without assurance they could establish at least a prima facie case. Popper’s view is different and idiosyncratic, philosophical, perhaps, but hardly ‘scientific’ in the world of the scientific practitioner. Moreover, it is flat out incompatible with legal practice:

1. The Burden of Proof

In law, we expect the plaintiff to prove his or her claims, and not for the defendant to disprove them; indeed, the defendant has no burden of proof at all. Thus, if plaintiff’s evidence is not believed or does not rise to the quantum necessary to convince a jury – the case falls; the defendant need do nothing. We do not say that because the plaintiff brought in some evidence, however infirm it may be, the defendant must now disprove it, and we do not infer the plaintiff wins simply because the defendant did not bring in any evidence at all. Just like the plaintiff must a.) prove his or her claims b.) by a certain quantum of evidence c.) to the satisfaction of the decision-maker, and d.) whose decision may not be based on conjecture or speculation, so the experimental or laboratory scientist (as opposed to the philosopher or theoretical physicist) must prove his or her hypothesis, satisfying the elements of proof pertinent to her/his discipline by a certain quantum of evidence. The elements of the game are identical under this view.
The Popperian view that there is no such thing as proof – only disproof -- cannot be properly translated into law, for the legal analog would require that after the plaintiff asserts his or her claim, the burden would shift to the defendant to disprove or ‘falsify’ it, a state of affairs the law would deem intolerable.

2. The Quantum of Proof

The focus on disproof statistically stacks the outcome in favor of a proponent, which is antithetical to law. Thus, in science, the scientist is betting against her/himself. Putting forth the null hypothesis, s/he has a 50-50 chance s/he will lose her bet – which means s/he wins (or the positive version of his hypothesis prevails). If the evidence is in equipoise, i.e. there is not enough evidence to disprove the claim, it is inferred that the proposal carries the day. In other words, the default position favors the proponent (i.e., disproof of the theory as stated negatively).

For the proponent of a legal claim, s/he is betting against an opponent. The ‘dice” are procedurally stacked against the proponent, to wit, the plaintiff bears the burden of proof. Thus, in statistical terms there are three options to the outcome: 1. The plaintiff is proves the claim; 2. The defendant disproves the plaintiff’s claim (while not required, this is not forbidden either) or 3. Neither side can prove their claim – i.e. the evidence is in equipoise – in which case the proponent loses. The probability that the plaintiff will win is 1/3, 13% less than in the Popperian (or statistical) system. The default position favors the opponent.

Thus, the Popperian scheme does not accommodate the stricter burdens the law imposes on the proponent. This situation cannot be stressed strongly enough, although attempts to muddle the effect of using the Null Hypothesis are pervasive.

3. Reliability (the sine qua non of Daubert) cannot be determined from negative proof
Popper “lays “stress on negative arguments, such as negative instances or counterexamples, refutation, and attempted refutations….”\textsuperscript{217} which is [he claims] incompatible with proving reliability.\textsuperscript{218} And insofar as reliability is one of the key Daubert tests, by relying on Popper Daubert becomes internally inconsistent. In other words, Popper’s view undoes reliability, a critical requirement for admissible evidence. Incorporating Popper’s views into Daubert can only curdle the Gatekeeper paradigm as acid curdles milk.\textsuperscript{219}

\textbf{B. Specific Errors Generated by Daubert’s Reliance on Popper}

Various Daubert-related errors require different mechanisms of redress.\textsuperscript{220} Some can be resolved by merely substituting ‘verify’ for ‘falsify’. Others need whole-scale adjustments, such as those pertaining to epidemiology. For now, we highlight the problem:

\textbf{1. False Negatives and False Positives}

On a universal level, false positives are not a problem for Popper. With the continuous testing Popper espouses, any False Positive (Alpha) error would ultimately be exposed. This, situation, however, does not help the individual plaintiff.\textsuperscript{221} However, Popper’s view of science

\textsuperscript{217} Popper, Conjectural Knowledge, n. 27
\textsuperscript{218} Susan Haack op cit, p. 129.
\textsuperscript{219} In U.S. v. Carucci (1997) citing to Popper’s “Conjectures and Refutations,” Judge Rakoff, obviously confused between the concepts, opines that psychiatric evidence “suffers from being unfalsifiable, and therefore, unreliable.”
\textsuperscript{220} This is true even in science. Lee Smolin, op cit. “This is as it should be: Different styles of research are needed to solve different kinds of problems.”
\textsuperscript{221} Thus, an individual who tests positive for anthrax may well be suffering from a \textit{B. cereus} infection, a false positive caused by to a natural phenomenon called cross-reactivity. Phillips AP\textsuperscript{1}, Ezzell JW. Identification of Bacillus anthracis by polyclonal antibodies against extracted vegetative cell antigens. J Appl Bacteriol. 1989 May;66(5):419-32.
was not designed to evaluate specific information needed in medicine -- or in the courtroom, which turns on the needs of the individual patient or plaintiff (regardless whether in the doctor’s office or the courtroom), both requiring an immediate and final answer.

The issue of False Negatives (Beta Errors) is harder for Popper to handle. Most commentators blame the situation on isolated instances of observer bias (flawed observation, seeing what we want to see) which Popper is ready to handle. Errors also arise from problems with calibration of equipment. These issues also can easily be addressed (and eventually exposed by further repeated experiments. And although false positives can cause untoward effects (e.g. mammograms causing unnecessary invasive diagnostic procedures), the ramifications of false negatives (e.g. from laboratory tests, radiological results or epidemiological studies) is the stuff that makes for litigation, judicial headache and Daubert hearings, and one Popper is powerless to address. The essential problem is that False Negatives can cause massive harm via a systematic (a study-implementation) defect, akin to a manufacturing defect or systemic defect (akin to a design defect), as in a flawed survey design or improper sampling methodology. They can also arise from an incomplete understanding of biological mechanisms, such as where the body requires two or more forces acting in unison (joint causes acting in a prescribed temporal sequence) to exert an effect. If both causes are not identified or understood, testing for one discourages further investigation when negative results

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222 In some cases the importance of the finding far transcends individual concerns, even impacting on national security. David Francis, “U.S Defends Tularemia Response,” Global Security Newswire, Oct. 26, 2005, Tuesday, October 18, 2005; See also, Mark Benjamin, Biological alarm in Washington. Did terrorists attack Washington with a deadly pathogen? http://www.salon.com/2005/10/18/tularemia/

223 Popper SELECTIONS, op cit. p43.

224 Typhoid Mary might be an example of a False Negative – as she was totally asymptomatic for the disease. Indeed, only later did invasive examinations disclose the presence of the bacteria colonizing her gall bladder.
are obtained. This issue has generated errors in legal interpretation of epidemiologic evidence, based, for example, on the misassumption that the only means of establishing legal causation is but/for causation generated by individual causes.

2. Falsifying Falsification

Another major problem arises because the Popperian System, while perhaps useful to address single causes or single states or what in law translates into but/for causation (roughly equivalent to Attributable Risk in epidemiology), cannot handle multiple causal mechanisms. Thus, where two or more forces unite or act sequentially (e.g. joint or concurrent causation in law), or where two results accrue from one cause, the system breaks down.

In general terms, Popperism stands for the concept if ‘A’ is not true (because we have found even a single instance where it has been falsified)-- then the only alternative (or logical inference) is that ‘not-A’ is true. What the system doesn’t tolerate is the possibility that both ‘A’ and ‘not-A’ are true. Notions of dual states and multi-causal mechanisms, key concepts in toxic tort and products liability, are not compatible with Popperian logic. This may not be a fatal flaw in examining cosmological forces at the inception of the Universe, but forensic paradigms must be compatible with notions of law in today’s world.

225 “[T]he relative risk of limb reduction defects arising from the epidemiological data . . . will, at a minimum, have to exceed ‘2.’” Daubert II, 43 F.3d at 1321 (quoting DeLuca, 911 F.2d at 958). See also Michael D. Green et al., Reference Guide on Epidemiology in REFERENCE MANUAL ON SCIENTIFIC EVIDENCE, supra note 14, at 333, 383-84.

226 Manko, supra.

227 In this convention, the null hypothesis is used in reverse. The scientist just casts his/her hypothesis in the negative, and by disproving it statistically (without showing why or how), the hypothesis is now ‘proven.’ Since the statistical null hypothesis doesn’t define ‘not A’, the proponent does not even have to propose an actual alternative hypothesis.
We have previously demonstrated instances of scientific propositions that cannot be falsified, and instances of religious propositions that can be falsified. Now we demonstrate instances where true scientific propositions can be falsified, leading to incorrect science, i.e. rejection of valid scientific knowledge.

Again, we shall disprove Popper again using his own method:

Let’s say I have a hypothesis that water freezes at zero degrees Centigrade.

Now, in real life, if I take an ice tray from my freezer, pick up an ice cube and measure its temperature, the thermometer will always read zero (assuming I am at sea level or nearby), which comports nicely with our personal experiences. The hypothesis is also falsifiable, so it qualifies as Popperian science and I can easily set up an experiment to falsify it.

And in fact, I will. If I empty the ice tray in a bowl at room temperature, in a fairly short while, the ice will melt. I can wait until almost all the ice melts, remove the residual cubes and measure the temperature of the water in the bowl. It will read zero degrees.

I have now falsified my hypothesis and must conclude water does not freeze at O degrees – after I have just proven that it does. (!)

Eventually Popper must have figured out that this situation presents a problem because, indeed, water can and does exist both as a solid and a liquid at zero degrees (and as a gas and a liquid at 100 degrees) without any special considerations. Forty years after his Logic of Scientific Discovery was published Popper returns to ‘explain away’ some not clearly stated theoretical issue – regarding water. He proposes a two part solution to this conundrum:

(a) Instead of calling the notion that water freezes at zero degrees a ‘hypothesis,’ he now calls it a definition – hence it can be changed at will without dissembling the theory that

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228 Which elsewhere are defined as “either beliefs” [as in religious]? or “conjectures”
water freezes at zero degrees. (Interestingly, as we saw, he disinclined the revised definitional approach when it comes to the biology of swans). In other words, Popper says where we have some substance with certain “atomic weights and melting points and similar properties used as defining points; but since “there can be no water whose freezing point differs from 0 degrees C; it would just not be ‘water’. (i.e. it would be something else).” [emphasis supplied].

(b) Next he says, “let us assume we have discovered ‘water’ with a different freezing point… The scientific hypothesis was that a liquid (no matter what you call it) with a considerable list of chemical and physical properties freezes at 0C. If this doesn’t happen, Popper says, then “we were wrong.” As to whether this is still to be called ‘water’? I answer that the question is totally irrelevant,” he says.230 “[emphasis in original]

Philosophers Ernest Cohen and Morris Nagel addressed this very issue in 1934. They introduce a dialogue between “two popular philosophers, Mutt and Jeff” who are also discussing the chemical properties of water. They note that “Jeff’s difficulty [like Popper’s] arises from a misapplication of the sound logical principle of identity, that water is water and not something else.” But, they point out, to a scientist, ‘water’ has a very specific meaning which arises by virtue of its chemical moniker H$_2$O, a “fact which enables us to understand many … properties of water, [including] some … which we would not have otherwise suspected.”231 To a scientist the term ‘water’ is interchangeable with the scientific name, H$_2$O, or two hydrogen molecules and

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229 Popper however is notoriously loose in his use of scientific definitions. He uses the term ‘class’ of mammal to convey ‘category,’ illustrates an unfamiliarity or lack of respect for with the scientific system of biologic classification (the Linnaean system) in which ‘class’ is a term of art with a precise meaning. “The Logic of Scientific Discovery,” at 43-44.


one oxygen molecule combined in a certain way. In other words, the substance’s chemical name defines its properties – and hence the (scientific) name is hardly irrelevant; the scientist cannot simply call the substance C₃PO or R₂D₂ because it behaves in an unanticipated fashion.

Let us reframe the hypothesis to demonstrate: The molecule H₂₅O freezes at 0°C.

If Popper were to measure the temperature of the pool of recently melted (liquid) H₂₅O molecules, he would discover it would be 0°C, just as Joseph Black, the Scotch Chemist and physician, demonstrated about 250 years ago. Now, Popper may think he has disproved his hypothesis, but he hasn’t -- because zero degrees IS the freezing point of H₂₅O.

Popper now is faced with admitting that “either my criterion of demarcation is refuted, or we have to admit the possibility of discovering water whose freezing point is other than zero degrees,” i.e. one he doesn’t know. Unfortunately, a statement that we have ‘water’ whose freezing point we don’t know (i.e., one we cannot disprove) is neither scientific, nor capable of falsification. Popper can’t very well say what’s in the bowl isn’t H₂₅O (that it’s something else) because analytically it verifiably IS H₂₅O; and he can’t (not in the world of real science, anyway) say he falsified the hypothesis and disproved the notion that at zero degrees H₂₅O freezes – even

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232 Popper contradicts himself here. In THE LOGIC OF SCIENTIFIC DISCOVERY at pages 43-44 he first acknowledges that ‘H₂O’ is a universal concept or name, ‘which he considers of fundamental importance,’ noting that “we can use signs which are not proper names but which to some extent are interchangeable with proper names or individual co-ordinates.” He then raises the infirmities of the practice, noting that definitions, e.g. the term “mammal” might give rise to confusion, depending on our intentions. He concludes by telling us that the difference between individual and universal concepts “ would be of very little value....”.

233 Popper was familiar with Black’s work, citing his “Lectures on the Elements of Chemistry,” on page 62 (note 1) ibid. The quote of Black’s that Popper cites is unfortunate: “A nice adaptation of conditions will make almost any hypothesis agree with the phenomena,” as in the instance of the freezing point of water, the change in phenomena occurred irrespective of any adaptation of conditions.

234 G. Gore, op. cit. 529-530. Dr. Clark made this discovery in 1761.

235 Popper SELECTIONS op cit at.126.
though it sure looks like he has, because we have shown that the contrary is also true: At zero degrees water is a liquid.

While Popper’s method of falsification precludes dual-cause type of statement, we can legitimately conclude that the ‘H₂0’ can live in two states at the same time (or temperature), an increase in our ‘pool’ of scientific knowledge. And now we can proceed to expand our scientific knowledge further by finding out why, a realm of investigation that would be foreclosed if we were to follow Popper’s routine.

Let’s further demonstrate what Popper (and his science) is missing: Not only can I get my H₂0 molecule to live in two ‘alternative’ universes at the same time (e.g. frozen and liquid), but I can ‘teach my molecule’ new tricks. I can get it to remain a liquid as low as -40 degrees Centigrade if the water is very pure (this is called supercooled water), and there is no ‘kernel’ of something for the first ice crystal to glom on to.

So we have three mutually exclusive and mutually existing hypothesis, all true:

Water freezes at zero degrees.

Water doesn’t freeze at zero degrees.

Water is a liquid well below zero degrees.

Thankfully, Joseph Black did not reject his hypothesis as Popper would have had him do. What he did was to investigate further and discover a new phenomenon called “latent heat,” -- a discovery which became important in the development of the steam engine.

_In summary, the Popperian system of deductive thought is single-minded – if not this, then that, and if not that, than neither. But the science of real life (which finds its way into the courtroom) doesn’t behave the way Popper’s idealized Universe of quantum physics does, indeed duality is a common feature of our ever-day lives._
3. **Multiple Causation: The Dangers of Dust**

The worlds of chemistry and biology are replete with instances of dual causation which affect the way the body or our environment behaves. For example, certain aerobic bacteria which require oxygen to live can under certain conditions morph into anaerobic bacteria, called ‘*facultative anaerobes*’. This fact is easy to verify but can be most difficult to falsify.

Here is another example, this time in the field of medicine very relevant to toxic tort causation: In 1870 John Tyndall discovered that dust transmits infectious disease. By demonstrating that ‘optically pure air’ was incapable of developing bacterial life, he was able to *infer* that dust spread bacterial infection. His discoveries had “great value in combating the doctrine of the spontaneous generation of life [although] it met with much criticism and some ridicule” at the time. But eventually, Tyndall’s science was accepted. His “celebrated Friday Evening Discourse’ on the topic (given on January 21, 1870) entitled ‘Dust and Disease’ was more portentous than he realized.

Tyndall’s discovery is easily falsifiable. To falsify Tyndall’s discovery, we need only take a certain amount of dust, sterilize it and then expose a respectable quantity of test subjects (let’s say rats) to our sample If the dust we use is of a certain size and shape, the rats will come down with serious ailments, from pneumonia to fibrotic lung disease, to asthma to alveolitis and

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236 “Facultative anaerobes… have two alternative energy-yielding mechanisms at their disposal. In the presence of oxygen, they employ aerobic respiration, but they can employ fermentation if no free oxygen is present in the environment.” Roger Stanier, Michael Douderoff and Edward Adelberg, “The microbial world [sic],” 3rd edition, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, (1970) p. 12. Two other metabolic states exist: *microaerophiles*, which need oxygen because they cannot ferment or respire anaerobically and *aerotolerant* organisms which do not require oxygen as they metabolize energy anaerobically. However, unlike obligate anaerobes, they are not poisoned by oxygen. Experimentally, their existence is difficult to establish, as their microbial spread in the conventional thioglycollate testing broth may be very similar in dispersal pattern to the facultative anaerobe.

237 Thomas Martin op cit. at 52.
even cancer. In this experiment, we would have falsified the notion that the dust is a carrier of bacteria which cause disease because we would have proved that the dust itself caused disease. And indeed we would be right, depending on the size and shape of the dust particle and there are many dusts that fit the necessary disease-producing criteria: coal, wood, quartz, cement, nickel, beryllium, lead, volcanic ash, pollen, sand, and of course, the ubiquitous cotton would all qualify as disease-causing agents, along with the better known asbestos and silica (including glass). In this case, falsification deprives us of an important scientific concept: the germ theory of disease, since we would be required to conclude that the dust itself, rather than microbes which ride on it, is the causative agent. Tyndall’s conclusion that dust spread bacterial infection was of course true, but it was not the only possible or valid conclusion that could be reached. This duality of dust as independently capable of causing disease and as a carrier of biological disease agents (mold, fungi and bacteria) was well known by 1959 when Popper’s English (rewritten) version of ‘The Logic of Scientific Discovery’ was published. Paul Kotin, senior vice president for Health, Safety and Environment for the Johns-Manville Corporation in Denver (1974) had in his library the 1954 publication “Dust is Dangerous” which documents the double mechanism of disease causation as well as the disease producing effects of asbestos.

In medicine, multi-causal effects are of key concern, both to doctors and public health practitioners: How much of TB causation is attributable to the bacillus and how much to poor health and socio-economic conditions? How will an immunocompromised patient react to a

certain drug or vaccine? Is a patient’s liver cancer a metastasis with a short prognosis, or due to concurrent ingestion of Tylenol and alcohol – with a longer prognosis?

In the courtroom, duality of states or causes arises in multiple (legal) causation and multi-causal negligence, be it legally imposed such as joint and several liability or factually derived such as concurrent causation and dual actors. The concept may apply in criminal courtroom where clues identifying a defendant are not inconsistent with ruling out the identity of a second or third suspect. In short, we must conclude that the notions of falsification are unsuited to either the legal, biological or chemical forensic investigation.

IV. An Alternative Universe: What is science and how do we do it?

So, if falsification doesn’t tell us what science is\(^\text{240}\) let alone what ‘good science’ is, then what, the Gatekeeper may ask, can?

A. Addressing the Needs of the Gatekeeper: Redefining Science

One might start by re-addressing ‘what is knowledge’,\(^\text{241}\) as science is, at the very least, an accumulation of this commodity, albeit organized in a particular way, as we saw at the outset.

\(^\text{240}\) An example of the dual causal or contributing requirements to causation can be found in work relating to child development where taken-for granted maxims such as positive reinforcement were found to work only in children with a particular genetic makeup. Unless one had the technological capacity to examine the involvement of genetic contribution, the hypothesis of the benefit of behavior modification would have been disproved (falsified), and the inference would be environmental modification is useless, which is erroneous. See, Marinus H. van IJzendoorn, Marian J. Bakermans-Kranenburg, Jay Belsky, Steven Beach, Gene Brody, Kenneth A. Dodge, Mark Greenberg, Michael Posner & Stephen Scott, Gene-by-environment experiments: a new approach to finding the missing heritability, 12 NATURE REVIEWS, GENETICS, 881 (December, 2011) | doi:10.1038/nrg2764-c1.

\(^\text{241}\) Popper claims that knowledge is independent of the observer, something Plotkin defines as ontology. DARWIN MACHINES AND THE NATURE OF KNOWLEDGE Harvard University Press, Cambridge, Mass (1992) at. ix, telling us that “To know something is to incorporate the thing known into ourselves.”
Popper’s position is that: "all knowledge is hypothetical" or "All knowledge remains... conjectural," which is the essence of his philosophy, leaving its indelible paw-print on Daubert. Popper’s views on knowledge that “We never know what we are talking about” derive in large measure from Wittingstein, whose “theory of knowledge was closely linked with his cosmology.” Henry Plotkin, Professor of Psychobiology and Psychology at University College in London says: “Knowledge is what gives our lives order. The early medieval philosopher, scientist and scholar, Saadia Gaon provides a system more tenable with the needs of judge and juror: There are “four modes of proper knowing,” he tells us, “viz. knowledge from sense perception, knowledge from reason, knowledge from inference and knowledge from tradition,” a form of knowledge others have termed ‘cultural’ knowledge or ‘received wisdom.’

The word ‘scientist’ is relatively recent—coined by William Whewell in the 19th century. Beforehand people investigating nature called themselves ‘natural philosophers.’

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242 Nikolas Dykes, op cit.
243 Popper divides Knowledge into three worlds; only third world he claims constitutes science; the first is the physical world (which Popper excludes from the world of science); the second is the world of ‘critical arguments.’ Popper’s view is opposed by proponents of ‘scientism’ as well as more moderate schools of thought.

244 Nikolas Dykes op cit.
246 Plotkin, op cit. at 11.
250 Henry Plotkin (1992), supra. at 11.
debate of viewing ‘science’ philosophically as opposed to practically emerged at the end of the 19th century, only to re-emerge at the turn of the 20th century with Popper championing the pursuit, we argue, well beyond its time. However, “the controversy is continuing… involve[ing] rival understandings of what we mean by “science”, to the point where the European Commission has sponsored the notion of “post-normal science”. This is an idea of science drawing its authority from a consensus of “stakeholders” rather than from the traditional standards of rigorous proof,”251 indicating that the meaning of ‘science’ has been hijacked by a host of hangers-on with differing agendas.

In 1911 the Encyclopedia Britannica opined that: “Science may be defined as ordered knowledge of natural phenomena and of the relations between them.” 252 In 1955, Marshall Clagett tells us: “Science comprises, first, the orderly and systematic comprehension, description and/or explanation of natural phenomena and, secondly, the [mathematical and logical] tools necessary for the undertaking.”253 And in 1993, shortly before Daubert was decided, Paul Hoyningen-Huene a physicist and Director of the University of Hanover’s Center for Philosophy and Ethics published a detailed and useful list of what science is:254

➢ “Science studies nature or the world
➢ “Science aims at an understanding of nature or the world which captures its order with maximal precision and universality

251 Zoakus, op. cit.
“Science’s orientation toward this goal demands that it search for a set of propositions exhibiting maximal internal coherence with nature or the world.

“Science is mostly detail work; it strives toward understanding of nature of the world by way of a precise understanding of the individual aspects of nature or the world.

“Sciences proceeds empirically; in other words the acceptability of propositions is strongly regulated by observation and experience.

“herefore there exists a universal characterization both of the production of methods of scientific knowledge and the type of arguments that may be used in support of claims to such epistemological status.”

Subject to one modification, that the first criterion be amended to read, “ Science studies nature or the ‘finite’ world, we suggest that” the definition of science as the building block for a Gatekeeper paradigm be predicated on Hoyningen-Huene’s formulation.

Nevertheless, these basic postulates, while guiding us as to what is eligible to be considered ‘scientific’ as opposed to ‘new-ageism’ in any of its varieties, still leaves us adrift in deciding how good science is done. Since we have rejected Popper and his falsification scheme, we need to substitute another approach:

**What is science?**

**Science is Verifiable Knowledge about the Natural or Finite Universe**

Science is the pursuit of knowledge that studies the natural world or finite universe by an organized and reproducible methodology, seeking to a). categorize, b). organize and c.) understand the modality of working and interworking of its component parts. It aims to produce **verifiable** (objective) results.

Philosophers Cohen and Nagel advise us that “a hypothesis must be capable of **verification.**” They remind us that at the time a hypothesis is developed it may be impossible to
verify because of practical or testable difficulties (Popper would call this these pre-verified hypothesis ‘metaphysics’). But Cohen and Nagel indicate that a hypothesis is frequently incapable of immediate verification and this is not an impediment to its scientific standing, a diametrically opposite view, and “while it can never be demonstrated if [a proposition] asserts a truly universal consequence, it must be verifiable.”[emphasis in the original]

The notion of proof by “verifiability, is called “positivism.” Popper considered himself a staunch opponent; the cosmologist and physicist Stephen Hawkings, considers himself a positivist.

The post-scientific revolution demonstrates that the mission of scientists is to embark on a mission of verification, meaning that they attempt to “to prove the truth of,” of a proposition, “by evidence or testimony;” In other words, the plain dictionary meaning would have scientists confirm or substantiate a contention or ascertain the truth or correctness of a hypothesis, “by examination, research, or comparison,” of a claim. In this regard the principles of science (and we shall exclude from here on the fields of cosmology, quantum mechanics and Einsteinian physics) and law are remarkably similar in objectives: “[to prove or confirm (an allegation) or to state to be true, especially in legal use, formally or upon oath], such that the dictionary meaning of ‘verifiability’ in law is virtually synonymous with its general meaning: to act as ultimate proof or evidence of something. It should be noted that the origin of the word ‘verification’ derives from the Latin “verus” meaning true. , and certainly the tenor of law is to establish truth by verification or proof. Thus, notwithstanding attempts to differentiate the fields of science and law by Popper’s adherents, (and to be sure there are differences), the quest for truth and the approach

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255 The theories of consciousness enunciated by Penrose, for example.
256 Cohen and Nagel, op. cit p. 211.
257 “I, on the other hand, am a positivist who believes that physical theories are just mathematical models we construct, and that is meaningless to ask if they correspond to reality, just whether they predict observations.” In Penrose, op. cit. 169.
258 http://dictionary.reference.com/browse/verifiability
for truth-seeking is far more compatible than either Daubert or misguided jurists would have us believe. 259

Indeed, the method ‘modern’ scientists used to establish their claims is verifiable
demonstrative experiments, such as Sir Humphrey Davy used to create the new sciences of
electro-chemistry in 1806. 260 Falsification, to be, sure was undertaken during the early years of
science –mostly by prominent scientists whose reputations (or theories) were being upstaged by
some young upstart – or a rival whose theory was being attacked. The nature of these attacks,
often ad hominem, set back the cause and progress of science by decades if not centuries. The
proponent of a new theory was generally only successful (during his lifetime) if well-backed,
well-heeled or well-liked. Thus when the Abbe Nollet attacked Franklin’s view of electricity, it
was a massive PR campaign by his friends and colleagues that saved Franklin – and his
reputation. And their refutation was mostly done in letters and articles, not experiment. 261

Thus, in the world of experimental science, we talk of testability by experiment as a
means to verify a hypothesis; a valid “a hypotheses must be capable of verification.” 262
[emphasis in original]. As one scientist noted: “what it… means to be scientific brings us right
back to …: experimentation and experimental design. If I (as a scientist) propose a scientific

259 The pronouncement from the National Research Council report (2009) evidences this
misapprehension: “Since as far back as the fourteenth century, scientific evidence has posed
profound challenges for the law. At bottom, many of these challenges arise from fundamental
differences between the legal and scientific processes. . . . The legal system embraces the
adversary process to achieve “truth,” for the ultimate purpose of attaining an authoritative,
final, just, and socially acceptable resolution of disputes. Thus law is a normative pursuit that
seeks to define how public and private relations should function.... In contrast to law’s vision of
truth, however, science embraces empirical analysis to discover truth as found in verifiable
facts.” [emphasis supplied].

260 Thomas Martin, THE ROYAL SOCIETY, Oliver Burridge & Co, Ltd, Crawley, Sussex, first
printed in 1942, third edition revised and reset 1961, p16,
261 Barbara P Billauer, “Benjamin Franklin: Scientist-Statesman and the Father of Scientific
262 Cohen and Nagel, op cit. p211.
explanation for a phenomenon, it should be possible to subject that theory to an empirical test or experiment… . Scientists are usually very good at designing experiments to test theories. We invent theoretical entities and explanations all the time, but very rarely are they stated in ways that are falsifiable. It is also quite rare for anything in science to be stated in the form of a deductive argument. Experiments aren’t often done to falsify theories, but to provide the weight of repeated and varied observations in support of those same theories. Sometimes we’ll even use the words verify or confirm when talking about the results of an experiment.” Id.\textsuperscript{263} 

The language of Thomas Martin, a Historian for the Royal Institution, is illustrative: “In a series of beautiful experiments, Faraday proved, by systematic comparison of its chemical, magnetic and other effects that ‘electricity’ whatever may be its source is identical in nature,"\textsuperscript{264} To Popper, this formulation – evincing a certainty about the nature of electricity –is an anathema. And although it may be theoretically possible to falsify Faraday’s discoveries, it is difficult to conceive that falsification could happen, as should it happen, along with it would tumble the whole derivative science of electrical engineering.\textsuperscript{265}

In summary, both law and science require empirical and verifiable facts that we rely on; in science via experiment and direct sensory observation; in law via testimony based on first-hand knowledge, direct sensory observation and expert testimony based on ‘good science’. Thus, 


\textsuperscript{264} Ibid. p. 38

\textsuperscript{265} Ibid p. 50.
it can be said that ‘truth is truth’ – and science’s view of ‘truth’ is no different than the law’s,\textsuperscript{266} notwithstanding the proliferation of opinion to the contrary that leaked into ‘common-think’.

C. **Redefining ‘Good Science’?**

Perhaps then, the notion ‘what is science’ might be addressed by a philosopher, but what is ‘scientific,’ the critical question that plagues the Daubert judges, can only be answered by a scientist, who actually ‘does’ science.

The history of modern science demonstrates that every piece of knowledge is built on the presumption that the prior one is sound, relying on prior discoveries\textsuperscript{267} to generate new ones without constantly looking backward for errors. This principle is reflected in the term ‘valid’ (a term, haphazardly bandied about in Daubert and mish-mashed with ‘reliability’). Disentangling the two terms is of the critical requirements for forging a new forensic system evaluating scientific evidence for admissibility. \textit{For now, it is sufficient to realize there can be no ‘valid’ science without it being somehow related to pre-existing scientific knowledge – and this pre-existing knowledge must engender such profound trust that we call it ‘true’}. If Popper is correct, however, there can never be new and \textit{valid} science, since we can never be sure the basis upon which the new science is developed will someday become disproved.

\textsuperscript{266} Albert Logan, the Executive Director of the North American Judges Association, plainly states that “The hallmark of justice is the eternal search for truth.” In \textit{May a Man Be Punished Because He Is Ill?} ABA JOURNAL, (October, 1966) at 933. But compare: the claim that \textit{only} science involves the truth for search made by D. Allen Bromley in \textit{Science and the Law}, Address at the 1998 Annual Meeting of the American Bar Association (Aug. 2, 1998).” Cited in Goodstein, ibid. [emphasis supplied].

\textsuperscript{267} As Isaac Newton famously declared, “If I have come this far, it is because I have stood on the shoulders of giants.”
In 1878 George Gore,\textsuperscript{268} (an electro-chemist elected as a Fellow to the Royal Society of Britain in 1865) published a book entitled, “The Art of Scientific Discovery,”\textsuperscript{269} the stated purpose of which was to advise young people who have decided to pursue a career in science, on how to do it. The 648 page book comprehensively reviews every aspect of ‘practical science’ along with furnishing theoretical implications, philosophical musings and providing historical example where appropriate.\textsuperscript{270}

Gore tells us that the objective of good science is critical evaluation of all evidence i.e., testing and verification along with logically assessed results. For starters, he gives Gatekeepers their first rules:

1. “A true scientific statement,” he says, “is one which does not contradict any of the facts or laws of nature, but which agrees with and is supported by all of them.

2. “So-called facts cannot be relied on as facts, unless they have been at one time or another carefully \textit{verified}.”\textsuperscript{271} [emphasis supplied] Gore suggests that if we cannot trust the chemist who supplied the materials we must test the substances.

3. “That which is not to be depended on is not science; assumptions and hypotheses are also not strict science, but only a means to discovering it.

\textsuperscript{268} Ibid. “There is no tyranny equal to that of false impressions.”
\textsuperscript{269} G. Gore, ““The Art of Scientific Discovery,”” Longman’s, Green, and Co. (1878). The book is painstakingly researched, even including a section on women scientists and wives of scientists involved in their research along with the work of hundreds of scientists from all branches.
\textsuperscript{270} “As the object of all scientific research is the attainment of truth, and as mistake hinders that object, knowledge of error and the means of avoiding or correcting it is often a condition of success in research.” Gore, “The Art of Scientific Discovery.” Gore believed in scientific truth noting that facts, which are the basis for all science (p.85) are truths (p.82) that are lasting in nature (“forever” p.8). He well-recognizes mistakes have been made, (listing dozens by name and error) and advises that upon being presented with a fact, the responsible scientist will \textit{verify} it (p.85), going so far in some cases to personally repeat all experiments relied ( e.g., Faraday).
\textsuperscript{271} Ibid. p. 87
4. “Trustworthiness [qualitative truth] is the first object, and accuracy [quantitative truth] is the perfection and final aim of science.”

Gore elucidates and distinguishes between qualitative truth (what we might call validity) and quantitative truth or accuracy (what we might call reliability), noting that qualitative truth is far more important than quantitative truth. (Thus, he says “Priestly was an example of a chemist who was trustworthy, but not accurate”).

5. “A qualitative truth is not one of degree; it is absolute. “In a qualitative sense, a thing must either be or not ;

6. “The idea of accuracy is a quantitative one, and accuracy may exist in all degrees from nothing to perfection.”

What is ‘good science’?

‘Good science’ is objective knowledge produced via experiments or observations generating trustworthy (valid) and accurate (reliable) results. The first requirement requires a qualitative assessment that the results both answer the hypothetical proposition and conforms to previously validated scientific thought. The second requires is a quantitative assessment that the results are ‘good enough’ to be relied on by others.

Conclusion

Popper’s notions of falsifiability and falsification and emphasis on disproof, it is submitted, are inapplicable to the law of the courtroom. Thus this paper establishes that:

1. Popper’s ideas were conceived in response to and provoked by personal dilemmas in quantum physics and cosmology, and have no relevance to biology, chemistry and Newtonian physics, the ‘stuff’ of litigation.
2. Not all bone fide scientific statements can be falsified. Popper classifies these (e.g. existential statements, axioms and definitions) as ‘metaphysical’ and hence outside the aegis of legal admissibility.

3. Statements about religion can be falsified, debunking Popper’s notion that falsifiability differentiates between science and metaphysics.

4. Scientific statements which are falsified can lead to false knowledge (nescience).

5. Popper’s falsification does not tolerate dual or multi-causation

6. Law relies on proof, not in the disproof of falsifiability and falsification.

7. The legal burden of proof favors the status quo (the default position is that the defendant wins); the scientific burden of proof favors the proponent; i.e., in the event the evidence is in equipoise regarding the null hypothesis, the presumption is that the reverse proposition (the actual hypothesis) prevails.

8. The odds of prevailing favor the defendant in law, the proponent under Popper.

9. Evidence of disproof is not reliable. Reliability is the key requirement of Daubert.

10. Per Popper: There is no truth in science, except in the temporary sense.

According to Daubert, to qualify as "scientific knowledge," an inference or assertion must be derived by the scientific method. Proposed testimony must be supported by appropriate validation--i.e., "good grounds," based on what is known. In short, the requirement that an expert's testimony pertain to "scientific knowledge" establishes a standard of evidentiary reliability. Having now removed the taint of Popper, falsifiability and falsification, and recrafted a scientifically viable definition of science and good science, it is now possible to examine the requirement of conformity to the scientific method in order to fully devise a new gatekeeper paradigm.
APPENDIX

Jonathan Bing  by Beatrice Curtis Brown

Poor old Jonathan Bing,
went out in his carriage to visit the King,
but, everyone pointed and said 'look at that'!
Jonathan Bing has forgotten his hat!
(He'd forgotten his hat!)

Poor old Jonathan Bing,
went home and put on a new hat for the King,
but up by the Palace a soldier said, 'Hi!,
you can't see the King; you've forgotten your tie'!
(He'd forgotten his tie!)

Poor old Jonathan Bing,
went and put on a beautiful tie for the King,
but when he arrived, an Archbishop said, 'Ho!
You can't come to court in pajamas,
you know!

   Poor old Jonathan Bing
Went home and addressed a short note to the King:
"If you please will excuse me, I won't come to tea;
For home's the best place for all people like me."
I. Introduction: The Current State of Affairs > Immortalized Error
   A. The Five Errors of the Daubert Postulates
   B. Objectives of This Research
   C. Objectives

II. Falsifying Falsifiability
   A. Science 101 According to Daubert-93
   B. The Consequences of Falsifiability
   C. Popper’s Past as Prologue: Quantum Obsession and Skewed Motivation
   D. Who Sold Out Bacon? A prelude
   E. Popper and Biology: Once Upon a Popper There Were (Only) White Swans:
   F. Popper and Chemistry: Elemental Obstacles
   G. Popper and Religion: Alchemical Science
      1. We can falsify religion > Therefore, per Popper, it’s science
      2. Faith-Based Science
   H. Finality in Law and Science

III. So Falsifiability is Falsified: Who cares?
   A. Popperism is Incompatible with Legalism
      1. The Burden of Proof
      2. The Quantum of Proof
      3. Popper’s Reliability
   B. Specific Errors Generated by Daubert’s Reliance on Popper
      1. False Negatives and False Positives
      2. Falsifying Falsification
      3. Multiple Causation: The Dangers of Dust

IV. An Alternative Universe: What is Science and How Do We Do It?
   A. Addressing the Needs of the Gatekeeper: Redefining Science
   B. Understanding Verifiability,
   C. Redefining ‘Good Science’