

**Falsifiability as a Science/Non-Science Demarcation
Criterion in the Battle Against Creationism**

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Abstract: In the effort to keep creationism out of U. S. public schools, scientists and civil libertarians have successfully argued that creationism is not science and therefore has no place in science classes. Testability/falsifiability plays an important role in these arguments, as exemplified in two key U. S. court cases and a document produced by the National Academy of Sciences. Although there is little question that creationism is not science, the falsifiability criterion used to reach this conclusion is flawed in important ways. Drawing on the work of Ludwig Wittgenstein, I suggest an alternative.

Religiously based opposition to evolution is generally known as creationism. In the broadest sense, a creationist is anyone who endorses the theistic creation of the universe and/or life within the universe. Under this definition, even theistic evolutionists could be classified as creationists, despite their acceptance of the antiquity of the earth (approximately 4.5 billion years) and their acceptance of the evolution of life on earth. However, during the twentieth century the use of the word “creationism” has gradually narrowed to exclude theistic evolutionists (Numbers, 1992). Today a typical “creationist” adheres to the Judeo-Christian tradition and relies on biblical accounts, especially the book of Genesis, to inform belief about the origin and history of the natural world, and rejects Darwinian evolution. While “old earth” creationists reconcile geologic time scales with a literal view of the bible, “young-earth” creationists believe that the universe was created in six twenty-four-hour days less than 10,000 years ago and typically believe that much of the geologic column was laid down during the Noachian Flood described in Genesis chapters 6-8.

Along with sex education and school-sanctioned prayer, evolution is one of the most contested curricular issues faced by educators in the United States. Following Oklahoma’s passage of the first anti-evolutionary law in 1923, the 20th century witnessed a steady stream of statewide and local initiatives intended to prohibit, restrict, or offer alternatives to the teaching of evolution in public schools, together with numerous successful law suits challenging these laws and policies (Alters & Alters, 2001, pp. 203-206; Larson, 1985). In order to defeat the theory of evolution, creationists need intellectual validity, and the best validation of all would be recognition as science. According to Christopher Toumey, respect for science has grown to the point that it is granted “plenary authority” among the nonscientific public, even when the science is not understood. Toumey refers to such “respect without comprehension” as “science in an old testament style” (Toumey, 1996). Creationists claim this plenary authority when they use the term “creation science” and when they attempt to obtain legal recognition of creationism as a scientific pursuit. Scientists, science educators, and others respond by attempting to deny creationism the status of science and the authority that comes with that status. The result has been an extensive boundary dispute enacted in the courts and in creationist and anti-creationist literature.

The Legal Landscape

Early Cases: Creationism and the Establishment Clause

Court cases involving creationism and the public schools have centered on the Establishment Clause of the First Amendment to the U. S. Constitution: “Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof.” If it could be shown that creationism and/or anti-evolutionism rests in specific religious doctrines, then its introduction into public schools (a government institution) would violate the Establishment Clause. Tennessee’s Butler Act of 1925 is a fairly clear example of such an Establishment Clause violation:

[I]t shall be unlawful for any teacher in any of the Universities, Normals and all other public schools of the State which are supported in whole or in part by the public school funds of the State, to teach any theory that denies the story of the Divine Creation of man as taught in the Bible, and to teach instead that man has descended from a lower order of animals (Butler Act, 1925).

Soon after the Butler Act became law, the American Civil Liberties Union advertised for a test case. Prompted by local businessmen in Dayton, Tennessee, substitute teacher John Thomas Scopes intentionally violated the law in a science class and was convicted of having violated the Butler Act. However, the Tennessee Supreme Court reversed the ruling because of a procedural error on the part of the judge in the Scopes trial. When the attorney general refused to retry Scopes, the American Civil Liberties Union was left without a defendant or a route to federal court. As a result, the Butler Act remained unchallenged and in force until the Tennessee Legislature repealed it in 1967 (Moore, 1998a, 1998b).

The first Establishment Clause challenge to anti-evolutionary legislation would wait until *Epperson v. Arkansas* in 1968. In 1928, the citizens of Arkansas had passed the Rotenberry Act (Initiated Act No. 1 of 1928) by a statewide ballot initiative. The act reads in part:

It shall be unlawful for any teacher or other instructor in any University, College, Normal, Public School, or other institution of the State, which is supported in whole or part from public funds derived by State and local taxation to teach the theory or doctrine that mankind ascended or descended from a lower order of animals . . . (Moore, 1998c)

Just as the American Civil Liberties Union had done in 1925, the Arkansas Education Association recruited a volunteer to challenge the Rotenberry Act. Arkansas biology teacher Susan Epperson volunteered and petitioned the courts to invalidate the Rotenberry Act. After hearing arguments on April 1, 1966, a lower court ruled in Epperson’s favor, stating that since the Rotenberry Act was arbitrary and vague, it violated the Fourteenth Amendment to the U. S. Constitution (requiring due process). The Arkansas Supreme Court reversed the decision, clearing the way for a challenge in the U. S. Supreme Court. The U. S. Supreme Court, in turn, reversed the Arkansas Supreme Court decision. The Court concurred with the lower court that

the Rotenberry Act violated the Fourteenth Amendment, but the Supreme Court focused on the Establishment Clause:

Arkansas has sought to prevent its teachers from discussing the theory of evolution because it is contrary to the belief of some that the Book of Genesis must be the exclusive source of doctrine as to the origin of man. No suggestion has been made that Arkansas' law may be justified by considerations of state policy other than the religious views of some of its citizens. It is clear . . . that fundamentalist sectarian conviction was and is the law's reason for existence . . . The law's effort was confined to an attempt to blot out a particular theory because of its supposed conflict with the Biblical account, literally read. Plainly, the law is contrary to the mandate of the First, and in violation of the Fourteenth, Amendments to the Constitution (*Epperson v. Arkansas*, 1968).

Here the Supreme Court ruled that even a comparatively modest anti-evolutionary law (the Rotenberry Act prohibited the teaching of human evolution from other animals, but not evolution in general) violated the Establishment Clause because it was motivated by and favored a particular sectarian religious view.

Following *Epperson*, numerous anti-evolutionary laws were abandoned or struck down on Establishment Clause grounds (Moore, 1999a). Also, creationists mounted legal challenges to the teaching of evolution in public schools, claiming that since the theory of evolution advances a “religion of secular humanism,” presenting it in public schools violates the Establishment Clause. These efforts also failed. Consequently, in legislative and legal efforts, creationists increasingly expressed creationism in the language of *science* rather than *religion*.

Recent Cases: Anti-Evolution Becomes Creation Science

In 1981, the state of Arkansas enacted Act 590: The Balanced Treatment for Creation-Science and Evolution-Science Act (Arkansas Act 590, 1981). As its title implies, Act 590 mandated that all instruction in evolutionary theory in the Arkansas public schools must be counterbalanced by equivalent instruction in “creation-science.” In *Epperson*, the court had ruled that outlawing the teaching of evolution amounted to governmental establishment of a religious viewpoint. But in Act 590, the State of Arkansas did not forbid evolutionary instruction, but rather mandated an additional “scientific” point of view, “creation-science.” Yet the religious content of Act 590’s “scientific” point of view was fairly transparent. Consider the definition of creation science in Section 4, part (a) of Act 590:

“Creation-science” means the scientific evidences for creation and inferences from those scientific evidences. Creation-science includes the scientific evidences and related inferences that indicate: (1) Sudden creation of the universe, energy, and life from nothing; (2) The insufficiency of mutation and natural selection in bringing about development of all living kinds from a single organism; (3) Changes only within fixed limits of originally created kinds of plants and animals; (4) Separate ancestry for man and apes; (5) Explanation of the earth’s geology by catastrophism, including the occurrence of a worldwide flood;

and (6) A relatively recent inception of the earth and living kinds
(*McLean v. Arkansas Board of Education*, 1982, p. 1264).

Although the parallels between this definition and the first 11 chapters of Genesis are obvious, the Arkansas legislature hoped that by explicitly couching creationism in scientific rather than religious terms, Act 590 would survive an Establishment Clause challenge. This did not prove to be true. Less than three months after the passage of Act 590, a coalition of 23 Arkansas citizens and organizations challenged the law on First Amendment (Establishment Clause) grounds as well as Fourteenth Amendment grounds, arguing that Act 590 was unconstitutionally vague and thereby denied citizens due process (Moore, 1999b). In the resulting case, *McLean v. Arkansas Board of Education* (1982), Judge William Overton ruled that Act 590 failed the “Lemon Test” (*Lemon v. Kurtzman*, 1971) for Establishment Clause compliance: The statute must have a secular legislative purpose, the statute’s principal effect must be neither advancement nor inhibition of religion, and the statute must not foster “an excessive government entanglement with religion.” Although failure of any one of these indicates an Establishment Clause violation, Judge Overton ruled that Act 590 failed all three parts of the Lemon test. Act 590’s failure of the second part of the Lemon Test, that the statute’s principal effect must be neither advancement nor inhibition of religion, hinged on Overton’s conclusion that “creation science” is not science at all.¹ Overton initially invoked a very general definition of science: “science is what is ‘accepted by the scientific community’ and is ‘what scientists do’” (*McLean v. Arkansas Board of Education*, 1982, p. 1267). Noting that “there is not one recognized scientific journal which has published an article espousing the creation science theory described in section 4(a)” (*McLean v. Arkansas Board of Education*, 1982, p. 1268), Overton ruled that creation science is neither accepted by the scientific community nor what scientists do. Yet Overton also relied on a more precise definition of science offered in the testimony of philosopher Michael Ruse:

The essential characteristics of science are:

- (1) It is guided by natural law;
- (2) It has to be explanatory by reference to natural law;
- (3) It is testable against the empirical world;
- (4) Its conclusions are tentative, i. e., are not necessarily the final word; and
- (5) It is falsifiable (*McLean v. Arkansas Board of Education*, 1982, p. 1267).

¹ In his decision, Overton wrote:

The conclusion that creation science has no scientific merit or educational value as science has legal significance in light of the Court’s previous conclusion that creation science has, as one major effect, the advancement of religion. The second part of the three-pronged test for establishment reaches only those statutes having as their *primary* effect the advancement of religion. Secondary effects which advance religion are not constitutionally fatal. Since creation science is not science, the conclusion is inescapable that the *only* real effect of Act 590 is the advancement of religion. The Act therefore fails both the first and second portions of the test in *Lemon v. Kurtzman* (*McLean v. Arkansas Board of Education*, 1982, p. 1272).

Overton ruled that creation science fails to adhere to the first and second of these characteristics of science when, for example, creationists rely on supernatural intervention to produce a worldwide flood. He also ruled that creation science fails to adhere to characteristics 3-5, noting, for example, that the definitions of creation science in section 4(a) are not subject to revision:

A scientific theory must be tentative and always subject to revision or abandonment in light of facts that are inconsistent with, or falsify, the theory. A theory that is by its own terms dogmatic, absolutist and never subject to revision is not a scientific theory. The creationists' methods do not take data, weigh it against the opposing scientific data, and thereafter reach the conclusions stated in Section 4(a). Instead, they take the literal wording of the Book of Genesis and attempt to find scientific support for it . . . While anybody is free to approach a scientific inquiry in any fashion they choose, they cannot properly describe the methodology used as scientific, if they start with a conclusion and refuse to change it regardless of the evidence developed during the course of the investigation (*McLean v. Arkansas Board of Education*, 1982, p. 1268-1269).

Since creation science rests on an unalterable foundation (the book of Genesis), it is not testable, falsifiable, or tentative. Therefore, the court concluded, "creation science" does not meet the criteria of science.

Shortly after the Arkansas legislature passed Act 590, Louisiana considered a nearly identical Balanced Treatment for Evolution-Science and Creation-Science bill (Balanced Treatment Act, 1981; Moore, 1999c). However, the day after *McLean et. al.* filed suit against the Arkansas Board of Education, the sponsors of the Louisiana bill deleted the definition of creation science which proved to be constitutionally fatal to Act 590. This modified version of the Balanced Treatment Act became Louisiana law in 1981. Following a lower-court decision and an appeal, the Balanced Treatment Act reached the U. S. Supreme Court in 1986 as *Edwards v. Aguillard*, where the Court held that despite the law's careful deletion of religious references and its very general definition of creation science as "the scientific evidences for creation and inferences from those scientific evidences," it failed the first part of the *Lemon Test* (the Act does not have a clear secular purpose), and therefore it violated the Establishment Clause (*Edwards v. Aguillard*, 1987). Like *McLean*, the Court ruled in *Edwards v. Aguillard* that creation science is religiously motivated, yet unlike *McLean*, the Court did not explicitly rule on the question of whether creation science is science.²

Finally, in *Kitzmiller et. al. v. Dover Area School District* (*Kitzmiller v. Dover*, 2005), Judge John E. Jones III presided over a case involving Intelligent Design (ID), a form of

² However, a coalition of 72 Nobel Laureates, 17 State Academies of Science, and 7 other scientific organizations filed an Amicus Curiae Brief for *Edwards v. Aguillard* (1986) which declared that creation science is not science because: (a) science is restricted to natural explanations for phenomena, while creation science invokes supernatural explanations; and (b) a scientific explanatory principle "must be consistent with prior and present observations and must remain subject to continued testing against future observations," while creation science invokes non-testable explanatory principles.

creationism which avoids religious references. Jones ruled that the Dover, PA Board of Education violated the Establishment Clause when it required that a disclaimer be read in high school biology classes which referenced alleged flaws in evolutionary theory and offered Intelligent Design as an alternative.³ Jones ruled that this disclaimer failed the *Lemon* test for permissibility under the Establishment Clause as well as an “endorsement test” for the Establishment Clause (that a knowledgeable, objective observer would not perceive a statute as a state endorsement of religion). Specifically, Jones found that the Dover School District failed the endorsement test because:

1. “An objective observer would know that ID and teaching about ‘gaps’ and ‘problems’ in evolutionary theory are creationist, religious strategies that evolved from earlier forms of creationism” (pp. 716-723);
2. Both an objective student and an objective Dover citizen would view the disclaimer as an official endorsement of religion (pp. 723-735); and
3. Intelligent Design is not science (pp. 735-746).

Jones listed at least three reasons that ID is not science. First, Jones noted that the invocation of supernatural causes “violates the centuries-old ground-rules of science” (p. 735), thereby rendering many of its assertions untestable and causing ID to be rejected by every major scientific organization. Second, Jones noted that in 1981, Judge Overton criticized creationism in *McLean* for employing an illogical “contrived dualism,” whereby every argument *against* evolution is taken as an argument *in favor of* creationism. Jones noted that ID employs the same logical fallacy when it mounts arguments against evolution. Yet unlike the arguments for the

³ The full text of the disclaimer is:

The Pennsylvania Academic Standards require students to learn about Darwin's Theory of Evolution and eventually to take a standardized test of which evolution is a part.

Because Darwin's Theory is a theory, it continues to be tested as new evidence is discovered. The Theory is not a fact. Gaps in the Theory exist for which there is no evidence. A theory is defined as a well-tested explanation that unifies a broad range of observations.

Intelligent Design is an explanation of the origin of life that differs from Darwin's view. The reference book, *Of Pandas and People*, is available for students who might be interested in gaining an understanding of what Intelligent Design actually involves.

With respect to any theory, students are encouraged to keep an open mind. The school leaves the discussion of the Origins of Life to individual students and their families. As a Standards-driven district, class instruction focuses upon preparing students to achieve proficiency on Standards-based assessments (*Kitzmiller v. Dover*, 2005, pp. 708-709).

existence of a designer, the arguments against evolution are testable and have accordingly been refuted by the scientific community. Jones emphasized that these are tests of evolutionary theory rather than the existence of a Designer, and thus there is no logical contradiction between the untestability of ID and the failure of its anti-evolutionary arguments: “[E]ven if irreducible complexity had not been rejected, it still does not support ID as it is merely a test for evolution, not design” (p. 741). Third, Jones noted that since ID has no peer-reviewed publications in the scientific literature and does not research or test its theories, it is not science.

Testability/Falsifiability

Testability/Falsifiability as a Unitary Demarcation Criterion

We have seen that creationist’s efforts to remove evolution from and/or introduce creationism into the public school curriculum have been defeated in numerous court cases. (For other examples, see Alters & Alters, 2001, pp. 203-206.) As we have seen, an important component to many of these defeats has been the failure of creation science (including intelligent design) to find acceptance as science in court. Consequently, it is not surprising that pro-evolutionary scientists and science educators emphasize a distinction between science and creationism/intelligent design theory. The National Academy of Sciences (NAS) is the pre-eminent scientific organization in the United States, members of which are elected “in recognition of their distinguished and continued achievements in original research” (National Academy of Sciences, 2006), and over 200 of whose nearly 2500 members and associates are Nobel Laureates. In *Science and Creationism* (National Academy of Sciences, 1999), the NAS Steering Committee on Science and Creationism emphasizes a distinction between science and creationism, relying on testability as its primary demarcation criterion. For example, Bruce Alberts writes in the preface: “[T]he claims of creation science do not refer to natural causes and cannot be subject to meaningful tests, so they do not qualify as scientific hypotheses” (p. ix). In the introduction, the NAS notes:

The theory of evolution has become the central unifying concept of biology and is a critical component of many related scientific disciplines. In contrast, the claims of creation science lack empirical support and cannot be meaningfully tested. These observations lead to two fundamental conclusions: the teaching of evolution should be an integral part of science instruction, and creation science is in fact not science and should not be presented as such in science classes (pp. 1-2).

The NAS concludes:

Creationism, intelligent design, and other claims of supernatural intervention in the origin of life or of species are not science because they are not testable by the methods of science. These claims subordinate observed data to statements based on authority, revelation, or religious belief. Documentation offered in support of these claims is typically limited to the special publications of their advocates. These publications do not offer hypotheses subject to change in light of new data, new interpretations, or demonstration of error. This contrasts with science, where

any hypothesis or theory always remains subject to the possibility of rejection or modification in the light of new knowledge (p. 25).

Creationist claims are not subject to empirical tests, so they cannot be modified in response to empirical observation. Since they are neither testable nor tentative, data-driven modification and improvement of creationist theories are out of the question. Thus along with a stricture against invoking supernatural causes to explain natural phenomena, the NAS uses the non-testability of creationist claims as an important disqualifier to the designation of “science.” By contrast, the authors repeatedly emphasize the testability of the theory of evolution:

The fossil record thus provides consistent evidence of systematic change through time—of descent with modification. From this huge body of evidence, it can be predicted that no reversals will be found in future paleontological studies. That is, amphibians will not appear before fishes, nor mammals before reptiles, and no complex life will occur in the geological record before the oldest eukaryotic cells. This prediction has been upheld by the evidence that has accumulated until now: no reversals have been found (p. 14).

[Comparative anatomists] provide important inferences about the details of evolutionary history, inferences that can be tested by comparisons with the sequence of ancestral forms in the paleontological record (p. 14).

Evolutionary theory explains that biological diversity results from the descendants of local or migrant predecessors becoming adapted to their diverse environments. This explanation can be tested by examining present species and local fossils to see whether they have similar structures, which would indicate how one is derived from the other. Also, there should be evidence that species without an established local ancestry had migrated into the locality (p. 15).

In these excerpts, the NAS emphasizes the point that the theory of evolution can be tested against empirical evidence and therefore meets an important criterion for a scientific theory. Thus the theory of evolution is scientific and belongs in science classrooms, while creation science is unscientific and does not.

The Failure of Testability/Falsifiability as a Unitary Demarcation Criterion

The first serious problem with relying on testability, falsifiability, or tentativeness to disqualify creationism as science is that creationists test, falsify, and correct themselves. For example, as mentioned above Whitcomb and Morris reported that overlapping human and dinosaur footprints had been found in the Paluxy River bed near Glen Rose, Texas (Whitcomb & Morris, 1961, pp. 167, 172-176). Yet in 1986 Morris’s own organization, the Institute for Creation Research, concluded that none of the marks in the Paluxy River bed are of human origin (Numbers, 1992, p. 267). Or consider creationist Robert Gentry’s careful studies of radiohalos in granite (scars in the granite attributed to emission of alpha particles by radioactive particles). Gentry argues that some of these radiohalos indicate that granite is a “Genesis rock,” i. e. that granite could not have gradually cooled from a molten state as standard geologic theory

holds, but must have been created suddenly in a solid state, thereby supporting the six-day creation story (Gentry, 2003). Although Gentry was a rising star among creationists in the 1960s and 1970s, conducting research at the Oak Ridge National Laboratory and publishing radiohalo studies in *Science* (Gentry, 1968, 1970, 1974a, 1976) and *Nature* (Gentry, 1973, 1974b), the *Creation Research Quarterly* published a detailed criticism of Gentry's work and conclusions by young-earth creationist Kurt Wise (1989) together with Gentry's response (Gentry, 1989). Since then, the Institute for Creation Research has rejected Gentry's conclusions (see, e. g. Snelling, 2005). Other proposals are subject to vigorous debate among young-earth creationists. For example, D. Russel Humphreys (1994; 1997) has proposed a relativistic solution to the problem of astronomical appearance of age (the detection of light from astronomical objects 15 billion light-years away in a 6,000-year-old universe) which has been vigorously debated among young-earth creationists (e. g. Byl, 1997; Humphreys, 1997), and the young-earth publication *Creation Ex Nihilo Technical Journal* has published extensive criticism of Humphreys' views from outsiders, along with Humphrey's responses (Conner & Page, 1998; Fackerell & McIntosh, 2000; Humphreys, 1998, 2000). The young-earth International Conference on Creationism has rejected Humphreys' proposal, while Answers in Genesis, the Institute for Creation Research, and the Creation Research Society promote his work (Conner & Ross, 1999). Creationists debate where geologic evidence indicates that the Flood occurred in the geologic column—above the Pleistocene layers, the Cretaceous layers, or the Carboniferous layers (Tyler, 1997), or whether the geologic column is even a valid concept in Flood Geology (Reed & Froede, 2003). All of this points to an internal process by which creationists debate, test, and modify their conclusions based on physical evidence as well as theoretical considerations. Therefore neither the courts nor the NAS can accurately disqualify creationism as science based on a testability/falsifiability criterion.

A strategic error and a logical contradiction present further weaknesses in using testability or falsifiability as a science/non-science demarcation tool. Writing about the *McLean* decision, philosophers Larry Laudan (Laudan, 1982/1996) and Philip Quinn (Quinn, 1984/1996) point out that if creationist claims are not falsifiable by the methods of science, then science can say nothing about whether or not creationism is true. As Laudan aptly puts it:

In brief, [creationist] claims are testable, they have been tested, and they have failed those tests. Unfortunately, the logic of the [*McLean*] Opinion's analysis precludes saying any of the above . . . Asserting that Creationism makes no empirical claims plays directly, if inadvertently, into the hands of the creationists by immunizing their ideology from empirical confrontation. The correct way to combat Creationism is to confute the empirical claims it does make, not to pretend that it makes no such claims at all (Laudan, 1982/1996, p. 352).

Laudan's point is that claiming the untestability of creationism is poor strategy on the part of scientists and their allies because it disables one of science's most effective tools, namely the ability to devise experiments and make empirical observations. Quinn echoes Laudan when he argues that scientists commit a logical as well as a strategic error when they claim that creationism is not testable. Quinn points out that biologist Stephen Jay Gould (1983) asserts that creationist claims are not falsifiable but also asserts that they are easily refuted (Quinn, 1984/1996, p. 377). Logically, creationist claims can be irrefutable or refuted, but not both.

Unfortunately the National Academy of Sciences commits the same logical error in *Science and Creationism*. Within the same document, the NAS claims that creationism is untestable (see above) and identifies several instances in which creationism fails empirical tests. For example, the NAS lists numerous fields of study falsifying the young-earth hypothesis (National Academy of Sciences, 1999, p. 7), cites extensive evidence falsifying a worldwide Noachian flood (p. 8), and enumerates considerable paleontological evidence falsifying the hypothesis of simultaneous creation of all creatures (pp. 20-21). The National Academy argues, correctly in my view, that creationist claims are inconsistent with the physical evidence. Since creationist claims have been tested and found wanting, the NAS falls into a logical error when it simultaneously asserts that creationist claims cannot be tested.

The Failure of An Improved Testability/Falsifiability Boundary Criterion

Occasionally a more sophisticated version of “testability” appears which avoids the problems noted above. For example, Stephen Jay Gould, whom Quinn takes to task for simultaneously claiming that creationism fails tests and yet is untestable, eventually distinguished untestable central tenets from testable peripheral claims:

The flood story is central to all creationist systems. It also has elicited the only specific and testable theory the creationists have offered . . . Creationism reveals its nonscientific character in two ways: its central tenets cannot be tested and its peripheral claims, which can be tested, have been proven false. At its core, the creationist account rests on “singularities”—that is to say, on miracles (Gould, 1984, p. 129).

If we grant Gould the dubious premise that the Noachian flood could be “central to all creationist systems” and yet a “peripheral claim,” he appears to have escaped the logical inconsistency shown above by dividing essential/untestable from inessential/testable facets of creationism. Judge Jones employed similar reasoning in *Kitzmiller* when he found fault with “irreducible complexity,” the ID argument that structures and processes such as the bacterial flagellum, the human immune system, or blood clotting could not have evolved because the removal of any part disables them. Jones argued that “irreducible complexity” is testable and that it has failed its tests. However, Jones argued that tests of “irreducible complexity” are really tests of the falsehood of evolution rather than tests of the ID hypothesis:

We therefore find that Professor Behe’s claim for irreducible complexity has been refuted in peer-reviewed research papers and has been rejected by the scientific community at large . . . Additionally, even if irreducible complexity had not been rejected, it still does not support ID as it is merely a test for evolution, not design (*Kitzmiller v. Dover*, 2005, p. 741).

Intelligent Design, by contrast, argues that biological systems were designed and created by a “tactically unnamed designer” (p. 718). Jones concluded that since Intelligent Design requires a suspension of natural law, ID is untestable:

[T]he purported positive argument for ID does not satisfy the ground rules of science which require testable hypotheses based upon natural explanations. ID is reliant upon forces acting outside of the natural world, forces that we cannot see, replicate, control or test, which have produced changes in this world. While we take no position on whether such forces exist, they are simply not testable by scientific means and therefore cannot qualify as part of the scientific process or as a scientific theory (pp. 742-743).

Therefore the “irreducible complexity” claims of ID are testable, albeit as tests of evolution, but the core claim of ID, that the world was designed, remains untestable. Thus both Gould and Jones offer a nuanced version of the testability criterion, acknowledging that some aspects of creationism are testable while others are not.

However, like creationism/ID, scientific thought can be divided into untestable and testable features. The best contemporary example may be string theory, which is particularly well known for its long-term pursuit of theory in the absence of proposed empirical tests (Greene, 1999, 2004). Nobel Laureate Steven Weinberg wonders aloud whether or not string theory’s untestability disqualifies it as science (Cort & McMaster, 2003), but most physicists agree that string theory is science, albeit in a highly speculative form. But even less speculative forms of science include untestable features. Physicists assume, for example, that the principles and laws of the universe are simple in some fundamental way, that the same natural laws apply to all parts of the universe, and that the same natural laws apply through time (see, e. g. Rutherford & Ahlgren, 1990, pp. 3-4). These assumptions are the “rules of operation” for physics, and they are untestable because any test would rely on these very assumptions. Yet few would argue that physics is less scientific for maintaining these untestable assumptions. Furthermore, numerous non-scientific theories, such as astrology and literary theory, are testable (Laudan, 1983/1996; Morris, 1991). The lack of testability does not disqualify scientific theories, nor does the presence of testability validate a theory as being scientific. Therefore even in this sophisticated form, testability fails as a singular demarcation criterion.

When Gould and Jones refer to the “testable” aspects of creationist theories, they do not stop at the simple question of whether or not empirical tests can be devised. Gould writes that tests of the Noachian flood have led to its refutation, and Jones notes that tests have led to the refutation of irreducibly complexity. For both Gould and Jones, empirical tests imply the possibility that theories can be falsified, i. e. that empirical tests are conducted precisely to determine whether or not a theory is true. Although testability and falsifiability are not identical (e. g. testability is a necessary but not a sufficient condition for falsifiability), Gould and Jones use them to mean essentially the same thing. This leads to an additional problem with Gould and Jones’ assertion that creationism is non-scientific because some of its tenets are untestable. Thomas Kuhn famously argued that scientists operate under “paradigms,” exemplars of practice which guide their scientific work, and that these paradigms are irrefutable by empirical tests:

It has often been observed, for example, that Newton’s second law of motion, though it took centuries of difficult factual and theoretical research to achieve, behaves for those committed to Newton’s theory very much like a purely logical statement that no amount of observation could refute . . . [S]cientists fail to reject

paradigms when faced with anomalies or counterinstances. They could not do so and still remain scientists (Kuhn, 1970, p. 78).

Thus scientists routinely invoke infallible assumptions. Arguing in a similar vein, Imre Lakatos parses scientific theory into a “hard core” of central tenets surrounded by a methodological “protective belt.” Like Kuhn, Lakatos uses historical case studies to show that the protective belt effectively shields the hard core from falsification based on empirical tests (Lakatos, 1972). Since philosopher/historians such as Kuhn and Lakatos demonstrate that numerous aspects of science are non-falsifiable, Gould and Jones’ argument, namely that the presence of irrefutable elements in creationist claims disqualifies them as science, is undermined. Falsifiability as a science/nonscience demarcation criterion has notable supporters such as Karl Popper (Popper, 1961, 1968), but its numerous weaknesses (see, e. g. Chalmers, 1999, pp. 87-103) warrant its abandonment as a demarcation criterion (Laudan, 1983/1996). Therefore declarations that creation science is not science on testability/falsifiability grounds, such as those found in Judge Overton’s *McLean* decision, Judge Jones’s *Kitzmiller* decision, and the National Academy of Science in *Science and Creationism*, do not withstand scrutiny.

Additional Demarcation Criteria

Tentativeness

Other science/non-science criteria used in *McClean* and *Kitzmiller* fare no better. For example, the fourth of Judge Overton’s criteria for science is that “Its conclusions are tentative, i. e., are not necessarily the final word” (“*McLean v. Arkansas Board of Education*,” 1982, p. 1267). That is, the claims of science are held tentatively and are revised as new evidence is produced. Yet some features of science fail to exhibit tentativeness. As argued above, numerous scientific claims are not falsifiable by empirical evidence, so they are anything but tentative. On the other side, creationists have revised their claims and arguments over time, often in response to new data (Laudan, 1982/1996). The gradual rejection of the Paluxy River footprints and the reinterpretation of granitic radiohalos (see above) serve as examples. Therefore “tentativeness” fails to characterize all science, and “tentativeness” fails to rule creationism out. Therefore tentativeness cannot stand alone as a boundary criterion.

Methodological Naturalism

Overton wrote that “science is guided by natural law” and must be “explanatory by reference to natural law” (*McLean v. Arkansas Board of Education*, 1982, p. 1267). As Laudan (1982/1996) points out and Quinn (1984/1996) echoes, a great deal of scientific work is done before an explanatory framework has been developed:

Galileo and Newton took themselves to have established the existence of gravitational phenomena, long before anyone was able to give a causal or explanatory account of gravitation. Darwin took himself to have established the existence of natural selection almost a half-century before geneticists were able to lay out the laws of heredity on which natural selection depended. If we took the *McLean* Opinion criterion seriously, we should have to say that Newton and

Darwin were unscientific; and, to take an example from our own time, it would follow that plate tectonics is unscientific because we have not yet identified the laws of physics and chemistry which account for the dynamics of crustal motion (Laudan, 1982/1996, p. 354).

Clearly Galileo, Newton, and Darwin were doing science, but their guidance by or reference to natural law was unclear. Since geologists have yet to settle on an explanatory model for plate tectonics (see, e. g. Monroe & Wicander, 2005, pp. 356-357), the connection between plate tectonics and natural law remains tenuous and yet there is no question that plate tectonics is science. Yet in referring to natural law, Judge Overton likely meant that scientists do not invoke supernatural causes for natural events, i. e. they practice methodological naturalism. This can be seen in Overton's only direct reference to natural law in *McLean*. Section 4(a), of Arkansas Act 590 reads in part:

Creation-science includes the scientific evidences and related inferences that indicate: (1) Sudden creation of the universe, energy, and life from nothing.

Commenting on this section of Act 590, Overton writes:

First, the section revolves around 4(a)(1) which asserts a sudden creation "from nothing." Such a concept is not science because it depends upon a supernatural intervention which is not guided by natural law. It is not explanatory by reference to natural law, is not testable and is not falsifiable (*McLean v. Arkansas Board of Education*, 1982, p. 1267).

Thus Overton's assertion that scientific statements rely on natural law amounts to a prohibition of supernatural intervention as an explanatory principle.

In *Kitzmiller*, Judge Jones did not refer to natural law, but specifically invoked a prohibition against supernatural intervention in scientific explanation:

Expert testimony reveals that since the scientific revolution of the 16th and 17th centuries, science has been limited to the search for natural causes to explain natural phenomena . . . This revolution entailed the rejection of the appeal to authority, and by extension, revelation, in favor of empirical evidence . . . While supernatural explanations may be important and have merit, they are not part of science . . . This self-imposed convention of science, which limits inquiry to testable, natural explanations about the natural world, is referred to by philosophers as "methodological naturalism" and is sometimes known as the scientific method . . . Methodological naturalism is a "ground rule" of science today which requires scientists to seek explanations in the world around us based upon what we can observe, test, replicate, and verify (*Kitzmiller v. Dover*, 2005, p. 735).

Although early scientists such as Boyle and Newton regularly invoked divine intervention as an explanatory principle (Burt, 1932, pp. 191-195), Jones correctly observes that in the intervening centuries, scientists have come to eschew divine intervention as an explanatory device for natural

phenomena. Yet as Jones also notes, creationists would like to “change the ground rules of science to allow supernatural causation of the natural world” (*Kitzmiller v. Dover*, 2005, p. 736). In other words, creationists believe that such a prohibition is unwarranted. Although this prohibition against supernatural intervention does not encounter the sorts of objections that bedevil falsification or tentativeness, it only applies to explicitly religious practices such as creationism. It is ineffective against practices such as astrology, homeopathy, or extra-sensory perception because these do not invoke supernatural causes. Therefore methodological naturalism is a necessary but not a sufficient condition to define science. Furthermore, the methodological naturalism criterion is a true and helpful criterion with respect to creationism, but it does little philosophical work because it is tautological: scientists study the natural world while theologians (or other religious people) study the divine.

Mertonian Norms

Robert Merton (1973/1938; 1973/1942) attempted to describe science by its norms and values, but these fail to provide workable demarcation criteria as well (Evans, 2005). Merton lists norms such as universalism (scientific work is accepted on its merits, regardless of the nationality, ethnicity, or social status of those doing the work), communism (scientific knowledge is common property), disinterestedness, and organized skepticism (Merton, 1973/1942). Yet for each of these and other norms which have been proposed in science, counter-norms have been identified which are equally important to scientific practice. For example, universalism is balanced by preference for the work of specific scientists, communism is balanced by secrecy, and disinterestedness is countered by the norm of emotional commitment (Mulkay, 1976, 1980). Depending on context, scientists use norm or counter-norm to justify their actions and both are considered to be scientific (see, e. g. Collins & Pinch, 1998; Keller, 1983; Latour, 1987; Traweek, 1988).

A Wittgensteinian Approach to Science/Non-Science Demarcation

A Wittgensteinian Approach to Science/Non-Science Demarcation

In *Philosophical Investigations*, Ludwig Wittgenstein (1958) sheds light on the persistent failure of definitive context-independent epistemic or normative criteria for “science.” Wittgenstein shows that numerous everyday concepts elude rigorous philosophical definition, including “game” (§66-71), “exactness” (§88), “understanding” (§152-154), “reading” (§156-171), “being guided” (§172), and “carefulness” (§173). Wittgenstein argues that although these concepts frustrate attempts at demarcation criteria, any competent participant in the language can use and communicate these concepts without confusion. No single meaning runs through all examples of a concept, yet the many overlapping uses of a concept bear a “family resemblance” to one another. Consider the case of the word “game”:

For how is the concept of a game bounded? What still counts as a game and what no longer does? Can you give the boundary? No. . . . (But that never troubled you before when you used the word “game”) . . . We do not know the boundaries because none have been drawn. To repeat, we can draw a boundary—for a special purpose. Does it take that to make the concept usable? Not at all!

(Wittgenstein, 1958, §68-69).

The concept of “game” is indistinct, yet this fact does not diminish its utility for thinking and speaking. In fact, as Masterman (1970) claims with respect to the “paradigm” concept and Wittgenstein (§71) claims generally, the indistinctness or crudeness of a concept can *increase* its usefulness for thinking and discourse. Therefore philosophy is severely limited in what it can say about a concept. It cannot establish the foundation of a concept and it cannot control its use; in the end, philosophy can only describe language (§124). Therefore it is not surprising that when one tries to squeeze a definition out of the idea of “science,” it slips through the fingers.

However, this is not to say that various indicators are not useful. Falsifiability fails as an either/or demarcation criterion, but as we saw, scientists such as Stephen Weinberg express misgivings about string theory because it is not testable. Here testability does not serve as a definitive science/non-science boundary marker, but an untestable theory raises concern. In Wittgenstein’s terms, testability is a typical characteristic of the science family, but like any family trait, some members of the family do not share that characteristic. The same is true of tentativeness, methodological naturalism, or Merton’s norms--each is useful as indicators of family resemblance, but none of them is sufficient to rule a practice in or out as science. This is particularly visible in McComas, Almazroa, and Clough’s list of consensus views of the nature of science compiled from eight international science standards documents:

- Scientific knowledge while durable, has a tentative character.
- Scientific knowledge relies heavily, but not entirely, on observation, experimental evidence, rational arguments, and skepticism.
- There is no one way to do science (therefore, there is no universal step-by-step scientific method)
- Science is an attempt to explain natural phenomena
- Laws and theories serve different roles in science, therefore students should note that theories do not become laws even with additional evidence
- People from all cultures contribute to science
- New knowledge must be reported clearly and openly
- Scientists require accurate record keeping, peer review and replicability
- Observations are theory-laden
- Scientists are creative
- The history of science reveals both an evolutionary and revolutionary character
- Science is part of social and cultural traditions
- Science and technology impact each other
- Scientific ideas are affected by their social and historical milieu

(McComas, Almazroa, & Clough, 1998, pp. 6-7; McComas, Clough et al., 1998, p. 513)

Many of these areas of consensus are notably imprecise. Scientific knowledge tends to be both durable and tentative, to rely heavily on observation and other practices, but not entirely, to be methodical but to include many methods, to be evolutionary as well as revolutionary, etc. None of them could define science, but to borrow Wittgenstein’s metaphor, each attribute of science is a fiber in a thread, “[a]nd the strength of the thread does not reside in the fact that some one fibre runs through its whole length, but in the overlapping of many fibres” (Wittgenstein, 1958, §67).

We don't expect to find a single unitary definition of science which applies to all contexts; instead, many overlapping indicators assist in reaching a judgement regarding whether or not any particular practice should be classified as "science."

Having given up on identifying a context-independent science/non-science demarcation criterion, Larry Laudan concludes that

[i]f we would stand up and be counted on the side of reason, we ought to drop terms like "pseudo-science" and "unscientific" from our vocabulary; they are just hollow phrases which do only emotive work for us (Laudan, 1983/1996).

I agree with Laudan that "scientific" is unworkable as a context-free epistemic category, but I do not agree that the distinction between science and non-science is useless. Science is a practice whose existence precedes and presupposes efforts to define it. Consequently, no formulaic definition can separate science from non-science, but judgements can be and are made about whether or not a practice is "science." In making boundary judgements, special attention must be paid to the opinions of scientists themselves. As Judge Overton initially defined science in *McLean*: "science is what is 'accepted by the scientific community' and is 'what scientists do'" ("McLean v. Arkansas Board of Education," 1982, p. 1267). Occasionally the work of scientific outsiders comes to be accepted by the scientific community years later, so there is no warrant for elevating "acceptance by the scientific community" to the status of a single, unitary, and sufficient boundary criterion. However, as Phillip Quinn (1984/1996, p. 368) observes, non-scientists generally defer to the judgment of scientists in the case of boundary disputes. When scientists disagree about the scientific status of a practice, such as epidemiology (Amsterdamska, 2005) or clinical recovery of suppressed memory (Ashmore, Brown, & MacMillan, 2005), non-scientists generally wait for scientists to reach a consensus and then accept that judgment. Thus when Judge Jones observed in *Kitzmiller* that creationism/ID is uniformly rejected by every major scientific organization and has essentially no publication record in peer-reviewed scientific journals, this near-consensus is a strong indication, although not a proof, that creationism/ID is not science. Arguments from tentativeness, falsifiability, etc. are useful, but they are generally made posterior to the judgement among scientists that creationism is not science.

Conclusion

We have seen philosophical difficulties in relying on such bright-line science/non-science demarcation criteria as falsifiability, testability, or tentativeness. Yet these difficulties may not affect the outcomes of future court cases. Together with creationists' abandonment of methodological naturalism, creationists' failure to establish a publication record in mainstream scientific literature, and the rejection of creationism by scientists, the unfalsifiable and non-tentative aspects of creationism can signal its unscientific character. In the aggregate, such indicators can remove the "reasonable doubt" that creationism is a religious practice rather than a scientific practice and therefore should not be taught as "science" in the public schools. However, given the evidence that some of the practices of mainstream science are unfalsifiable, untestable, and non-tentative, scientists and civil libertarians who battle creationism should avoid claiming too much for these criteria. In the end, the distinction between science and non-science is a practical judgement for which there is no definitive test. Acknowledgement of this reality

may actually strengthen the position of scientists in future legal disputes with creationists, especially if creationists begin to exploit the philosophical weaknesses of demarcation criteria.

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