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REVIEW ARTICLE

Darwin, Dover, 'Intelligent Design' and textbooks

Kevin PADIAN[1] and Nicholas MATZKE

Department of Integrative Biology and Museum of Paleontology, University of California, Berkeley, CA 94720-3140, U.S.A.

ID ('intelligent design') is not science, but a form of creationism; both are very different from the simple theological proposition that a divine Creator is responsible for the natural patterns and processes of the Universe. Its current version maintains that a 'Designer' must intervene miraculously to accomplish certain natural scientific events. The verdict in the 2005 case *Kitzmiller, et al. v. Dover School District, et al.* (in Harrisburg, PA, U.S.A.) was a landmark of American jurisprudence that prohibited the teaching of ID as science, identified it as religiously based, and forbade long-refuted 'criticisms of evolution' from introduction into public school classes. Much of the science of the trial was based on biochemistry; biochemists and other scientists have several important opportunities to improve scientific literacy and science education in American public schools ('state schools') by working with teachers, curriculum developers and textbook writers.

Key words: creationism, evolution, history of science, intelligent design, science education.

INTRODUCTION

On the morning of 20 December, 2005, Judge John E. Jones III, of Pennsylvania's middle Federal district, handed down a 139-page decision that blasted the attempts by the DASB (Dover Area School Board) to introduce ID ('intelligent design') as an alternative curriculum to evolution in its high-school biology classes [1]. (The decision is available online at http://www.pamd.uscourts.gov/kitzmiller/decision.htm. A complete archive of trial proceedings and case documents is available at http://www2.ncseweb.org/wp/?p=150.) The verdict was hailed by scientists and science educators around the world, and continues to receive journalistic and academic attention. To date it has been the subject of four books [2–5] and an award-winning PBS (Public Broadcasting Service) *Nova* documentary [6].

The decision covered, as required, numerous technical issues, both legal and scientific. All of these were resolved in favour of the plaintiffs' general arguments that ID was creationism, not science, and therefore illegal under the Constitution's prohibition against government action with the primary purpose or effect of a sanctioning a particular group's religious views. But the decision was notably punctuated by the Court's specific assessment of the actions by the DASB. The judge railed against the "breathtaking inanity" of the school board members who trumpeted their support for budgetary austerity and conservative Christian values, and then proceeded to abandon their mission of educational stewardship and waste tax dollars in an attempt to overturn long-established norms of science and American public school ('state school') science education. Most damagingly, the judge concluded that the court record showed that the ID leaders on the school board pettifogged, evaded questions, or outright lied about their involvement and intentions during sworn testimony, noting that it was "ironic" that they were the very same board members who "so staunchly and proudly touted their religious convictions in public."

Those antievolutionary religious convictions are another reason for continuing interest in the case. Dover, very much like the Scopes Monkey Trial (Figure 1) 80 years before in Dayton, Tennessee, was seen by many to represent in a microcosm the American public's split feelings over evolution. Before it became clear that statements of religious motivation were constitutionally problematic, the ID leaders on the DASB had been quite clear about why they felt the need to fight this battle. The standard biology textbook was "laced with Darwinism," complained one member, William Buckingham, who also said, "it is inexcusable to have a book that says man descended from apes with nothing to counterbalance it." He also declared after one school board meeting: "This country wasn't founded on Muslim beliefs or evolution. This country was founded on Christianity and our students should be taught as such."

The attitude of the DASB members is not unusual. A recent comparison of 34 industrialized nations found that the U.S. ranks second-to-last in public acceptance of evolution, ahead of only Turkey [7] (Figure 2). What these two countries share is a relatively large population of religious fundamentalists; the difference is whether they are Christians or Muslims. Still, the proportion of U.S. citizens who appear to reject evolution, the central organizing principle of biology, is astounding. Polls taken by the Gallup organization since the 1980s show consistently that almost half of Americans polled think that "God created human beings pretty much in their present form at one time within the last 10000 years or so" [8].

It is tempting to dismiss these respondents as people who also think that *The Flintstones* is a documentary, but the truth is more complex. It is a tenet of survey research that how the questions are asked and understood can influence the results in counterintuitive ways. A portion of those who agreed with this answer might, for example, feel that God chose a specific moment to invest humans with a soul, at which point they would have pretty much achieved their present form. It is also likely that a substantial

Abbreviations used: ACLU, American Civil Liberties Union; CSI, complex specified information; CS(R)C, Center for (the Renewal of) Science and Culture; DASB, Dover Area School Board; DI, Discovery Institute; ID, intelligent design; NCSE, National Center for Science Education; PBS, Public Broadcasting Service; TMLC, Thomas More Law Center.

[1] To whom correspondence should be addressed (email kpadian@berkeley.edu).

Figure 1 Clarence Darrow (left) and William Jennings Bryan (right) in conversation in court during the Scopes trail

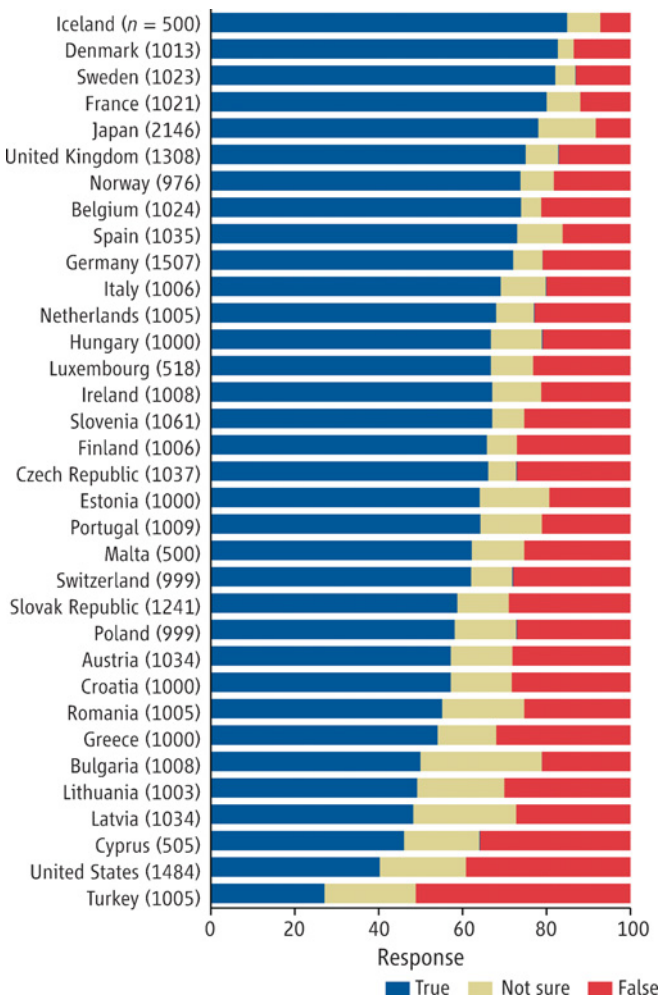

Figure 2 Relative public acceptance of evolution in 34 countries

From Miller, J. D., Scott, E. C. and Okamoto, S. (2006) Public acceptance of evolution. Science 313, 765–766. Reprinted with permission from AAAS. (http://www.sciencemag.org/cgi/content/full/313/5788/765)

proportion of the public has not thought much about the difference between 10 000 years and millions, and just automatically lumps them together into a 'long time ago'. Similarly, those who accept mainstream science (evolution as an entirely natural process) but happen to be religious might equally well choose either the 'God guided' or 'God had no part' answers, depending on what they assumed these vague phrases meant. So precise interpretation of the Gallup survey, the only long-term dataset available, is problematic, especially because George Gallup, the *éminence grise* of pollsters, is an evangelical Christian who sees his polling operation as his ministry to understand God's will for his people on Earth [9,10].

A poll taken by a rather different organization, People for the American Way [11], got a different result. When asked, "Is the scientific theory of evolution compatible with a belief in God?", 68 % of respondents replied affirmatively; only 28 % disagreed. What accounts for the difference between the two polls? Approx. 25–30 % of Americans, depending on how the question is asked, identify themselves as conservative, evangelical or fundamentalist Christians, i.e. those who would be expected to reject evolution and support creationism. The rest of the alleged 'pro-creationism' opinion is more a matter of unfamiliarity or a post-modernist view that all knowledge is relativistic and culturally conditioned (see more details of this survey in [11]).

Why is America like this? To answer this question, we review very briefly the history of the 'evolution versus creation' controversy in American jurisprudence, focusing on the Dover trial as a watershed in the latest iteration of American creationism, namely 'intelligent design'. We review what ID is and what it claims to be, and how it differs from classical ID theology. We discuss the fallout from the Dover trial decision and what the antievolution forces are doing in its wake. And finally, we suggest what scientists – whether evolutionists, biochemists, geologists or physicists – can do about the collective societal inertia that continues to impede an integrative understanding of science among the American public.

A BRIEF HISTORY OF EVOLUTION VERSUS CREATION IN THE COURTS

Many scientists are under the impression that science and religion have always been at war over evolution and the age of the Earth, but historians have shown that this was not the case. By the 1910s, Darwin's *Origin of Species* was over 50 years old and not a topic of major religious controversy (Figures 3 and 4). Even *The Fundamentals*, a series of pamphlets published between 1910 and 1915 to explain and defend Biblical inerrancy, did not target evolution as a major, irreconcilable opponent [12–15]. The situation changed for 'fundamentalists' (as they came to be named, after the pamphlets) only after World War I, which destroyed naïve faith in 'progress' and launched a search for the cause of such carnage [16]. Fundamentalists blamed the historical field of 'higher criticism' of the Bible (which began in Germany) for a loss of faith and then morality in that country. Fearing the same would happen in the U.S., fundamentalists battled more liberal 'modernists' for the soul and control of their denominations. The controversy spilled over into the political domain when three-times presidential candidate William Jennings Bryan, who had spent his career on nationwide political 'crusades', decided that evolution, now widespread with the rise of high schools and biology classes, had been a contributing factor in the loss of Biblical faith and rise of German militarism. He launched his final crusade against evolution in the schools [13,17].

From 1921 to 1929, twenty state legislatures considered 37 bills banning or otherwise interfering with the teaching of evolution in the public schools. The bills failed in most states (e.g. in

Rhode Island, the bill was referred to the Committee on Fish and Game [17]), but they passed in Oklahoma and Tennessee, and a state ballot measure with the same effect passed in 1928 in Arkansas. The then-new ACLU (American Civil Liberties Union) wanted a case to put it on the map and so advertised for a teacher to challenge the constitutionality of the Tennessee law. John Scopes volunteered, and thus came about the famous Scopes Monkey Trial of 1925, well covered elsewhere [17–19]. Famed defence attorney Clarence Darrow goaded Bryan into taking the stand as a witness on the Bible, and embarrassed him in the national media: an apparent 'victory' solidified when Bryan died of diabetes days after the trial. Fundamentalists were scorned by the media, lost their denominational battles, and faded from public view by the 1930s. However, it is often forgotten that Scopes was actually convicted, and although this conviction was later overturned on a technicality, Tennessee's law banning evolution, and other such state laws and many local policies, remained on the books for decades. As a result, textbook publishers, who wanted to publish one book and sell it across the country, deleted or minimized the treatment of evolution, and even teachers who were not officially barred from teaching evolution would often avoid it [16,20]. This remained the status quo until the 1960s, when, in the wake of Sputnik and the fear that the communists were ahead of the U.S. in science, the federal government poured money into science education and textbooks. With evolution re-entering the schools, the old conflicts re-emerged. The ACLU challenged the 40-year-old Arkansas ban in 1968 and convinced the Supreme Court to vote 9-0 to overturn it because it was "clear that fundamentalist sectarian conviction was and is the law's reason for existence," and this violated constitutionally mandated governmental neutrality on religion [21].

The Scopes-era bans on teaching evolution were defeated in a stroke, and some thought that antievolutionism was an anachronism that would soon be forgotten. But creationism did not become extinct; it evolved [14,16]. The dominant form of creationism actually became more radical. Bryan and many creationists of the 1920s had been 'old-earth creationists', denying common ancestry, particularly of humans and apes, but accepting the ancient age of the earth. In the 1960s, however, extreme literalists became predominant, and promoted the 'young-earth creationist' view that the six days of creation in Genesis were six literal 24-hour days and that any other reading was an unacceptable compromise [22]. As soon as laws banning evolution were overturned, creationists lobbied for 'equal time' for creationism instead. Because the courts mandated religious neutrality from the government, the creationist view was re-branded as 'scientific creationism' (or 'creation science') in 1970. Another wave of proposed bills swept the country's state legislatures, and 'equal-time' laws were adopted in Arkansas and Louisiana in 1981. The Arkansas law was challenged first, and over a 2-week trial famous scientists testified against creationist 'experts'. The Court ruled that "creation science" was fundamentalist religion in disguise, and concluded "[n]o group, no matter how large or small, may use the organs of government, of which the public schools are the most conspicuous and influential, to foist its religious beliefs on others" [23]. Creationists tried to defend the nearly identical Louisiana bill by stripping down creation science to the bare minimum, 'abrupt appearance' of life forms, but was nevertheless ruled unconstitutional on summary judgment. This decision became national law in 1987 when it was confirmed by the Supreme Court 7-2 in *Edwards v. Aguillard* [24]. 'ID' was born as a direct result of the litigation over creation science in the 1980s [1,25]. Much of the creationist ancestry of ID was hidden until the Kitzmiller litigation.

THE SETTING OF THE DOVER 'ID' CASE

The conflict addressed in the trial that began in Harrisburg, PA, U.S.A. in the fall ('autumn') of 2005 began to coalesce in the interaction between DI (Discovery Institute) staffer and attorney Seth Cooper and creationist William Buckingham, chair of the DASB curriculum committee, in June 2004 [1,26]. The DI in Seattle is an umbrella organization focusing on several public policy issues, including regional traffic control, but in 1996 it started the CSRC (Center for the Renewal of Science and Culture), locus of the 'ID' creationism movement. (The CSRC later dropped "Renewal" from its name and changed its logo from Michelangelo's Adam being touched by the hand of God to a rather more nebulous … well, nebula [27].) In 1998 the CSC developed a semi-confidential manifesto called "The Wedge" (scan online at: http://www.antievolution.org/features/wedge.pdf), an ambitious socio-political plan to avoid the "devastating" "…social consequences of materialism" by "cut[ting materialism] off at its source … *scientific* materialism." "[M]aterialistic science" is viewed "as a giant tree", the trunk of which can be cut by the "wedge" of ID. (This imagery, with evolution as the trunk supporting innumerable social and theological evils, is actually extremely traditional creationist 'tree of evil' iconography; see [28]).

The 'Wedge' strategy was mostly the brainchild of now-retired Berkeley law professor Phillip E. Johnson, who experienced a religious epiphany after a midlife crisis and took up the evolution issue after the *Edwards* decision, arguing that it established 'naturalism' in the public schools [29]. Johnson and allies organized in the early 1990s and raised large sums of money from conservative donors such as Christian Reconstructionist Howard Ahmanson, funding about 40 'Fellows' allegedly to conduct scientific research on ID. Instead, the primary products of the CSC have been opinion pieces, plus attempts to lobby politicians and school boards and influence legislation with the goal of getting ID and/or more subtle forms of antievolutionism into the public schools. Few of its 'Fellows' are particularly distinguished academically, and few have any training or reputation in science, let alone biology and especially evolution; the partial exception is biochemist Michael Behe of Lehigh University (Bethlehem, PA, U.S.A.), of whom more later.

Buckingham, for his part, was a young-earth creationist who, along with several companions, had been fighting regular culture wars at school board meetings. Following scattered antievolution activity in previous years, which included the burning of a student-painted mural of human evolution [1,3,6], Buckingham became particularly offended in 2004 when he read the District's standard biology textbook, Miller and Levine's *Biology* [30], which he found to be "laced with Darwinism." He and others on the school board had already had a series of unsatisfactory meetings with the science teachers, who had attempted to explain to him that they did not teach that humans came from monkeys, did not teach about the origin of life, and took every measure to respect student beliefs. Buckingham began making strong remarks at board meetings about the need to teach creationism to balance evolution, and these ended up in the newspapers. The DI's Seth Cooper saw an article, and called Buckingham and told him that creationism was a non-starter legally, but that there was a legal alternative called ID. Cooper denies strongly that he recommended any policy that required that ID be taught [26], and says he recommended the "strengths and weaknesses" approach; this is consistent with indications that, starting around 2004, the DI regularly called creationist school board members who had appeared in the news, and coached them to adopt more circuitous antievolution strategies. Cooper sent Buckingham a standard DI care package,

which included the ID video *Unlocking the Mystery of Life* [31] and the book and video of *Icons of Evolution* [32,33]. *Icons* claims officially that textbooks are full of errors regarding evolution, and unofficially makes the case that all major pieces of evidence for evolution are vicious frauds and that children are being lied to by scientists, textbooks and their teachers. Buckingham got the hint and ran with it.

Buckingham, enraged at what he thought were lies being taught in the textbooks (he objected to the discussion of Darwin's finches, apparently because they had the word "Darwin" in their name [1]), forced the teachers to watch *Icons* (twice), and attempted to extract promises from the teachers to restrict their teaching of evolution. The teachers refused to be pushed further, however, and, frustrated at this, Buckingham and allies moved to force changes to the District curriculum. By July 2004 all talk of creationism had disappeared and 'ID' was *de rigueur*. Buckingham sought legal assistance (the DI is not a law firm and claims it tried to dissuade Buckingham, even at this early date, although Buckingham does not confirm this) and found the TMLC (Thomas More Law Center), whose attorneys had been seeking a test case on ID for 5 years [34]. The TMLC advertises itself as "the Sword and Shield for People of Faith" and "a Christian answer to the ACLU" [35]. The irony of a school board hiring an aggressively conservative Christian law firm to defend an avowedly non-religious policy seems not to have occurred to the parties involved.

The TMLC offered to defend the school board *pro bono*, and expressed confidence in the outcome, suggesting the ID "textbook" *Of Pandas and People* [36] as a supplemental classroom text. *Pandas* was put in the curriculum in October 2004, and about 60 copies were 'anonymously' donated to the school district. When the teachers refused the plan, insisting (correctly) that ID was not accepted as science and that it was their job to teach the state curriculum, the school board drew up a statement that they insisted teachers would have to read to students before evolution was discussed:

> (a) 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.
> (b) Because Darwin's Theory is a theory, it is still being 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.
> (c) 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 to see if they would like to explore this view in an effort to gain an understanding of what Intelligent Design actually involves.
> (d) As is true with 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.

The policy was to go into effect in January 2005, prompting eleven parents to bring suit against the district on December 14, 2005. However, the lawsuit was not going to immediately block implementation of the policy, so the teachers of their own accord refused to read the statement. The Board decided that district administrators would come into the classrooms and read it; but, unusually for an educational experience, no questions or discussion would be allowed afterwards; and anyone could be excused voluntarily from hearing the statement. In January 2005, the statement was read to the biology classes under the glare of subpoenas and national press coverage.

It was at this point that the DI began to spin into damage control mode. Previously, they had worked in Kansas and elsewhere, trying to encourage 'alternatives' to evolutionary science in public school classrooms. In the 1990s, in the Wedge strategy document and elsewhere, DI fellows had clearly advocated presenting ID in science classrooms and had even published a booklet specifically detailing how to do it [37,38]. But, after the exhilarating early years, it was clear that their planned programme of scientific research had not kept up with their programme of writing op-ed pieces and lobbying school boards. Moreover, the early flush of curiosity and sympathy that ID had garnered from media outlets had begun to fade as scientific critics spoke out. As the media became more familiar with the ID movement and its critics, they began to move from the superficial "he said, she said" reporting that is common in media coverage of stories involving science, and began more critical journalism, asking tougher questions. This was met with increasing truculence and obfuscation from the DI public relations staff. The DI realized that it could not control the DASB, whose members had already given away the game by telling the newspapers that they wanted creationism taught in classrooms. A public relations disaster in the making was being compounded by a possibly catastrophic trial outcome. The DI announced it was opposed to requiring ID in the classroom, but initially, at least, seemed willing to advise the TMLC behind the scenes; five DI fellows signed on as experts for the defence. Only in June 2005 did the DI 'jump ship' completely, taking many of their experts with them, and leaving the DASB and the TMLC 'holding the bag' [39].

As Dover teachers and parents became more concerned about the intransigence of the school board, they turned to two places for help. One was the American Civil Liberties Union (ACLU). The regional director, attorney Vic Walczak of Pittsburgh, saw the need for a full-court press against an infringement of First Amendment rights. The other was the NCSE (National Center for Science Education) in Oakland, California (http://www.ncseweb.org). The NCSE is the only organization in the country whose full-time mission is the protection of evolution and other scientific concepts from assault in the public schools by sectarian threats; it is also the premier organization in the country that clarifies "the nature of science", i.e. what science is and how it differs as an approach from other modes of human inquiry, to the general public, government agencies, the media and educational administrations. The NCSE had been following the Dover situation for some months as part of its monitoring of 'flare-ups' of creationist activity in the U.S. The approach of the NCSE is always to educate people about what has been regarded historically, scientifically and legally as science and non-science, and to expose sectarian religious challenges to good science education.

The ACLU's Walczak knew that he would need further legal help in order to conduct the case effectively. Dr Eugenie Scott, Executive Director of the NCSE, proposed to consult one of NCSE's legal advisory board, Eric Rothschild of Pepper Hamilton LLC in Philadelphia, who jumped at the chance. He was joined by his colleagues Steven Harvey, Tom Schmidt, Alfred Wilcox, and many talented legal assistants. Pepper eventually donated over one million dollars of uncompensated legal assistance to the trial. AU (Americans United for Church and State) also joined the suit, and AU's Richard Katskee served as the Establishment Clause specialist for the plaintiffs' team.

Before describing the trial, we will examine the key concept at issue in the case, 'ID'. What is it, and why do some support it so rabidly?

WHY THE DI'S VERSION IS NOT YOUR FATHER'S 'ID'

Like many famous scientists, Darwin has been posthumously enlisted in a great many causes by both supporters and enemies. Among these is atheism. To the contrary, like Jefferson, Franklin, Madison, Hamilton and other geniuses of the Enlightenment, for most of his life Darwin fell somewhere on the spectrum of deism [40]. He spoke of a Creator not in personal or personified terms, but as a distant, reliable lawgiver; similar language is found in the Declaration of Independence ("Laws of Nature and Nature's God"). Like most of the Founding Fathers, he did not use the terms Christ, Lord, Saviour or Redeemer. And, like them, Darwin saw the universe as having a purpose: he could not conceive how the universe itself could have been the result of "blind chance and necessity"; for him, all this must have had a "First Cause" with "an intelligent mind in some degree analogous to that of man".

Figure 3 Charles Darwin photographed in 1860, the year after the publication of *On the Origin of Species*, aged 51

The structure of much of Darwin's argument in the *Origin of Species* [41] came from the works of the theologian William Paley, which were standard curricular material at Cambridge, even a century after Darwin had read them in the 1820s. The core of Paley's *Natural Theology* [42], one of his best known books, was based on a simple analogy. If, Paley said, you were walking along a heath and stubbed your foot against a stone, you would think nothing of it; the stone may have been there for ages, as far as you knew. But if you had stubbed your foot against a watch, you would not have drawn the same conclusion. A watch is a highly complex device, obviously made for a purpose and by an intelligent maker. So, he claimed, the intricate adaptations of organisms for their needs in their environment are clear indicators of a Designer, a grand Watchmaker.

Darwin was very much impressed by the rhetorical force of Paley's argument from design, and to some extent by its substance (although the logic of the argument had been shattered by Hume and other philosophers decades earlier). Readers will quickly see that Darwin used the same rhetorical structure when he undermined Paley's argument in the *Origin of Species* [41]. He began by describing the very small differences between breeds of pigeons, flowers and crops that people had judiciously selected for centuries, resulting in the great variety of fruits, grains and domesticated animals that sustain civilization. How much more effective, he reasoned, would Nature have been, working for uncounted millennia on the same kinds of small variations in natural communities, and thus shaping the diversity of life? Darwin turned the design argument in biology on its head with his law of natural selection, but this was not at all injurious to deistic convictions; Darwin simply had discovered new 'cogs' in the Designer's 'watch-like universe', regular processes by which Nature's God shaped life.

The 'ID' purveyed by the DI takes some elements from 'Paleyism', but is much more ambitious than Paley's deist-friendly argument. Contrary to Paley, the whole point of ID is to establish that miraculous supernatural intervention was required in the history of life. The possibility of a lawgiving God is not good enough; what is desired is scientific confirmation of an Old Testament God, actively and personally interventionist. ID is not a generic religious apologetic for the existence of God; it is a specific apologetic for the existence of ubiquitous miracles, i.e. the sort of God that fundamentalists believe in. As the ID textbook *Of Pandas and People* puts it, "Intelligent design means that various forms of life began abruptly through an intelligent agency, with their distinctive features intact – fish with fins and scales, birds with feathers, beaks, and wings, etc." Because ID proponents are notoriously evasive about some of their views, even many critics are under the impression that ID proponents accept common ancestry and the ancient age of the Earth. But almost all reject common ancestry in favour of the notion that only minor evolution can occur, and only within the specially created "kinds" commanded by God to reproduce "after their kind" in Genesis [43,44]. A substantial proportion are 'young-earthers', or even profess agnosticism on the age issue [25,43,44].

ID proponents attempt scientifically to demonstrate their proposal, i.e. repeated miraculous intervention in the history of life, with one main argument: some things are so complex that they could not have come into being by natural processes alone. These phenomena, therefore, must be manifestations of a 'supernatural Creative Intelligence'. There are two allegedly empirical approaches to testing this hypothesis. The first is 'irreducible complexity': if you can remove some of the working parts of a system and it can no longer function, then it cannot have evolved and it must have been designed by a Creative Intelligence. The main proponent of this idea is the aforementioned Dr Michael Behe, a biochemist at Lehigh University (Behe is often described as a biologist, but he earned his doctorate and tenure in chemistry departments, working on the structure of DNA). Behe has never tested his 'irreducible complexity' hypothesis in a peer-reviewed scientific journal, and he is possibly unique in the compass of American academics in having his entire department agree on their website that his views are scientifically groundless (http://www.lehigh.edu/~inbios/news/evolution.htm). Behe enjoys being the centre of attention, but he apparently does not take his avocation seriously, given his complete deficit of serious academic work devoted to demonstrating that 'irreducible complexity' is unevolvable, a contention which he feels no responsibility to test personally [1]. Behe's contentions were rebutted extensively at trial in the Dover case (see below), and the biochemical rhetoric of Behe and other ID creationists has recently received a thoroughly critical review [45].

A similar dilemma confronts the other pillar of ID, William Dembski, who has doctoral degrees in mathematics and theology but not in any branch of science. Dembski's hobby horse is a concept called CSI ('complex specified information'), or 'specified complexity', which is supposedly found in coding DNA and amino acid sequences just as much as it is found in English sentences. CSI leads to a design inference because, says Dembski, all natural phenomena are the result of three possible

processes: chance, necessity (by which is meant some natural agency) and design. If you can eliminate the first two from consideration, you must admit that a Designer is responsible. Dembski eliminates chance by calculating the miniscule odds of assembling a gene or other complex biological structure all at once by chance. Because no biologists propose that evolution works by all-at-once random assembly, this is a 'straw man' argument. Dembski dispenses with 'necessity' by arguing that natural selection cannot produce new genetic information. But Dembski never takes seriously the crucial point that biological change is the result of both chance and necessity – that is, mutations create variety, and natural selection non-randomly preserves the variations that work. This process gradually builds up new alleles, genes and adaptations, i.e. genetic 'information' as commonly understood. (We lack space to discuss this term, which is highly problematic in biology if assumed to be easily quantifiable. ID advocates fling it about with the appearance of erudition, but in fact never stick with a rigorous quantifiable definition, which is required to test their assertion that evolution cannot increase genetic 'information'.) Dembski's only attempt to block the combination of mutation and selection is to invoke Behe's 'irreducible complexity', so in the end Dembski's argument, despite impressive-looking equations, is irrelevant and reduces to Behe's argument.

ID proponents do not like to talk about the theological basis of their creationism. Speaking in academic or educational settings, they claim that they are purely scientific in their approach. But in front of religious audiences and in sectarian publications, proponents such as Dembski will claim that "[i]ntelligent design is just the Logos theology of John's Gospel restated in the idiom of information theory" [46].

Once it is admitted that ID is theology, there are immediate and critical problems with introducing it into scientific or educational discussions. Because many biochemists and biochemistry students, like everyone else, have strong religious backgrounds, it is useful to consider some of the implications of current ID theology. First, ID theology implies that the natural processes instantiated by the Creator were imperfect and have required frequent 'tinkering' to run. This is a difficulty for those who believe that the works of the Creator must be perfect. Secondly, ID requires frequent Divine intervention in natural processes and events, which is very much a 'pre-Enlightenment' theological approach to the role of God with respect to Creation. Thirdly, by pretending to be scientific, ID implies that science can test religious ideas. Fourthly, ID opens a difficult question: if a Creator can intervene in natural events, why does He not do so more often to alleviate suffering and evil? This age-old problem of theodicy is glossed over by the ID advocates. Each of these points opens a can of worms in secular fora like scientific journals or public school classrooms: do we really want students and scientists arguing arcane and probably unresolvable theological disputes on time that should be devoted to learning and doing science?

SCIENCE VERSUS 'ID'

The Dover 'ID' trial began on September 26, 2005. Judge John Jones III, appointed to the bench by President George W. Bush, was well connected to Republican leaders such as Tom Ridge and Rick Santorum. This gave the defence team and its supporters early confidence that a ruling would go in their favour. The judge, however, was an independent thinker with a strong liberal arts education who hewed to no party line. The attorneys in the trial agreed that he ran a very fair courtroom. Because this was a case dealing with constitutional law, it was decided not by a jury, but by a judge; the jury box was occupied instead by reporters.

The case was complex because several kinds of arguments were being presented at once. The Dover policy could be unconstitutional, because the board members acted with the purpose of favouring a specific religious view, or because 'ID' and the other forms of antievolution (e.g. portraying evolution as a speculative guess by calling it "theory, not fact," a fundamentalist trope that goes back to the 1920s [47]) were themselves specific religious views, and thus an unconstitutional religious effect regardless of what could be proven about the purpose of the board members. The plaintiffs asserted both claims. The responses from the defence were essentially that ID was good science and not religion, and therefore there was a predominantly secular purpose and effect to teaching it, whatever a few board members may have said in heated moments. It was therefore the defence's argument, in rebuttal to the plaintiffs' main assertion, that made science legally relevant in the case.

Expert witnesses for the plaintiffs

The plaintiffs' legal team and their advisors spent many months analysing previous court decisions on creation and evolution, the published arguments of 'ID' advocates and their intellectual antecedents in 'creation science', 'scientific creationism', 'Bible science' and other antievolutionary movements, and the actual scientific evidence for evolution that could reasonably be presented at trial. In consultation with the NCSE, expert witnesses were chosen for their ability to address critical factors that would neutralize the scientific pretensions of the ID proponents, expose their arguments as untested and antithetical to scientific philosophy and method, lay out the history of the ID movement with its roots squarely in conservative Christian socio-politics, and show why ID was both poor pedagogy and poor theology.

The strategy for the plaintiffs was to begin testimony with Kenneth R. Miller, a cell biologist from Brown University (Providence, RI, U.S.A.), who is also one of the authors of the high-school biology textbook that the DASB wanted supplemented by *Of Pandas and People* because it was allegedly "laced with Darwinism." Miller, a lifelong Catholic and the author of *Finding Darwin's God* [48], was the obvious choice to begin for several reasons. He could explain with authority the 'nature of science' and how it differs from faith and other human ways of thinking; he could testify as a practising scientist that there is no necessary conflict between science and religion for millions of Americans; and he could anticipate and neutralize the arguments of defence witness Michael Behe that are based on uncorroborated and unreviewed interpretations of biochemistry, cell biology and immunology. So, for example, Miller was able to deflate Behe's contention that molecular structures like the bacterial flagellum are "too complex" to have evolved by natural means, because allegedly the flagellum can have no function until all the parts are present. Behe has consistently ignored a basic conclusion of evolutionary research: that structures can and do change function in evolution, and that complex systems evolve by secondary co-option of a structure for another function [49] (for example, wings and flippers evolved from walking forelimbs). This is a ubiquitous and crucial process recognized and emphasized by evolutionary biologists ever since Darwin, and destroys the assertion that 'irreducible' systems cannot evolve [44].

Miller used the flagellum as a case in point. Behe had contended that the bacterial flagellum consists of over 50 working parts, and if any of these were removed, the motor would no longer work. But Miller showed that flagella work with as many as 20 fewer parts, and if the structure is simplified further, although it may lose its locomotor function, it still works as part of the type III

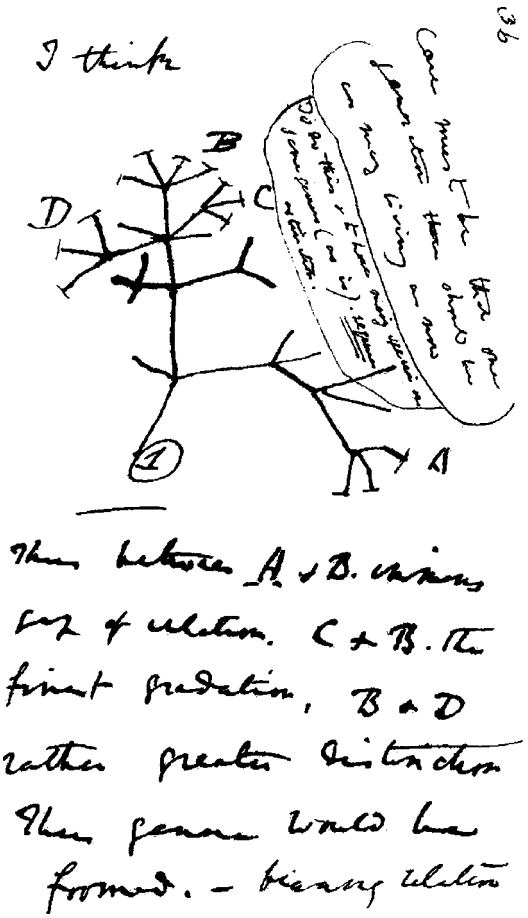

Figure 4 Darwin's first sketch of an evolutionary tree, featured in his *First Notebook on Transmutation of Species* (1837)

secretory system. Further studies have since shown that only about 20 proteins are universally required for flagellar motility, and of those, only a few have no known evolutionary relatives [50]. Miller drove the point home by looking at another of Behe's systems, the vertebrate adaptive immune system, and pointing to a series of papers confirming the transposon model for its origin [51].

Robert T. Pennock, a professor of philosophy and biology at Michigan State University (Eastin Lansing, MI, U.S.A.), was chosen for his background in both fields. Pennock is the author of *Tower of Babel* [52], a critique of ID. He is also an expert on the computer modelling of evolutionary systems that, among other things, merely through random instructions and probabilities of change, can develop patterns that are not only orderly and evince statistical non-random 'trends'; they also appear to be goal-directed in improving survival capability in the landscape of artificial intelligence. The work of Pennock and his colleagues [53] refutes the charge that the evolutionary process of variation and selection could never assemble complex multipart adaptations. Pennock also addressed the nature of science and reasons that science, for hundreds of years, has focused on natural causes, not supernatural ones (reviewed in [54,55]).

John Haught, a theologian of Roman Catholicism and a Professor of Theology at Georgetown University (Washington, DC, U.S.A.), has written extensively on the relationship (and non-conflict) between science and religion [56,57]. A proponent of the need to respect different domains of human thought and endeavour, Haught carried on a gentlemanly conversation with attorney Wilcox on science and theology, which appeared to captivate the judge. In contrast, the defence cross-examination, which focused on obscure points of Catholic dogma, did not.

Perhaps the most damaging testimony of any expert witness was provided by Barbara Forrest, Professor in the Department of History and Political Science at Southeastern Louisiana University (Hammond, LA, U.S.A.). Forrest is a philosopher by trade, but one who believes that to be useful philosophy must address practical problems in the real world. Significantly, she was the only expert witness in the trial that the opposing side attempted to have dismissed, in this case on the grounds that she was a philosopher and not a scientist. (Most of the original defence expert witnesses could have been challenged on the same grounds, but as it turned out most of them excused themselves anyway.) Forrest is co-author, with Paul R. Gross of Rutgers University, of the book *Creationism's Trojan Horse: The Wedge of Intelligent Design* [58], a history of the recent ID movement that shows its religious roots and the broad socio-political compass of its conservative Christian "Wedge" strategy. The defence actually wanted her dismissed because they knew that her testimony alone could sink their case; they characterized her as "a conspiracy theorist and a web-surfing 'cyber-stalker' of the DI", and mockingly asked if she was an atheist and a "card-carrying member of the ACLU" (the answer was "yes" to both) [59]. Ironically, however, the defence challenge backfired: the defence's cross-examination of Forrest's qualifications fell flat, and the judge enhanced her credibility by overruling their objection.

In the course of rummaging through old NCSE library files, archivist Jessica Moran had come across a telling 1987 document. Scribbled across the top was a 1995 note by the late Berkeley professor of biochemistry and biophysics, Thomas H. Jukes, who told NCSE, "I found this in an old file, but it is certainly fascinating!". The document was a prospectus for a book to be entitled *Biology and Origins*, which was described as a book about creationism, rather than ID. The book was being developed by the Foundation for Thought and Ethics, a conservative publisher near Dallas. Nick Matzke, then a researcher and 'flare-ups wrangler' at NCSE, pursued the lead and determined that this book eventually became the book *Of Pandas and People*. NCSE alerted the plaintiffs' attorneys, and all the drafts of *Pandas* and its antecedents were eventually subpoenaed. They told an interesting tale: the draft book's title changed from *Creation Biology* (1983) to *Biology and Creation* (1986) to *Biology and Origins* (1987), and finally to *Of Pandas and People* (two drafts from 1987, with the first edition finally published in 1989; [60]). Up through the first 1987 draft entitled *Pandas*, variants on the words 'creation' and 'creationist' were used over 100 times; but after the Supreme Court's 1987 *Edwards v. Aguillard* decision [24] against creation science, virtually all of the instances of 'creation' in the second 1987 *Pandas* draft were changed to variations on 'ID' or "design proponents." As if a smoking gun were still needed, Forrest found one instance of an incomplete electronic word switch in the manuscript that bizarrely referred to "cdesign proponentsists" [44] (Figure 5). It appears that even creationism evolves; or sometimes tries to.

The legal significance of this was monumental: the Supreme Court had already decided the unconstitutionality of creationism in 1987; ID was indisputably a literal re-labelling of creationism that occurred after the decision; therefore, all that was left for the district judge in the Dover case to do was to be a conservative and apply the Supreme Court's precedent and rule ID unconstitutional [38].

Brian Alters, a Professor of Education at McGill University who holds an adjunct position at Harvard, is a specialist in

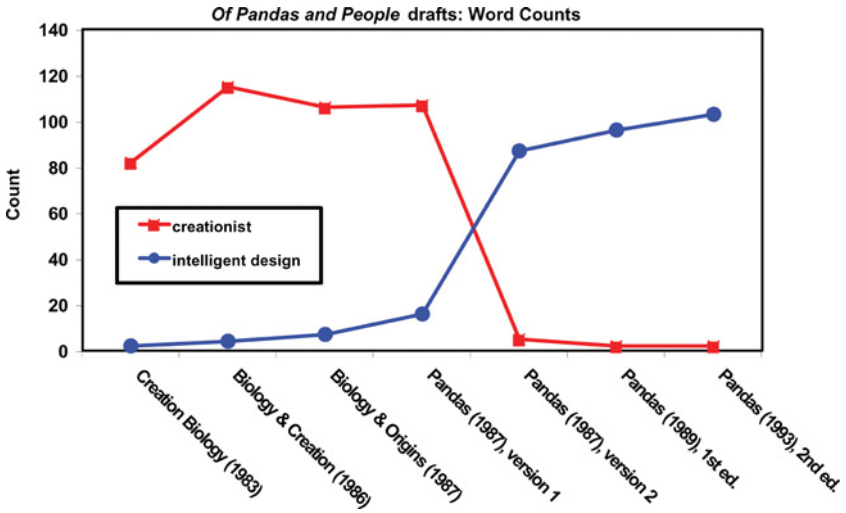

Figure 5 Frequency of usage of the terms 'creationist' and 'ID' presented in the *Kitzmiller* trial during Forrest's testimony

This graph was presented in the *Kitzmiller* trial during Forrest's testimony. Word counts were conducted on five unpublished drafts (1983–1987) and two published editions (1989, 1993) of the ID textbook *Of Pandas and People*. The first four drafts used the term 'creationist' and cognates frequently, but between two drafts dated 1987, the creationist terminology was replaced wholesale with 'ID' language. The *Edwards v. Aguillard* Supreme Court decision banning 'creation science' was handed down on June 19, 1987.

evolution education. In addition to many articles and several textbooks, he is the author (with his wife, Sandra M. Alters) of *Defending Evolution* [61], a book that attempts to help scientists and educators to effectively engage students whose religious upbringings have left them ignorant of or hostile to evolution. He has emphasized the need to respect and understand differing philosophical and theological backgrounds as a teaching opportunity. Alters was able to show that the tenets of ID were not accepted in science curricula across the US and in other countries, that creationism/ID is universally rejected by scientific societies [62,63], and that the policy of the Dover school board and its one-minute statement were decidedly poor pedagogy.

Kevin Padian is a Professor of Integrative Biology and a Curator in the Museum of Paleontology at the University of California (Berkeley, CA, U.S.A.). He is also President of the NCSE. Most of his research has been on macroevolution, specifically how major new evolutionary changes get started in the history of vertebrates. He and his students have focused on major adaptations such as the origin of flight, how vertebrates came on to land, how dinosaurs evolved, and how they evolved many of their bizarre structures and important new adaptations. He has also worked on the history of evolutionary thought and has served on many pre-college educational panels in California, including those that drafted the *Science Framework* for public schools and adopted science textbooks [64]. Padian was the plaintiffs' concluding witness, meaning that Miller and Padian book-ended the plaintiffs' case as scientists who could address the scientific and methodological claims of ID and to review the quality of *Pandas* as a high-school biology textbook. Most of Padian's testimony demonstrated the factual fallacies of *Pandas*; whereas Miller concentrated on molecular, genetic and immunological problems, Padian concentrated on *Pandas'* claims about the fossil record, classification, homology and the evolution of major groups and adaptations. He showed that there is much more evidence for the Cambrian Explosion, the origin of tetrapods, birds, mammals and whales than *Pandas* suggested. Padian's testimony, including detailed graphical exhibits with explanatory captions on each of these topics, is freely available online as an educational resource (http://www2.ncseweb.org/kvd/exhibits/Padian/kpslides.html). Behe restricted claims about 'irreducible complexity' to molecular structures, but his *Pandas* co-contributors were not so circumspect, writing repeatedly about the impossibility of finding intermediate features in fossils. The educational dilemma is that if students are taught that science will never find the answers to some questions, and then those answers are found, are the answers *de facto* false or is ID theory false?

One expert witness for the plaintiffs did not have to testify. This was Professor Jeffrey Shallit of the University of Waterloo (Ontario, Canada), an expert in mathematics and computer science. He did not have to testify because his main function was to evaluate the scholarly credentials of William Dembski, who withdrew from the case. Shallit's expert witness report showed that the "Isaac Newton of information theory," as Dembski has been called by supporters, has no reputation in the field of information theory or of mathematics in general, having published only two peer-reviewed mathematical papers in a career of over 15 years: not enough to get tenure at any university that values research. Shallit showed that Dembski's allegedly peer-reviewed books have come in for withering criticism by actual mathematicians (to which he has never responded), and that he is not a scientist, has never published a peer-reviewed scientific paper, and has never been funded for scientific research.

Expert witnesses for the defence

There were only three expert witnesses called for the defence. There had been eight, but five eventually did not testify. Warren Nord and Dick M. Carpenter II were on the witness list at trial, but were not called by the defence. John Angus Campbell, Steven C. Meyer and William Dembski withdrew, allegedly because they were not allowed by the TMLC to bring their own counsel to the pre-trial depositions, a strategy apparently advised by the DI to protect its fellows, supporters and itself from uncontrollable damage. It is our conjecture that Dembski decided to withdraw at least partly upon seeing the expert witness report of Jeffrey Shallit, who would have thoroughly exposed and shredded any expertise that Dembski might have professed [39]. This is ironic because Dembski had claimed only a month before that he and his colleagues would relish this opportunity to destroy the

foundations of Darwinism. We can do no better than to quote Barbara Forrest's account [59]:

> "Dembski was waiting for the day when the hearings [referring to a series held by the Kansas Board of Education in May 2005, which evolutionists boycotted in protest] are not voluntary, but involve subpoenas in which evolutionists are deposed at length. When that 'happy day' came, Dembski predicted, the Darwinists 'won't come off looking well'. On May 11, Dembski portrayed 'evolutionists' as too chicken to participate: '[E]volutionists escaped critical scrutiny by not having to undergo cross-examination ... by boycotting the hearings.' He proposed a 'vice strategy' for 'interrogating the Darwinists to, as it were, squeeze the truth out of them', childishly illustrated with a photograph of a Darwin doll with its head compressed in a bench vice. On May 16, he outlined his strategy: 'interrogating Darwinists' about 'five terms: science, nature, creation, design and evolution.' Under subpoena, they would be compelled to answer, hence the 'vice' metaphor."

There is little doubt about who actually turned 'chicken' when just such an opportunity for deposed, cross-examined, sworn testimony presented itself in the Dover trial. To add insult to injury, Dembski charged $200 per hour (reportedly some $23 000 in total) for his expert witness report, which was never used, then threatened to sue the TMLC when it did not promptly pay him. None of the expert witnesses for the plaintiffs charged for their services; all of the defence's expert witnesses did.

Michael Behe was the main expert witness for the defence, and it was up to him to do most of the 'heavy lifting' in their cause. Behe has no established expertise in evolutionary biology, palaeontology or organismal biology, and as noted earlier, he restricted his claims about 'irreducible complexity' and other alleged phenomena of ID to the molecular level. Defence attorney Robert Muise led him through a tortuously detailed explanation of the bacterial flagellum and numerous other molecular systems that appeared to make the judge's eyes glaze over.

However, things got lively on cross-examination by plaintiffs' attorney Eric Rothschild. There, Behe was drawn into several devastating admissions. He acknowledged that there were no peer-reviewed scientific papers that demonstrated anything in favour of ID (in contrast with the expert witness report of his colleague Stephen Meyer, who withdrew from testifying and then tried to get his report admitted in an amicus brief, which angered the judge). Because ID proponents advocate an 'expanded' definition of science in which non-naturalistic phenomena and explanations must also be considered, Behe was forced to admit that, by his definition, astrology would qualify as science.

One of the turning points in the trial came when Rothschild got Behe to confirm his published statement that "The scientific literature has no answers to the question of the origin of the immune system" [51]. Rothschild then proceeded to layer a pile of books and articles over two feet tall on the witness stand; each of them focused on the evolution of the immune system. Behe did not admit that they destroyed his argument, to which Rothschild (and the judge, in his ruling) suggested that they were 'not good enough' for him. In fairness, Behe's argument was somewhat different. He maintains that they do not show that these features evolved through a system of 'random mutation and natural selection', which is his definition of evolution. But Behe's claim, whereas technically moot, is both irrefutable and nonsensical. Biologists do not use his definition of evolution, for several reasons (see the Addendum).

The second expert witness for the defence was Steven Fuller, an American who is a professor of sociology at the University of Warwick, U.K. Fuller is a post-modernist who sees scientific enquiry as relativistic and entirely situated in social context. He advocated a kind of 'affirmative action' in tolerance for the new approach of ID, but also admitted that ID had so far shown no conventional scientific advances. His testimony did not seem to do much to advance the arguments for ID in the eyes of the judge.

The final expert witness for the defence was Associate Professor Scott Minnich of the University of Idaho (Moscow, ID, U.S.A.), also a DI fellow. Minnich began to testify about the bacterial flagellum, which elicited a virtual groan from the judge. In perhaps the most memorable riposte of the trial, Minnich compared his task to Zsa Zsa Gabor's fifth husband: "I know what to do, I just don't know how to make it interesting," he quipped. Unfortunately for the defence, Minnich could add little to Behe's arguments.

THE JUDGE'S VERDICT

At the end of the trial proceedings (which took 40 days), both sides submitted their Proposed Findings of Fact to the judge. These are standard documents which both sides write, in the Court's voice, in the hope that the judge will adopt some or all of their proposed findings, preferably verbatim. The plaintiffs' attorneys asked the judge to rule that 'ID' is a religious proposition and is not in any sense scientific; that "the Dover school board sought to promote creationism in the guise of ID and denigrate the scientific theory of evolution on religious grounds"; and that "the claim that board members acted for the purpose of improving science education is a pretext to hide the true motive for changing the biology curriculum, which was to provide students with a religious alternative to the theory of evolution."

Conversely, the defence attorneys asked the judge to rule, among other things, that ID is science; that "it is not creationism nor does it advance a religious belief"; that it "advances scientific arguments" and "makes testable scientific claims"; that plaintiffs misrepresented ID and made a variety of flawed and fallacious arguments (apparently, to them, it was fallacious for Barbara Forrest to claim that because the arguments of ID as manifested in their historical development are primarily religious, that therefore ID has any religious basis); that the school board's policy "promotes valid educational goals"; that the plaintiffs were all biased; and that history and philosophy of science have nothing to do with whether a proposition is scientific.

The judge's verdict was unusually long at 139 pages, but he was purposeful in stating that he went through the various arguments in such detail so that another court would not have to go through the same expense of time and money in the near future [1]. In the end, there was probably not a single sentence in the decision that would have pleased the defence. It was perhaps the most one-sided victory in the history of American jurisprudence. These are his principal conclusions.

The judge spent considerable effort (pp. 25–35) showing that, by the arguments of the ID proponents themselves, ID is not in any sense science but is entirely a religious proposition; that any objective observer would see this, and that any objective Dover citizen would have seen the school board's intent as religious (pp. 35–64). Most devastating to the ID case, the judge found that ID is not science, for three main reasons (p. 64): (1) ID violates the centuries-old ground rules of science by invoking and permitting supernatural causation; (2) the argument of irreducible complexity, central to ID, employs the same flawed and illogical contrived dualism that doomed creation science in the 1980s; and (3) ID's negative attacks on evolution have been refuted by the scientific community. As we will discuss in more detail below, it is additionally important to note that ID has failed to gain acceptance in the scientific community, it has not generated

peer-reviewed publications, nor has it been the subject of testing and research.

He also found that the DASB's ID policy failed both the endorsement and the three-prong *Lemon* tests of religious intent in over twenty instances, and this discussion comprised the bulk of the text of his decision. His three-page conclusion stated that the DASB's policy violated the Establishment clause; that ID is not science, as understood by the scientific community; that evolution is not antithetical to all religion or to the idea of a divine creator; and that several of the school board members had lied during their testimony. The judge recognized that he would be labelled "activist" by some factions, but he countered that it was instead the activism of an "ill-informed faction of a school board," aided by an organization like the TMLC, that was responsible for the "breathtaking inanity" of the enacted policy. The judge struck down the policy, found for the plaintiffs on all counts, and instructed the DASB to pay all court costs and damages.

THE AFTERMATH OF THE DOVER CASE

The DI tries to 'swift-boat' Judge Jones

Reaction to the judge's decision by ID proponents was so rapid that they probably suspected what was coming. The predictable members of the commentariat, such as Bill O'Reilly and Ann Coulter, lamented it, although the Fox News coverage itself was laudably "fair and balanced." The DI reacted to their drubbing in Federal Court without the least introspection, immediately trying to 'swift-boat' the judge. Even before the electrons on the PDF had cooled, the DI released the following salvo:

> "The Dover decision is an attempt by an activist federal judge to stop the spread of a scientific idea and even to prevent criticism of Darwinian evolution through government-imposed censorship rather than open debate, and it won't work," said Dr John West, Associate Director of the CSC at the Discovery Institute, the nation's leading think-tank researching the scientific theory known as intelligent design. (http://www.evolutionnews.org/2005/12/dover_intelligent_design_decis.html).

As noted above, the judge's decision was not 'activist', but instead simply followed the Supreme Court's precedent set in the 1987 *Edwards* case. The DI's John West went on to say of the judge, "He has conflated Discovery Institute's position with that of the Dover school board, and he totally misrepresents ID and the motivations of the scientists who research it." Not so. The DI was not on trial here; the judge was merely going on the basis of the statements of the defence's own witnesses, including Dr Behe and Dr Minnich, who are fellows of the DI, and he took pains to respect their motivation and ability. They acknowledged under oath that ID cannot qualify as science unless the definition of science is completely changed to admit the supernatural. They admitted that ID is more plausible to those who believe in God: a rather peculiar feature of an allegedly scientific theory. They insisted that the 'Designer' does not have to be supernatural, but were unable to come up with any credible account or hypothesis of what such a 'natural Designer' would be, or how to test for its existence. And this is after over a decade of research by the self-described "nation's leading think-tank researching the scientific theory known as ID."

The DI hoist on its own petard

The DI staunchly maintained after the trial that they never said that ID should be taught as science, but that they did advocate, as they did in front of the Kansas school board, that it should be mentioned in science classrooms, apparently as an 'alternative' to evolution. Consider, in contrast, this passage from *Intelligent Design in Public School Science Curricula: A Legal Guidebook* [37] by DI associates David K. DeWolf and Mark E. DeForrest, and the Director of the DI's CSC, Stephen C. Meyer: "school boards have the authority to permit, and even encourage, teaching about design theory as an alternative to Darwinian evolution – and this includes the use of textbooks such as *Of Pandas and People* that present evidence for the theory of ID." It is difficult to see where that would fit in a curriculum, except in a science class. Moreover, after the trial, at a panel discussion at the DI's Washington, DC, office, when the DI's Mark Ryland maintained that the DI never advocated teaching ID as science, TMLC head attorney Richard Thompson stood up and challenged him, waving a copy of the DI's *Legal Guidebook*.

It is also worth looking at what the DI was telling its donors in 1999, based on the now-infamous "Wedge Strategy" document. 'Teacher training' is mentioned as a project three times, including once in the context of "Potential Legal Action for Teacher Training." This last occurs in the "Cultural Confrontation and Renewal" section. One of the DI's 5-year goals was that "Ten states begin to rectify ideological imbalance in their science curricula and include design theory." The "Wedge" document lays out the DI's 5-year "Strategic Plan Summary" in three phases. The first phase is scientific research, "the essential component of everything that comes afterward." The second phase is to "prepare the popular reception of our ideas," for example, through "apologetics seminars." And in Phase III, which is supposed to begin near the end of the 5-year plan, the DI writes:

> "Once our research and writing have had time to mature, and the public prepared for the reception of design theory, we will move toward direct confrontation with the advocates of materialist science through challenge conferences in significant academic settings. We will also pursue possible legal assistance in response to resistance to the integration of design theory into public school science curricula."

And yet, when this event finally occurred, in Dover, PA, in 2005, exactly six years after the 1999 "Wedge Strategy", the DI claimed that they did not support putting ID into science curricula, and that they had never suggested such a thing.

Should judges decide what science is?

DI spokesmen and other political supporters of ID criticized the judge for overstepping his intellectual and legal bounds by ruling on whether or not ID was science. But Judge Jones literally had no choice but to rule on whether or not ID was science. The plaintiffs asked him to rule on exactly this, and so did the defence. The TMLC's chief counsel for the defence, Richard Thompson, acknowledged that, like the attorneys for the plaintiffs, the defence had asked the judge to rule on the question of whether ID was science. They staked their whole case on the notion that ID was legitimate science, and that therefore teaching it had a legitimate secular purpose and secular effect, and this outweighed any religious goals that individual board members might have had. The judge did exactly what both sides asked him to do. It is unfortunate for the ID supporters that they did not take that brief more seriously. And it is important to understand that the judge did not decide what is science and what is not. Nobody inside or outside the legal profession wants judges to do that. What the judge did was to rule on what the scientific community considers science, which is quite a different thing. His path was easy in that respect, because the DI and other ID proponents had

no support whatsoever from the scientific community, whereas evolution received nothing but the strongest support.

WHAT'S NEXT FOR THE CREATIONISTS

There are two ways to answer this question. The first concerns the future credibility of 'ID' and its supporters, notably the DI. The second concerns the activities of these and other creationists to undermine evolution, which is the 'negative' side of their 'positive' (and now collapsed) case for ID.

Where will ID go from here?

ID has been soundly rejected by the scientific community, rejected by organizations of science educators, and rejected in Federal Court. What does the DI's William Dembski say about that? "I think the big lesson is, let's go to work and really develop this theory and not try to win this in the court of public opinion," Dembski said in a *New York Times* interview [65]. "The burden is on us to produce." That's what scientists were saying all along. And in the same *New York Times* article, the TMLC's Richard Thompson appeared to agree. "A thousand opinions by a court that a particular scientific theory is invalid will not make that scientific theory invalid. . . . It is going to be up to the scientists who are going to continue to do research in their labs that will ultimately determine that." Based on past performance, however, the prognosis is not good.

The fact is that the DI took a terrible beating in the Dover trial. 'ID', their main industry, which they peddled relentlessly for over a decade as the 'Next Great Idea' in science, was revealed as religion, not science at all. The DI's "Wedge strategy" was exposed and established as a crypto-fundamentalist Christian ideology of politics and social change. Their alleged 'experts' withdrew, leaving the defence in confusion. Their amicus briefs, which attempted to introduce expert testimony in the case without the danger of cross-examination, were ignored by the judge (as is typical in bench trials with an extensive record of testimony that is sworn and cross-examined). The media 'darlings' of the mid-1990s turned surly and uncommunicative with the press. They refused to participate in the PBS *Nova* documentary about the trial [6], unless PBS met demands that would violate the journalistic integrity of any news organization. And they have refused to allow the reprinting of some of their essays and articles, even *in toto*, by authors who they think will not be supportive of them. The credibility of the DI is inextricably linked to ID, and no one with scientific or philosophical integrity is going to take either of them seriously in future.

Future creationist strategies

The fates of movements such as ID ('Bible science', 'scientific creationism', 'creation science') in the past have always been similar. Supported by vocal factions on policy-making bodies from school boards to state legislatures, they rise in prominence until they begin to be adopted by political bodies dominated by fundamentalists; and then, they invariably fail in the courts. Generally, these strategies have served the important purpose of convincing the credulous that there is or could be a 'positive' (usually more overtly religious) alternative to evolution. But, historically, this approach has been complemented by the 'negative' approach towards evolution: namely, that it is bad science, that its 'weaknesses' should be stressed, and that alternative viewpoints should be respected. The 'negative' approaches fall into several overlapping categories, mostly distinguished by key words and phrases.

"Teach the controversy"

ID proponents and other creationists do not accept that evolution has occurred and continues to occur, nor that all life is related by common ancestry. When it is pointed out that in scientific circles evolution is not controversial, the response is "See? There's the controversy!" The 'controversy' may be identified by the fact that "not all" scientists accept evolution, or because evolution is controversial outside science in some circles. Another dimension is the definition of evolution used: Michael Behe and other DI associates (including Cardinal Christoph Schoenborn of Vienna, whose op-ed pieces and essays have been scripted by the DI), define evolution as "random mutation and natural selection", which is not a definition used by evolutionary biologists (see the Addendum).

"Viewpoint discrimination"

Here, the 'viewpoint' is commonly identified as that of the 'Christian child', as if children had viewpoints on complex scientific issues, and as if there were a single Christian perspective. To fundamentalists, who are the only Christians who have a real problem with evolution, theirs is 'the' Christian viewpoint. The argument is that not to present the children's (read: "the parents'") viewpoint is discriminatory and disrespectful.

"Strengths and weaknesses of evolution"

No scientific theory answers all questions relevant to it; theories change as new evidence is introduced and existing hypotheses that comprise the overarching theory are modified. The history of plate tectonics is a great example of this. Here, the object is to bring up alleged problems with evolutionary theory and to assert that since not everything is known (or 'proven', as if scientists 'prove' theories), nothing is therefore reliable about it. However, the alleged 'weaknesses', as Judge Jones noted in his Dover trial decision, have all been refuted by evolutionists and other scientists countless times. Part of his ruling forbade the introduction into classrooms of such bogus 'criticisms of' or 'evidence against' evolution. Scientists are delighted to have students learn about the real controversies and open questions in evolution; that is, those that scientists actively discuss.

"Critical thinking"

Critical thinking is one of the greatest skills that students can learn. But what is meant by the term? Academics and pedagogy specialists denote by it the ability to understand the terms of argument in the field, its principles and methods, and to be able to evaluate viewpoints accordingly. Creationists, however, would like students to hear and learn 'criticisms' about evolution (see 'strengths and weaknesses' above). But they have no interest in having students learn 'critical thinking' about any other topics, such as American history, theology or grammar.

"Academic freedom"

Schoolteachers who try to introduce 'alternatives' to evolution in their classrooms (and there are thousands of teachers across the country who do so), or to denigrate the scientific acceptance of evolution, frequently cry that it is a violation of their 'academic freedom' not to allow them to teach anything they want. In fact, it is the duty of pre-college teachers to teach what is in their state's syllabus or curriculum; they are not authorized to do otherwise. Of course, they may question the curriculum to state authorities and thereby change it, and it is expected that curricula will evolve as scientific knowledge does.

A final question concerns whether college and university professors have the 'academic freedom' to do what pre-college teachers cannot. Generally, post-secondary institutions do not have standardized curricula; on the other hand, it is regarded as irresponsible and unethical for professors to purvey untested or discredited hypotheses and views to students. This is more acute at institutions where professors do little or no research on the subjects they teach. At major research universities, in contrast, new research that has been published in peer-reviewed journals often outstrips its incorporation into textbooks. The guideline should be that, in cases of this sort, an instructor should explain the conventional view and then indicate why new and decisive peer-reviewed research (not simply the isolated article) suggests a paradigm shift.

How effective will the creationists be?

As indicated above, antievolutionists are always most successful at the grassroots level, harassing the individual teacher, principal, or school board member. Although many 'flare-ups' of this type are communicated to the NCSE office each year, a great many more pass 'under the radar' because teachers and other school officials are afraid to offend community members and community standards. It is testimony to the courage and integrity of the Dover, PA teachers that they stood united and unswerving, even when it was clear that the opportunity of a 'teaching moment' was lost on their intransigent board members. Nevertheless, we can expect redoubled efforts at the community level in the wake of the Dover decision.

WHAT CAN SCIENTISTS DO?

Many scientists are frustrated by the 'evolution versus creation' issue in America, and rightly so. Why should the nation with the greatest scientific accomplishments of any nation in history have a populace of which perhaps as much as half are not convinced that life evolved from common ancestors?

It has often been remarked that America has two traditions. One is that of the rationality of the Enlightenment, which informed the views of Jefferson, Hamilton and Franklin in building the greatest democracy on Earth and establishing fundamental principles about human life and identity. The other is that of the Puritans, pilgrims who emigrated to America to escape religious persecution at home, only to inflict it on everyone in their new land who didn't agree with them. Much of the American populace, it seems, is between these two worldviews. The question is how to bring this large segment of the populace (perhaps 40–50 %) to the side of rationality. Here are some suggestions, culled from over 20 years of experience at NCSE.

This problem will not be solved merely by throwing more science at it

Whereas Americans, as a whole, are not as scientifically literate as the citizenries of most other developed countries (and many underdeveloped ones), this is not a problem of mere ignorance but of worldview (see preceding paragraph).

Evolution education has to be more effective in making students literate

A glance at any beginning biology textbook, or upper-level textbook in evolutionary biology, reveals that almost all of the coverage of evolutionary processes and patterns is at the level of genes and populations (with some discussion of how species form). This is collectively called 'microevolution'. Creationists generally do not have a problem with most of this literature because, as far as they are concerned, this is all just variation within 'created kinds', not worth arguing about except to question the assertions that natural selection is driving most of it. On the other hand, creationists are virulently opposed to any teaching that some major groups of organisms have evolved from others, that life has a common ancestry, and that major new adaptations have evolved from simpler structures and functions. This study is called 'macroevolution', and its representation in college textbooks is abysmal [66,67]. There is a great amount of evidence, some dating back to before the Civil War, about how animals came up on to land and how they proliferated into different groups; about the origins of dinosaurs, birds, mammals, whales and many other animals and plants and their adaptations. Books such as *Pandas* denied that this evidence exists; yet Judge Jones accepted the evidence given during trial that this was well established and that no one in the ID movement had any expertise whatever in these fields.

The simple message is this: put more macroevolution in the textbooks, show students how we know about the major evolutionary changes in the history of life, and it will be very difficult for creationists to state otherwise.

Educators must understand and work with the values and experiences of their students

The goal of many academics is to find and shape students into future scientists much like themselves. With those students there is little that has to be done to encourage a rational worldview and an appreciation of the scientific method. But even the most willing student who is uneducated must be led to understand how science works; and those who are not only unwilling but even suspicious of science can only be reached by understanding their worldviews and what has influenced them. Alters and Alters [61] provide a sensitive and effective approach to this problem for students who are not inclined even to listen to a professor until they are convinced that he or she respects their religious beliefs.

Scientists must be more effective when communicating with the public

We highly recommend Randy Olson's film *Flock of Dodos* [68], which eclipses any information we could impart on this subject. Olson, a Harvard-trained evolutionary biologist turned filmmaker, asks why so many Americans do not understand evolution. The 'dodos' of his title are not average Americans, nor even the creationist distorters of evolution, but the evolutionists themselves: the scientists who cannot explain the most basic concepts to the man or woman in the street, the experts who convey such elitism and condescension that previously open-minded audience members recoil from them and embrace the smooth-talking, smiling, and apparently equally open-minded creationists. Who would you rather have a beer with? This film is highly recommended for faculty meetings. The use of departmental funds for training of faculty in public communication and media relations is highly recommended, too.

Scientists can support teachers in the fight to teach good science

The average teacher is alone in the struggle to teach good science. Any complaining parent can reduce the honest presentation of science to a 'he said, she said' dispute about personal values. Teachers have learned to their dismay innumerable times that school administrators cannot be expected to back them, even when they are teaching what is in the textbooks and state curricula. Scientists can contribute simply by visiting local school board meetings, school administrators and teachers, and offering their

support for the teaching of good science. In this way, they may be more likely to be consulted by teachers or administrators if an unusual problem presents itself. Scientists should be ready to defend teachers, but not to act peremptorily or disdainfully of other points of view that may appear to disrespect science. Rather, by explaining what science is and how it works, and by explaining that the goal of education is not to compel belief, but understanding, scientists can show that it is in everyone's interest to observe legal and educational statutes. Students do not have to 'believe' anything they learn in school, but if they want to be educated members of the citizenry they should at least understand what is being presented. The NCSE is always ready to help in these cases.

One point worth making is that many science teachers are timid or hesitant to discuss science with scientists; they feel that their knowledge of science is vastly inferior to that of a person who does this for a living, and do not want to reveal what they consider their ignorance. Scientists should not treat teachers as they would their undergraduate students, regardless of perceived inadequacies in understanding, before a deep bond of trust and mutual help is formed. The best thing that a scientist can do, for the most part, is listen.

Scientists can become involved in their state and local educational processes

The U.S.A. is unusual among developed nations in not having any national curricula in any subject. Without national standards it is difficult to legislate a system such as the No Child Left Behind Act, which uses standardized tests as a 'compass' to reward or fail school districts based on their test performance. Regardless, every U.S. state has a state curriculum (variously called standards, syllabus, framework, guidelines, etc.) for the major subjects taught in pre-college. Of the 50 states, 23 are 'adoption states', which means that they select competitively among programmes offered as textbooks plus other instructional materials for the various disciplines, and only allow state funds to be used for those approved programmes. In most states, both scientists and educators are involved in crafting curricula and selecting programmes to adopt. The problem has been that, historically, scientists have been unwilling to be involved in these processes, citing the pressure of research and teaching of their universities. This is a shame for the scientists and a shame on the universities that do not reward this as strongly as they would the acceptance of papers in *Nature* or *Science*. Educators need scientists to correct outdated curricular objectives and scientific premises, expel old textbook myths, and introduce new accepted methods and conclusions. Educators do not have the time, access to peer-reviewed materials, and in many cases the scientific training to accomplish these goals themselves. A partnership between research scientists and teaching clinicians is therefore all the more necessary. And it is also self-preservational for scientists: if pre-college students and their teachers are not taught what is right, how will future generations of college students matriculate with useful knowledge?

Change the textbooks

Finally, we pose a question to research scientists. How much of what you teach in your classes is not covered in the textbooks you use? Do you find that you have been reading literature that seems to explode old knowledge and replace it with more sensible new findings, yet the texts you use could have been written decades ago? Biologists find this all the time. Why should this be tolerated? We argue that you, and not your students (who are only the helpless purchasers), are the only people who can improve the delivery of knowledge. If your textbooks are outdated or wrongheaded in what they present, call the sales representative and say you're not going to use that book any longer. Then call the editor at the publishing house and say the same thing. And call the authors. After all, they're your colleagues. Tell them that their coverage is not doing the job any more, and offer to help. If you don't change the curricula and the texts at the college level, it will never seep down to the pre-college level. This is because nothing is covered in pre-college grades unless it is used at the next level up. This 'trickle-down' process [66] is the most effective tool that scientists can use to make sure that education at the 'lower' levels, where the development of scientific literacy is most important, keeps pace with research.

Addendum

There is no standard definition of evolution, possibly because evolution is so complex, works at so many levels, and can be studied in so many ways. A definition of evolution as 'random mutation and natural selection' is popular among ID advocates and other creationists, but as far as we know is not used by biologists, most of whom prefer Darwin's formulation "descent with modification". The ID definition refers only to two processes of evolution and does not acknowledge that all life is interrelated. It is problematic for other reasons.

(1) Mutation is not 'random' in any causal sense; the use of the term 'random' implies the statistical distribution of its phenotypic consequences in a population. There are, of course, changes in the configuration of DNA (insertions, deletions, transpositions) that affect frame-reading and other processes, and the distribution of these events is stochastically random in genomes. But their effects are not, because the developmental programme can only produce variations on the possibilities that it already has. In other words, a duck's head is not going to pop up suddenly on a trout. The causes and processes of evolution are not random in any important sense. Darwin's emphasis on two major mechanisms of selection – natural and sexual – epitomize the opposite of random processes in shaping evolution.

(2) Natural selection is one of the major mechanisms of change in populations, but even Darwin did not view it as the only process of importance (this is why he wrote another book on sexual selection, for example). Biologists study selection in living populations by documenting variation, adaptive advantage, heritability and change from generation to generation. For obvious reasons, selection cannot be viewed in past (extinct) populations as it is in living populations because direct heritability of genetic features cannot be observed in deceased individuals and populations; however, natural selection is easily observable in macroevolutionary lineages in which progressive adaptation to functional and environmental opportunities can be documented. Adaptation, by definition, is the result of natural selection. So the argument of ID supporters that the fossil record cannot document evolution is specious.

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