

# **NOT IN OUR CLASSROOMS**

Why Intelligent Design  
Is Wrong for Our Schools

**Edited by Eugenie C. Scott  
and Glenn Branch**

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## 2: Analyzing Critical Analysis: The Fallback Antievolutionist Strategy

NICHOLAS J. MATZKE AND PAUL R. GROSS

### Introduction

The primary challenge to teaching evolution in public school science classrooms no longer comes labeled as *creationism*, *creation science*, or even *intelligent design*. The strategies those labels represent have all failed in the federal courts because they boil down to special creation—the theological doctrine that God intervened miraculously in the history of life. Plainly, this is a specific religious claim, not even shared by all Christian denominations. Furthermore, because the U.S. Constitution prohibits an establishment of religion by government, it prohibits government-employed science teachers from presenting religious views as though they were, or had the support of, genuine science.

Creationism does not become extinct; it evolves. The history of creationism (as reviewed in chapter 1) makes it clear that court defeats cause creationists to change labels and legal strategies but do little or nothing to change their underlying objective. In fact, by the time a definitive court case settles the fate of one tactic, legal difficulties have usually become apparent, and another tactic is already in the works. Creation science was developed in the years preceding the Supreme Court's 1968 *Epperson* decision, which overturned bans on teaching evolution; intelligent design developed between the crushing defeat of creation science in the 1982 district court decision *McLean v. Arkansas* and the 1987 Supreme Court *Ed-*

*wards* decision. (These cases are discussed further in chapter 4.) Given the defeat of intelligent design in *Kitzmiller v. Dover* in 2005, what can we expect to see next by way of creationist attacks?<sup>1</sup>

It appears certain that the main challenge to teaching evolution in public schools will be educational policies that propose critical analysis and similar invocations of critical thinking—specifically in connection with evolution-related science. Reviewing the history and origins of these critical analysis interventions, and examining the common so-called evidences against evolution that creationists have promoted in the guise of critical analysis—for example in Kansas, Ohio, and South Carolina—it becomes clear that while labels have changed, the content of these standards and their accessory material remains the same. All the critical analysis arguments are traceable to primary texts of the intelligent design (ID) and creation science (CS) movements. They are, without exception, aimed at promoting the sectarian doctrine of special creation.

### Origins of the Critical Analysis Tactic

The critical analysis tactic has deep roots in the creationist movement. In the face of political and especially legal opposition to policies requiring equal time for creation science, creationists in the 1980s suggested alternatives. For example, following the *Edwards* decision against creation science in 1987, the Institute for Creation Research hoped for another major test case that would reach a different result but in the interim recommended a new tactic:

*In the meantime, school boards and teachers should be strongly encouraged at least to stress the scientific evidences and arguments against evolution in their classes (not just arguments against some proposed evolutionary mechanism, but against evolution per se), even if they don't wish to recognize these as evidences and arguments for creation (not necessarily as arguments for a particular date of creation, but for creation per se). To do anything less is equivalent to making humanistic evolution an article of faith, and this would be an establishment of religion!<sup>2</sup>*

As for the ID movement, it was clear even before *Kitzmiller* that it was sidling away from policies that encouraged intelligent design directly. In 1998, the Discovery Institute's Center for the Renewal of Science and Culture was clearly committed to teaching ID in the public schools. For example, the Discovery Institute's strategic plan, the Wedge Strategy, had the following as one of its five-year goals: "Ten states begin to rectify ideological imbalance in their science curricula and include design theory."<sup>3</sup> This is an unambiguous endorsement of efforts to make ID a requirement of curriculum. By 2004, however, the Discovery Institute was denying adamantly that it had ever advocated such a thing. Instead, it was promoting critical analysis of evolution, teaching the strengths and weaknesses of evolution, or teaching the controversy.

The beginning of the ID movement's shift toward critical analysis can be traced to two factors. The first is *Icons of Evolution* (2000), a blustering antievolution polemic written by Discovery Institute fellow Jonathan Wells, which succeeded in intimidating many educators by attacking biology textbooks for allegedly crude mistakes or worse.<sup>4</sup> The second is the so-called Santorum amendment, a nonbinding "sense of the Senate" provision that Pennsylvania senator Rick Santorum attempted to insert into the No Child Left Behind Act in June 2001. Santorum's amendment (written, in fact, by ID leader Phillip Johnson) did not mention creationism or ID, but it did single out evolution as controversial science. The amendment was eventually stripped from the statute language. Instead, a watered-down version appeared in the joint explanatory statement of the House-Senate conference committee. This statement had no force as law, but it was nevertheless trumpeted by antievolutionists as a signal victory for their cause.

The Santorum language was cited in subsequent battles over critical analysis policies, and it paved the way for the ID movement's two major state-level victories: critical analysis language in the science standards of Ohio (2002) and Kansas (2005). Creationists and ID advocates have also pushed unsuccessfully for critical analysis language in the science standards in Minnesota, New Mexico, Pennsylvania, South Carolina, West Virginia, Arizona, and Geor-

gia. Of the proposed antievolution legislation tracked by the National Center for Science Education in 2005, many of the bills employed critical analysis or similar euphemisms for the deprecation of evolutionary science. Furthermore, many local school boards have been the scenes of battles over similar policies—prominent examples include Roseville, California; Darby, Montana; Grantsburg, Wisconsin; and Cobb County, Georgia.<sup>5</sup>

#### OHIO, 2002

Critical analysis of evolution was codified as the ID movement's favorite tactic by its insertion into the Ohio science standards in 2002. The federal No Child Left Behind Act was passed in December 2001, and the Santorum language was immediately put to use in a science standards battle brewing in Ohio. In the wake of proposals to include ID in the Ohio standards, the Ohio Board of Education scheduled a debate between proponents of evolution (Kenneth Miller of Brown University and Lawrence Krauss of Case Western Reserve University) and advocates for intelligent design (Discovery Institute senior fellow Jonathan Wells and Stephen C. Meyer, director of the Discovery Institute's ID program). In a surprise move, Meyer announced that he did not want ID taught; he offered, instead, a compromise, which was simply to critically analyze evolution. The board eventually adopted Meyer's position. The resulting long (and generally thoughtful and correct) standard concerning evolution read, in one place, "Describe how scientists continue to investigate and critically analyze aspects of evolutionary theory." In response to criticism of this, a parenthetical qualifier was added: "The intent of this indicator does not mandate the teaching or testing of intelligent design." But the Discovery Institute and the Intelligent Design Network (a Kansas-based ID-advocacy organization) saw the final result as a great victory.<sup>6</sup>

They had reason to be encouraged by what happened after the Ohio Board of Education passed the otherwise acceptable science standards. The time came to write model lesson plans based on the standards. Predictably, creationists got themselves on the commit-

tee writing the lesson plan for standard L10H23, *Critical Analysis of Evolution*. The lesson produced was clearly based on the creationist/ID literature, especially *Icons of Evolution*. The lesson targeted common descent. The original title for the lesson plan was *The Great Macroevolution Debate*.<sup>7</sup> Under criticism, that sample lesson was cut back substantially—the title was changed, some of the *Icons*-derived material was dropped, and references to nonexistent articles and to creationist and Christian apologetics Web sites were deleted. The resulting lesson was passed in 2004—but after a national review of state standards awarded a grade of only B to Ohio's massive, complicated, but generally competent science standards.<sup>8</sup> The lesson included standard creationist arguments about homology, the fossil record, antibiotic resistance, peppered moths, and endosymbiosis, and it misled students about a distinction between microevolution and macroevolution. Because its use was, in principle, optional for teachers, it was not officially a standard or a benchmark; this made it difficult to challenge legally.

Supporters of the lesson nevertheless stated publicly that they had developed a lawsuit-proof antievolution tactic. The legal question was mooted in February 2006, when in the wake of the *Kitzmiller* decision and a series of embarrassing revelations from Freedom of Information Act requests, the Ohio Board of Education reversed itself and voted 11–4 to eliminate the *Critical Analysis of Evolution* lesson plan and the language in the standards documentation on which it was based. Up to the last moment, however, it was a close call.

#### KANSAS, 2005

The critical analysis tactic achieved its most prominent success to date in the 2005 Kansas science standards. The Kansas-based Intelligent Design Network led the charge here. But despite its name, it did not push for an explicit intelligent design requirement in the Kansas science standards revision of 2005. This was because of the national developments already described and because the creationists on the Kansas Board of Education had been voted out of

office in 2000 after deleting evolution and related concepts from the standards in 1999. (The new board restored evolution to the standards in 2001.) Instead, when creationists again won a majority in the 2004 elections, the Intelligent Design Network persuaded the board to include “scientific criticisms of [evolutionary] theory,” encouraging students thereby to “critically analyze the conclusions that scientists make.”<sup>9</sup>

The board's official rationale stands as a monument to the doublespeak of this tactic. The critical analysis move was justified by this assertion: “The Board has heard credible scientific testimony that indeed there are significant debates about the evidence for key aspects of chemical and biological evolutionary theory.” It failed to mention that said scientific testimony was just the set of presentations from some twenty creationists and intelligent design proponents the board itself had invited to speak in May 2005. Almost all of those speakers denied a common ancestry of humans and apes, and some stated that they thought the Earth was only thousands of years old.<sup>10</sup>

Left unsaid in the rationale was the fact that all the Intelligent Design Network's changes to the science standards were taken directly from creationist/intelligent design literature. Nevertheless, in keeping with the critical analysis tactic, the board “emphasize[d] that the Science Curriculum Standards do not include Intelligent Design,” even though (in the very same sentence!) the board promoted the scientific credibility of ID, describing it as “the scientific disagreement with the claim of many evolutionary biologists that the apparent design of living systems is an illusion.” The idea that living things exhibit design is not foreign to biology, contrary to the board's suggestion, but no competent biologist thinks that the presence of design in living things necessarily implies a conscious, purposeful designer.

The board concluded that “these standards neither mandate *nor prohibit* teaching about this scientific disagreement” (emphasis added), thus giving a wink and a nod to any creationists on local school boards who might be paying attention. The numerous edits to the science standards included a number of favorite creation-

ism/ID talking points. In effect, the Intelligent Design Network, by way of the Kansas Board of Education, put a government-sponsored advertisement for ID on the front page of the Kansas science standards, and inserted everything except the actual words *intelligent design* into the science benchmarks. The attempt is to avoid legal challenge by *encouraging* rather than *requiring* ID, and by cloaking the standard ID talking points in such locutions as “critical thinking,” teaching “the full range of scientific views,” and “scientific criticism.”

#### CRITICAL ANALYSIS OF EVOLUTION AS A POLITICAL TACTIC

Like creation science and intelligent design, critical analysis is not a coherent scholarly undertaking but rather a political tactic. In all three approaches, the goal is to appear to make scientific rather than religious arguments, with the hope that science teachers, the public, and especially the courts will perceive this as legitimate government activity rather than as governmental promotion of a particular religious view. Because it is impossible to gather physical scientific evidence to support any hypothesis of supernatural causation, CS and ID attempted to establish special creation primarily through arguments against evolution. Relying on the contrived dualism that evolution and creationism are the only two possible explanations of life's origins and history, the CS and ID movements try to disparage evolution and then argue that special creation is the only alternative. Thus, arguments against evolution comprise the vast bulk of all the CS/ID literature. ID is just a subset of the claims made by CS, and critical analysis, deployed as described here, is just a subset of ID.

#### Critical Analysis of “Critical Analysis”

Shouldn't we encourage truly critical thought about dominant scientific theories? The answer, of course, is yes. But that is not what these policies are doing. They are, instead, uncritically promoting

creationism-driven pseudoscience, in full accord with the traditional creationist goal: getting public school science classes to teach as science the theological doctrine that God intervened to create each kind of organism, including humankind. This is effected by singling out evolution *alone* for special criticism, ignoring all other major scientific theories, including those about which there really is a current argument (the relation between quantum mechanics and gravity, for example). To complete the job, long-debunked creationist criticisms of evolution are presented as though they are real, current science.

The problem for science education is that critical analysis policies promote creationist pseudoscience, or just bad science known to be fallacious. Students will simply be misinformed if these claims are taught as if they are accepted science. Supporters of first-rate science education need to be aware of critical analysis claims and some of the problems with these claims, because they are often disguised in science-style phrases and promoted as cutting-edge science. To illustrate, we offer here some actual critical analysis of the “critical analysis” items presented in the 2005 Kansas science standards.

#### INCONSISTENCIES IN PHYLOGENETIC TREES

The new creationism offers a standard list of challenges to the evidence that modern organisms share common ancestry. The Kansas science education standards that were adopted on November 8, 2005, list several. The first deals with disagreements between phylogenetic trees (lineages, or patterns of descent) constructed from DNA or protein-similarity analyses:

*The view that living things in all the major kingdoms are modified descendants of a common ancestor (described in the pattern of a branching tree) has been challenged in recent years by:*

i. *Discrepancies in the molecular evidence (e.g., differences in relatedness inferred from sequence studies of different proteins) previously thought to support that view.*

The claim is that phylogenetic trees based on different data sets conflict so badly as to call common ancestry into question. The usual creationist procedure is to dig through the scientific literature to find cases where studies disagree on the exact phylogenetic relationships of organisms and then to trumpet these as inexplicable discrepancies that refute common ancestry. ID creationists universally fail to acknowledge that the similarity of phylogenetic trees can be measured statistically, and that trees derived from independent data sets typically have extremely *strong* statistical correlations. Such findings, which are very common indeed, support the notion that there are real phylogenetic trees, and that scientists are mapping them. The touted disagreements, measured quantitatively, are rather like the disagreement between two independent dating methods for the age of the Earth, one giving the age as 4.50 billion years, and another giving it as 4.55 billion years—very similar measurements with a small amount of experimental error. Even phylogenies derived independently from morphological (anatomical) and molecular (chemical) data sets typically show a high degree of correlation.<sup>11</sup> Any ID/creationist claim that phylogenetic trees show discrepancies is worthless unless they report proper similarity statistics, and this they have never done. By contrast, a recent striking example of molecular and morphological (fossil) data coming into astonishing agreement is the documentation of a connection between the ancestors of whales and those of hippos.<sup>12</sup>

#### ABSENCE OF TRANSITIONAL FORMS AND THE CAMBRIAN EXPLOSION

The Kansas science standards state,

*Patterns of diversification and extinction of organisms are documented in the fossil record. Evidence also indicates that simple, bacteria-like life may have existed billions of years ago. However, in many cases the fossil record is not consistent with gradual, unbroken sequences postulated by biological evolution.*

*[Common ancestry is challenged by a] fossil record that shows sudden bursts of increased complexity (the Cambrian Explosion), long periods of stasis and the absence of abundant transitional forms rather than steady gradual increases in complexity.*

These two elements in the Kansas science standards make assertions about gaps in the fossil record. The ubiquitous creationist argument about transitional fossils is generally conducted by misquoting or distorting the words of a paleontologist, such as Stephen Jay Gould. Gould expressed outrage over this, memorably:

*Since we proposed punctuated equilibria to explain trends, it is infuriating to be quoted again and again by creationists—whether through design or stupidity, I do not know—as admitting that the fossil record includes no transitional forms. Transitional forms are generally lacking at the species level, but they are abundant between larger groups.<sup>13</sup>*

Here, Gould refers to the Eldredge-Gould theory of Punctuated Equilibria, which simply took a standard model of speciation called allopatric speciation and applied it to the fossil record. In allopatric speciation, a small subpopulation of a species becomes geographically isolated. For reasons of population genetics, small populations are more likely to evolve quickly than large ones. Eldredge and Gould argued that if this were the dominant mode of speciation, then the fossil record should record relatively few smooth transitions between very closely related species. Gould was not saying that fossil species bridging large transitions, for example between mammals and their reptilelike ancestors, should be rare. *And they aren't*. In general, it is simply false to assert that transitional fossils (a century ago they were called missing links) are unknown or very rare. As Gould states, such transitions are abundant.

The second standard refers specifically to the Cambrian Explosion. Creationists consider the Cambrian Era as displaying the biggest gaps. For creationists, the Cambrian Explosion refers to the sudden appearance of complex animals—marine invertebrates—in

the fossil record about 520 million years ago. In many cases, the first fossil record of a phylum occurs in the Cambrian—for example, the classic Cambrian animal is the trilobite, which belongs to the phylum Arthropoda along with insects, crustaceans, and other groups. Although the definition of *phylum* is somewhat arbitrary, other often-recognized phyla are the chordates (including vertebrates), mollusks (such as clams, squid, and octopuses), and echinoderms (starfish and sea urchins). In Darwin's time, the fossil record of these animals did appear to begin abruptly in the Cambrian, with no precursors, and creationists have attempted to exploit this gap ever since. The Cambrian Explosion is thus a prominent feature of all varieties of creationism and ID, and in several of the critical analysis proposals.

Unfortunately for the creationists, the Cambrian Explosion was not literally a sudden event: its duration was, conservatively, ten million years. But the most important fact that creationists ignore is the evidence from trace fossils and from recently discovered ancestral forms. While body fossils of soft-bodied organisms are very scarce, their crawling and burrowing activity disturbs sediments, leaving traces such as tracks and burrows that petrify and become fossils. This leaves a massive record in sedimentary rocks that must be taken into account. Before animals evolved, there was nothing macroscopic able to crawl around and eat the algal mats on the sea floor; therefore, such sediments are undisturbed. A few tens of millions of years before the animal phyla appear, however, worm tracks begin to appear—very simple, and then gradually increasing in complexity. At first, the worms moved only horizontally on the surfaces of the algal mats, but eventually they started to burrow into the sediment. Around the world, this bioturbation of the ocean floor meant an end to the world of undisturbed algal mats and the delicate Ediacaran frond forms: worms were eating everything! Just before the base of the Cambrian, about 543 million years ago, the first tiny shell is observed in the fossil record—*Cloudina*.

The shell was probably secreted to protect this worm from other worms that might eat it—evidence of shell borers is also preserved. With the start of the Cambrian, small, shelly fossils increase in di-

versity and complexity until classic Cambrian Explosion representatives like trilobites are observed—for example, in the fossil beds of Chengjiang, China, about 515 million years ago, and in the Burgess Shale around 500 million years ago. Creationists focus on these two fossil locations, but they completely ignore the earlier events recorded in the trace fossils and by the small shelled forms. When this full record is considered, the evidence indicates that in the early Cambrian, evolution was proceeding rapidly and many ecological niches were being occupied for the first time.<sup>14</sup>

As for transitional forms, recent discoveries are filling in the gaps even among the Cambrian phyla. Remember that the big picture painted by the trace fossils is of the gradual diversification of worms—relatively simple tubes with mouths. It should also be remembered that at least half of the animal phyla living today are still wormlike. Even for the various advanced phyla—mollusks, chordates, echinoderms, and arthropods—basal members of the phyla, or closely related sister phyla, are basically wormlike. So it is not surprising that paleontologists have discovered wormlike fossils in the Cambrian that share some, but not all, of the features of the modern phyla. For example, a diverse group of lobopod fossils illustrates the step-by-step acquisition of characteristics that define the living arthropods. Graham Budd, a specialist on the Cambrian arthropods, describes the real situation:

*A remarkably complete series is now available, demonstrating how the most basal, worm-like taxa of the entire Arthropoda sequentially acquired the important features characteristic of their clade... Clearly, for the arthropods at least, current opinion now stands rather far away from the view expressed only a decade ago that the Cambrian record did not reveal anything of the origin of the phyla.*<sup>15</sup>

Simon Conway Morris, another leading specialist of the Cambrian, places a sluglike fossil named *Halkeria* as intermediate between the mollusk, brachiopod, and annelid phyla. As for chordates and echinoderms, early chordate relatives are represented by fossils like *Haikouella*, *Yunnanozoon*, and *Pikaia*, and early vertebrates by

fossils like *Haikouichthys*—all small wormlike forms very different from what anyone would consider modern fish—and early echinoderm relatives include homalozoans and the remarkable vetulocystids.<sup>16</sup>

In short, evolutionary biologists have found abundant fossils with transitional characteristics showing how the body plans defining modern phyla were acquired step by step in the course of the Cambrian Explosion. Many contemporary leaders in the field have noted that the old issues—such as the contention that phylum-level characteristics are special and appeared only during the Cambrian Explosion, that stasis followed, or that the gaps among phyla were especially large—were based on the misapplication of the old Linnaean classification system to the fossil record, rather than on actual data. According to Simon Conway Morris, “the strangeness of the problematic Cambrian animals is really a human artifact, a construct of our imagination.”<sup>17</sup> Creationists still cling to these old, discredited, and now imaginary problems, and have enshrined them in the Kansas science standards!

#### HAECKEL'S EMBRYO DRAWINGS

The Kansas science standards state that common ancestry is called into doubt by “studies that show animals follow different rather than identical early stages of embryological development.” This is a key claim from Jonathan Wells's book *Icons of Evolution*. The argument is this: evolution is demonstrated by the embryological similarities shown in Ernst Haeckel's famous embryo drawings, but Haeckel faked these drawings to make the embryos more similar than they actually were, and this fake evidence for evolution has been reproduced in textbooks for school use.

The facts: Haeckel did exaggerate similarities in very early embryos of different species, and his figures, or derivatives of them, have appeared in a few textbooks (three of the ten textbooks that Wells examined).<sup>18</sup> But *photographs* of embryos show strong and unquestionable similarities. The embryos of reptiles, birds, and mammals all resemble one another other much more strongly than do

the adult forms, exactly as Darwin noted in the *Origin of Species*. Moreover, the similarities are not just superficial. They involve most of the fundamental pathways and structures of embryogenesis. Darwin and Haeckel asked why such different adult forms should all be modifications of what amounts to the same embryological plan—if organisms were specially created, they could just as well each develop directly into the adult forms with no embryological resemblance and no cumbersome remodelings during late embryonic life. Michael Richardson, the specialist who, in an exhaustive critique of Haeckel's work, reexamined all the drawings, observes:

*On a fundamental level, Haeckel was correct: All vertebrates develop a similar body plan (consisting of notochord, body segments, pharyngeal pouches, and so forth). This shared developmental program reflects shared evolutionary history. It also fits with overwhelming recent evidence that development in different animals is controlled by common genetic mechanisms.*<sup>19</sup>

The cry of “Fake!” from Wells and friends is a completely manufactured scandal.

#### THE ORIGIN OF INFORMATION IN DNA

The Kansas science education standards state that “the sequence of the nucleotide bases within genes is not dictated by any known chemical or physical law.” This assertion is copied from the 1980s creationists who wrote *Of Pandas and People* and later founded the ID movement. Dean Kenyon, for example, included it in his 1984 affidavit in defense of the creationist Louisiana Balanced Treatment Act as it wound its way up to the Supreme Court. It formed the basis of books and articles written by two leading ID proponents: Charles Thaxton, academic editor of the *Pandas* project, and Stephen Meyer.

Their argument: The order of the chemical “letters” in DNA is not dictated by any known physical or chemical law; therefore, the information in DNA cannot be explained by natural processes;

therefore, the information in DNA must have a supernatural cause. Stephen Meyer explains in his chapter for the 1994 anthology *The Creation Hypothesis*:

*Scientists have attempted to explain how purely natural processes could have given rise to the unlikely and yet functionally specified systems found in biology systems that comprise, among other things, massive amounts of coded genetic information. The origin of such information, whether in the first protocell or at those discrete points in the fossil record that attest to the emergence of structural novelty, remains essentially mysterious on any current naturalistic evolutionary account.*<sup>20</sup>

It would be no exaggeration to say that this argument is at the heart of the ID movement. The only problem is that it is scandalously *wrong*. Competent scientists know how new genetic information arises: a variety of well-understood mutational mechanisms copy and modify the DNA letter sequence that makes up a gene. If the new sequence is advantageous to the organism, natural selection spreads the new gene through the population by way of well-understood processes of population genetics. This shows where new genetic information comes from, and it fully explains, as a bonus, the otherwise puzzling fact that most genes belong to large families and superfamilies of similar composition.

One particularly useful paper was published in *Nature Reviews Genetics* in 2003; written by Manyuan Long of the University of Chicago, it reviews all the mutational processes involved in the origin of new genes and then lists dozens of examples in which research groups have reconstructed the genes' origins. The paper lists 122 references, virtually all of them published in the last ten years. None has ever been mentioned by the ID movement, let alone rebutted. Dr. Long has devoted his whole career to studying the origin of new genes; his online résumé lists some two dozen recent publications on the topic.<sup>21</sup>

The other problem with the argument of the Kansas science standards is the obfuscation "any known chemical or physical law."

It is deviously phrased to have two meanings: it could simply mean that no laws of chemistry or physics specify the order of the chemical "letters" in DNA. In that limited sense, the statement is approximately correct, but pointless. The shape of the Grand Canyon is also not strictly specified by any chemical or physical process—so what? The shape of the Grand Canyon is in fact specified by complex but reasonably well-understood interactions of erosion, rock structure, weather patterns, plate tectonics, and the like. But the Kansas science standards statement is meant to imply that no natural explanation exists for genetic information. That is a radical and false claim. Like the Grand Canyon, no simple physical law determines the DNA sequence, but the complex interacting processes that do explain it, described above, are well known. The game being played here is that the radical claim—that there is no natural explanation for DNA—will be taught to students, but when the standard comes up for criticism, the limited but mostly true claim—that we do not know the exact laws of physics or chemistry governing the structure of DNA—will be used to defend the phrase.

#### IRREDUCIBLE COMPLEXITY AND MICROEVOLUTION/MACROEVOLUTION

The Kansas Science Education Standards state on page 76,

*Whether microevolution (change within a species) can be extrapolated to explain macroevolutionary changes (such as new complex organs or body plans and new biochemical systems which appear irreducibly complex) is controversial. These kinds of macroevolutionary explanations generally are not based on direct observations and often reflect historical narratives based on inferences from indirect or circumstantial evidence.*

IRREDUCIBLE COMPLEXITY (IC) is a term coined by ID advocate Michael Behe in his 1996 book *Darwin's Black Box*. It is used seriously only by ID advocates and other creationists. ID advocates cannot say truthfully that the Kansas science standards do not mandate ID

because the universally favorite ID argument—IC—is explicitly a part of the standards. Furthermore, that argument is just a biochemical version of the now ancient creationist canard, “What good is half a wing?” (Correct answer: “Ask a feathered dinosaur fossil.”)

The irreducible complexity argument for intelligent design proceeds as follows: First, the uncontroversial observation is made that many biological systems have multiple required parts. Second, it is asserted that gradual, step-by-step evolution—natural selection acting on natural variations—cannot produce a system with multiple required parts, because, allegedly, any intermediate system lacking all of the required parts would have no function, and therefore would not be preserved by natural selection. The final step in the argument is to conclude that these systems look designed, and to conclude further that if natural selection can’t produce these systems, then intelligent design is the only other alternative.

There are severe problems with the second and third steps of these arguments. The most important objection to the second step is that it incorrectly assumes that evolution by natural selection always proceeds in only one way—gradual improvement of an already existing function. But it has been well known, and repeatedly emphasized by evolutionary biologists ever since Darwin, that biological systems commonly *change function*. Consider the flipper of the penguin. It is descended from the flapping wing of a bird, and indeed many sea birds today use their wings for both flying and swimming. In penguins and several other flightless birds, a complete transition to swimming has occurred. As for where bird wings came from, a fantastic series of fossils of feathered dinosaurs has been uncovered in China over the last decade—bird wings are modified versions of the forelimbs of small, bipedal dinosaurs. Moving farther back still, dinosaur forelimbs are modified versions of the front feet of four-legged reptiles. And of course tetrapod feet are ultimately modified versions of the fins of lobe-finned fish. Thus the same fundamental structure was used progressively for swimming, walking, grasping and climbing, flying, and finally back to swimming. In each case we have evidence that the transition could occur smoothly, with intermediate structures performing multiple

functions at once. The same point can be made for many other structures. Stephen Jay Gould and Elisabeth Vrba even gave this process a name, *exaptation*, to emphasize the point. The significance for creationist claims about irreducible complexity is clear: the possibility of change of function in evolution vitiates the argument.

Faced with such anatomical counterexamples, Behe tends to assert that his argument is restricted to the molecular level (where fossil evidence is lacking), and that all of the evidence for the evolution of complex systems at the anatomical level should be ignored when examining his argument. This is a specious assertion because irreducible complexity is a scale-free concept. Behe’s own favorite example of irreducible complexity—the mousetrap—proves the point: the size of a mousetrap doesn’t matter, nor does it matter that the wooden base is composed of very complex plant cells. Moreover, creationists and ID advocates before and after Behe have gladly applied the multiple-parts-required argument at all levels of biology.

Nevertheless, Behe has gotten substantial traction from his biochemical examples, because they are wondrously complex and they certainly seem difficult to explain by way of gradual evolution—at least to evolutionists who know little about biochemistry and to biochemists who know little about evolution. But interdisciplinary research reveals that *change of function* is equally important for evolution at the molecular level. This is spectacularly proven by one of Behe’s own favorite examples, the adaptive immune system of vertebrates. In the adaptive immune system, invading bacteria and viruses are recognized with protein receptors called immunoglobulins. In order to recognize any possible invader, the immune system produces billions of different receptors by rearranging pieces of receptor genes in a complex process called VDJ recombination. Behe says that VDJ recombination is irreducibly complex and could not have evolved, and in *Darwin’s Black Box* he famously asserted, “We can look high or we can look low, in books or in journals, but the result is the same. The scientific literature has no answers to the question of the origin of the immune system.”<sup>22</sup> But in fact, back in 1979, seventeen years before *Darwin’s Black Box* was

published, scientists proposed a hypothesis to explain the evolutionary origin of this DNA rearrangement, suggesting that perhaps a “jumping gene” called a transposon inserted itself into a primitive, nonrearranging receptor gene. When this gene was expressed, the transposon would cut itself out of the gene, but because this process is inexact, the resulting protein product would be variable. Multiple rounds of gene duplication and rearrangement would expand this basic system into the modern version of VDJ recombination.

Behe didn't buy this story, and said so in his book. But unfortunately for him, starting in the mid-1990s immunologists have published discovery after discovery that have confirmed the transposon hypothesis. In 2005, a stunning prediction was fulfilled when a relative of one of the immune system's recombination activating genes, called RAG1, was found as a free-living transposon in tunicates. When Behe was cross-examined during the *Kitzmiller v. Dover* trial in October 2005, he was asked if he still believed that the scientific literature had no answers on the origin of the immune system. He said that he did. Then, in a Perry Mason-like flourish, the plaintiffs' attorney piled fifty-eight peer-reviewed articles and a stack of books about the origin of the immune system on the witness stand in front of Behe. When asked, Behe said that he had not read most of them, but dismissed the pile with a wave of his hand. As the cell biologist Kenneth Miller, who testified for the plaintiffs in the trial, put it later, “Ain't nothing going to convince this guy.” Judge Jones, however, was convinced, and noted in his decision that the concept of exaptation—change of function—was fundamental in evolutionary biology, and that if it is given appropriate attention, Behe's arguments fail.<sup>23</sup>

**MICROEVOLUTION/MACROEVOLUTION.** The claim that microevolution can't be extrapolated to macroevolution is ubiquitous among ID advocates and the creationists who preceded them. It is a central theme in the Kansas science standards and the Ohio critical analysis of evolution lesson plan (originally entitled *The Great Macroevolution Debate*). But it is nothing more than standard creation science terminology for the creationist claim that various groups of

organisms were specially created by God, with specified limits on how far they could change over time. Creationists say that macroevolution—which they define as transformations among biblical kinds—just can't happen. Skeptics search in vain for any objective definition of *kind*—in practice, creationists make the definition strategically elastic. Any evidence for evolution so overwhelming that even creationists cannot deny it is labeled *microevolution within a kind*. Macroevolution of new kinds, conveniently, is never attained.

This smoke-and-mirror tactic is at the heart of the creationist enterprise. It persists unchanged among creation science, intelligent design, and critical analysis, and is uniformly employed to protect a single thing: the biblical doctrine of special creation of the Genesis kinds (and particularly of the human kind). At the Kansas Board of Education hearings on evolution, witness after witness—all allegedly respectable scientists testifying in support of critical analysis of evolution—stammered out denial of common ancestry when asked the question. As the microevolution/macroevolution distinction is a central feature of all three antievolution tactics, its origins and problems will be explored in more depth.

### Special Creation in Disguise

#### THE CREATIONIST ROOTS OF MICROEVOLUTION VERSUS MACROEVOLUTION

The creationist Frank Lewis Marsh, writing in the *Creation Research Society Quarterly* in 1969, carefully defined the two categories, “microevolution and *megaevolution* (also called *macroevolution*)” as follows:

Microevolution is the term applied to the demonstrable production of new varieties or breeds within any basic type.

Megaevolution, on the other hand, is the term applied to the doctrine which holds that, if given enough time, basic types can eventually, through natural processes, produce new basic types.

Microevolution, says Marsh, is “demonstrable variation.” He finds it unfortunate that microevolution is called evolution at all, “because the special creationist who accepts all demonstrable variation does not accept the theory of evolution.” Marsh lists fifteen breeds of cow and six kinds of corn and calls them all products of “only microevolution.” To emphasize the point he even says that microevolution can produce new species. But, says Marsh, it “can never accomplish megaevolution.”

Marsh used the micro/macro distinction in defense of the fundamentalist belief that the kinds of animals described in the Book of Genesis were specially created by divine action. After reviewing the days of creation in the Genesis story, Marsh focuses on the Bible’s repeated statement that organisms reproduce after their kind, writing,

*The record states, in Genesis 1:11, 24, that the command to the earth was to produce these organisms after their kinds. In other words these forms were first conceived in the mind of God, and then at the fiat to the earth to bring forth, the Spirit of God (Genesis 1:2) working with the dust of the earth (Genesis 2:7, 19) produced from it the living forms patterned according to the plan.*

Marsh recognizes that variation from type occurs, and that it can and does lead to change of type, but that is not enough to overcome the biblical account of creation: “Variation does occur abundantly within kinds, but no coercive, compulsive evidence can be produced to show the production of even one new basic kind.” He dismisses common examples of evolution, such as the remarkable diversity of finches Darwin found in the Galápagos. These are, in Marsh’s view, mere variations within the kind: “Darwin failed to recognize the tremendously important fact that the tortoises were still tortoises and the finches still finches.”<sup>24</sup>

Similar sentiments are ubiquitous in creationist literature. In an informal search of *Creation Research Society Quarterly*, we were able to find twenty examples between 1970 and 1976 of creationists be-

laboring the microevolution/macroevolution distinction. For example, a 1970 article states,

*A fruit fly or lamp shell after mutation is still a fruit fly or a lamp shell. Does “microevolution” prove “macroevolution”? i.e., does the production of a new variety of fruit fly or lamp shell explain the creation of the fruit fly or lamp shell itself?*

The universal creationist reaction to the peppered moth, which evolved its camouflage from white to black when the background trees were darkened by industrial soot, is to state that this is just microevolution. This is very often accompanied with an accusation of evolutionist dishonesty, for example,

*Actually [the peppered moth] is not an example of evolution at all. The moths are just the same as they were before the industrial revolution and are not in a process of becoming anything else. Thus it may be charged that referring to such phenomena as any kind of evolution (as micro-evolution) amounts to a brainwashing technique to make real evolution seem less objectionable to those who have scruples against the concept of evolution.*

The actual point of the peppered moth example—that it illustrates how camouflage, a common adaptation that appears designed, can evolve through a simple natural process—is always completely ignored.<sup>25</sup>

#### WHAT’S WRONG WITH THE CREATIONIST DEFINITION OF MACROEVOLUTION

To a biologist, the “it’s just microevolution” argument is painfully obtuse. In normal science, microevolution refers to evolutionary processes within gene pools, such as the origin and spread of individual gene variants. Macroevolution refers to evolutionary processes that work across separated gene pools. Speciation, a process that can be

observed in nature, and that creationists accept, is the boundary between microevolution and macroevolution, because speciation occurs when one gene pool permanently splits into two separate gene pools. A speciation event is a case of macroevolution. So are other events that apply to whole gene pools, such as extinction.

For biologists, then, the microevolution/macroevolution distinction is a matter of *scale of analysis*, and not some ill-defined level of evolutionary newness. Studies that examine evolution at a coarse scale of analysis are also macroevolutionary studies, because they are typically looking at multiple species—separate branches on the evolutionary tree. Evolution within a single twig on the tree, by contrast, is microevolution.

It is true that scientists themselves contribute to confusion over this issue. This typically occurs because *macroevolution* is such a broad term that it can be applied to a wide range of proposed processes, ranging from uncontroversial (extinction, speciation, adaptive radiation, ecological drift), to controversial (punctuated equilibria, species selection), to discredited (orthogenesis, saltation). In a perfect world, scientists would refer to these specific processes rather than the very general micro/macro distinction, but as long as the terms are being used, it behooves us to understand what they mean within the scientific community. Evolutionary biologists on both sides of famously contentious debates seem to agree that the definition of macroevolution boils down to “evolution above the species level.”<sup>26</sup>

#### WHAT’S WRONG WITH THE IDEA OF CREATED KINDS

Once we get past the definitional distraction, we are left with the creationist assertion that there are groups of organisms called kinds, and that as much evolution as you like can occur within these kinds, but that evolution can never, ever, cross the border of the kind. Unfortunately, *the creationists have offered no rigorous criteria for determining the limits of a kind*. The only constant rule seems to be that humans are their own kind.

Indeed, the creationists have been promising rigorous criteria

for decades, but they continue to insist that more research is needed. Even the cutting-edge creationists who call themselves baraminologists—*baramin* is a term for created kinds introduced by Frank Marsh, based on the Hebrew words for “created” and “kind”: *bara* and *min*—admit that they have a long way to go. When they actually do empirical work, they tend to posit massive baramins. For example, they have determined baraminologically that the entire horse fossil series, from the twelve-inch-high fossil *Hyracotherium* to the modern horse, is all one created kind and therefore the progeny of a unique common ancestor. A baraminological analysis of the group of plant species related to sunflowers found that this created kind contains 5730 species, and the creationist researchers conclude further that “we still cannot rule out the possibility that all 20,000 species of the Asteraceae represent a single holobaramin [i.e., created kind sharing common ancestry].” Asteraceae is the sunflower family, and it is one of the two largest families of flowering plants, competing with the orchids. The family contains annuals, perennials, stem succulents, vines, shrubs, and trees, including everything from lettuce to the dwarf fluffweed of the southern California desert (whose adult plant is one inch high and one inch wide) to twenty-five-foot trees.

As the historian of creationism Ronald Numbers notes, the strictest creationists of all, the young-Earth creationists, now tell us that macroevolution is impossible—except, ironically, for the massive amount of extremely rapid evolution that they propose as having occurred just after Noah’s Flood, producing tiny weeds and trees from a common ancestor, and producing modern horses from foot-high precursors.<sup>27</sup>

In the creationist concept of created kind—and the creationist demand to “Show me macroevolution”—we have a classic example of the movable-goalposts strategy for winning. Any amount of evolution that can be demonstrated to the creationists’ satisfaction is effectively by definition microevolution within a kind. No matter how extensive the documented change is, the macroevolution goalposts are always out of reach. The inviolable biblical kind is protected with strategic vagueness.

## SPECIAL CREATION IN INTELLIGENT DESIGN

The ID movement adopted the microevolution/macroevolution distinction unchanged from its young-Earth creationist inventors, except for hiding the biblical source and the motivation of their insistence upon it. Phillip Johnson, godfather of the ID movement, wrote in *Darwin on Trial*,

*Everyone agrees that microevolution occurs, including creationists. Even creation-scientists concur, not because they "have tightened their act," but because their doctrine has always been that God created basic kinds, or types, which subsequently diversified. . . . The point in dispute is not whether microevolution happens, but whether it tells us anything important about the processes responsible for creating birds, insects, and trees in the first place.*<sup>28</sup>

Unfortunately for Johnson, even the young-Earth creationists are forced to admit that trees can be produced by microevolution as they define it, as we saw in the baraminological treatment of sunflowers reported above.

The term *macroevolution* occurs fifty times in the ID textbook *Of Pandas and People*, and in some forty of those instances (excluding headings, index entries, and so on) it is contrasted with verifiable microevolution—or otherwise disparaged. For example,

*What breeders accomplish is diversification within a given type, which occurs in microevolution. What is needed is the origin of new types, or macroevolution.*

Predictably, the peppered moths get their microevolution label:

*Before taking a closer look at the genetic world, it will help us to recognize that there are two levels or categories of evolution, **microevolution** (small-scale evolution) and **macroevolution** (large-scale evolution). The shift in populations of moths from light coloring to dark illustrates microevolution.*

Even apart from the now-famous creationist drafts of *Pandas*, it is easy to show that the assertions in *Pandas* are simply the fundamentalist Christian view of special creation, relabeled for public school use. Nancy Pearcey wrote the long overview chapter in *Pandas*. She is currently a fellow at the Discovery Institute's ID program, but in the 1980s she was a contributing editor for the young-Earth creationist *Bible-Science Newsletter*. She republished most of the *Pandas* overview chapter in three articles in the *Bible-Science Newsletter*, with minor sentence rearrangements, and with the systematic omission of creationist terminology from *Pandas*. Although special creation is implicit in *Pandas*, the *Bible-Science Newsletter* version of the chapter contains some additional text so that one doesn't have to read between the lines:

*Darwin believed change is unlimited, that species are infinitely plastic. He thought a species could vary indefinitely and in any direction. Creationists believe change is limited by a basic organic unit, the created "kind." Within the boundary of that fundamental unit, variation can be profuse. But it never leads to the creation of a new basic type.*

*The fact that the organic world fits a hierarchical pattern constitutes evidence against the evolutionary view and in favor of a theory of separate creations.*

Furthermore, each *Bible-Science Newsletter* article is followed by a Bible-study article that discusses the various Bible passages relevant to the preceding scientific article. For example, Pearcey's BSN article "Of Fins and Fingers" is followed by an article entitled "Bible Study: Which Is More Scientific: 'Kinds' or 'Species'?" Here, Pearcey lays out the theological interpretation on which she is basing the microevolution/macroevolution distinction:

*Begin by reading Genesis 1:11-25 to make sure that you see both the creation according to kinds for each creature, and the reproduction according to kinds. How many times does the word "kind" or "kinds" ap-*

pear in this section of Scripture? Why is this concept repeated so often in this section?

Would God have known that man would eventually try to explain life in evolutionary terms?<sup>29</sup>

Frank Lewis Marsh himself could not have put it better for a biologically challenged readership.

#### SPECIAL CREATION IN CRITICAL ANALYSIS OF EVOLUTION

We found thirty-four pages on the Discovery Institute's Web site containing both *microevolution* and *macroevolution*. For example, a FAQ sheet called "Summary: The Scientific Controversy over Whether Microevolution Can Account for Macroevolution" states,

*The scientific controversy over whether processes observable within existing species and gene pools (microevolution) can account for large-scale changes over geological time (macroevolution) continues to this day.*<sup>30</sup>

This FAQ is a stew of misinformation and quotes taken out of context. For example, it quotes an article on evolutionary developmental biology (evo-devo) discussing the relative importance of micro-mutations and macro-mutations, and uses this to support the claim of a controversy about macroevolution. However, macro-mutations, like any mutations, occur within a gene pool and would therefore be microevolutionary phenomena analyzable within population genetics. Indeed, the whole point of evo-devo has been to bring developmental biology into the evolutionary synthesis with population genetics. The other two quotations simply refer to the distinction between population genetics within lineages and the dynamics of distinct lineages.

Since 2002, the Discovery Institute has been pushing hard for states and local school districts to require the teaching of false controversies like this; their 2005 FAQ lobbies as follows:

*Since the controversy over microevolution and macroevolution is at the heart of Darwin's theory, and since evolutionary theory is so influential in modern biology, it is a disservice to students for biology curricula to ignore the controversy entirely. Furthermore, since the scientific evidence needed to settle the controversy is still lacking, it is inaccurate to give students the impression that the controversy has been resolved and that all scientists have reached a consensus on the issue.*

What would really be a great disservice would be for the state to require teachers to teach the falsehood that there is any scientific doubt about common ancestry, which is the true target of the creationist microevolution/macroevolution argument. Unfortunately, it is clear that this is exactly what the Kansas Board of Education is doing. Steve Abrams, one of the creationist leaders on the Kansas Board of Education, said it clearly in an op-ed ironically entitled "Science Standards Aren't about Religion."

*That is one of the reasons that we tried to further define evolution [in the Kansas standards]. We want to differentiate between the genetic capacity in each species genome that permits it to change with the environment as being different from changing to some other creature. In our science curriculum standards, we called this microevolution and macroevolution—changes within kinds and changing from one kind to another.*<sup>31</sup>

#### Conclusion

Although supporters of strong science education should not expect that the courts will always ride to the rescue, there are reasons to be hopeful in the case of critical analysis of evolution. First, although critical analysis as the creationists see it consists not of critical analysis in the ordinary sense but of a haphazard collection of objections to evolution, it emerges on closer inspection that every single critical analysis argument can be traced directly to established, long-discredited creation science and intelligent design claims. This is important because courts have repeatedly empha-

sized the relevance of the historical lineage of governmental policies. A court that is made aware of this history should and may well conclude that critical analysis of evolution is substantially the same as creation science and intelligent design and see it as one more in an unending series of attempts to privilege the same sectarian view—creationism—with a new and deceptive label.

Second, derived as they are from creationist literature, critical analysis arguments share all the problems of their creationist ancestors. The objections to evolution are not serious scientific arguments; they are superficially investigated and poorly reasoned talking points. Like all creationist arguments, they are aimed at uninformed audiences: they sound good in op-eds, media sound bites, and sermons, but they disintegrate upon detailed examination in court or in serious and extended public discussion.

### 3: Theology, Religion, and Intelligent Design

MARTINEZ HEWLETT AND TED PETERS

Although many interpret the controversy over the teaching of evolutionary biology in public and private schools as a battle between science and religion, we believe this is a mistaken perception. At the deepest level, no conflict between genuine science and healthy religion exists. All parties to the controversy have a positive view of science, even outspoken religious debaters. Virtually all religious voices are raised on behalf of good science, even though what constitutes the best science is a matter of dispute. It is the view of the two authors of this chapter—one a Lutheran theologian and the other a Roman Catholic biologist—that the standard model of evolutionary biology constitutes the best science. Further, we contend that evolutionary biology—even when understood as the Darwinian or neo-Darwinian model—should be taught in science classes in both public and private schools. We recommend against giving equal time to intelligent design (ID) and to scientific creationism. We deem both ID and creationism to be unsatisfactory models for scientific research; further, they are not even science at all, as we understand the discipline. It is incumbent on us as a society to offer our young people only the best science, and the best biological science in our era proceeds from the recognized theory of evolution complete with random variation and natural selection.

Why do we take this position? Because we believe that science at its best and religious commitment at its best honor truthfulness. Further, we believe that religious communities and scientific re-

13. Randy Moore, "Thanking Susan Epperson," *American Biology Teacher* 60, no. 11 (November/December 1998): 642-646.
14. Wendell R. Bird, "Resolution for Balanced Presentation of Evolution and Scientific Creationism," *Impact* 71 (May 1979): 4.
15. Anonymous, "Creation Science and the Local School District," *Impact* 67 (January 1979): 4.
16. For Alabama through Washington, see Wayne Moyer, "Legislative Initiatives," *Scientific Integrity* (June 1981): 1-4; for Georgia through Wisconsin, see Anonymous, "Update on Creation Bills and Resolutions," *Creation/Evolution* 2, no. 1 (1998): 1-44; for the remaining states, consult various Memoranda to Liaisons for Committees of Correspondence, available in NCSE's archives.
17. Anonymous, Act 590 of 1981, reprinted in *Creationism, Science, and the Law*, ed. M. C. La Follette (Cambridge, MA: MIT Press, 1983).
18. Charles B. Thaxton, Walter L. Bradley, and Roger L. Olsen, *The Mystery of Life's Origin: Reassessing Current Theories* (New York: Philosophical Library, 1984).
19. Fred Hoyle and Chandra Wickramasinghe, *Diseases from Space* (New York: Harper and Row, 1979).
20. Percival W. Davis and Dean H. Kenyon, *Of Pandas and People*, 2nd ed. (Dallas: Foundation for Thought and Ethics, 1993).
21. Henry M. Morris, "The Design Revelation," *Back to Genesis* 194 (February 2005): 2-3.
22. Duane T. Gish, *Evolution: The Fossils Still Say No!* (San Diego: Institute for Creation Research, 1985).
23. Jonathan Wells, *Icons of Evolution: Science or Myth?* (Washington, DC: Regnery, 2000).
24. Wayne Frair and Percival Davis, *A Case for Creation*, 3rd ed. (Chicago: Moody Press, 1983); Stephen C. Meyer, "The Origin of Biological Information and the Higher Taxonomic Categories," *Proceedings of the Biological Society of Washington* 117, no. 2 (2004): 213-239.
25. William Dembski, *The Design Inference: Eliminating Chance Through Small Probabilities* (New York: Cambridge University Press, 1998).
26. Wayne Frair, "Baraminology—Classification of Related Organisms," *Creation Research Quarterly* 37, no. 2 (2000): 82-91.

27. William Dembski, "Why President Bush Got It Right about Intelligent Design," blog post dated August 4, 2005; available online at [www.uncommondescent.com/index.php/archives/222](http://www.uncommondescent.com/index.php/archives/222); Henry Morris, *That You Might Believe* (Chicago: Good News, 1946).
28. Phillip E. Johnson, *Darwin on Trial* (Washington, DC: Regnery Gateway, 1991).
29. Ken Walker, "Young-Earth Theory Gains Advocates," *Christianity Today* 42, no. 5 (1998): 24.
30. Bruce Chapman, press release (Seattle: Discovery Institute, Oct. 10, 1996).
31. William Dembski, *Intelligent Design: The Bridge Between Science and Theology* (Downers Grove, IL: InterVarsity Press, 1999), 13.
32. Barbara Forrest and Paul R. Gross, *Creationism's Trojan Horse* (New York: Oxford University Press, 2004).
33. David K. DeWolf, Stephen C. Meyer, and Mark E. DeForrest, *Intelligent Design in Public School Science Curricula: A Legal Guidebook* (Richardson, TX: The Foundation for Thought and Ethics, 1999).

## 2. Analyzing Critical Analysis:

### The Fallback Antievolutionist Strategy

1. For the history of creation science, see Ronald L. Numbers, *The Creationists: The Evolution of Scientific Creationism* (New York: Alfred A. Knopf, 1992). For the legal history of the issue, see Edward J. Larson, *Trial and Error: The American Controversy over Creation and Evolution*, 3rd ed. (New York: Oxford University Press, 2003). For the history of ID, see *Kitzmiller v. Dover Area School District*, et al. (December 20, 2005), available at [www.pamdcourts.gov/kitzmiller/kitzmiller\\_342.pdf](http://www.pamdcourts.gov/kitzmiller/kitzmiller_342.pdf).
2. Wendell R. Bird and Institute for Creation Research staff, "The Supreme Court Decision and its Meaning," *Impact* 170 (August 1987), emphasis in the original.
3. The Discovery Institute CRSC has since relabeled itself the Center for Science and Culture, presumably to appear more secular. See NCSE (2002), "Evolving Banners at the Discovery Institute," [www.ncseweb.org/resources/articles/8325\\_evolution\\_banners\\_at\\_the\\_discovery\\_8\\_29\\_2002.asp](http://www.ncseweb.org/resources/articles/8325_evolution_banners_at_the_discovery_8_29_2002.asp). For the relationship of "The Wedge" to earlier DI documents, see Barbara Forrest and Paul R. Gross, *Creationism's Trojan Horse: The Wedge of Intelligent*

*Design* (New York: Oxford University Press, 2004), 15–33. A scan of the original Wedge document was put online in 2006 by the *Seattle Weekly* at [www.seattleweekly.com/news/0605/discovery-wedge.php](http://www.seattleweekly.com/news/0605/discovery-wedge.php).

4. Jonathan Wells, *Icons of Evolution: Science or Myth?* (Washington, DC: Regnery Publishing, 2000). For an overview critique, see Kevin Padian and Alan D. Gishlick, “The Talented Mr. Wells,” *The Quarterly Review of Biology* 77, no. 1 (2002): 33–37. For more details, see Alan D. Gishlick, “Icons of Evolution? Why Much of What Jonathan Wells Writes about Evolution Is Wrong,” available at [www.ncseweb.org/icons/](http://www.ncseweb.org/icons/), and various articles available at [www.talkorigins.org/faqs/wells/](http://www.talkorigins.org/faqs/wells/).

5. See “NCSE Compilation on Santorum Amendment,” [www.ncseweb.org/resources/articles/7202\\_ncse\\_compilation\\_on\\_santorum\\_a\\_6\\_13\\_2002.asp](http://www.ncseweb.org/resources/articles/7202_ncse_compilation_on_santorum_a_6_13_2002.asp). For summaries of recent controversies, see [www.ncseweb.org/pressroom.asp](http://www.ncseweb.org/pressroom.asp).

6. Ohio Board of Education (2004), “L10H23 Lesson Plan: Critical Analysis of Evolution.” See <http://science2.marion.ohio-state.edu/ohioscience/lesson-plans.html>.

7. Patricia Princehouse, Ohio Citizens for Science, personal communication.

8. Paul R. Gross et al., *The State of State Science Standards 2005* (Washington, DC: Thomas B. Fordham Institute, 2005).

9. Kansas Board of Education, “Kansas Science Education Standards, Approved November 8, 2005,” available at [www.ksde.org/outcomes/sciencestd.pdf](http://www.ksde.org/outcomes/sciencestd.pdf). In this chapter, we quote from the Rationale, p. ii, and Standard 3: Life Science, pp. 71–83.

10. Transcripts of the hearings are available online at: [www.talkorigins.org/faqs/kansas/kangaroo.html](http://www.talkorigins.org/faqs/kansas/kangaroo.html). Scientists properly qualified in the subject matter boycotted these hearings, arguing that they amounted to a kangaroo court since they were overseen by the three staunchest creationists on the board, aided by lawyer John Calvert of the Intelligent Design Network, and this group would devise the rules and serve as judge and jury.

11. The topic of statistical similarity of differing phylogenetic trees is discussed in detail, with a thorough review of the relevant scientific literature, by Douglas Theobald, “Statistical Support for Phylogenies.” See [www.talkorigins.org/faqs/comdesc/phylo.html#reliability](http://www.talkorigins.org/faqs/comdesc/phylo.html#reliability).

12. The key paper is Jean-Renaud Boisserie, Fabrice Lihoreau, and Michel

Brunet, “The Position of Hippopotamidae Within Cetartiodactyla,” *Proceedings of the National Academy of Sciences* 102, no. 5 (2005): 1537–1541; Robert Sanders provides a nontechnical account: “UC Berkeley, French Scientists Find Missing Link Between the Whale and Its Closest Relative, the Hippo.” See [www.berkeley.edu/news/media/releases/2005/01/24\\_hippos.shtml](http://www.berkeley.edu/news/media/releases/2005/01/24_hippos.shtml).

13. Stephen Jay Gould, “Evolution as Fact and Theory,” in *Hen’s Teeth and Horse’s Toes: Further Reflections in Natural History* (New York: W. W. Norton, 1983), 258–260.

14. For shell borers, see p. 301 of Stefan Bengtson, “Origins and Early Evolution of Predation,” *The Fossil Record of Predation*, eds. Michal Kowalewski and Patricia H. Kelley, *The Paleontological Society Papers* 8 (2002): 289–317. The Cambrian Explosion was not an instantaneous event: “The oldest trace fossils are approximately 550 Ma, giving a period of at least 30 Ma before the appearance of trilobites.” From p. 161, Graham E. Budd, “The Cambrian Fossil Record and the Origin of the Phyla,” *Integrative and Comparative Biology* 43 (2003): 157–165.

15. Graham E. Budd, “The Cambrian Fossil Record and the Origin of the Phyla,” p. 159, emphasis ours.

16. Degan G. Shu, Simon Conway Morris, Jian Han, Zhifei F. Zhang, and Jianni N. Liu, “Ancestral Echinoderms from the Chengjiang Deposits of China,” *Nature* 430, no. 6998 (2004): 422–428.

17. David Fitch and Walter Sudhaus, “One Small Step for Worms, One Giant Leap for ‘Bauplan’?,” *Evolution and Development* 4, no. 4 (2002): 243–246. The Conway Morris quote is on p. 170 of Simon Conway Morris, *The Crucible of Creation: The Burgess Shale and the Rise of Animals* (New York: Oxford University Press, 1998). For a discussion of this and related research, see the post “Down with Phyla!” at the Panda’s Thumb blog: [www.pandasthumb.org/archives/2005/04/down\\_with\\_phyla\\_1.html](http://www.pandasthumb.org/archives/2005/04/down_with_phyla_1.html).

18. Alan D. Gishlick, “Icons of Evolution?” See especially figure 8, comparing embryo photos, and figure 10, comparing textbooks, at: [www.ncseweb.org/icons/figures.html](http://www.ncseweb.org/icons/figures.html).

19. Michael K. Richardson, James Hanken, Lynne Selwood, Glenda M. Wright, Robert J. Richards, Claude Pieau, and Albert Raynaud, “Letter,” *Science* 280, no. 5366 (1998): 983.

20. For Kenyon’s affidavit, see [www.talkorigins.org/faqs/edwards-v-aguillard/kenyon.html](http://www.talkorigins.org/faqs/edwards-v-aguillard/kenyon.html). The Meyer quote is from p. 68 of Stephen C. Meyer, “The Methodological Equivalence of Design and Descent: Can There Be a

Scientific 'Theory of Creation?', in J. P. Moreland, ed., *The Creation Hypothesis: Scientific Evidence for an Intelligent Designer* (Downers Grove, IL: InterVarsity Press, 1994), 67–112.

21. Manyuan Long, Esther Betrán, Kevin Thornton, and Wen Wang, "The Origin of New Genes: Glimpses from the Young and Old," *Nature Reviews Genetics* 4, no. 1 (2003): 865–875. For Manyuan Long's homepage, see <http://pondside.uchicago.edu/ceb/faculty/Long.html>.

22. Michael J. Behe, *Darwin's Black Box* (New York: The Free Press, 1996), 138.

23. For a discussion of the role of immunology in the *Kitzmiller v. Dover* trial, containing references to the literature surveyed here, see Andrea Bottaro, Matt A. Inlay, and Nicholas J. Matzke, "Immunology in the Spotlight at the Dover 'Intelligent Design' Trial," *Nature Immunology* 7, no. 5 (2006): 433–435.

24. Frank Lewis Marsh, "The Form and Structure of Living Things," *Creation Research Society Quarterly* 6, no. 1 (1969): 13–25. The quoted passages are from pp. 18–20, emphases in the original.

25. Ian McDowell, "Questions for Evolutionists," *Creation Research Society Quarterly* 7, no. 3 (1970): 182–183; Bolton Davidheiser, "The Human Quest: A New Look at Science and Christian Faith by Richard H. Bube" (review), *Creation Research Society Quarterly* 9, no. 2 (1972): 141–142. In addition to the "it's just microevolution" pseudoargument about peppered moths, teachers regularly confront exaggerated new challenges to the peppered moth example. For a recent informed review of the situation, see Jim Mallet, "The Peppered Moth: A Black and White Story After All," *Genetics Society News* 50 (2004): 34–38.

26. Douglas J. Futuyma, *Evolutionary Biology* (Sunderland, MA: Sinauer Associates, 1998); Stephen Jay Gould, "Macroevolution," in Mark Pagel, ed., *Encyclopedia of Evolution* (Oxford: Oxford University Press, 2002), vol. 1: E-23–E-28; Richard Dawkins, *The Ancestor's Tale: A Pilgrimage to the Dawn of Evolution* (Boston: Houghton Mifflin, 2004).

27. Kurt P. Wise, "The Evolution of Creationist Perspective on the Fossil Equid Series," *Geological Society of America 2003 Annual Meeting Abstracts with Programs* 35, no. 6 (2003): 610; David P. Cavanaugh and Todd Charles Wood, "A Baraminological Analysis of the Tribe Heliantheae sensu lato (Asteraceae) Using Analysis of Pattern (ANOPA)," *Occasional Papers of the Baraminology Study Group* 1 (2002): 1–11; Wayne P. Armstrong, "Sunflower Family (Asteraceae): The Largest Plant Family on Earth," *Wayne's Word: An Online Textbook of Natural History* 9, no. 3 (2000); Ronald L. Numbers, "Ironic Heresy: How Young-Earth Creationists Came to Embrace Rapid Microevo-

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28. Phillip E. Johnson, *Darwin on Trial* (Downers Grove, IL: InterVarsity Press, 1991), 68.

29. The Pendas quotes are from Percival William Davis and Dean Kenyon, *Of Pandas and People: The Central Question of Biological Origins*, 2nd ed. (Dallas: Foundation for Thought and Ethics, 1993), 11, 61, emphasis in original. The Bible-Science Newsletter articles by Nancy R. Pearcey are "Bible Study: Which Is More Scientific: 'Kinds' or 'Species'?", *Bible-Science Newsletter* 27, no. 5 (1989): 9–10; "Echo of Evolution? The Revolution in Molecular Biology," *Bible-Science Newsletter* 27, no. 12 (1989): 7–11; "Of Fins and Fingers: Patterns in Living Things," *Bible-Science Newsletter* 27, no. 5 (1989): 6–9; "What Species of Species?—or, Darwin and the Origin of What?," *Bible-Science Newsletter* 27, no. 6 (1989): 7–9.

30. Discovery Institute, "The Scientific Controversy over Whether Microevolution Can Account for Macroevolution," available at [www.discovery.org/scripts/viewDB/filesDB-download.php?id=118](http://www.discovery.org/scripts/viewDB/filesDB-download.php?id=118).

31. Steve Abrams, "Science Standards Aren't about Religion," *Wichita Eagle*, November 15, 2005.

### 3. Theology, Religion, and Intelligent Design

1. William Paley, *Natural Theology: or, Evidences for the Existence and Attributes of the Deity, Collected from the Appearances of Nature* (London: R. Faulder, 1802).

2. Richard Dawkins, *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design* (New York: W. W. Norton, 1987).

3. Phillip E. Johnson, *Darwin on Trial* (Washington, DC: Regnery Gateway, 1991), 69.

4. Henry M. Morris, *Scientific Creationism* (Green Forest, AR: Master Books, 1974, 1985); Duane T. Gish, *Evolution: The Fossils Still Say No!* (El Cajon, CA: Institute for Creation Research, 1985).

5. Michael Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: Touchstone/Simon Schuster, 1996), 39.

6. William Dembski, *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence* (Lanham, MD: Rowman & Littlefield, 2002), 12.

16. David Shipley, "And Now a Word from Op-Ed," *New York Times*, February 1, 2004.

17. A useful article, both to help you understand the challenges faced by the press in covering the creationism/evolution issue and to recommend to journalists facing those challenges, is Chris Mooney and Matthew C. Nisbet, "Undoing Darwin," *Columbia Journalism Review* 44, no. 3 (September/October 2005): 31-39.

18. Usually held on or near February 12, Darwin Day celebrations provide a marvelous opportunity not only to honor the life and work of Darwin but also to engage in public outreach about science, evolution, and the importance of evolution education. To find a Darwin Day event in your area, or to register your own event, see [www.darwinday.org](http://www.darwinday.org).

19. Indeed, because slick creationist programs such as *Unlocking the Mystery of Life* have occasionally found their way into PBS distribution networks, it is worth educating the programming staff at your local PBS station about the need to ensure that the science programs they broadcast are indeed legitimate.

20. *The Science Teacher* and *The American Biology Teacher* are published by the National Science Teachers Association ([www.nsta.org](http://www.nsta.org)) and the National Association of Biology Teachers ([www.nabt.org](http://www.nabt.org)), respectively. The Evolution and the Nature of Science Institutes Web site is at [www.indiana.edu/~ensiweb/home.html](http://www.indiana.edu/~ensiweb/home.html). The University of California Museum of Paleontology's Understanding Evolution Web site is at <http://evolution.berkeley.edu>.

21. A blueprint for organizing such workshops is available at [www.ucmp.berkeley.edu/ncte/twb/](http://www.ucmp.berkeley.edu/ncte/twb/).

22. The 197th anniversary of Darwin's birthday, February 12, 2006, was also the first Evolution Sunday. More than 450 churches across the country conducted sermons or adult religious education programs affirming the compatibility of science with their religious faith. For details, see [www.evolutionsunday.org](http://www.evolutionsunday.org).

23. Available at [www.dfms.org/19021\\_58393\\_ENG\\_HTM.htm](http://www.dfms.org/19021_58393_ENG_HTM.htm).

24. Jay Hosler, *The Sandwalk Adventures* (Columbus, OH: Active Synapse, 2003).

25. Stephen Jay Gould, "Dorothy, It's Really Oz: A Pro-Creationist Decision in Kansas Is More Than a Blow Against Darwin," *Time*, August 23, 1999, 59.

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