

Rebuttal to Reports by Opposing Expert Witnesses

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1 Introduction

I have carefully read the reports by the six opposing expert witnesses. In this rebuttal, I will respond to five of the reports, omitting the one by Brian Alters. Alters's report focuses on philosophy of education, the pedagogical value of teaching intelligent design in the high school biology curriculum, and the reception of intelligent design among educators (especially among the professional educational associations concerned with science instruction). Alters's main concern is that through the teaching of intelligent design, science teachers will "engender needless misconceptions" in their students' understanding of evolutionary biology (Alters, p. 3). Other experts in these matters take exactly the opposite view. For instance, according to Larry Arnhart evolutionary theory cannot be properly understood and taught without considering ID as its foil and counterpart.¹ Note that Arnhart himself is not a proponent of ID.²

Although the pedagogical value of teaching ID is an interesting question, the key question is whether intelligent design constitutes a scientific program and whether the textbook in question, *Of Pandas and People* (2nd ed.), adequately represents the theory of intelligent design. Because

the other reports address this key question, this rebuttal will focus on these other reports. I therefore defer to the expert witnesses on my side who are more qualified to rebut Alters's concerns about the educational value of ID (especially Warren Nord, Dick Carpenter, and John Angus Campbell).

I am a philosopher of science and have published on the relation between science and religion. I therefore feel qualified to respond to the expert witness reports of Barbara Forrest, Robert Pennock, and John Haught in their entirety. As for the reports by Kenneth Miller and Kevin Padian, I am qualified to assess the logic of their arguments. In particular, as a professional mathematician, I am qualified to critique their assessments of my own mathematical work on design detection.

Except for Barbara Forrest and Brian Alters, I have interacted professionally with the opposing expert witnesses regarding intelligent design: Kevin Padian and I were together on Jack Ford's PBS program *Inside the Law* back in 1996. Kenneth Miller and I have squared off at a number of conferences and debates (e.g., the *Design and Its Critics* conference at Concordia University in Mequon Wisconsin in 2000 and at the *World Skeptics Conference* in Burbank in 2002). Robert Pennock and I met for a formal debate at the American Museum of Natural History in New York in 2002. Finally, John Haught and I were together for a week at Oxford University (Wycliffe Hall) in the summer of 2001 to discuss intelligent design.

2 Barbara Forrest

2.1 The Myth of Religious Neutrality

Does intelligent design have at its core a scientific theory and research program? This is the key question that needs to be addressed in deciding *Kitzmiller v. Dover*. Forrest touches on this question at a few points in her expert witness report, and I will return to her treatment of this question. But the inordinate amount of space she devotes in her report to charting ID's religious associations requires some comment first.

No party to this debate is religiously neutral. Indeed, for every citation she gives in which ID proponents obtain religious mileage from intelligent design, it is possible to cite evolutionists who obtain equally religious (or anti-religious) mileage from evolution. Forrest's expert witness report never makes clear the distinction between the religious motivations of some ID proponents, the religious implications of ID, and ID as such (i.e., as a scientific program).

Forrest, for instance, accurately quotes one of my theological publications as stating that intelligent design is the Logos of John's Gospel restated in the idiom of information theory (Forrest, p. 27). But consider Barry Lynn, who heads Americans United for Separation of Church and State. In a 1997 PBS Firing Line debate on intelligent design, he too invoked the opening chapter of John's Gospel, but this time to support evolution: "In the beginning was the word..." Indeed that word just might turn out literally to have been a command: 'Evolve!'"³ Given the history of New Testament scholarship on John's Gospel,⁴ Lynn's use of this passage to support evolution is even more radical than my use of it to support intelligent design.

Lynn and I are both bringing our knowledge of contemporary science to bear on our religious understanding of the world. For Lynn, it is evolution that brings religious insight. For me it is intelligent design. In fact, I write entire books on the theological implications of intelligent design.⁵ But I also write academic monographs and research articles on intelligent design as such, notably, my 1998 monograph *The Design Inference* (published with Cambridge University Press in the monograph series *Cambridge Studies in Probability, Induction, and Decision Theory*). Forrest in her expert witness report obscures this distinction.

Most philosophy programs at the college level offer a course in critical thinking. Although Barbara Forrest is a professional philosopher, much of her expert witness report consists in committing what such courses refer to as the *genetic fallacy*. According to one standard text on critical thinking,

[The genetic fallacy is] a type of argument in which an attempt is made to prove a conclusion false by condemning its source or genesis. Such arguments are fallacious because how an idea originated is irrelevant to its viability.⁶

Every variant of the genetic fallacy that Forrest employs against intelligent design can be employed against evolution. To discredit the Discovery Institute and its support for intelligent design, she notes that Howard Ahmanson, one of the chief funders of the Discovery Institute, has in the past supported the Chalcedon Foundation, a Christian reconstructionist organization (Forrest, p. 29). Ahmanson has since repudiated his involvement with the Chalcedon Foundation. But even if he had not, why should his support of certain initiatives play any role in assessing the intrinsic worth of those initiatives? In the case of the Discovery Institute, why should the fact that he has given money toward its work on intelligent design undercut the institute's work on intelligent design? That work must stand or fall on its own merits.

Forrest is engaging in guilt by association, which is a variant of the genetic fallacy. One could make a parallel argument against National Center for Science Education (the premier watchdog group for debunking intelligent design — www.ncseweb.org). For many Americans, Hugh Hefner does not exemplify moral probity. Yet Hugh Hefner has lent his name to support the NCSE: for her work with the NCSE, Eugenie Scott received the Playboy Foundation's 1999 Hugh H. Hefner First Amendment Award.⁷ Should those opposed to Hugh Hefner's moral views for that reason reject the work of the NCSE? Of course not. The work of the center must be judged on its own merits.

Forrest decries the religious and moral implications drawn from ID. But what about those drawn by evolutionists from evolutionary theory? Consider the following:

RACISM AND GENOCIDE:

“At some future period, not very distant as measured by centuries, the civilised races of man will almost certainly exterminate, and replace, the savage races throughout the world.... The break between man and his nearest allies will then be wider, for it will intervene between man in a more civilised state, as we may hope, even than the Caucasian, and some ape as low as a baboon, instead of as now between the negro or

Australian and the gorilla.”⁸ [Just so there is no doubt, the author in particular is claiming that whites will exterminate blacks.]

—Charles Darwin, *The Descent of Man*, 1871, ch. 6.

BESTIALITY:

Evolution teaches that “we are animals” so that “sex across the species barrier ceases to be an offence to our status and dignity as human beings.”⁹ [Just so there is no doubt, “sex across the species barrier” is a euphemism for bestiality.]

—Peter Singer, “Heavy Petting,” 2001

RAPE:

Rape is “a natural, biological phenomenon that is a product of the human evolutionary heritage,” akin to “the leopard’s spots and the giraffe’s elongated neck.”¹⁰

—Randy Thornhill and Craig Palmer, “Why Men Rape,” 2000

BASIS FOR MORALITY:

“As evolutionists, we see that no [ethical] justification of the traditional kind is possible. Morality, or more strictly our belief in morality, is merely an adaptation put in place to further our reproductive ends. Hence the basis of ethics does not lie in God’s will.... In an important sense, ethics as we understand it is an illusion fobbed off on us by our genes to get us to cooperate. It is without external grounding.”¹¹

—E. O. Wilson and Michael Ruse, “The Evolution of Ethics,” 1991

ORIGIN OF RELIGION:

According to Darwin, religious belief arises from ignorance of natural causes: “The tendency in savages to imagine that natural objects and agencies are animated by spiritual or living essences, is perhaps illustrated by a little fact which I once noticed: my dog, a full-grown and very sensible animal, was lying on the lawn during a hot and still day; but at a little distance a slight breeze occasionally moved an open parasol, which would have been wholly disregarded by the dog, had any one stood near it. As it was, every time that the parasol slightly moved, the dog growled fiercely and barked. He must, I think, have reasoned to himself in a rapid and unconscious manner, that movement without any apparent cause indicated the presence of some strange living agent, and that no stranger had a right to be on his territory. The belief in spiritual agencies would easily pass into the belief in the existence of one or more gods.”¹²

—Darwin, *Descent of Man*, 1871, ch. 3

JUSTIFICATION FOR ATHEISM:

According to Richard Dawkins “the evidence of evolution reveals a universe without design.” Moreover, “Darwin made it possible to be an intellectually fulfilled atheist.”¹³

—Richard Dawkins, *The Blind Watchmaker*, 1986

GOAL OF SCIENCE:

“I personally feel that the teaching of modern science is corrosive of religious belief, and I’m all for that! One of the things that in fact has driven me in my life, is the feeling that this is one of the great social functions of science — to free people from superstition.”

Lest there be any doubt about what Steven Weinberg here means by “superstition,” he adds, “this progression of priests and ministers and rabbis and ulamas and imams and bonzes and bodhisattvas will come to an end, that we’ll see no more of them. I hope that this is something to which science can contribute and if it is, then I think it may be the most important contribution that we can make.”¹⁴ [Weinberg, a Nobel laureate physicist, is well-known as an ardent evolutionist. He has debated Phillip Johnson on a number of occasions on this topic.¹⁵ Note that the demise of religion is for Weinberg *the most important contribution of science.*]

—Steven Weinberg, “Free People from Superstition,” 2000

NON-NEGOTIABILITY OF MATERIALISM:

“We take the side of science in spite of the patent absurdity of some of its constructs, in spite of its failure to fulfill many of its extravagant promises of health and life, in spite of the tolerance of the scientific community for unsubstantiated just-so stories, because we have a prior commitment, a commitment to materialism. It is not that the methods and institutions of science somehow compel us to accept a material explanation of the phenomenal world, but, on the contrary, that we are forced by our a priori adherence to material causes to create an apparatus of investigation and a set of concepts that produce material explanations, no matter how counterintuitive, no matter how mystifying to the uninitiated. Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door.... To appeal to an omnipotent deity is to allow that at any moment the regularities of nature may be ruptured, than miracles may happen.”¹⁶

—Richard Lewontin, *New York Review of Books*, 1997

This last quote is particularly revealing. It, and others like it, prompted Phillip Johnson to introduce the “wedge metaphor,” the very metaphor about which Barbara Forrest is so exercised in her expert witness report. Harvard geneticist Richard Lewontin, a well known proponent of evolutionary theory and collaborator with the late Stephen Jay Gould, is here counseling that science’s commitment to materialism is not merely a working hypothesis that helps science to succeed. Rather, it must be held as an absolute, a priori principle, and thus regardless of scientific evidence. Question: what happens when this commitment to materialism conflicts with scientific evidence, as intelligent design indicates? It’s this dilemma that Johnson’s wedge metaphor highlights, forcing scientists to choose between two conceptions of science: science conceived as following the evidence wherever it leads and science conceived as following the evidence only where materialism allows.

Note that there has never been any hidden or conspiratorial agenda behind the wedge as Barbara Forrest suggests throughout her expert witness report. Johnson introduced the wedge metaphor in his 1997 book *Defeating Darwinism by Opening Minds* (and thus a full year before the “wedge document” that Forrest cites appeared) and further reinforced it in his 2000 book *The Wedge of Truth*. Johnson and the Discovery Institute have always been entirely above board in their use of the term. To suggest, as Forrest does in the title of her book (*Creationism’s Trojan Horse: The Wedge of Intelligent Design*), that the wedge advertises itself as one thing but is really another is unfounded. The wedge is exactly what it has been advertised to be right along.

Over the last five years, I personally have become the special target of Barbara Forrest's criticisms. Her book *Creationism's Trojan Horse* cites me 130 times in the index (more than any other entry in the book). In April 2000, I organized a conference at Baylor University titled *The Nature of Nature*, which featured Nobel laureates Steven Weinberg and Christian de Duve as well as members of the National Academy of Sciences. Scholars on both sides of the ID question were invited to discuss their differences freely. Rather than allow this event to take place unimpeded, Forrest wrote a letter to derail the conference, using the same guilt-by-association approach that appears in her expert witness report (for her letter, see Appendix 1).

Where does that leave Barbara Forrest? Is she an unbiased, neutral commentator on this debate. She herself is on the board of directors of the New Orleans Secular Humanist Association.¹⁷ Although secular humanists deny that secular humanism is a religion,¹⁸ secular humanism is anything but religiously neutral. Indeed, secular humanism rejects "traditional views of God and divinity" and discounts "the illusions of immortality or reincarnation."¹⁹ Moreover, evolution is a necessary feature of secular humanism.²⁰ Given her secular humanist presuppositions, her opposition to intelligent design follows as a matter of course.

Nor does it lessen her bias to note that people can hold to evolution and be Christians or religious believers of other faiths. The question is not whether some religious believers have made their peace with evolution, or whether the rational course is for religious believers to make their peace with evolution, but whether some religious believers see evolution in its conventional, materialistic form as fundamentally incompatible with their religious beliefs. So long as there are people like this (and Gallup polls consistently indicate that about half the U.S. population falls in this category²¹), the teaching of evolution in high school biology curricula will not be religiously neutral. The only way, then, to effect religious neutrality is either to remove evolution from the biology curriculum (which clearly is not an option) or to offset it by also teaching intelligent design (which is an option).

Cornell's Will Provine, a well-known evolutionist, in a synopsis for his 1998 Darwin Day address, acknowledges this dilemma and offers the following advice:

Naturalistic evolution has clear consequences that Charles Darwin understood perfectly. 1) No gods worth having exist; 2) no life after death exists; 3) no ultimate foundation for ethics exists; 4) no ultimate meaning in life exists; and 5) human free will is nonexistent.... Evolution is of interest to all. 50% of Americans believe humans were created by God.... Most other Americans who do believe in evolution think that God guided it. But a small group of powerful naturalist evolutionists have taken control of our schools. They want to stifle discussion of evolution in the classroom by everyone according to his or her beliefs. Discussion may then change minds. Evolutionists are their own worst enemies by preventing free discussion of all views in the biology classroom.²²

Although Provine is right as far as he goes, the issue here goes beyond simply freeing up discussion in the high school biology classroom or counterbalancing the teaching of evolution. To be sure, no one on reflection takes seriously the claim that evolution is religiously neutral. At the same time, the teaching of intelligent design in the high school biology curriculum must not be viewed as deference to the religious preferences of certain special interests. This is not a

matter of charity but of honesty and fairness. Intelligent design is a scientific theory and research program. It deserves a place at the table in the high school biology curriculum.

2.2 ID and Creationism

Barbara Forrest is meticulous at ferreting out older quotes by ID proponents in an effort to show that intelligent design is a repackaging of old-style creationism. Nonetheless, her use of these quotes is misleading. In particular, it does not do justice to ID as a developing discipline whose aim and ideas are, for lack of a better word, evolving. Here are three of her most damning quotes:

“Our first project is a rigorous scientific critique of the theory of prebiotic evolution. Next, we will develop a two-model high school biology textbook that will fairly and impartially give scientific evidences for creation side by side with evolution. (In this case, Scripture or even religious doctrine would violate the separation of church and state.) A credentialed author team and a consulting editorial board of scholars are being assembled for the project. The manuscript will be placed with a secular publisher for publication.” (quoted by Forrest on pp. 23-24)
—Foundation for Thought and Ethics planning document, ca. 1980 [FTE publishes *Of Pandas and People*]

“Although students generally hear only one side on the origins question, increasing numbers of scientists are now abandoning evolution for a new scientific version of creationism. Creationist scientists now number in the hundreds, possibly in the thousands, in the States and other countries.” (quoted by Forrest on p. 20)
—Affidavit by Dean Kenyon, co-author of *Pandas*, 1986

“This isn’t really, and never has been, a debate about science... It’s about religion and philosophy.” And “My colleagues and I speak of ‘theistic realism’ — or sometimes, ‘mere creation’ — as the defining concept of our movement. This means that we affirm that God is objectively real as Creator, and that the reality of God is tangibly recorded in evidence accessible to science, particularly in biology.” (quoted by Forrest on p. 31)
—Phillip Johnson, from two sources, 1996

The most recent of these quotes is about a decade old now. The oldest dates back twenty-five years. What do these quotes say about the state of intelligent design today? Has the field developed since then so that these quotes no longer adequately represent ID? Or has ID stood still and merely changed its terminology? This is an important question. Nor is the answer immediately evident inasmuch as the two seminal book that have defined the ID movement, namely, Michael Behe’s *Darwin’s Black Box* (1996) and my own *The Design Inference* (1998), had not yet appeared and made an impact on the intellectual world when these statements were first written or uttered.

The most troubling aspect of these quotes for Barbara Forrest is their explicit reference to “creation.” What Forrest seems not to appreciate is that just like “evolution,” the term “creation”

has several senses. For instance, the evolutionary literature will use the term evolution to mean everything from changes in gene frequencies to universal common ancestry to a purely materialistic process of organismal change driven by natural selection to an encompassing philosophy of life and the world.²³ Likewise, creation has several senses. Thus, it can mean everything from innovative design to a religious doctrine about God bringing the world into being to a particular interpretation of Genesis about how and when God brought the world into being.

Creation in the first, religiously neutral, sense can be found in both the engineering sciences and the biological sciences. Consider, for instance, the title for the following engineering text on technological evolution: *Engineering of Creativity: Introduction to TRIZ Methodology of Inventive Problem Solving*.²⁴ From the biological sciences, consider the following remark by Wallace Arthur, a geneticist at the University of Chicago and not an ID-proponent:

How can a theory of evolution that purports to explain how creatures with trillions of cells arose from unicellular beginnings lost in the mists of pre-Cambrian time be taken seriously if all it tells us is that differential rates of destruction can alter the genetic composition of populations? How are the new variants that natural selection spreads through populations created in the first place? Although the phrase “creation science” carries disreputable connotations because of its frequent use by some religious fundamentalists, we truly need some “creation science” (in the other sense of that phrase) as a major component of evolutionary theory.²⁵

The references to “creation” and “creation science” in the first two passages quoted above by Barbara Forrest (i.e., the FTE planning document and the affidavit by Dean Kenyon) are not referring to a religious doctrine of creation in which God brings the world into being but rather to a generic intelligence capable of bringing about biological complexity. Precisely because these senses of the term creation are so distinct, “intelligent design” rather than “creationism” is now the preferred way to speak about a science of biology in which intelligence plays a key role. Forrest, to be sure, insists on referring to intelligent design as a form of creationism, but this is simply to discredit intelligent design, not to clarify the underlying issues.

Forrest’s quotes of Johnson fall in a different category. I know Johnson personally, and he really does aspire to see our culture imbued with a broadly theistic understanding of the world as a divine creation. The question remains, however, what his aspirations have to do with ID as a scientific theory and research program. Take his claim, “This isn’t really, and never has been, a debate about science... It’s about religion and philosophy.” Johnson never claimed that there is no scientific debate over evolution and intelligent design (see, for instance, chapter 6 of his book *The Wedge of Truth*, in which he summarizes what he takes to be the scientific case for ID and the failure of evolutionists to mount an adequate scientific refutation). It’s just that for him the scientific debate is a matter of details, and what’s really driving this debate are political, religious, philosophical, and cultural forces. The obsessive quality of Barbara Forrest’s writings on intelligent design (evident in her expert witness report) suggests that Johnson is right on this matter. Yet regardless of whether he is, nothing he has said or written contradicts the claim that ID is science.

Forrest also faults Johnson for associating ID with “theistic realism” or “mere creation” or the view that a creator God has left tangible marks in the natural world. What Forrest fails to note is that ID proponents are free to reject Johnson’s theistic realism and still call themselves ID proponents. Moreover, Johnson has since embraced such proponents of ID. Take David Berlinski. He is an ID proponent warmly embraced by Johnson, and yet when charged with being a creationist, Berlinski has remarked: “I have no creationist agenda whatsoever and, beyond respecting the injunction to have a good time all the time, no religious principles, either.”²⁶

In her expert witness report, Forrest gives the impression that what is now known as intelligent design was set in stone decades ago and that the only thing to have changed since is the vocabulary to describe it. But that is not the case. As with most intellectual movements, intelligent design has gone through a continual process of development and refinement, clarifying its scientific critique of conventional evolutionary theory, building a positive scientific alternative, and separating off interpretations of ID’s cultural and religious significance. Johnson made his remarks in 1996. Berlinski, who provides a counterexample to Johnson’s “theistic realism,” did not enter the ID movement until November of 1996, when he spoke at the *Mere Creation* conference at Biola University.²⁷ Since then, Johnson has placed less and less emphasis on “theistic realism” (it does not even get an index entry in his 2000 book *The Wedge of Truth*). Also since then, ID has become a discipline in its own right whose price of admission is not the acceptance of any religious doctrine but the rejection of methodological materialism.

2.3 Methodological Materialism

At the start of her expert witness report, Barbara Forrest identifies a normative principle for science known as methodological naturalism or methodological materialism. According to her, this is a “scientific procedural protocol of seeking only natural explanations of natural phenomena.” She then adds, “ID’s rejection of naturalism in any form [and thus as a methodological principle for science] entails its appeal to the only alternative, supernaturalism, as a putatively scientific explanation for natural phenomena. This makes ID a religious belief” (Forrest, p. 1) Forrest also quotes an article of mine from 1992 in which I refer to “supernatural design.” (Forrest, p. 35)

The impression Forrest leaves is that whereas conventional evolutionary theory is engaged in the hard work of real science, intelligent design appeals to the supernatural and thus gives up on science, substituting magic for as she puts it “natural explanations.” But what are “natural explanations”? Forrest doesn’t say. Indeed, what constitutes nature remains very much an open question. If one reviews the ID literature, one finds that early on there were quite a few references to “the supernatural,” but that by 2000 (especially with Baylor’s Nature of Nature conference, which I helped organize), references to the supernatural largely disappear. The reason for this is that the very term “supernatural” concedes to materialists like Barbara Forrest precisely the point at issue, namely, what is nature like and what are the causal powers by which nature operates.

Forrest wants to say that nature operates only by natural causes and is explained scientifically only through natural explanations. But what does Forrest mean by nature? In my expert witness report, I briefly criticized methodological materialism. There I cited Eugenie Scott as follows:

Most scientists today require that science be carried out according to the rule of *methodological materialism*: to explain the natural world scientifically, scientists must restrict themselves only to material causes (to matter, energy, and their interaction). There is a practical reason for this restriction: it works. By continuing to seek natural explanations for how the world works, we have been able to find them. If supernatural explanations are allowed, they will discourage—or at least delay—the discovery of natural explanations, and we will understand less about the universe.²⁸

In response, I noted in my expert witness report the following:

There are two problems with this [Eugenie Scott's] statement. First, if methodological materialism is merely a working hypothesis that scientists employ because "it works," then scientists are free to discard it when it no longer works. Design theorists contend that for adequately explaining biological complexity, methodological materialism fails and rightly needs to be discarded. Second, and more significantly, in defining science as the search for natural explanations, Scott presupposes precisely what must be demonstrated. If, by natural explanations, Scott simply means explanations that explain what is happening in nature, there would be no problem, and intelligent design would constitute a perfectly good natural explanation of biological complexity. But that is not what she means.

By natural explanations, Scott means explanations that resort only to material causes—as she puts it, to "matter, energy, and their interaction." But that is precisely the point at issue, namely, whether nature operates exclusively by such causes. If nature contains a richer set of causes than purely material causes, then intelligent design is a live possibility and methodological materialism will misread physical reality. Note, also, that to contrast natural explanations with supernatural explanations further obscures this crucial point. Supernatural explanations typically denote explanations that invoke miracles and cannot be understood scientifically. But explanations that call upon intelligent causes require no miracles and give no evidence of being reducible to Scott's trio of "matter, energy, and their interaction." Indeed, design theorists argue that intelligent causation is perfectly natural provided that nature is understood aright.

Because so much of this debate over intelligent design hinges on the nature of nature, I need to expand on these remarks. Nature, as conceived by Scott, Forrest, and the other expert witnesses opposed to ID, consists of material entities ruled by fixed laws of interaction, often referred to as "natural laws." These laws can be deterministic or nondeterministic, which is why some scientists refer to nature as being governed by "chance and necessity."²⁹ Obviously, these laws of interaction rule out any form of intelligent agency acting real-time within nature. They operate autonomously and automatically: given certain material entities with certain energetic properties in certain spatio-temporal relationships, these entities will behave in certain prescribed ways.

An inescapable question now arises: How do we know that nature is in fact a set of material entities ruled by fixed laws of interaction? In particular, how do we know that everything that happens in nature can be accounted for in terms of antecedent material conditions and the processes that act on them characterized by these laws of interaction? Once the question is posed this way, it becomes an open question whether nature comprises a set of material entities ruled by fixed laws of interaction. In fact, it becomes a live possibility that nature, so conceived, is radically incomplete. In my book *No Free Lunch* I summarize what's at issue here as follows:

In arguing that naturalistic explanations are incomplete or, equivalently, that natural causes cannot account for all the features of the natural world, I am placing natural causes in contradistinction to intelligent causes. The scientific community has itself drawn this distinction in its use of these twin categories of causation. Thus, in the quote earlier by Francisco Ayala, "Darwin's greatest accomplishment [was] to show that the directive organization of living beings can be explained as the result of a natural process, natural selection, without any need to resort to a Creator or other external agent." Natural causes, as the scientific community understands them, are causes that operate according to deterministic and nondeterministic laws and that can be characterized in terms of chance, necessity, or their combination (cf. Jacques Monod's *Chance and Necessity*). To be sure, if one is more liberal about what one means by natural causes and includes among natural causes telic processes that are not reducible to chance and necessity (as the ancient Stoics did by endowing nature with immanent teleology), then my claim that natural causes are incomplete dissolves. But that is not how the scientific community by and large understands natural causes.³⁰

The point to appreciate here is that Forrest and her fellow expert witnesses, in assuming methodological materialism, have assumed precisely the point at issue. Specifically, to say, as Forrest does, that science is the search for natural explanations of natural phenomena is to presuppose that such explanations exist for *all* natural phenomena. But how is this claim to be justified? Rather than justify it, Forrest begs the question. To see that Forrest has indeed made a question-begging assumption here, consider the following analogy drawn from the game of chess. In chess, there are initially thirty-two pieces arranged on an eight-by-eight chessboard as follows:



Moreover, chess operates by certain fixed rules. For instance, bishops move diagonally, pawns only move forward and only take one square diagonally, etc. In this analogy, the chess pieces in their initial configuration correspond to the material entities that for Forrest constitute nature and the rules of chess correspond to the laws of interaction that for Forrest govern nature.

Given the initial position of chess pieces and the rules of the game, we can ask whether the following position is possible:



It turns out that it is not. There is no way to get from the first position to the second by the rules of chess.

So too, intelligent design purports to show that there exist configurations of material entities (e.g., bacterial flagella, protein synthesis mechanisms, and complex organ systems) that cannot be adequately explained in terms of antecedent material conditions together with processes characterized by fixed laws that act on them. Granted, chess constitutes a toy example whereas the biological examples ID theorists investigate are far more complicated. Moreover, whereas chess operates according to precise mathematical rules, the laws of interaction associated with material entities are probabilistic, so the obstacles to producing complex biological configurations of material entities are not logical impossibilities but empirical improbabilities. But the point of the analogy still holds. Whenever you have a theory about process — how one state is supposed to progress into another — it is perfectly legitimate to ask whether the process in question is capable of accounting for the final state in terms of the initial state.

It follows that the charge of supernaturalism against intelligent design cannot be sustained. Indeed, to say that rejecting naturalism entails accepting supernaturalism holds only if nature is defined as a closed system of material entities ruled by unbroken laws of material interaction. But, as we have just seen, this begs the question. In his expert witness report, Robert Pennock asks: “If you call a tail a leg, how many legs does a dog have?” Pennock rightly answers, “*Four*; calling a tail a leg doesn’t make it one.” (Pennock, p. 24) Likewise, defining nature as a closed system of material entities operating by fixed laws of interaction doesn’t make it so. Nature is what nature is, and prescribing methodological materialism as a normative principle for science

(as Forrest and the other expert witnesses do) does nothing to change that. ID theorists argue that methodological materialism fundamentally distorts our understanding of nature. For the purposes of this case, the crucial thing is not whether they are right but whether they might be right. Given that they might be right, methodological materialism cannot be taken as a defining feature of science, much less should it be held dogmatically. To make methodological materialism a defining feature of science commits the premodern sin of forcing nature into a priori categories rather than allowing nature to speak for itself.

To sum up, Forrest and her fellow expert witnesses present us with a false dilemma: either science must be limited to “natural explanations” (taken in a highly tendentious sense) or it must embrace “supernatural explanations,” by which she means magic. But there is a third possibility: *neither materialism nor magic but mind*. ID theorists are not willing to concede the materialist claim that a designing intelligence (mind) interacting with matter is “supernatural.” Indeed, investigations by ID theorists are beginning to demonstrate that this interaction is perfectly natural — that nature cannot be properly understood apart from the activity of a designing intelligence.

2.4 ID’s Contribution to Science

Critics of intelligent design like Barbara Forrest have adopted a *zero-concession policy* toward intelligent design. According to this policy, absolutely nothing is to be conceded to intelligent design on the scientific front. Indeed, to do otherwise is to allow that intelligent design might have something going for it scientifically, in which case its legitimacy in the public school biology curriculum would be immediate. To block this possibility, Forrest must assert that intelligent design has contributed zero to science. As she puts it (and she makes identical claims throughout her report): “[intelligent design’s] effect on science is nil” (Forrest, p. 30).

Let’s examine this charge and how Forrest attempts to substantiate it. One way is by quoting design theorists and attributing to them the admission that ID has contributed nothing to science. Thus, for instance, on page 26 of her report, she quotes my article “Becoming a Disciplined Science: Prospects, Pitfalls, and Reality Check for ID.” In that article I wrote: “Because of ID’s outstanding success at gaining a cultural hearing, the scientific research part of ID is now lagging behind.”³¹ Forrest quotes this statement and then interprets it as follows: “Dembski has admitted that the ID movement has produced no science on its own” (Forrest, p. 26). This is wishful thinking on her part. I’ve never made any such admission. In the passage Forrest quotes, I was simply stating that as both a cultural and a scientific movement, intelligent design was progressing faster on the cultural than on the scientific front. But this is a far cry from denying that ID is progressing scientifically, much less conceding ID has made no contribution to science. ID was making scientific progress back in 2002 when I wrote these words, and its scientific progress has accelerated since then.

In this same vein, Forrest quotes Paul Nelson as saying “Easily the biggest challenge facing the ID community is to develop a full-fledged theory of biological design. We don’t have such a theory right now, and that’s a problem” (Forrest, p. 48). Forrest takes this as a grand admission that ID is scientifically deficient. But, in fact, Nelson’s statement reflects a profound malaise

within the scientific community about the absence of a general theory of biological form. Scientific theories vary in their scope and power. As a theory of design detection and technological evolution, intelligent design is now well in hand. But as a general theory of biological form, ID has a long way to go. Intelligent design, however, is hardly alone in this regard. Consider the following admissions about the lack of a general theory of biological form by mainstream biologists and scientists:

“The strange thing about the theory of evolution is that everyone thinks he understands it. But we do not.”³² —Stuart Kauffman, 2003

“Biology still lacks a theory of organization.... The need for a conceptual framework for the study of organization lies at the heart of unsolved problems in both ontogeny and phylogeny.”³³ —Mary West-Eberhard, 2003

“We do not claim that the fundamental laws of physics (and thus of chemistry) do not hold in biology; they, of course, do. But we do claim that their conceptual frame is too narrow. Rather we have to find new concepts that transcend the purely microscopic descriptions of systems.”³⁴ —Kelso & Haken, 1995

“We do not even know what biology is *about*, in the same sense that we know what mechanics is about, or what optics is about, or what thermodynamics is about. We thus do not know the scope of the domain of biology, for it has as yet no objectively definable bounds. In place of these, we have only a tacit *consensus*.”³⁵ —Robert Rosen, 1991

*“S’il est vrai que le darwinisme est le seul lieu théorique de la biologie, c’est qu’en effet il est le seul à introduire un virtuel, l’ensemble des évolutions possibles d’une espèce en un temps et en lieu donnés. Mais ce virtuel est incontrôlé, on ne peut rien en dire.”*³⁶
 [“If it’s true that Darwinism alone constitutes the theoretical portion of biology, that’s is because it alone introduces a virtual reality, namely, the collection of all the possible evolutions of a species in a given time and place. But this virtual reality is uncontrolled; one can say nothing about it.”] — René Thom, 1990

“The delusion of the finished [evolutionary] synthesis places restrictions on freedom of thought of which its believers are unaware. Selectionists [i.e., those who think that natural selection is the principal mechanism in evolution] point to the internal debates as evidence of free discussion, but the freedom is bounded by the dead hand of Darwin.”³⁷
 —Robert Reid, 1985

Another way Forrest attempts to substantiate the charge that ID has contributed nothing to science is by doing database searches of scientific journals: “In order to document the absence of articles using ID as a biological theory in peer-reviewed, scientific journals, I searched scientific databases such as Medline, Zoological Record, etc.” (Forrest, p. 11). “There are no peer-reviewed ID articles in which ID is used as a biological theory in mainstream scientific databases such as Medline” (Forrest, p. 45).

An obvious question now arises: How did Forrest conduct her search? What key words and key phrases did she punch into her search engines? She doesn't say. Suppose she was punching in "intelligent design." In that case, it is unlikely she would turn up very much in the scientific literature. The reason for this, however, would not be because intelligent design is not represented in the scientific literature. New scientific theories tend to face considerable opposition when they are first proposed (Forrest's own opposition is a case in point). As Thomas Kuhn, a well-known historian of science, noted in the case of Nobel laureate Max Planck:

Max Planck, surveying his own career in his *Scientific Autobiography*, sadly remarked that "a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."³⁸

There's a good sociological reason for this. Machiavelli put it this way:

It must be considered that there is nothing more difficult to carry out nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all those who profit by the old order, and only lukewarm defenders in all those who would profit by the new order, this lukewarmness arising partly for fear of their adversaries, who have the laws in their favor; and partly from the incredulity of men, who do not truly believe in anything new until they have had actual experience of it.

— Niccolò Machiavelli (1469–1519), *The Prince*, ch. 6

As is evident from the expert witness reports, Barbara Forrest and her fellow witnesses are defending an old order and reluctant to concede anything to the new order.

Despite Forrest's failure to find intelligent design fruitfully employed in the scientific literature, a more careful search of that literature reveals that intelligent design is making a scientific impact. The way to see this is to focus not on whether scientists attach the label "intelligent design" to their work, but on what they are actually saying and what ideas they are engaging. At the *Design and Its Critics* conference at Concordia University in Mequon Wisconsin (June 2000), Kenneth Miller took much the same line as Barbara Forrest in her expert witness report by claiming that database searches of the scientific literature revealed that no one was engaging Michael Behe's concept of irreducible complexity. But Miller was mistaken: several months earlier Randy Thornhill and David Ussery had published an article in the *Journal of Theoretical Biology* devoted entirely to analyzing the concept of irreducible complexity.³⁹

Interest in and discussion of intelligent design in the scientific literature is growing. Part of the reason Forrest doesn't see this is that she is looking in the wrong places. For instance, there is now growing interest in the bioengineering community regarding intelligent design, especially in the subdisciplines of bioinformatics, biocomputing, and biomimetics. Take, for example, an article by my colleague David Chiu at the University of Guelph in Canada. This article looks at polynucleotide sequence data taken from biological systems and analyzes them in light of my work on the design inference. The article, which appeared in the *International Journal of Fuzzy Systems* and belongs to the bioinformatics literature, opens as follows:

Detection of complex specified information is introduced to infer unknown underlying causes for observed patterns [ref#10]. By complex information, it refers to information obtained from observed pattern or patterns that are highly improbable by random chance alone. We evaluate here the complex pattern corresponding to multiple observations of statistical interdependency such that they all deviate significantly from the prior or null hypothesis [ref#8]. Such multiple interdependent patterns when consistently observed can be a powerful indication of common underlying causes. That is, detection of significant multiple interdependent patterns in a consistent way can lead to the discovery of possible new or hidden knowledge.” [Observe that ref#10 here is to my book *The Design Inference*].⁴⁰

David Chiu is a design theorist. As a fellow of the International Society for Complexity, Information, and Design (see <http://www.iscid.org/fellows.php>) is a card-carrying member of the ID movement. Forrest’s claim that “no one in the ID movement has produced original scientific research in its support” (Forrest, p. 11) is therefore demonstrably false, with David Chiu and this one paper serving as a counterexample. But there are others, notably the work of Douglas Axe, who is a molecular biologist and publishes in the biological literature. I cite some of Axe’s work in my expert witness report (Dembski, appendix 3 of that report, not of this rebuttal).

David Chiu’s article falsifies another of Forrest’s claims, namely, that “the ID movement touts” Stephen Meyer’s article in the *Proceedings of the Biological Society of Washington*, which appeared in 2004, “as the first ID paper to be published in a mainstream peer-reviewed journal” (Forrest, p. 38). Chiu’s article predates it. But even leaving Chiu’s article aside, I don’t know of anyone in the ID movement who regards Meyer’s article as the first ID paper published in a mainstream peer-reviewed journal. Usually, when people debate whether ID research has entered the peer-reviewed literature, they cite my monograph *The Design Inference*, which appeared in 1998 and which is now widely regarded as the theoretical manifesto of the intelligent design movement. As part of a monograph series with an academic editorial board (*Cambridge Studies in Probability, Induction, and Decision Theory*), *The Design Inference* is the equivalent of a journal article — the reason monographs get published as books is that they are too long to fit in journals.

In attempting to show that intelligent design has contributed nothing to science, Forrest offers one further argument, namely, that no scientist has “produced original data to support ID” (Forrest, p. 38). Thus, with regard to Meyer’s article in the *Proceedings of the Biological Society of Washington*, she dismisses it as “a review essay that presents no original ID research” (Forrest, p. 46, n. 193). As we have seen, this line of criticism fails for the work of David Chiu and Douglas Axe (see in particular Axe’s 2004 article in the *Journal of Molecular Biology* cited in appendix 3 of my expert witness report). But there is a deeper problem with Forrest’s charge. Forrest is, in effect, claiming that for something to constitute a scientific contribution, it must present new data. In other words, it must point us to some new natural phenomena and new data associated with those phenomena before it can rightly be regarded as contributing to science. Forrest here betrays a serious misunderstanding of both science and its history.

Consider the case of Albert Einstein. He wrote his seminal paper on relativity theory in 1905 as a patent clerk in Switzerland. As a patent clerk, he had no access to laboratories, experimental apparatus, or other ways of generating novel data. His breakthrough came not by, as Forrest would insist, “producing original data to support” relativity theory. Quite the contrary. All the data were already in place and known for years. Einstein’s genius was to look at those data differently and see new patterns and possibilities that had eluded other scientists.⁴¹ No wonder that Hermann Minkowski, Einstein’s former mathematics professor, remarked: “Oh, that Einstein, always missing lectures — I really would not have believed him capable of it!”⁴² Not an illustrious student, relegated to a patent office, with no access to “original data,” Einstein nonetheless did great science.

In my expert witness report, I cited Nobel laureate William Lawrence Bragg for the following insight into the nature of science: “The important thing in science is not so much to obtain new facts [or data] as to discover new ways of thinking about them.”⁴³ Einstein did just that as a patent clerk in Switzerland. Intelligent design is attempting to do that for biology—discovering fruitful ways of thinking about and interpreting well-established facts of science that pertain to biological complexity and diversity.

3 Robert Pennock

Robert Pennock’s expert witness report covers much of the same ground as Barbara Forrest’s. This is not surprising given that both are philosophers of science with similar views of science and thus a similar critical bent toward intelligent design. Because Forrest’s report is so much longer and more detailed than Pennock’s, I have focused principally on hers (note in particular that Pennock’s concerns about methodological naturalism are handled in the rebuttal to Forrest, section 2.3). Yet despite the overlap, Pennock raises several points that are worth noting separately.

3.1 *Intelligent Design Creationism and Its Critics*

CLAIM: Pennock refers to his book *Intelligent Design Creationism and Its Critics: Philosophical, Theological, and Scientific Perspectives* as “the most complete source book on the topic.” (Pennock, p. 1)

RESPONSE: Given its sheer size, this is the largest anthology on the topic. But it is hardly complete. Not only are critics of ID given far more space than supporters, but also the supporters are not given a chance to adequately defend their views. The two articles I have in this book, for instance, were not reprinted with my permission. Rather, Pennock obtained permission to reprint my two articles directly from the publishers. I therefore learned of their publication in Pennock’s book only after the book appeared in print.

Pennock in one case took a 2,200-word popular essay of mine (“Who’s Got the Magic?”) and followed it with a 9000-word response by him. He took another of my essays (“Intelligent Design as a Theory of Information”) and followed it with three essays critical of it. In neither

case was I given a chance to respond or to pick a more suitable essay that would enable me to make a stronger case for intelligent design. Because Pennock's use of my work misrepresented my scholarship, I issued two press releases about this book (the second in response to a false statement by him that he had indeed informed me that my essays were to be reprinted). My two press releases appear in Appendix 2.

A far more balanced anthology on intelligent design is my collection, co-edited with Michael Ruse (a well-known Darwinist) and published with Cambridge University Press in 2004, namely, *Debating Design: From Darwin to DNA*. In this latter book, all parties to the debate over intelligent design are given a chance to put their strongest foot forward.

3.2 The AVIDA Simulation

CLAIM: "My colleagues and I have demonstrated experimentally that a Darwinian mechanism can discover irreducible [sic] complex system [sic]." (Pennock, p. 19 — presumably he meant to write "irreducibly complex systems") He then references "Lenski, Ofria et al. 2003." In the bibliography, he gives this article as appearing in *Science*, but in fact the paper appeared in *Nature*. Here is the exact reference: Richard E. Lenski, Charles Ofria, Robert T. Pennock, and Christoph Adami, "The Evolutionary Origin of Complex Features," *Nature* 423 (May 8, 2003): 139-144. Earlier Pennock remarks: "I also do scientific research on experimental evolution and evolutionary design using evolving computer organisms, including work showing how evolutionary mechanisms can produce the kinds of complex features creationists say is impossible." (Pennock, p. 1) Pennock here clearly has this article from *Nature* in mind. Moreover, Kenneth Miller, in his expert witness report (p. 18), in a section titled "The Origin of Biological Information," references this article and uses it to argue that evolutionary mechanisms *can* generate biological information.

RESPONSE: As a general rule, laypersons are advised to keep a watchful eye on any computer simulations that purport to elucidate how real-life biological evolution might have happened. The danger with computer simulations is that programmers can always tinker with their programs and stack the deck until they get the result they are after. Pennock's work in this area is a case in point. His article with Lenski describes a computer program called AVIDA. This program is supposed to show that complex biological functions can evolve because AVIDA evolves certain types of logical functions within a computational environment modeled on natural selection. But I have a program of my own (written jointly with Micah Sparacio and John Bracht) that highlights the difficulty facing natural selection in "evolving" certain bit strings (the program is known as MESA, Monotonic Evolutionary Simulation Algorithm, and is available online at www.iscid.org/mesa). So, which program gives a better insight into biological evolution, AVIDA, which seems to confirm it, or MESA, which seems to disconfirm it?

It's precisely because computer programs can be concocted to prove the result one is trying to prove that ICAM was started. ICAM stands for Institute for Complex Adaptive Matter (<http://cnls.lanl.gov/ICAM/>). Its mission is to understand how real-world material systems (as opposed to "virtual systems") become complex and adaptive. Talk to most working biologists, and they will tell you that computer simulations do not shed much light on actual biological

evolution. Richard Lenski, the lead author on the paper in question, understands this as well, even if he would not admit to it in the context of these Dover proceedings.

Lenski, it turns out, is best known not for his work on computer programs that simulate biological evolution, but rather for his work as a straight biologist trying to evolve populations of bacteria in the lab. For many years, Lenski has cultured bacteria and placed them under selection pressure. He ran one experiment for 20,000 generations (if we think of the average generation time for humans as 20 years, then his experiment on bacteria corresponds to 400,000 years of human evolution).⁴⁴ What did Lenski find in his experiments with these bacteria (notice that these are real, as opposed to virtual, biological systems)? Did he find that his bacteria evolved novel irreducibly complex molecular machines of the sort that Michael Behe regards as indicative of intelligent design. Not at all. There were some small scale changes, but nothing surprising. And yet, when Lenski turns his attention to computer simulations, he finds that logical functions exhibiting irreducible complexity are much easier to evolve, requiring only a few hundred generations to form within the computer's virtual environment.

I commented on the fallacy underlying Lenski's computer simulation in the introduction to my book *Uncommon Dissent: Intellectuals Who Find Darwinism Unconvincing* (ISI Books, 2004, p. xxix):

Richard Lenski et al.'s May 8, 2003 paper in *Nature* titled "The Evolutionary Origin of Complex Features" ... describes a computer simulation and thus contains no actual biology. Go to the discussion section, and you'll read: "Some readers might suggest that we 'stacked the deck' by studying the evolution of a complex feature that could be built on simpler functions that were also useful. However, that is precisely what evolutionary theory requires...." In other words, the computer programmers built into the simulation what they thought evolution needed to make it work. The validity of this study therefore depends on whether the simulation faithfully models biological reality.

Unfortunately, the simulation presupposes the very point at issue. It therefore begs the question and doesn't prove a thing about real-life biological evolution. The Lenski simulation requires that complex systems exhibiting complex functions can always be built up from (or decomposed into) simpler systems exhibiting simpler functions. This is a much stronger assumption than merely allowing that complex systems may include functioning subsystems. Just because a complex system can include functioning subsystems doesn't mean that it decomposes into a collection of subsystems each of which is presently functional or vestigial of past function and thus amenable to shaping by natural selection.

The simulation by Lenski et al. assumes that all functioning biological systems are evolutionary kludges of subsystems that presently have function or previously had function. But there's no evidence that real-life irreducibly complex biochemical machines, for instance, can be decomposed in this way. If there were, the Lenski et al. computer simulation would be unnecessary. And without it, their demonstration is an exercise in irrelevance.... [Accordingly,] Behe's ideas about irreducible complexity, and

in particular the criticism they raise of Darwinism, remain very much alive and topics for discussion among biologists.

I want to add one final comment here. Kenneth Miller, on page 18 of his expert witness report, has a brief section titled “The Origin of Biological Information.” In it he references the *Nature* article by Lenski et al. and claims that it and others like it show that evolutionary mechanisms can generate biological information. As I stress in chapter 4 of my book *No Free Lunch*, there is a big difference between evolutionary mechanisms shuffling around preexisting biological information and evolutionary mechanisms actually generating it from scratch. In that chapter I show that evolutionary mechanisms can do the former but not the latter. I argue this explicitly. Miller, on the other hand, merely asserts the opposite view without providing an argument. Moreover, the papers he cites don’t address my argument either. I’ve since filled in the mathematical details for chapter 4 of *No Free Lunch* in a paper titled “Searching Large Spaces: Displacement and the No Free Lunch Regress,” which is available on my website (http://www.designinference.com/documents/2005.03.Searching_Large_Spaces.pdf) and intended to be published in a special issue on these questions in an IEEE biocomputing journal.

3.3 ID’s Big Tent

CLAIM: On page 8 of his expert witness report, Pennock notes that some young earth creationists consider themselves as part of the ID movement. Pennock then adds that because such people are in the ID movement, “allowing ID into the schools thus allows all these views perforce.”

COMMENT: ID is indeed a big tent, and many people of different views and backgrounds have associated themselves with it. But it hardly follows that the idiosyncratic views of some of ID’s followers will therefore be mainstreamed and allowed into the schools. Young earth creationism has been roundly defeated in the courts. In particular, the U.S. Supreme Court in *Edwards v. Aguillard* has barred it from the high school science curriculum. There is thus no justification for thinking that ID can be parlayed into a young earth creationism in the schools. Pennock is here engaging in a bit of fear-mongering. I expect ID’s acceptance into the high school biology curriculum will proceed conservatively, preserving as much of “the settled findings of science” (as Pennock puts it on p. 8 of his report) as possible and coming into conflict with evolution mainly on the question of evolutionary mechanisms.

3.4 ID Proponents Recognize that ID Is Not Science

CLAIM: On pages 12 and 13 of his report, Pennock purports to show that ID proponents acknowledge that ID is not science.

COMMENT: Given methodological materialism as a regulative principle for science, ID is by definition excluded from science. ID proponents regard methodological materialism as an arbitrary rule imposed on science and therefore propose to get rid of it (see the section on methodological materialism in my rebuttal to Forrest). In so doing, they are changing the ground

rules of science. But this is nothing new. In the history of science, the ground rules of science have changed at several key junctures in the past (notably, the change from an Aristotelian conception of science to a mechanistic conception of science in the 17th century). ID proponents most emphatically claim to be doing science. At the same time, we refuse to do science under arbitrary strictures that privilege a materialistic ideology (methodological materialism) which cannot itself be empirically tested or assessed scientifically. (There is no experiment that can test methodological materialism.)

3.5 No Positive Evidence for Design

CLAIM: A running theme in Pennock's expert witness report, and which gets special attention on pages 16 to 19 of it, is that ID does not present positive evidence for design in nature but instead argues negatively against the adequacy of material causes.

COMMENT: Invoking the words "positive" and (implicitly) "negative" the way Pennock does plays on the connotations of these words but doesn't address the substance of ID's claims or for that matter ID's research potential. Consider the first and second laws of thermodynamics (and please note, I am not invoking these to justify ID or undercut evolution — I'm simply appealing to them by analogy). The first law says that in an isolated system energy remains constant (conservation of energy). The second law says that in an isolated system entropy is statistically bound to increase.

Both of these laws are what may be called "proscriptive generalizations." In other words, they preclude certain things from happening. Thus, the first law of thermodynamics precludes energy in an isolated system from fluctuating and the second law of thermodynamics precludes entropy from decreasing. By parity of reasoning, Pennock might therefore argue that those who propose these laws are not demonstrating anything positive about energy and entropy. But in fact, these proscriptive generalizations have been enormously useful and fruitful in the sciences. So too, for ID to gauge the unevolvability of biological systems and to establish the need for intelligence to bring about such systems may well turn out to be a catalyst of scientific research whose significance might even end up being comparable to that of the laws of thermodynamics. Time will tell.

3.6 No Way to Assess Probabilities

CLAIM: Pennock claims that complex specified information as I develop it is scientifically intractable. As Pennock puts it, "there is no way to assess the probability in any real biological case." (Pennock, p.19)

COMMENT: Pennock is in no position to make this claim. Probabilities can be assigned any number of ways. They can be empirical probabilities (probabilities based on past frequencies). The probability of coins landing in certain ways can also be assessed on the basis of the geometry of the coin. Additionally, probabilities can be assessed on the basis of the laws of physics and chemistry that govern the system (cf. quantum systems with certain probabilities

corresponding the wave function as it changes according to the Schrödinger equation). Probabilities can also measure degree of belief. My approach to design detection can accommodate all these approaches. Moreover, it does not need to evaluate precise probabilities. It is enough to establish upper bounds. That's because design detection depends on probabilities being *small enough* and not on them taking on any particular values.

3.7 ID as Effect to Cause Reasoning

CLAIM: On pages 20 to 23 of his report, Pennock claims that ID is committed to supernaturalism and therefore is not testable. In particular, he claims ID explanations are as unacceptable to science as explanations that invoke Zeus to explain lightning bolts. To drive home this point, Pennock formulates an explicit "Zeus hypothesis": "Lightning bolts never form unless Zeus throws them." (Pennock, p. 23)

COMMENT: As a matter of basic human rationality, we reason from causes to effects as well as from effects back to causes. Thus, when Pennock writes on page 21 that "experimentation requires observation and *control* of the variables," he is talking about cause to effect reasoning: the experimenter sets up certain causal processes in an experiment and then determines the outcome of those processes (the effect). But, in many cases, we don't have control of the relevant causal processes. Rather, we are confronted with an effect and must reconstruct its cause. Thus, an alien visiting Earth and confronted with Mt. Rushmore would need to figure out whether wind and erosion could produce it or whether some additional factors might be required. ID involves such effect to cause reasoning.

Now, granted, Pennock's supposed counterexample of Zeus throwing lightning bolts falls under effect to cause reasoning. But effect to cause reasoning is always comparative: before attributing lightning bolts to Zeus, one needs to compare the "Zeus hypothesis" with other hypotheses that are on the table. Even in ancient times, there were competing hypotheses (even naturalistic ones) to the Zeus hypothesis (cf. the pre-Socratic natural philosophers). The reason no one accepts the Zeus hypothesis for lightning bolts any longer is not because it is inherently silly but because we have explanations that are so much better. In this case, they are explanations in terms of physical laws and thus without reference to design. But that's not a problem. ID does not purport to explain everything.

Incidentally, lightning strikes might require an ID hypothesis if they exhibit some particularly salient pattern. Consider, for instance, the possibility that on a given day all, and only, those people in the United States who had written snide remarks about Zeus were hit by lightning and died (suppose these people were all scattered around the U.S.). In that case, a Zeus hypothesis for the pattern of lightning strikes might not seem entirely incredible. At the same time, our understanding of the physical mechanisms for how to produce individual lightning bolts would in this case remain unchanged.

3.8 ID's Incompatibility with Certain Theological Views

CLAIM: Pennock (p. 28) charges ID with “explicitly reject[ing] other theological views.” In particular, he claims that ID is incompatible with theistic evolution. Moreover, he claims that science should be “neutral and non-dogmatic with regard to metaphysical possibilities.” (Pennock, p. 29) The upshot of Pennock’s charges here is that ID is biased whereas evolution (theistic or otherwise) is not.

COMMENT: ID rejects theistic evolution not for theological but for scientific reasons. ID views evolution, insofar as it is committed to explaining the evolutionary process in terms of material mechanisms (like natural selection), as a failed research program. A guided form of evolution is fine for ID provided such guidance is empirically detectable, thereby facilitating a design inference. But theistic evolution is committed to methodological materialism and therefore rejects the very possibility of design being inferred scientifically for biological systems.

Pennock gives the impression here that ID is biased and narrow in the theological options it can accommodate whereas evolution is not. But in fact, every approach to biological origins has theological implications of its own, and these theological implications will invariably clash with the theological implications of other approaches. Theistic evolution, for which Pennock tries to leave room, has theological implications that are at odds with a Dawkins-style atheistic evolution. And even if we strip away the theology (or anti-theology) from evolution and focus purely on its scientific core, evolution will not be, as Pennock suggests, “neutral and non-dogmatic with regard to metaphysical possibilities.” (Pennock, p. 29)

Evolution, as guided solely by material mechanisms, suggests a world that is self-sufficient and that does not need God or any other designing intelligence. Neo-Darwinist Francisco Ayala has made exactly that point with respect to Darwinism: “The functional design of organisms and their features would therefore seem to argue for the existence of a designer. It was Darwin’s greatest accomplishment to show that the directive organization of living beings can be explained as the result of a natural process, natural selection, without any need to resort to a Creator or other external agent.”⁴⁵ What Ayala is describing here is anything but “neutral and non-dogmatic with regard to metaphysical possibilities.”

4 John Haught

John Haught claims that ID is an inherently religious idea. To justify this claim, he notes that many ID proponents draw religious implications from ID, connecting the designer of ID with the God of their religious faith. This, he insists, shows that attributing design to natural phenomena means ID is in the business of offering what he calls “ultimate explanations.” And this, in turn, is supposed to confirm that ID cannot be science because science is, according to Haught, not about ultimate explanations but instead about proximal, cause-and-effect explanations. To clinch his case, he notes that *Pandas*, an intelligent design textbook, refers to the designer responsible for biological complexity as “a master intellect.” (*Pandas*, pp. 58 and 85)

To see that this argument does not hang together, consider the following quip by an ID theorist friend of mine (Jay Wesley Richards): “I’ve always been troubled by the claim that Mt. Rushmore was carved by sculptors. After all, where did the sculptors come from?” Design explanations are not ultimate explanations. They are proximal explanations in the same way that other explanations in science are proximal explanations. By “proximal,” here, I simply mean that the explanations are attempting to explain the immediate cause of the thing in question. If the question is why does Mt. Rushmore exhibit the likenesses of four American presidents, it does no good to invoke wind and erosion. Those likenesses are the result of design, and that is the appropriate explanation.

But what about attributing the origin of life to “a master intellect,” as *Pandas* does on pages 58 and 85? Let me turn this question around: If life with its marvelous complexity is indeed the result of intelligent design, then why should it be inappropriate to refer to the designing intelligence responsible for it as “a master intellect”? Note that *Pandas* employs the indefinite article “a.” *Pandas* is not referring to any particular master intellect, much less to the God of some religious tradition. Indeed, *Pandas* emphasizes throughout the text that any designing intelligence responsible for biological complexity need not be God. Moreover, this is not a convenient ploy to sidestep the charge of “creationism.” It is simply not possible, as the text points out, to reason from the data of science, which necessarily is always about finite material objects, to an transcendent, infinite, personal creator.

The fact is that even in human contexts, we speak about designers as “master craftsmen” and praise designers like Michelangelo and da Vinci for their genius. To do so, however, is not to suggest that we are offering ultimate explanations. Ultimate explanations tell us about the source of being of the world, about its ultimate meaning and purpose. But that’s not what ID is doing. It is simply helping us to identify those patterns in nature that clearly signal the activity of an intelligence. This is a legitimate scientific inquiry despite Haught's protestations to the contrary. Thus Haught will write: “No good scientist would ever claim that scientific experiment detects intelligent causes, as Dembski claims. Nor would ‘intelligent cause’ ever appear as a specifically scientific category of explanation within the logic of accepted scientific discourse.” (Haught, p. 5) Elsewhere he adds, “There is no way in which ID could be the subject of empirical investigation or submit to the verificational procedures science employs. Nor could it lead to new and fruitful scientific discoveries in the future.” (Haught, p. 6)

Such statements betray ignorance about the nature of science and the role of intelligence in numerous special sciences. Take the Search for Extraterrestrial Intelligence (SETI). Go to the SETI Institute website, and there you will find the following summary of what SETI is: “SETI, the Search for Extraterrestrial Intelligence, is an exploratory science that seeks evidence of life in the universe by looking for some signature of its technology.”⁴⁶ In other words, SETI attempts to detect the presence of intelligent aliens by looking for signs of intelligence (a “signature”) they’ve left behind through their technology. Numerous special sciences, everything from archeology to random number generation to forensic science, make as their primary objective the detection of design even if the idioms they use to describe their primary activity doesn’t use that exact language of “design detection.”

Design detection is widespread, rational, and objectifiable. It appears throughout the sciences. It is even required to keep science honest by uncovering data falsification. Data falsification is far more common in science than many scientists would like to admit. To detect whether data has been “fudged” requires methods of design detection as described in my book *The Design Inference* (Cambridge, 1998). The case of J. Hendryk Schoen, a Bell Labs physicist who was fired for falsifying data, stands out. This case was widely reported back in 2002. It was methods of design detection of the sort that I have developed that nailed him (for the details of this case, see my book *The Design Revolution*, pp. 75-77). Since these methods are remarkably effective and fruitful in so many other contexts, Haught’s further claim that ID cannot “lead to new and fruitful scientific discoveries” is unfounded.

Besides denying that ID has anything to offer science, Haught’s other main move is to keep pressing that ID is inherently religious. In citing my own work, for instance, he tries to make me appear as though I’m speaking out of both sides of my mouth, on the one hand affirming that ID is straight science but then quoting my introduction to *Mere Creation* (an anthology I edited) in which I am supposed to admit that the ID program is “a sustained theological investigation that connects the intelligence inferred by intelligent design with the God of Scripture.” (Haught quotes me on p. 5 of his report; the quote is originally from p. 29 of my book *Mere Creation*.)

Haught is quoting me out of context. Here is the quote in context (*Mere Creation*, pp. 28-29):

Mere creation is a four-pronged approach to defeating naturalism. The prongs are as follows:

- (1) A scientific and philosophical critique of naturalism, where the scientific critique identifies the empirical inadequacies of naturalistic evolutionary theories, and the philosophical critique demonstrates how naturalism subverts every area of inquiry that it touches;
- (2) A positive scientific research program, known as Intelligent Design, for investigating the effects of intelligent causes;
- (3) A cultural movement for systematically rethinking every field of inquiry that has been infected by naturalism, reconceptualizing it in terms of design; and
- (4) A sustained theological investigation that connects the intelligence inferred by Intelligent Design with the God of Scripture, and therewith formulates a coherent theology of nature.

Haught latches on point (4) and thereby tries to paint intelligent design as an inherently religious enterprise. But in doing so, he puts the cart before the horse. Point (4) depends on point (2), which requires that intelligent design first be developed as a strictly scientific research program before its theological implications can be fully developed and justified. The success of the scientific program is prerequisite to the success of any theological investigation based on it. Granted, many proponents of ID want to get religious mileage out of it. But how is that any different from evolutionists wanting to get atheistic and anti-religious mileage out of evolution (cf. the views of Richard Dawkins, Steven Weinberg, and Will Provine described in my rebuttal to Barbara Forrest)? The religious mileage associated with ID is as separable from the actual

science of ID as the anti-religious mileage associated with evolution is separable from the actual science of evolution.

Not content with merely identifying ID as a form of theology, Haught goes further and attempts to discredit it as a bad form of theology. Thus, he remarks that “from the point of view of the most prominent theologians . . . not only is ID poor science, it is also appalling theology.” (Haught, p. 6 — note that he provides no citation for this contentious claim) Haught writes this because he equates the designer of ID with God and, further, sees ID as committed to a conception of divine action in which God acts in the world in the same way that physical causes act (namely, by moving material objects and thus by “intervening” or “interfering” in the causal processes of nature). In opposition to this view, Haught writes: “Major [theological] traditions maintain that if God influences and interacts with the created world it cannot be in the same way that physical causes operate.” (Haught, p. 6) So, the problem with intelligent design, according to Haught, is that it requires a God who pokes a divine finger into the world, thereby upsetting its causal structure and thus undermining the very order of the world that God had previously instituted. This, in Haught’s words, is supposed to constitute “appalling theology.”

Now, regardless of whether such an interventionist view of divine action constitutes “appalling theology,” the fact is that intelligent design is not committed to it—or indeed to any view of divine action. In the summer of 2001, John Haught and I spent a week together at the University of Oxford in England as part of a Templeton Foundation summer conference. There we spoke in conversation about these very issues. At the time, I stressed to him that ID, insofar as one attempts to make sense out of it theologically, is not committed to any view of divine action. I made this same point subsequently in my book *The Design Revolution* (pp., 179, 181):

Intelligent design is not a theory about the frequency or locality or modality by which a designing intelligence intervenes in the material world. It is not an interventionist theory at all. Indeed, intelligent design is perfectly compatible with all the design in the world coming to expression by the ordinary means of secondary causes over the course of natural history. . . . The crucial question for intelligent design is not how organisms emerged (for example, by gradual evolution or sudden special creation) but whether a designing intelligence made a discernible difference regardless of how they emerged.

This last point is indeed crucial. Intelligent design is about design detection, which refers to our ability as scientific investigators to detect signs of intelligence. Conversely, it is not a theory about how the design got there in the first place. Thus, to charge ID with being an interventionist theory and therefore constituting “appalling theology” is beside the point. Intelligent design simply doesn’t get into these issues. It is not about *how* a designer acted. It is about *whether* a designer acted, however that designer might have acted.

Once the issue is framed in this way, it is not at all evident whether a designer had to “intervene” in any theologically unsatisfactory sense to bring about the designs of nature. John Polkinghorne, a physicist who works on the interface between science and theology, suggests that a designing intelligence could guide nature along goal-directed paths through what he terms “active information” without intervening and thereby upsetting the causal structure of the world.⁴⁷ Haught himself indicates an openness to this possibility in chapter five of his book *God After*

Darwin (titled “Religion, Evolution, and Information”) where he considers how information in the world might reflect divine purpose. My notion of specified complexity is itself formulated as a type of information. Where I part company with Polkinghorne and Haught is in claiming that certain forms of information render design in nature detectable and therefore a part of science.

Finally, Haught charges ID with being narrow and parochial. He writes: “the contemporary notion of ID is historically unintelligible apart from the religious agendas of Paley and Aquinas.” (Haught, p. 4) But, in fact, the scope of intelligent design is quite a bit broader. No doubt, if William Paley and Thomas Aquinas were alive today, they would support ID. But so would Plato, Aristotle, Cicero, Augustine, Blaise Pascal, Isaac Newton, Immanuel Kant, Charles Babbage, James Clerk Maxwell, and a host of other illustrious thinkers of the past who understood nature in teleological terms and not in the materialistic terms to which so many contemporary scientists are committed, a materialism that Haught mistakenly regards as mandatory for science.

Science is about following the evidence wherever it leads, and one place it could lead is to intelligence.

5 Kevin Padian

Paleontology is a historical science, not an exact science. To understand the difference, consider quantum electrodynamics, a theory from physics that makes predictions that have been verified to an accuracy of fourteen decimal places. Paleontology, by contrast, offers no such precision. Instead, it is a matter of detective work, looking for clues to reconstruct what might have happened or been the case way back when. Such reconstructions are often referred to as *historical narratives*. The clues paleontology employs to construct its historical narratives come from fossils and molecular sequences. Such data are invariably incomplete and equivocal, allowing for multiple explanations and interpretations, though some may be better confirmed than others.

Harvard’s Ernst Mayr, the dean of American evolutionists until his recent death, made this point in his final book, *What Makes Biology Unique?* Here is how *Scientific American*’s book club review of *What Makes Biology Unique?* put it: “Unlike physics, evolutionary biology deals with unique events, e.g., dinosaurian extinction or human origins. In place of experiments, biology uses a framework of historical narratives to characterize these events.”⁴⁸ Mayr himself put it this way in his book: “A knowledge of history is . . . indispensable for the explanation of all aspects of the living world that involve the dimension of historical time.... To obtain its answers, particularly in cases in which experiments are inappropriate, evolutionary biology has developed its own methodology, that of *historical narratives* (tentative scenarios).”⁴⁹ Note well the reference to “tentative scenarios.”

Thus, according to Mayr, to sketch the shape of the past, evolutionary theorizing proposes tentative scenarios with varying degrees of plausibility. By contrast, Padian’s expert witness report gives the impression that paleontology is an exact science and that its claims are slam-dunk certainties. Consider, for instance, the following two statements by Padian from his report:

“It is quite clear that birds evolved from a group of small theropod (carnivorous) dinosaurs sometime in the Late of Late Middle Jurassic.” (Padian, p. 5) “The first known bird, *Archaeopteryx*, has very few characteristics apart from a feathered wing that would allow us to recognize it as closer to living birds than to other small carnivorous dinosaurs.” (Padian, p. 11) Now, Padian may be right that birds evolved from dinosaurs and that *Archaeopteryx* is basically a dinosaur with feathers. But the impression he gives is that this is a consensus view among paleontologists when it is not.

In fact, there exists a spirited controversy about the dino-bird theory in the scientific literature. Consider, for instance, the work of Alan Feduccia and Larry Martin, both experts in bird paleontology and evolutionists. Feduccia, in examining evidence for differing forelimb structures, concluded that dinosaurs are unlikely to have been ancestors of birds. This study appeared in the journal *Science*.⁵⁰ According to Feduccia, “Paleontologists have tried to turn *Archaeopteryx* into an earth-bound, feathered dinosaur. But it’s not. It is a bird, a perching bird. And no amount of ‘paleobabble’ is going to change that.”⁵¹ Martin, a University of Kansas paleontologist, sees the evidence for the dino-bird theory as so problematic that he has remarked, “I’d be embarrassed every time I had to get up and talk about it.”⁵²

Nor do the mainstream basal biology textbooks line up with Padian on his dino-bird theory. Take Sylvia Mader’s 1998 biology text. It identifies *Archaeopteryx* as “a transitional link between reptiles and birds.”⁵³ Thus, if *Pandas* is at fault for not treating *Archaeopteryx* as an evolved dinosaur, then so are mainstream textbooks and journal articles. But then why does Padian single out *Pandas*? And why does he give the impression that there is consensus among paleontologists about the dino-bird theory when there is not?

Humility needs to be the order of the day for paleontology. In point after point where Padian chides *Pandas* for being wrong in its statements about biological classification and evolutionary lineages, it is merely a case of different paleontological interpretations, each plausible as far as it goes, but none of them decisive because the data simply don’t allow for decisive determinations. To see what’s at issue here, ask yourself whether Julius Caesar had a mole on the sole of his left foot. The question is meaningful, and there is a definite fact of history that correctly settles the question (Caesar either did or did not have that mole). Nevertheless, all the evidence that might help us resolve that question is long lost. So too, fossil and molecular evidence is typically too sparse to allow exact conclusions that rule out other possible explanations. These considerations raise deep and interesting questions about how scientists ought to deal with incomplete data—see, for instance, Elliott Sober’s *Reconstructing the Past*.⁵⁴ Unfortunately, Padian’s expert witness report demonstrates no sensitivity to such questions.

Consider, for instance, Padian’s criticism of how *Pandas* treats the classification of the giant panda and the red panda. Padian remarks that “it’s been known for decades that the first is a bear and the second is a type of raccoon, and the only similarity is the Chinese common name. There is no reasonable controversy about this.” (Padian, p. 12) On the pages from *Pandas* that Padian cites, *Pandas* admits that this is the standard interpretation: “The in 1964, Dwight David, Curator of Vertebrate Anatomy at the Field Museum of Natural History in Chicago, published what soon became widely accepted as the definitive discussion on the matter, which finally solved the

mystery of the pandas. Davis had concluded, and most agreed, that the giant panda was not a raccoon but a bear, and that the red panda was not a bear but a raccoon!” (*Pandas*, p. 118)

So what is the problem here? Padian’s objection in this case is not that *Pandas* got the facts wrong but that it raised questions about their standard interpretation. Even so, there are some serious questions here, and *Pandas* is right to raise them: if the one panda is a bear and the other is a raccoon, how is it that they share so many common features (notably, an appendage known as “the panda’s thumb”)? If one is a bear and the other a raccoon, it can’t be that some common ancestor shared those features and passed them on to both pandas as a matter of heredity. Rather, those features had to re-evolve twice. This is known as *evolutionary convergence*, and it raises genuine difficulties for Padian’s approach to biological classification.⁵⁵

That is because Padian is committed to an approach to biological classification known as *cladistics*. This approach requires that systematists (i.e., biologists in the business of classifying living systems) focus exclusively on “transitional features” in determining biological classification. This, in turn, leads to paleontological data being forced into evolutionary tree diagrams (known as cladograms) even if other data (e.g., geological data) and other theoretical considerations (e.g., evolutionary processes responsible for biological adaptation and convergence) contradict it.

Take Padian’s dino-bird theory. According to this theory, feathered theropods (i.e., small feathered meat-eating dinosaurs) are ancestral to birds. Yet standard geological dating of theropod fossils places them well after the first birds (geological dating places the theropods at 120 to 135 million years ago whereas the first true birds are placed at 140 to 150 million years ago).⁵⁶ In other words, here we have a supposed ancestor of birds appearing millions of years after the first birds. This is like parents being born after their children. By looking only to “transitional features,” cladistics forces the theropods to be ancestral to birds, positing earlier theropods even though there is no evidence for them among actually found fossils. Not surprisingly, cladistics as an approach to biological classification and tracing evolutionary lineages is itself the subject of controversy in the biological community.⁵⁷

To see that Padian is a cladist in his approach to paleontology, consider the following two quotes from his expert witness report : “Scientists search for transitional features, not for transitional forms; direct ancestors are not required to substantiate evolutionary theory.” (Padian, p. 8) Or again, “scientists do not search for intermediate fossil forms, but for organisms that may show some intermediate features, even though in other ways they may be unique.” (Padian, p. 11) What Padian is saying here is that paleontologists must base any evolutionary lineages they derive strictly on transitional features. Nevertheless, to construct evolutionary trees strictly on the basis of “transitional features” ignores evolutionary convergence and geological dating. Cladistics thereby aspires to turn paleontology into an exact science, but at the cost of destroying its contact with much relevant scientific data.

Yet, contrary to Padian, what scientists want to identify are not simply transitional features but actual transitional forms. What Padian calls transitional features can arise through convergent evolution and can arrive on the scene in ways that cannot be reconciled with geological dating. The point of paleontology is therefore to try to bring all the relevant evidence to bear on deciding

whether one form really is transitional to another. Kenneth Miller, in his expert witness report, exemplifies this approach. In describing the fossil evidence for the first land vertebrates evolving from lobe-finned fish, Miller asserts of *Acanthostega* that “it was a true ‘transitional form’.” (Miller, p. 20) Note that he is not content to leave the discussion here simply at “transitional features.”

Besides mischaracterizing paleontology as an exact science in order to discredit *Pandas*, Padian also mischaracterizes *Pandas* directly. For instance, he cites the following statement from *Pandas* (p. 23), “*Archaeopteryx* has only one birdlike feature, much like the duck-billed platypus [i.e., a bill]” and then adds:

Archaeopteryx does not have a bill at all. It has a narrow, pointed, toothed, bony snout, like its dinosaurian relatives. The platypus has a broad, leathery, prehensile snout that lacks the sharp, needle-like teeth found in *Archaeopteryx*, and no one would ever mistake the two structures for each other. *Archaeopteryx* has many features that birds have that the platypus does not, and it is amazing that the *Pandas* authors did not research this before writing their second edition.

But reading the sentence Padian quoted in context makes clear that the authors of *Pandas* never meant to suggest a similarity between the *Archaeopteryx*'s beak and the platypus's bill. Here is how the passage from *Pandas* that Padian quotes reads in context (I've put the portion that Padian quoted in bold):

The puzzle raised by *Archaeopteryx* has to do with the “avian complex” or adaptational package of characteristics making flight possible in birds. The feathers in *Archaeopteryx* are identical to those in modern birds, having the structure of a genuine airfoil. Yet in place of the “avian complex,” *Archaeopteryx* has eight reptilian features. No process capable of sculpting its feathers while leaving its other reptilian features untouched is known to current Darwinian theory. In fact, ***Archaeopteryx* has only one birdlike feature, much like the duck-billed platypus** living in Australia today. The platypus has a bill like a duck and fur like a mammal, but has never been considered transitional. (*Pandas*, p. 23)

In context, it is clear that *Pandas* was not asserting that *Archaeopteryx* had a bill like the platypus. Rather, the point of the passage was to note that just as the platypus has one bird feature (its bill) and the rest mammal features, so *Archaeopteryx* had one main bird feature (its feathers) and the rest reptile features. Given this clarification, Padian might now argue that these other features were dinosaur features rather than reptile features. But the point is that Padian attributed a gross blunder to the authors of *Pandas* when their argument was in fact sound and nuanced. Padian's misreading of *Pandas* here raises questions about the care with which he read *Pandas* as a whole.

A good portion of Padian's expert witness report concerns setting turf boundaries and barring those without the requisite credentials from entering his own turf (i.e., paleontology). Thus, Phillip Johnson is dismissed as unqualified to critique the fossil evidence for evolution because he is a “retired law professor.” (Padian, p. 8) Thus Jonathan Wells is dismissed because even

though “he received a Ph.D. in molecular biology from Berkeley,” he “has never published a peer-reviewed article on paleontology.” (Padian, p. 9) And Stephen Meyer is dismissed as a “professor of philosophy at a small religious college” who “has never published a peer-reviewed paper in paleontology, to my knowledge.” (Padian, p. 10) Leaving aside Johnson and Wells for the moment, it turns out that Meyer is no longer affiliated with Whitworth College (presumably the school Padian has in mind) but has for several years now been active full-time as the director of Discovery Institute’s Center for Science and Culture. Moreover, Meyer has in fact published a peer-reviewed paper in paleontology: “The Origin of Biological Information and the Higher Taxonomic Categories,” *Proceedings of the Biological Society of Washington*, 117(2) (2004): 213–239.

Thus, with respect to Meyer, Padian got his facts wrong. But there is a deeper issue here, which also concerns Johnson, Wells and others who argue against conventional evolutionary theory on the basis of fossil evidence. Padian is correct that many of them are not professional paleontologists. But why should this matter? In the end, the inherent intellectual merit of an idea or argument needs to be assessed independently of the credentials of the person who proposes the idea or makes the argument. Well-credentialed people can mess up even in their fields of expertise. Conversely, non-credentialed people can make valid points even outside their field of expertise. Considered in this light, Padian’s boundary-setting does not withstand scrutiny.

Also worth keeping in mind is that biology is a cross-disciplinary field that historically has welcomed ideas from many disciplines. For instance, the 20th century revolution in molecular biology, for which James Watson and Francis Crick stand as figureheads, received a huge impetus from physicists who during and right after World War II jumped from physics to biology. Erwin Schrödinger, who received the Nobel prize for his work on quantum physics, is a case in point. His book *What Is Life?* inspired Watson to understand the molecular basis for biological heredity.⁵⁸ Another well-known physicist from that time who turned to biology and made significant contributions to it was Max Delbrück.⁵⁹

There is also an irony to Padian’s boundary setting: he shows no compunction about invading other people’s disciplines. Thus, he criticizes Michael Behe’s notion of irreducible complexity as it applies to molecular machines in the field of biochemistry. And again, Padian criticizes my own notion of specified complexity as it is developed within my own discipline of mathematics. Yet, Padian gives no indication of being a biochemist or a mathematician. Instead, he delves into these areas with blithe disregard for the restrictions he has placed on others, namely, that they not cross into his discipline of paleontology. Clearly, there’s a double-standard at work here. I’ll leave Padian’s criticism of Behe till later, when I address Kenneth Miller’s more detailed criticism of Behe’s work. But I do want here to comment on Padian’s critique of my own work.

In Padian’s critique of my work on specified complexity, he attributes mistakes to me that I did not make. Here is the main mistake that he attributes to me:

Dembski’s fundamental error is simply analogized. He writes as if evolution were a never-ending game of dice, in which each roll had no effect upon the next in terms of the probability of successive outcomes. The probability of complex features assembling, in Dembski’s world, is equal to the probability of A *times* the probability of B *times* the

probability of C ... and this leads us quickly to nearly infinite improbability. But in fact, once event A has occurred in evolution, it has happened, and so the probability of B occurring in a subsequent generation (and therefore evolving the condition AB), is simply the probability of B, and not a product of the individual probabilities of A *times* B. And so on. Evolution is a bit more like a game of Monopoly. It is a cumulative process. (Padian, p. 7)

What I find remarkable about this passage is that I'm charged so basic an error as not realizing that the probabilities involved in evolution need not multiply. I did my Ph.D. in mathematics at the University of Chicago with one of the best known probabilists in the nation (Patrick Billingsley, whose books every probabilist knows). I did postdoctoral research in probability theory at MIT. I initially wrote *The Design Inference*, in which the idea of specified complexity is first developed, as a second doctoral dissertation, this time in philosophy. That dissertation was carefully vetted by several very technically proficient philosophers of science who know much about probability theory. In 1997, this dissertation received the University of Illinois at Chicago's annual award for best dissertation.

Subsequently, *The Design Inference* was accepted at Cambridge University Press in a monograph series: *Cambridge Studies in Probability, Induction, and Decision Theory*. This series is structured as any scientific journal. It has an academic editorial board. Its chief editor, who saw *The Design Inference* through a rigorous refereeing process, is Brian Skyrms, a member of the National Academy of Sciences. He, like Padian, is on faculty at the University of California (Skyrms is at the Irvine campus). Skyrms's editorial board for this monograph series includes a Nobel laureate. Three anonymous referees reviewed the manuscript and approved it subject to certain revisions that they required me to make—revisions that I then did in fact make. It's therefore not clear to me how Padian thinks he can justify the following claim: "He [Dembski] has published his ideas in popular books and speeches, but has never subjected his full view of 'specified complexity' to peer review." (Padian, pp. 6-7) I would venture that given the antipathy to intelligent design that pervades so much of the academy, and which Padian exemplifies in his expert witness report, that *The Design Inference* has been subjected to a fuller peer review than anything Padian has ever published.

With regard to Padian's criticism that I mistakenly multiply probabilities in order to achieve what he calls "infinite improbability," I dealt with this very objection in *The Design Inference*. In fact, if you substitute coins for dice in the following passage, it would seem that this passage was tailored specifically to Padian's concerns:

[To draw a design inference] requires that we be clear what chance processes could be operating to produce the event in question. Suppose, for instance, I have before me a hundred pennies all of which have landed heads. What is the probability of getting all one hundred pennies to exhibit heads? This probability depends on the chance process controlling the pennies. If, for instance, the chance process flips each penny individually and waits until it lands heads, after two hundred flips there will be an even chance that all the pennies exhibit heads (and after a thousand flips it will be almost certain that all the pennies exhibit heads). [This is the case that Padian thinks applies to evolution in which desired outcomes cumulate and their probabilities do not multiply.] If, on the other hand, the chance process operates by flipping all the pennies simultaneously, and does not stop

until all the pennies simultaneously exhibit heads, it will require about 10^{30} [i.e., 1,000,000,000,000,000,000,000,000,000] such simultaneous flips for there to be an even chance that all the pennies exhibit heads. [This is case where the probabilities do multiply and which Padian thinks does not apply to evolution.]⁶⁰

In this passage, I stress that successfully drawing a design inference depends on correctly identifying the probability distribution that characterizes the event in question. Contrary to what Padian claims, my theory of design detection is therefore not wedded to the probabilities multiplying. Instead, it accommodates whatever probabilities may arise in a given scientific inquiry. For Padian to write that “Dembski’s equations are based on nonsensical assumptions” is therefore doubly false. Any equations I propose, far from imposing arbitrary restrictions on probabilities, instead gives free rein to whatever probabilities nature may hand us. That’s why William Wimsatt, at the University of Chicago, could endorse my book *The Design Inference* as follows:

Not since David Hume’s *Dialogues Concerning Natural Religion* has someone taken such a close look at the design argument, but it is done now in a much broader post-Darwinian context. Now we proceed with modern characterizations of probability and complexity, and the results bear fundamentally on notions of randomness and on strategies for dealing with the explanation of radically improbable events. We almost forget that design arguments are implicit in criminal arguments “beyond a reasonable doubt,” plagiarism, phylogenetic inference, cryptography, and a host of other modern contexts. Dembski’s analysis of randomness is the most sophisticated to be found in the literature, and his discussions are an important contribution to the theory of explanation, and a timely discussion of a neglected and unanticipatedly important topic.⁶¹

Wimsatt is a committed evolutionist, and yet he endorsed my book. Why? Not because my approach to design detection forces design into biology but because it allows an independent assessment of whether design is present in biology. If the probabilities come out one way, then design is implicated. If they come out another way, then not. There’s nothing in my approach to design detection that stacks the deck. As a consequence, Padian’s critique of my work on specified complexity and its role in design detection is deeply confused.

Finally, I want to comment on a list of charges against intelligent design that Padian makes at the end of his expert witness report. He writes, “not a single peer-reviewed paper testing a proposition of IDC has ever been published,” to which he adds, “they [i.e., proponents of intelligent design] have no laboratories, no research grants, no field studies, no museums or museum studies, no experiments that test their beliefs.” (Padian, p. 15) It is true that there is no ID museum. But the rest of his charges are false. ID is published in the peer-reviewed literature, and this includes not only straight theory and review articles but also actual experiments performed in laboratories (for the latter, see the work of Douglas Axe cited in my expert witness report). To say that we have no laboratories is therefore patently false because this research is being done in laboratories. Moreover, to say that we have no research grants is also patently false because this research is being funded, and hence by definition has to come through research grants.

Even so, once confronted with such facts, Padian is unlikely to admit that he was wrong or admit that there might be something to intelligent design after all. Instead, as the peer-reviewed articles that support ID keep mounting, expect two responses: (1) The article slipped passed the goalies but really shouldn't have. This was the response of the Biological Society of Washington to Stephen Meyer's article once it was published (to general consternation) in the pages of the society's journal.⁶² The other response is this: (2) The article really isn't about intelligent design at all. This response requires reinterpreting the article and denying its relevance to the debate over evolution and intelligent design. Increasingly, I see both responses as intelligent design gains ground.

The point to recognize is that for Padian, nothing will, or indeed can, ever support intelligent design as a legitimate scientific enterprise. The problem here is not with intelligent design but with Padian's unwillingness, for whatever reason, to follow the evidence where it leads. Why else was so much of his report be devoted to setting turf boundaries and following proper scientific protocols instead of dealing with the actual issues and arguments raised by intelligent design?

6 Kenneth Miller

I want in this rebuttal to Kenneth Miller's expert witness report to focus principally on the failures in logic that characterize his arguments and conclusions. Miller has publicly described himself as an "orthodox Darwinian."⁶³ His approach to evolution is therefore properly speaking neo-Darwinian, meaning that he regards natural selection and random genetic change as the principal mechanism driving evolution (though he admits that there are other mechanisms also). Now, evolutionary change that is neo-Darwinian is *gradual*. It proceeds, as Darwin put it in his *Origin of Species*, by "numerous, successive slight modifications." Given that this is what Miller means by evolutionary change, it is extravagant for him to claim that "not a single piece of scientific evidence has emerged to contradict the idea that a process of evolutionary change gave rise to the species that exist today." (Miller, p. 3)

Consider, for instance, the Cambrian Explosion. In a very brief window of time during the geological period known as the Cambrian, most of the extant animal types (called phyla) appeared suddenly in the fossil record with no trace of evolutionary ancestors. The Cambrian Explosion so flies in the face of conventional evolutionary theory that paleontologist Peter Ward wrote, "If ever there was evidence suggesting Divine Creation, surely the Precambrian and Cambrian transition, known from numerous localities across the face of the earth, is it."⁶⁴ Having made this statement, however, Ward, who is not a creationist, thinks that he can still get around the challenge of the Cambrian Explosion by pointing to multicelled organisms in the Precambrian (notably, what are known as the Ediacaran or Vendian biota).

Miller likewise appeals to these Precambrian fossils to ease the challenge to evolution posed by the Cambrian Explosion. This he does in his critique of *Pandas*: "The animals of the Cambrian were preceded by abundant soft-bodied animals known as Ediacaran fauna, which date at least a hundred million years back into the Precambrian. Unfortunately, the readers of *Pandas* will never learn these facts because the authors are so intent on pretending that all major groups of

organisms originated at just one period of time.” (Miller, p. 21) In fact, it is Miller who here is not telling the full story. The Ediacaran fauna went extinct before the Cambrian (a possible exception is *Thaumaptilon walcottii*, but even that is debated among paleobiologists).⁶⁵ Moreover, there is no evidence that the Ediacaran fauna evolved into the fauna of the Cambrian Explosion. And, even more significantly, *Pandas* does not claim, as Miller pretends, that “all major groups of organisms originated at just one period of time.” All major groups of organisms would include plants as well as animals, and *Pandas* never suggests that all major groups of plants originated in the Cambrian. Moreover, *Pandas* does not even claim that all major groups of animals originated in the Cambrian. Here is what *Pandas* actually says:

The great majority of the living animal phyla (roughly 30 — the number varies because scientists disagree on details of how to classify them) appear (or are thought by scientists to appear) in a remarkably brief period of time, geologically speaking, or somewhere between 10 and 30 million years at the Precambrian-Cambrian boundary, and are not connected by evolutionary intermediates. [*Pandas*, p. 94 — note that the 10 to 30 million years in this passage has in the last decade been revised down to 5 to 10 million years, thereby intensifying the challenge to evolution posed by the Cambrian Explosion.]

Two things are worth noting here: (1) The authors of *Pandas* are being careful to qualify and nuance their claims — note the parenthetical remarks. (2) They are much more careful in delineating the organisms under discussion than Miller. Miller attributes to the authors of *Pandas* the claim that “all major groups of organisms originated at just one period of time.” (Miller, p. 21) But, in fact, the authors of *Pandas* make clear that they are talking about “the great majority of living animal phyla.” This last class of organisms is much more tightly delineated than Miller’s “all major groups of organisms.” “The great majority” indicates that the authors are not talking about “all living animal phyla” but a proper subset of them. Also, by referring to animal phyla as “living,” it is clear that they are talking about extant animal phyla and not extinct ones like those of the Ediacaran fauna.

Miller’s invocation of the Ediacaran fauna does not solve the problem of the Cambrian Explosion. Unlike Miller, the late Stephen Jay Gould, a paleontologist and an ardent evolutionist, did not look for so simplistic a solution to the Cambrian Explosion. Gould wrote:

Nonetheless, these exciting finds in Precambrian paleontology do not remove the problem of the Cambrian explosion, for they include only the simple bacteria and blue-green algae, and some higher plants such as green algae. The evolution of complex Metazoa seems as sudden as ever. (A single Precambrian fauna has been found at Ediacara in Australia. It includes some relatives of modern fan corals, jellyfish, wormlike creatures, arthropods, and two cryptic forms unlike anything alive today. Yet the Ediacara rocks lie just below the base of the Cambrian and qualify as Precambrian only by the slimmest margin. A few more isolated finds from other areas around the world are likewise just barely Precambrian.) If anything, the problem is increased because exhaustive study of more and more Precambrian rocks destroys the old and popular argument that complex Metazoa are really there, but we just haven’t found them yet.”⁶⁶

Given such considerations (and the challenge posed by the Cambrian Explosion is hardly unique — we will turn to the challenge posed by Michael Behe’s irreducibly complex molecular machines shortly), it is irresponsible for Miller to claim that “not a single piece of scientific evidence has emerged to contradict the idea that a process of evolutionary change gave rise to the species that exist today.” (Miller, p. 3) No theory in science is so good that “not a single piece of scientific piece of evidence has emerged to contradict” it. There are always anomalies. There are always recalcitrant data. We may choose to ignore or dismiss them, and there may be good reasons to do so. But Miller does not indicate what such reasons might be in the case of evolution. Rather, he simply asserts that all the evidence fits. This is as convenient fiction, and it works only by closing one’s eyes.

Reading Miller’s opening section of his expert witness report (titled “The Scientific Status of Evolutionary Theory”), one gets the impression of a salesman who is omitting crucial details about the product he is selling. I’ve already commented on the claim in that introductory section about no scientific evidence contradict evolution. But consider Miller’s more subtle claim that “evolution is a hard-working and productive scientific theory put into practice every day by scientists in a wide variety of fields.” (Miller, p. 3) My own experience in reading the biological literature is that evolution has very little to do with nuts and bolts biology (e.g., genetics, biochemistry, anatomy and physiology). Biologists by and large try to understand existing systems and structures — what they’re made of, how they’re constructed, and how they function. How they evolved is largely beside the point.

I was therefore surprised to read that the first thing Miller attributes to evolution in its guise as a hard-working and productive scientific theory is its use “to *design* new drugs based on the process of natural selection.” (Miller, p. 3; emphasis added here) Despite a three and a half page bibliography, Miller provides no reference to this extravagant claim. I try to stay on top of the field of biocomputing, which uses models inspired by Darwinian evolution to solve problems at the intersection of biology and computation, but I’m unfamiliar with drug companies using these techniques to design new drugs. Moreover, even if these techniques are used to develop new drugs, Miller’s reference to *designing* new drugs actually vindicates intelligent design because these techniques, though inspired by Darwinian evolution, require careful engineering and thus are design intensive (see chapter 4 of my book *No Free Lunch* in which I show that evolutionary computing owes more to intelligent design than to Darwinian evolution).

My suspicion, therefore, is that Miller means something much more plebeian when he refers to evolution as a hard-working and productive scientific theory that is “used to design new drugs based on the process of natural selection.” What I suspect he is referring to is that bacteria, through a process of natural selection, tend to acquire immunity to antibiotics. Thus, for infections to be treated effectively, drug companies need to design new drugs to overcome the increased immunity of these bacteria. But, in that case, it is not the theory of evolution that provides insight into how to design new antibiotics that knock out bacteria that have developed an immunity to old antibiotics. Rather, it is the drug designer’s background knowledge and ability as a researcher that enables him or her to design appropriate new drugs that knock out these bacteria. All evolution is doing here is describing the process by which these bacteria acquire antibiotic resistance — not how to design drugs capable of overcoming that resistance.

To say that evolution is “used to design new drugs” is therefore grossly misleading. It is like saying that tooth decay is used to design new methods of filling cavities.

With regard to section 2 (titled “*Biology* by Miller and Levine”), I will leave a detailed rebuttal of this section to my fellow expert witnesses who are biologists. Nonetheless, there is a red flag at the start of that section that calls into question whether students in the Dover area and elsewhere should be limited to Miller and Levine’s text as their sole source of biological information. Alternatively, this red flag raises the question whether such students, to be properly educated in biology, need to be exposed to supplemental materials like *Pandas*.

According to Miller, this text “reflects the broad consensus on evolutionary biology held by the scientific community.” (Miller, p. 5) The problem with this statement is that no broad consensus on evolutionary biology is in fact held by the scientific community. To be sure, it’s fair to say that 80 to 90 percent of biologists are neo-Darwinists like Miller.⁶⁷ Thus, Miller’s text reflects a majority view. But the term “consensus” denotes overwhelming agreement and no serious controversy. This is simply not the case in the biological community. The closest Miller comes to admitting that there is in fact no broad consensus is when he lists the mechanisms of evolution and then remarks: “There is considerable discussion and debate within the scientific community as to the relative importance of these and other mechanisms, and these conflicts continue to motivate vigorous research and investigation.” (Miller, p. 4)

Cambridge paleontologist Simon Conway Morris, writing for the premier biology journal *Cell*, has remarked: “When discussing organic evolution the only point of agreement seems to be: ‘It happened.’ Thereafter, there is little consensus.”⁶⁸ Textbooks like Miller’s present a united front. But this illusion of consensus — a consensus trance, as it were — quickly evaporates once you go to the highest level of the academy and see what scientists are really saying. Miller, despite paying lip service to other mechanisms in evolution, gives pride of place to the neo-Darwinian mechanism of natural selection and random genetic change. But consider Lynn Margulis, a biologist who is also a member of the National Academy of Sciences. For her, the key mechanism in evolution is symbiogenesis (the production of new organisms through hybridization). In consequence, she regards Miller’s neo-Darwinian approach to biology as scientifically sterile: “Like a sugary snack that temporarily satisfies our appetite but deprives us of more nutritious foods, neo-Darwinism sates intellectual curiosity with abstractions bereft of actual details — whether metabolic, biochemical, ecological, or of natural history.”⁶⁹

Do these sorts of criticisms of neo-Darwinian evolution appear in Miller’s text? Does the text admit that the very mechanism Miller thinks is the main driving force of evolution is highly disputed by some highly qualified biologists? Not at all. Indeed, how could it if, as Miller claims, the text “reflects the broad consensus on evolutionary biology held by the scientific community.” (Miller, p. 5) In his expert witness report, Miller rightly admits that there is considerable discussion about mechanisms of evolution other than the neo-Darwinian mechanism of natural selection and random genetic change. But what if those other mechanisms contradict the neo-Darwinian mechanism? Could intelligence be such a mechanism? Not for Miller, and you won’t find these possibilities discussed as live scientific options in Miller’s text.

In section 3 of his expert witness report (titled “Language of the Dover Statement”), Miller’s main concern is that the Dover Statement calls special attention to evolution, singling it out for critical scrutiny. Miller sees this as a bad idea because, as he claims, “evolutionary theory enjoys the same status as other well-tested explanations in science, and there is no rational basis for suggesting that it, and it alone, should be mentioned in the context of doubt and skepticism that pervades this statement from the Dover Board.” (Miller, p. 8) This is wishful thinking. Evolutionary biology, as pointed out in my rebuttal to Kevin Padian, is a historical science — it’s business is constructing historical narratives or what Ernst Mayr calls “tentative scenarios.” (See my rebuttal to Padian.) The suggestion that evolutionary theory enjoys the same status as the theories of physics, for instance, is therefore absurd. I have seen biologists claim that evolutionary theory is as well established as Einstein’s theory of general relativity. But I have never seen a physicist, to bolster Einstein’s theory of general relativity, claim that it is as well established as evolutionary theory. Evolutionary theory does not enjoy the same status as the rigorous sciences. For this reason, it needs the critical scrutiny called for by the Dover Statement. To see how jaundiced many non-biologists are toward evolutionary theory, see Appendix 3.

Section 4 of Miller’s expert witness report takes on my work and that of Michael Behe. Much of the text in this section is taken verbatim from an article that Miller wrote for a book I edited with Michael Ruse (i.e., *Debating Design: From Darwin to DNA*, Cambridge University Press, 2004). Nor does Miller introduce any novel ideas in this section from his expert witness report that he did not introduce in his article for the book I co-edited. That article, titled “The Flagellum Unspun: The Collapse of ‘Irreducible Complexity,’” appeared on Miller’s website in late 2002/early 2003 (http://www.designinference.com/documents/2003.02.Miller_Response.htm). In that article, Miller critiqued Michael Behe’s notion of irreducible complexity as well as my notion of specified complexity as these apply to the evolution of the bacterial flagellum. I responded to Miller’s article at length in February 2003 with an online paper titled “Still Spinning Just Fine.” (See Appendix 4.)

The section in Miller’s expert witness report titled “the Informational Challenge to Evolution” (Miller, pp. 15-18) comprises two sections of his essay in my *Debating Design* anthology: “The Combinatorial Argument” and “Assuming Impossibility” (pp. 88-91 of that book) — he lifted these sections in their entirety from my book for his expert witness report. Since I’ve already responded to these criticisms in my paper “Still Spinning Just Fine,” I simply reproduce it in Appendix 4. Note that this paper responds not only to Miller’s criticisms of my work in his expert witness report (see the section in Appendix 4 titled “Miller’s Foray into the Mathematics of the Design Inference”) but also to his criticisms of Michael Behe. In addition, I include as Appendix 5 an abridged version of a paper I authored in 2004 that has been widely circulated on the web: “Irreducible Complexity Revisited.” This paper significantly extends the combinatorial argument against me that Miller critiques in his expert witness report. If Miller were up to date on my work, he would not simply have lifted a section from an essay he wrote three several earlier. Instead, he would have responded to the arguments in that new paper.

A section titled “The Origin of Biological Information” appears on page 18 of Miller’s report. There he claims that evolutionary mechanisms can generate biological information and thus, by implication specified complexity. I address this criticism in my rebuttal of Pennock when I discuss his AVIDA simulation.

In closing, I want to turn briefly to section 5 of Miller's report, where he criticizes *Pandas*. I'll leave Miller's more detailed criticisms of the biology in *Pandas* to my fellow expert witnesses who are biologists (note that some of his criticisms about the fossil record are also handled in my rebuttal to Padian). What I want to address here are two further misrepresentations of *Pandas* in Miller's expert witness report. Earlier in this rebuttal, I considered how Miller misrepresented *Pandas*' treatment of the Cambrian Explosion by misreading what *Pandas* said about it. Such misreading seems to be a pattern in Miller's criticisms of *Pandas*.

For instance, on page 19 of his report, Miller writes: "Not a word can be found anywhere in *Pandas* regarding the age of the earth or geological ages recognized by earth scientists." Presumably what's behind this objection is a concern on Miller's part that *Pandas* might be a stealth young-earth creationist text. But this concern is misplaced. If Miller had read *Pandas* carefully, he would see that it lines up with standard geological dating and timelines. For instance, on page 94, *Pandas* places the Middle Cambrian at "500 million years." This date is entirely mainstream and entirely at odds with young earth creationism. Nothing about *Pandas* is inconsistent with standard geological dating, nor does *Pandas* maintain a tendentious silence about geological dating. Where relevant, *Pandas* provides the relevant geological dates as recognized by earth scientists.

As a final example of Miller's misreading of *Pandas*, consider his claim on page 21 that "Pandas ignores the issue of extinction." Extinction is, according to Miller, easily explained by evolution but cannot be explained by intelligent design. Thus, he remarks, "Pandas avoids this embarrassing problem [of extinction]. Its authors cannot explain extinction, and therefore they short-change their student readers by stepping around the question." (Miller, p. 21) But in fact, much of chapter 3 in *Pandas* deals with extinction as it relates to speciation. Extinction comes up especially in *Pandas*' discussion in that chapter of Stephen Jay Gould's idea of punctuated equilibrium. Indeed, there is even a dinosaur illustration on page 87 of *Pandas* with a caption that reads "Some think the extinction of the dinosaurs occurred because they didn't have the genetic diversity to adapt to environmental changes."

For Miller to suggest that ID does not have the conceptual resources to deal with extinction is wishful thinking. ID sees life on earth as unfolding over time and thus as "evolving." But the conception of evolution here is that of *technological evolution guided by creative intelligence*, not of an unguided material process like the one envisioned by neo-Darwinism. Within technological evolution, new technologies regularly replace old technologies so that the old technologies may appropriately be described as going extinct.

Dated: May ____, 2005

William A. Dembski

Appendix 1: Barbara Forrest's Letter to Simon Blackburn

From: Barbara Forrest

To: Simon Blackburn [invited speaker to Nature of Nature conference]

Date: March 2000

This letter concerns the conference, "The Nature of Nature," hosted by the Michael Polanyi Center at Baylor University, which you will be attending in April. The title of this conference and the list of participants conceal the fact that the Polanyi Center is the most recent offspring of the creationist movement, the agenda of which is the destruction of evolutionary theory as the central principle of biology.

Even though I think that the participation—witting or unwitting—of reputable scholars in the Baylor conference plays into the hands of Dembski, Gordon, and the CRSC in that it lends them an undeserved academic legitimacy, I am not trying to dissuade you from going because I have no right to do that. You are already committed. I do, however, believe you have a right to know the nature of the atmosphere into which you are walking.

The director of the MPC is William Dembski, and the associate director is Bruce Gordon. Although they insist on calling their brand of creationism "intelligent design theory," its true nature is evident to anyone who has followed the development of creationism. For a thorough examination of creationism, including intelligent design, I refer you to *Tower of Babel: The Evidence Against the New Creationism* (MIT Press, 1999), an excellent book by a fellow philosopher, Prof. Robert Pennock of The College of New Jersey. Prof. Pennock critiques the work of Dembski, as well as the intelligent design movement as a whole.

Both Dembski and Gordon are members of the Center for the Renewal of Science and Culture, the creationist arm of the Discovery Institute, a conservative think tank in Seattle. It is significant that the CRSC recently received \$1.5 million from wealthy businessman Howard Ahmanson. See Walter Olson's article at <http://www.reason.com/9901/co.wo.darkbedfellows.html>. For over twenty years, Ahmanson has served on the board of Chalcedon, Inc., an extremist Christian organization run by R.J. Rushdoony. See Jerry Sloan's article, "The Man Behind Knight" at http://www.frontiersweb.com/sfv18iss21/Pages/feat_1.html. You can view the CRSC site from the Discovery Institute page at <http://www.discovery.org>. The page has an announcement about the Baylor conference and other activities in which Dembski is participating. You will find links to CRSC articles, including Dembski's.

The establishment of the Polanyi Center at Baylor has aroused the anger of Baylor science faculty since it was accomplished with no prior knowledge or input from them. However, the faculty's anger stems primarily from their recognition that this organization and its founders, Dembski and Gordon, are creationists with a religious/political agenda, and they fear that the prominence and influence of such creationists at Baylor will severely damage the good reputation the faculty has worked so hard to build there. In fact, the faculty senate at Baylor scheduled this matter at the top of its agenda for its March 2 meeting with Baylor University President Robert Sloan. The first two questions on the agenda, addressed directly to Sloan, were these:

1. By creating the Polanyi Center has Baylor not institutionalized the propagation of a position, Intelligent Design Creationism, which is contrary to the prevailing assumptions of the majority of the world's scientists, specifically the scientific commitment to methodological naturalism? Arguing for a controversial position is one thing, but institutionalizing it is another. Moreover, that those associated with the center are described by their own colleagues outside of Baylor as part of a "new generation of creationists" constituting a "coalition to bring down evolution" is creating serious problems for the reputation of Baylor's science and pre-medical programs? It is the belief of some of us that the center was established by the administration without an awareness of these implications, and it is the hope of others of us that you will step in and preserve the integrity of the university and its science programs. Please comment?

2. Since the establishment of an institution such as the Polanyi Center has far-reaching implications for areas of the university such as the biology and psychology departments, shouldn't faculty members from those departments be consulted when such an institution is being considered?

Some history leading up to the Baylor conference:

In 1996, Phillip Johnson, a law professor at Berkeley who has taken it upon himself to cleanse American education and culture of "naturalistic evolution," initiated a conference at Biola University called the "Mere Creation" Conference. Johnson recruited Dembski and a host of others to help him do this. Dembski was one of the most active organizers of this conference. You can find a 1996 article about the conference at http://www.worldmag.com/world/issue/11-30-96/national_2.asp. You can also view the web site for the Mere Creation conference at <http://www.origins.org/mc/menus/index.html>. Please follow the links to the off-site web pages as well. The nature of intelligent design as "mere creationism" is unmistakable.

If you go to Dembski's "virtual office" at "Leadership University," sponsored by the Christian Leadership Ministries, you can see Dembski's list of the most important creationist books in the movement, "The Intelligent Design Movement: A Brief Catalog of Resources," at <http://www.leaderu.com/offices/dembski/menus/reso.html>. Among them is *Of Pandas and People*, which creationists around the country have tried to get local school boards to adopt in public school science classes and which Dembski has defended as a legitimate science text. You can read the National Center for Science Education's analysis of *Pandas* at <http://www.natcensci.ed.org/mianal.htm#pandas>. I have also attached a critique of this book by Dr. Gary Bennett of Idaho, who recently spoke to Idaho legislators, urging them not to adopt this anti-evolution text. You can also see at <http://www.aclu.org/news/n100298a.html> an ACLU press release regarding the use of this book by Roger DeHart, a public school teacher in Burlington, WA, where a full-fledged fight against creationism has developed and is ongoing at this moment. According to the Burlington-Edison Committee for Science Education, several CRSC members have become involved in the controversy there on the pro-creationist side. Dembski recently traveled to the University of Washington to promote his latest book. While there, he conducted a book-signing to help Skagit Parents for Scientific Proof in Education, a parents group working on DeHart's behalf. See <http://www.skagitvalleyherald.com/daily/00/february/08/a3creation.html>.

Reflecting its agenda of getting intelligent design creationism into American schools, the CRSC recently added to its web site intelligent design lesson plans for teachers. Until sometime near the end of February, they could be viewed at <http://www.discovery.org/crsc/scied/evol.index.html>. Now, however, the CRSC has restricted public access to them and they are in a “Secured Administration Area” requiring a name and password. I have found nothing else on the CRSC site which requires this. The reason is obvious: restricted access prevents the lesson plans, which are unconstitutional, from being scrutinized and evaluated, and it allows the CRSC to know who is getting them. You can, however, see the CRSC document, written by Gonzaga law professor and CRSC member David DeWolf, outlining the legal aspects of trying to get ID into public schools, at <http://www.discovery.org/crsc/articles/TeachingTheOriginsControve.html>. The ID creationists are looking for loopholes in *Edwards v. Aguillard*, a 1987 Supreme Court ruling on a case which originated in my state of Louisiana and which outlawed creationism in public schools.

The agenda of the intelligent design movement is spelled out in a CRSC document which surfaced last year and is commonly referred to as the “wedge document” because of its enunciation of the creationists’ “wedge strategy,” the brainchild of Phillip Johnson, who has spoken openly about this strategy. This document outlines the intelligent design movement agenda from 1999-2003. My analysis of CRSC’s planned activities as stated in the document shows that they are systematically enacting every part of their agenda except the only one which would gain them the legitimacy they so crave: the production of scientific research using their “theistic science.” As I stated earlier, Johnson, Dembski, and their associates have assumed the task of destroying “Darwinism,” “evolutionary naturalism,” “scientific materialism,” “methodological naturalism,” “philosophical naturalism,” and other “isms” they use as synonyms for evolution. (You can see Dembski’s articles on a creationist web site, “Access Research Network,” at <http://www.arn.org/dembski/wdhome.htm>. One of them is “Teaching Intelligent Design as Religion or Science?”) The wedge document is available at <http://www.humanist.net/skeptical/wedge.html> and also at <http://www.infidels.org/org/aha/skeptical/wedge.html>. You can also find an article on the wedge strategy written by Jim Still, manager of the Internet Infidels web site, at http://www.infidels.org/secular_web/feature/1999/wedge.html. Another article written on the wedge document at the time it surfaced is at http://www.freethought-web.org/ctrl/archive/thomas_wedge.html. This was done by Keith Lankford, past president of the Sagan Society at the University of Georgia.

The wedge document specifically includes as one of its goals the following: “[W]e will move toward direct confrontation with the advocates of materialist science through challenge conferences in significant academic settings.... The attention, publicity, and influence of design theory should draw scientific materialists into open debate with design theorists, and we will be ready.” So the plan of the ID proponents is to lure legitimate, respected scholars into conferences they organize. Not only have they managed to “wedge” themselves into the “significant academic setting” of Baylor, but the MPC web site shows that they have long-term plans there.

Very important with respect to the MPC and the Baylor conference is an article on intelligent design’s move into the higher education mainstream (which is the purpose of the newly established Polanyi Center) at <http://www.natcensci.org/scot171.htm>. This was written by Eugenie Scott, director of the National Center for Science Education in Berkeley, CA. And at

<http://www.au.org/cs4995.htm> is an article by Americans United for the Separation of Church and State in which Johnson asserts that the wedge strategy “enables us to get a foothold in the academic world and the academic journals. You have to prepare minds to hear the truth. You can’t do it all at once.” This remark in itself explains the reason for the establishment of the MPC at Baylor and the naturalism conference you will be attending.

It is interesting to note the following information about the Baylor conference listings as they appear to date on the Polanyi Center web site at <http://www.baylor.edu/~polanyi>. Of the 31 confirmed participants, at least 10 appear to be part of Dembski’s network of creationists. Of these 10, 7 are members of the Center for the Renewal of Science and Culture. Of the 11 plenary sessions, 8 have participants who are creationists (not always as presenters, but with some serving as moderators). The only plenary sessions without creationists participating in some way are the one hosted by Stuart Rosenbaum (a Baylor philosopher), the one in which Simon Conway Morris is listed as the sole speaker, and the last session, for which the moderator is still to be announced.

A similar conference was held in 1997 at the University of Texas-Austin, organized by Robert Koons, a philosophy professor and also a CRSC member. The title was, like that of the Baylor conference, academically innocuous: “Naturalism, Theism, and the Scientific Enterprise.” See Koons’ web site at <http://www.dla.utexas.edu/depts/philosophy/faculty/koons/main.html/>, which has a link to information about this conference. You can read Koons’ assessment of the conference at <http://www.leaderu.com/real/ri9701/koons2.html>. However, Koons’ assertion of the high degree of consensus reached on the feasibility of and need for “theistic science” was not shared by all attendees. Legitimate scholars and students sent papers, only to find after they arrived that they had been lured into an event dominated by creationists and clearly organized as a platform for them.

I know several people who attended the UT conference in 1997. I have asked one of them, Wesley Elsberry, to attest to its nature. You may contact him at welsberr@inia.cls.org. Wesley is one of the most knowledgeable people in the country about the intelligent design movement and has extensively critiqued Dembski’s work, as has philosopher Elliot Sober. You will find Wesley’s writings, and a link to Sober’s, at http://inia.cls.org/~welsberr/evobio/evc/ae/dembski_wa.html.

Cordially,

Barbara Forrest, Ph.D.
Associate Professor of Philosophy Department of History and Political Science
Southeastern Louisiana University

Appendix 2: Press Releases in Response to Pennock

[Both press releases available online at
http://www.designinference.com/documents/01.02.pennock_anthology_MIT.htm]

January 8, 2002: FOR IMMEDIATE RELEASE

STATEMENT BY WILLIAM A. DEMBSKI ON THE PUBLICATION OF ROBERT PENNOCK'S NEW BOOK WITH MIT PRESS

How Not to Debate Intelligent Design
 By William A. Dembski

Intelligent design has many critics. Some play hard and fair. Robert Pennock is not one of them.

Pennock has just published *Intelligent Design Creationists and Their Critics* with MIT Press. It includes two essays by me. Pennock never contacted me about their inclusion. Indeed, I only learned of their inclusion after his volume was published and became available to the public last week.

It appears that Pennock and MIT Press are legally in the clear — Pennock selected pieces for which he was able to obtain copyright permissions without having to consult me.

There's more to ethics, however, than legalities. What Pennock and MIT Press have done is emblematic of the viewpoint discrimination that dissenters to Darwinism face in American academic culture. Pennock's volume is supposed to constitute a definitive refutation of intelligent design, allowing intelligent design proponents to have their say and then meet their strongest critics. Instead, it is a shabby ploy to cast intelligent design in the worst possible light.

Imagine if someone critical of Darwinian evolutionary theory decided to publish a book titled *Dogmatic Darwinian Fundamentalists and Their Critics*, managed to obtain copyright permissions for pieces by prominent Darwinists (mostly outdated pieces at that), and then situated their pieces within a collection of critical replies designed to make them look ridiculous. Substitute intelligent design for Darwinism, and that's what Pennock and MIT Press have done.

In my case, Pennock chose a popular 2,000 word essay of mine titled "Who's Got the Magic?" and followed it with a 9,000-word rebuttal by him titled "The Wizards of ID." For the other essay of mine, Pennock chose "Intelligent Design as a Theory of Information," which was a popular piece on information theory that's now five years old. I've written much on that topic since then, and the essay itself is now outdated. Moreover, Pennock followed that essay with three critical responses. One of those responses, by Elliott Sober, was a lengthy technical review (from the journal *Philosophy of Science*) of my technical monograph *The Design Inference* (Cambridge University Press, 1998). No portion of that monograph or anything comparable from my work was included in Pennock's book. Finally, I was given no chance to respond to my critics.

I contacted both Pennock and MIT Press to register my concerns. I would like to have seen a public apology by Pennock and some notice by MIT Press indicating that my essays appeared without my knowledge, that they represent my popular rather than technical work on intelligent design, and that I was not given a chance to reply to my critics. Pennock indicated that unless I chose to pursue legal action, he considered the matter closed. MIT Press ignored my concerns and indicated they would be happy to hear about any other concerns I might have.

I do not plan to seek legal redress, though it seems to me that Pennock and MIT Press have deliberately tried to undermine my standing in the academic community. Pennock chose popular and outdated work of mine, positioned various critiques of my work with it, gave me no opportunity to reply to my critics, and packaged it all in a volume titled *Intelligent Design Creationists and Their Critics*, thus casting me as a creationist, which in contemporary academic culture is equivalent to being cast as a flat earther, astrologer, or holocaust denier. There's no way I would have allowed my work to appear under such conditions if I had any say in the matter. Pennock saw to it that I had no say in the matter.

Some critics of intelligent design play hard and fair. They allow intelligent design proponents to put their best foot forward and they in turn produce their strongest counterarguments to intelligent design. Pennock, by contrast, is like the Emperor Commodus in the movie *Gladiator*, who first needs to hamstring his opponents before he tosses them into the arena.

Episodes like this are bad for American academic life. They undermine free and open exchange. They make for bad feelings on all sides. And they prevent ideas from getting the critical scrutiny they need. Intelligent design needs critical scrutiny. But by rigging the debate the way he did, Pennock ensures that intelligent design will continue to be politicized. Pennock's new book is an object lesson in how not to debate intelligent design.

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January 9, 2002: FOR IMMEDIATE RELEASE

FOLLOW-UP STATEMENT BY WILLIAM A. DEMBSKI ON THE PUBLICATION OF ROBERT PENNOCK'S NEW BOOK WITH MIT PRESS

How STILL Not to Debate Intelligent Design
By William A. Dembski

Robert Pennock has just published *Intelligent Design Creationists and Their Critics* with MIT Press. It includes two essays by me. In a press release dated yesterday, I claimed that Pennock never contacted me about their inclusion. Pennock now claims that he did. He said. She said. Who's right?

Consider the facts. Pennock published two essays of mine in his new book: "Who's Got the Magic?" and "Intelligent Design as a Theory of Information." With regard to the second essay, did he ever in any way refer to that essay, whether directly or indirectly, in any of our correspondence prior to the release of his book? No. He never even hinted at it, and there's no way it could be said that he contacted me about its inclusion in his volume. Pennock therefore never laid out which essays of mine he intended to include.

What about the other essay, "Who's Got the Magic?" Did Pennock ever advert to that essay in any of our correspondence? In April 2001, Pennock sent an email to my colleague Paul Nelson asking him to forward it to me. Nelson did forward Pennock's message to me. I had received no email from Pennock before that date and nothing after until the publication of his book. I read Pennock's email with only two pieces of relevant background knowledge: (1) that he was putting together an anthology for MIT Press titled *Intelligent Design Creationists and Their Critics* and (2) that my colleague Paul Nelson was a contributor to the volume and that he had been explicitly informed that he would be a contributor. My working assumption before receiving Pennock's email was that I would not be a contributor since I had not been similarly informed.

Pennock's forwarded message contained two items relevant here: (1) a short biosketch of me with a request that I correct it for inclusion in "my anthology" (no description of the anthology beyond this was

mentioned — Pennock simply assumed I knew what he was referring to) and (2) an enigmatic reference to being able to “add our Meta exchange when I sent in the ms [sic].”

Regarding the biosketch, Pennock did not state that this was a contributor biosketch. With a title like Intelligent Design Creationists and Their Critics, I took it that Pennock was compiling a “rogues gallery” of ID proponents and simply listing me as one of the rogues. He never used the word “contributor” or anything like it to refer to me in connection with his anthology.

Regarding Pennock’s reference to “our Meta exchange,” he never referred to my actual essay by title. The Meta exchange comprised my piece on www.metanexus.net titled “Who’s Got the Magic?” and his response there titled “The Wizards of ID.” I had never signed over the copyright for “Who’s Got the Magic?” to Pennock or anyone else for that matter. Was it therefore our entire exchange that he was planning to add, with copyright permissions requests (that never came) still down the road? Or was it just his portion of the exchange and a summary of mine that he was planning to add to “the ms”? Was his mention of adding it to “the ms” a reference to the MIT anthology or to some other work? Finally, the one other ID proponent whom I knew to be a contributor to Pennock’s anthology (i.e., Paul Nelson) had been explicitly contacted about being a contributor. I hadn’t.

Pennock’s forwarded message was ambiguous at best. Indeed, it came as a complete surprise when I learned last week that my essays were included in his volume. My surprise was not unjustified. I therefore continue to maintain that Pennock never contacted me about the inclusion of my essays in his volume. Indeed, the very fact that Pennock’s one piece of communication with me was a forwarded message should give one pause. Pennock, who casts himself as the defender of scientific correctness against ID reactionaries, has been remarkable for being able to uncover obscure work of mine (cf. his previous book with MIT Press titled Tower of Babel).

Pennock has been following the ID movement intently for at least ten years. I’m one of the most prominent people in the ID camp. My association with Baylor University and Discovery Institute is common knowledge. Pennock could easily have contacted me directly and informed me explicitly that I was to be a contributor to the volume. Instead, he sent a letter through an intermediary. There was a hint in that forwarded letter that one paper of mine might be appearing in some manuscript, which after the fact proved to be more than a hint. But I saw no reason to give it a second thought without further clarification from Pennock — clarification he never offered. And what about the other paper, about which there was no hint?

So much for he-said-she-said, my-word-versus-your-word. Such clarifications are needed to clear the air. But they really sidestep the central issue. By not contacting me about the inclusion of my essays in his volume, Pennock merely added insult to injury. The central issue, however, is not the insult but the injury. The injury is that Pennock situated my essays in a book that from its inception cast me and my colleagues as villains and demonized our work.

I’m still a junior scholar, early in my academic career. I don’t have tenure. When my contract runs out at Baylor University, I’ll have to hustle for another academic job. Under normal circumstances, I would love to have articles of mine (popular or technical) appear with prestigious academic presses like MIT Press. But the inclusion of my essays in Intelligent Design Creationists and Their Critics do not constitute normal circumstances.

To fair-minded individuals in the middle with no significant stake in the controversy over Darwinism and intelligent design, I ask: Would you like your work subjected to the same treatment that Pennock and MIT Press gave to my work and that of my colleagues? If you were a feminist scholar, would you want your work to appear in a book titled Misguided Liberationist Women and Their Critics? If you were a Muslim scholar, would you want your work to appear in a book titled Fanatical Believers in Allah and Their Critics? If you were a Marxist scholar, would you want your work to appear in a book titled Marx’s Theory of Surplus Value and Other Nonsense?

“Creationism” is a dirty word in contemporary academic culture and Pennock knows it. What’s more, as a trained philosopher, Pennock knows that intelligent design is not creationism. Intelligent design refers to intelligent processes operating in nature that arrange pre-existing matter into information-rich structures. Creation refers to an agent that gives being to the material world. One can have intelligent design without creation and creation without intelligent design.

The central issue is not that Pennock and MIT Press wanted to publish my essays but that they wanted to situate them in such a way as to discredit me, my work, and that of my colleagues. When I debated Darwinist Massimo Pigliucci at the New York Academy of Sciences last November, he stated: “Any debate between creationists and evolutionists is caused by the failure of scientists to explain how science works and should in no way be construed as a genuine academic dispute whose outcome is still reasonably doubtful.” Pennock would agree, though he would add that the failure is also on the part of philosophers and not just scientists.

According to Pigliucci and Pennock, intelligent design proponents are not scholars to be engaged on the intellectual merits of their case. Rather, they are charlatans to be discredited, silenced, and stopped. That’s the whole point of *_Intelligent Design Creationists and Their Critics_*. It’s not a work of scholars trying to come to terms with their differences. It’s not a work attempting to bring clarity to a “genuine academic dispute.” It’s a work of damage control to keep unwanted ideas at bay. It’s what dogmatists do when outright censorship has failed.

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Appendix 3: Berlinski Oped — Why Evolution Calls for Special Attention

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Darwinian Doubts

By DAVID BERLINSKI

The defense of Darwin's theory of evolution has now fallen into the hands of biologists who believe in suppressing criticism when possible and ignoring it when not. It is not a strategy calculated to induce confidence in the scientific method.

A paper published recently in the Proceedings of the Biological Society of Washington concluded that the events taking place during the Cambrian era could best be understood in terms of an intelligent design — hardly a position unknown in the history of western science. The paper was, of course, peer-reviewed by three prominent evolutionary biologists. Wise men attend to the publication of every one of the Proceedings' papers, but in the case of Steven Meyer's "The origin of biological information and the higher taxonomic categories," the Board of Editors was at once given to understand that they had done a bad thing. Their indecent capitulation followed at once. Publication of the paper, they confessed, was a mistake. It would never happen again. It had barely happened at all. And peer review?

The hell with it.

"If scientists do not oppose anti-evolutionism,"

Eugenie Scott, the executive director of the National Council on Science Education, remarked, "it will reach more people with the mistaken idea that evolution is scientifically weak." Scott's understanding of "opposition" had nothing to do with reasoned discussion. It had nothing to do with reason at all. Discussing the issue was out of the question. Her advice to her colleagues was considerably more to the point: "Avoid debates."

Everyone else had better shut up.

In this country, at least, no one is ever going to shut up, the more so since the case against Darwin's theory retains an almost lunatic vitality.

Look — The suggestion that Darwin's theory of evolution is like theories in the serious sciences — quantum electrodynamics, say — is grotesque. Quantum electrodynamics is accurate to 13 unyielding decimal places. Darwin's theory makes no tight quantitative predictions at all.

Look — Field studies attempting to measure natural selection inevitably report weak to non-existent selection effects.

Look — Darwin's theory is open at one end since there are no plausible accounts for the origins of life.

Look — The astonishing and irreducible complexity of various cellular structures has not yet successfully been described, let alone explained.

Look — A great many species enter the fossil record trailing no obvious ancestors and depart for Valhalla leaving no obvious descendants.

Look — Where attempts to replicate Darwinian evolution on the computer have been successful, they have not used classical Darwinian principles, and where they have used such principles, they have not been successful.

Look — Tens of thousands of fruit flies have come and gone in laboratory experiments, and every last one of them has remained a fruit fly to the end, all efforts to see the miracle of speciation unavailing.

Look — The remarkable similarity in the genome of a great many organisms suggests that there is at bottom only one living system; but how then to account for the astonishing differences between human beings and their near relatives — differences that remain obvious to anyone who has visited a zoo?

But look again — If the differences between organisms are scientifically more interesting than their genomic similarities, of what use is Darwin's theory since it's otherwise mysterious operations take place by



genetic variations?

These are hardly trivial questions. Each suggests a dozen others. These are hardly circumstances that do much to support the view that there are "no valid criticisms of Darwin's theory," as so many recent editorials have suggested.

Serious biologists quite understand all this. They rather regard Darwin's theory as an elderly uncle invited to a family dinner. The old boy has no hair; he has no teeth, he is hard of hearing, and he often drools. Addressing even senior members at table as *Sonny*, he is inordinately eager to tell the same story over and over again.

But he's family. What can you do?

David Berlinski holds a Ph.D. from Princeton University and is a senior fellow at the Discovery Institute in Seattle. He is the author of "On Systems Analysis," "A Tour of the Calculus," "The Advent of the Algorithm," "Newton's Gift," "The Secrets of the Vaulted Sky," and, most recently, "Infinite Ascent: A Short History of Mathematics."

Appendix 4: “Still Spinning Just Fine: A Response to Ken Miller”

This response by William A. Dembski to Kenneth Miller’s contribution to the Dembski-Ruse Debating Design anthology (Cambridge University Press, 2004) is available online at http://www.designinference.com/documents/2003.02.Miller_Response.htm. I wrote this response in February 2003, well in advance of the publication of the CUP anthology.

I read Ken Miller’s contribution to the volume I’m editing with Michael Ruse (*Debating Design: From Darwin to DNA*, Cambridge University Press, forthcoming 2004), I expected I would have till the actual publication date next year to respond to it. But since Miller’s contribution has now officially appeared on his website (<http://www.millerandlevine.com/km/evol/design2/article.html>) — it is titled “The Flagellum Unspun: The Collapse of ‘Irreducible Complexity’“), I want to comment on it at this time. I’ll go through Miller’s paper sequentially and respond bullet-point fashion:

The Argument from Personal Incredulity:

Miller claims that the problem with anti-evolutionists like Michael Behe and me is a failure of imagination — that we personally cannot “imagine how evolutionary mechanisms might have produced a certain species, organ, or structure.” He then emphasizes that such claims are “personal,” merely pointing up the limitations of those who make them. Let’s get real. The problem is not that we in the intelligent design community, whom Miller incorrectly calls “anti-evolutionists,” just can’t imagine how those systems arose. The problem is that Ken Miller and the entire biological community haven’t figured out how those systems arose. It’s not a question of personal incredulity but of *global disciplinary failure* (the discipline here being biology) and *gross theoretical inadequacy* (the theory here being Darwin’s). Darwin’s theory, without which nothing in biology is supposed to make sense, in fact offers no insight into how the flagellum arose. If the biological community had even an inkling of how such systems arose by naturalistic mechanisms, Miller would not — a full six years after the publication of *Darwin’s Black Box* by Michael Behe — be lamely gesturing at the type three secretory system as a possible evolutionary precursor to the flagellum. It would suffice simply to provide a detailed explanation of how a system like the bacterial flagellum arose by Darwinian means. Miller’s paper, despite its intimidating title (“The Flagellum Unspun”) does nothing to answer that question.

Getting from Irreducible Complexity to Design:

Miller, in line with his personal incredulity criticism, charges design proponents of reasoning directly from the premise “Shucks, no one has figured out how the flagellum arose” to the conclusion “Gee, it must have been designed.” Miller, despite a long exposure to ID thinkers and their writings, continually misses a crucial connecting link in the argument. So let me spell out the premises of the argument as well as its conclusion: Certain biological systems have a feature, call it IC (irreducible complexity). Darwinians don’t have a clue how biological systems with that feature originated (Miller disputes this premise, but we’ll come back to it). We know that intelligent agency has the causal power to produce systems that exhibit IC (e.g., many human

artifacts exhibit IC). Therefore, biological systems that exhibit IC are likely to be designed. Design theorists, in attributing design to systems that exhibit IC, are simply doing what scientists do generally, which is to attempt to formulate a causally adequate explanation of the phenomenon in question.

Irreducible Complexity Is Not Properly Ascribed to the Bacterial Flagellum:

According to Miller, Behe's claim that the bacterial flagellum is irreducibly complex is false. If Miller is right, then Behe and the intelligent design movement are in deep trouble. Think of it: Behe goes to all this bother to formulate some feature of biochemical systems that is a clear marker of intelligent agency and that decisively precludes the Darwinian mechanism. Behe then asserts that the bacterial flagellum exhibits that feature. Rather than argue about whether that feature reliably signals design or effectively precludes Darwinism, Miller claims to show that when it comes to the design community's best example of irreducible complexity — the bacterial flagellum — that it isn't even irreducibly complex. *What idiots these design theorists must be if they can't even apply correctly the very concepts they've defined!*

I'll let Behe respond for himself to this line of criticism. Behe's response will appear in the same volume that I'm editing with Michael Ruse (the one featuring Miller's piece discussed here). Miller has been recycling this criticism for some time now (the first time I heard it was at the *Design and Its Critics* conference at Concordia University, Mequon, Wisconsin, June 2000). This time around Behe is responding to Miller's criticism at a debate between the two of them at the American Museum of Natural History (April 23, 2002). Behe (2004) writes:

“If nothing else, one has to admire the breathtaking audacity of verbally trying to turn another severe problem for Darwinism into an advantage. In recent years it has been shown that the bacterial flagellum is an even more sophisticated system than had been thought. Not only does it act as a rotary propulsion device, it also contains within itself an elegant mechanism to transport the proteins that make up the outer portion of the machine, from the inside of the cell to the outside. (Aizawa 1996) Without blinking, Miller asserted that the flagellum is not irreducibly complex because some proteins of the flagellum could be missing and the remainder could still transport proteins, perhaps independently. (Proteins similar — but not identical — to some found in the flagellum occur in the type III secretory system of some bacteria. See Hueck 1998). Again he was equivocating, switching the focus from the function of the system to act as a rotary propulsion machine to the ability of a subset of the system to transport proteins across a membrane. However, taking away the parts of the flagellum certainly destroys the ability of the system to act as a rotary propulsion machine, as I have argued. Thus, contra Miller, the flagellum is indeed irreducibly complex. What's more, the function of transporting proteins has as little directly to do with the function of rotary propulsion as a toothpick has to do with a mousetrap. So discovering the supportive function of transporting proteins tells us precisely nothing about how Darwinian processes might have put together a rotary propulsion machine.”

To this let me add: A system is irreducibly complex in Behe's sense if all its parts are indispensable to preserving the system's basic function. That an irreducibly complex system may have subsystems that have functions of their own (functions distinct from that of the original

system) is therefore allowed in the definition. It seems that Miller is unclear about the distinction between a *definition* and an *argument*. Irreducible complexity is a well-defined notion that is appropriately and ascertainably applied to the bacterial flagellum. Miller's concern ultimately seems not over the definition but over its use as an argument to rebut Darwinism. Miller's point here generally is that if subsystems can be found with functions of their own (perforce different from that of the original system since otherwise the original system would not be irreducibly complex), then those subsystems and their functions can be grist for selection's mill and underwrite a Darwinian account of how the original system arose. Let's now turn to that possibility.

Connecting the Type III Secretory System to Bacterial Flagellum:

Miller's whole argument that the bacterial flagellum evolved by Darwinian means rests on the existence of the type III secretory system (TTSS). The TTSS is coded for by about ten genes, each of which is homologous to genes in the bacterial flagellum. Thus Miller sees the TTSS as embedded in the bacterial flagellum, capable of being selected for on its own, and as a possible evolutionary precursor to the flagellum. He writes: "The TTSS does not tell us how either it or the flagellum evolved. This is certainly true, although Aizawa has suggested that the TTSS may indeed be an evolutionary precursor of the flagellum (Aizawa 2001)."

Accordingly, the TTSS may be thought of as a possible subsystem of the flagellum that performs a function distinct from the flagellum. Nevertheless, finding a subsystem of a functional system that performs some other function is hardly an argument for the original system evolving from that other system. One might just as well say that because the motor of a motorcycle can be used as a blender, therefore the motor evolved into the motorcycle. Perhaps, but not without intelligent design. Indeed, multipart, tightly integrated functional systems almost invariably contain multipart subsystems that serve some different function. At best the TTSS represents one possible step in the indirect Darwinian evolution of the bacterial flagellum. But that still wouldn't constitute a solution to the evolution of the bacterial flagellum. What's needed is a complete evolutionary path and not merely a possible oasis along the way. To claim otherwise is like saying we can travel by foot from Los Angeles to Tokyo because we've discovered the Hawaiian Islands. Evolutionary biology needs to do better than that.

There's another problem here. The whole point of bringing up the TTSS was to posit it as an evolutionary precursor to the bacterial flagellum. The best current molecular evidence, however, points to the TTSS as evolving from the flagellum and not vice versa (Nguyen et al. 2000). This can also be seen intuitively. The bacterial flagellum is a motility structure for propelling a bacterium through its watery environment. Water has been around since the origin of life. But the TTSS, as Mike Gene (see citation at end) notes, is restricted "to animal and plant pathogens." Accordingly, the TTSS could only have been around since the rise of metazoans. Gene continues: "In fact, the function of the system depends on intimate contact with these multicellular organisms. This all indicates this system arose after plants and animals appeared. In fact, the type III genes of plant pathogens are more similar to their own flagellar genes than the type III genes of animal pathogens. This has led some to propose that the type III system arose in plant pathogens and then spread to animal pathogens by horizontal transfer.... When we look at

the type III system its genes are commonly clustered and found on large virulence plasmids. When they are in the chromosome, their GC content is typically lower than the GC content of the surrounding genome. In other words, there is good reason to invoke horizontal transfer to explain type III distribution. In contrast, flagellar genes are usually split into three or more operons, they are not found on plasmids, and their GC content is the same as the surrounding genome. There is no evidence that the flagellum has been spread about by horizontal transfer.”

It follows that the TTSS does not explain the evolution of the flagellum (despite the handwaving of Aizawa 2001). Nor, for that matter, does the bacterial flagellum explain in any meaningful sense the evolution of the TTSS. The TTSS is after all much simpler than the flagellum. The TTSS contains ten or so proteins that are homologous to proteins in the flagellum. The flagellum requires an additional thirty or forty proteins, which are unique. Evolution needs to explain the emergence of complexity from simplicity. But if the TTSS evolved from the flagellum, then all we’ve done is explain the simpler in terms of the more complex.

The scientific literature shows a complete absence of concrete, causally detailed proposals for how coevolution and co-option might actually produce irreducibly complex biochemical systems. In place of such proposals, Darwinists simply observe that because subsystems of irreducibly complex systems might be functional, any such functions could be selected by natural selection. Accordingly, selection can work on those parts and thereby form irreducibly complex systems. All of this is highly speculative, and accounts for cell biologist Franklin Harold’s (2001, 205) frank admission: “There are presently no detailed Darwinian accounts of the evolution of any biochemical or cellular system, only a variety of wishful speculations.”

When I challenged Ken Miller with this quote at the World Skeptics Conference organized by CSICOP summer 2002 (for a summary of the conference see <http://www.csicop.org/si/2002-09/conference.html>), Miller did not challenge the substance of Harold’s claim. Rather, he merely asserted that Harold had been retired a number of years. The implication I took was that Harold was old and out of touch with current biological thinking and therefore could be ignored (in which case one has to wonder what the editors at Oxford University Press were thinking when they agreed to publish Harold’s book). I wish that at the skeptics conference I had followed up more forcefully on Miller’s glib dismissal of Harold. Perhaps Miller will see my response here and clarify why Harold’s retirement has anything to do with the substance of Harold’s claim.

To sum up, the Darwinian mechanism requires a selectable function if that mechanism is going to work at all. Moreover, functional pieces pulled together from various systems via coevolution and co-option are selectable by the Darwinian mechanism. But what is selectable here is the individual functions of the individual pieces and not the function of the yet-to-be-produced system. The Darwinian mechanism selects for preexisting function. It does not select for future function. Once that function is realized, the Darwinian mechanism can select for it as well. But making the transition from existing function to novel function is the hard part. How does one get from functional pieces that are selectable in terms of their individual functions to a system that consists of those pieces and exhibits a novel function? The Darwinian mechanism is no help here. Darwin himself conceded this point. Writing in the *Origin*, he noted: “Unless profitable variations do occur, natural selection can do nothing.” To say that those profitable variations are random errors is to beg precisely the point in question.

Irreducible Complexity Hasn't Shown Darwinism to Be Logically Impossible:

Miller writes: “The doctrine of irreducible complexity was intended to go one step beyond the claim of ignorance. It was fashioned in order to provide a rationale for claiming that the bacterial flagellum couldn't have evolved, even in principle, because it is irreducibly complex. Now that a simpler, functional system (the TTSS) has been discovered among the protein components of the flagellum, the claim of irreducible complexity has collapsed, and with it any ‘evidence’ that the flagellum was designed.”

Miller is convinced that intelligent design must be after logical certainty and mathematical proof in eliminating natural mechanisms for the emergence of certain types of biological complexity and that if ID proponents cannot attain that level of certainty, then our efforts are wasted. What's more, Miller rightly maintains that no logical impossibility prevents the Darwinian mechanism from bringing about Behe's irreducibly complex biochemical systems — taken as a mere conceptual possibility, the TTSS might be a precursor to the bacterial flagellum via a Darwinian evolutionary pathway (absent any details, just about anything is after all logically or conceptually possible). Thus, if strict logical certainty were our aim, our case against Darwinian evolution would indeed “collapse,” much as any putative theorem in mathematics would “collapse” if the justification offered did not follow as a strict logical deduction from accepted axioms or premises.

But logical certainty or mathematical proof were never the issue. We are, after all, in the realm of science and empirics and not in the realm of pure mathematics and logic when it comes to understanding the emergence of biological complexity (despite mathematics' relevance to the discussion). In consequence, logical possibility and impossibility had better not be our only criteria for assessing the emergence of biological complexity. If they were, we wouldn't need Darwin. Indeed, there's no logical impossibility for some vastly improbable thermodynamic accident to bring about all the nifty life forms we see in nature. Chance unaided by natural selection is fully capable of accounting for biology if logical possibility and impossibility are our only constraints on theory construction.

Yet for Miller, intelligent design purports to show that it is logically impossible for the Darwinian mechanism to generate irreducibly complex biochemical systems. And since there is in fact no logical impossibility for the Darwinian mechanism to accomplish this feat, intelligent design has no traction against Darwinism and can safely be ignored (at least on scientific, though perhaps not on political, grounds). The question we should therefore be asking is why Miller, as a scientist, raises the standard so high against intelligent design. Certainly he realizes that as a criterion for judging claims, strict logical possibility/impossibility applies only in mathematics. Miller might answer that intelligent design proponents have themselves set so high a standard and that he is merely reporting that fact. But Miller is responding to Behe and me. For my part, I carefully avoid tying intelligent design's critique of Darwinism to the unreasonably high standard of logical impossibility or mathematical certainty (though, granted, I employ mathematics). Nor does a charitable reading of Behe yield such an interpretation. So let me pose the question again: Why is intelligent design held to such a high standard when that standard is

absent from the rest of the empirical sciences (nowhere else in the natural sciences is strict logical possibility/impossibility enforced, not even with the best established physical laws like the first and second laws of thermodynamics)?

What's behind this double-standard is a curious logic that propels evolutionary reasoning. I call it *evolutionary logic* or the *logic of credulity*. Evolutionary logic takes the form of a *reductio ad absurdum*. The absurdity is intelligent design or more generally any substantive teleology. For evolutionary biologists, to treat design or teleology as fundamental modes of explanation capable of accounting for the emergence of biological structures is totally unacceptable. Any valid argument that concludes design in such cases must therefore derive from faulty premises. Thus, in particular, any claim that entails, makes probable, or otherwise implicates design in the emergence of biological structures must be rejected. But evolutionary logic doesn't stop there. Not only must any claim that supports design be rejected, but any claim that rules out design thereby demands assent and commands belief. Hence evolution's logic of credulity — belief in an evolutionary claim is enjoined simply because it acts as a defeater to design and not because any actual evidence supports it.

Miller's appeal to the TTSS as a precursor on an indirect Darwinian pathway to the bacterial flagellum is a case in point. Behe has decisively ruled out direct Darwinian pathways as unable to account for irreducibly complex biochemical systems (a direct Darwinian pathway being one where a system evolves by improving a fixed given function). If indirect Darwinian pathways could also be ruled out as unable to account for such systems, that would sink Darwinism and support intelligent design (an indirect Darwinian pathway being one where a system evolves by also modifying its function). But intelligent design in biology is unthinkable — *you can't go there!* So anything that leads you there must be rejected and anything that protects you from going there receives support. The Darwinian conclusion: indirect Darwinian pathways are not ruled out and in fact account for the way such systems evolved. This is a counsel of credulity: Believe despite the lack of evidence because the alternative is unthinkable.

Behe decisively closes off avenues by which the Darwinian mechanism could have given rise to irreducibly complex systems. Yet instead of casting doubt on the Darwinian mechanism, Behe's closing off of avenues merely confirms for Miller that the Darwinian mechanism operated through other avenues, which have the advantage of being completely unspecified and unsupported by empirical evidence, to wit, indirect Darwinian pathways. Behe rules out ways the Darwinian hypothesis might be true. Is this hypothesis therefore disconfirmed or brought into question? No. Instead, ways (however implausible) that the Darwinian hypothesis might remain true are thereby confirmed.

Miller's Foray into the Mathematics of the Design Inference:

Miller critiques my combinatorial analysis of the bacterial flagellum from section 5.10 of *No Free Lunch* (2002). He makes two main points: (1) That the combinatorial analysis I develop cannot properly be applied to the flagellum. (2) That any such analysis presupposes the very outcome that ID theorists are supposed to be establishing, namely, that the bacterial flagellum is

beyond the remit the Darwinian mechanism (or, as Miller puts it, the ID approach “assumes impossibility”).

As for (1), Miller writes: “This approach [i.e., breaking the probability of the flagellum into an origination, localization, and configuration probability] overlooks the fact that the last two probabilities [i.e., localization and configuration] are actually contained within the first. Localization and self-assembly of complex protein structures in prokaryotic cells are properties generally determined by signals built into the primary structures of the proteins themselves. The same is likely true for the amino acid sequences of the 30 or so protein components of the flagellum and the approximately 20 proteins involved in the flagellum’s assembly.... Therefore, if one gets the sequences of all the proteins right, localization and assembly will take care of themselves. To the ID enthusiast, however, this is a point of little concern.”

Actually, I made a similar point in *No Free Lunch* (2002, 300): “An objection may now be raised against this analysis.... The parts of a flagellum do not have to simultaneously converge [i.e., localize] by chance — they self-assemble in order when chance collisions allow specific, cooperative, local electrostatic interactions to lock the structure together, one piece at a time.” Localization and configuration seem to come along for free once you’ve got origination. But this is too simple. We can imagine the various proteins that go into a flagellum occurring in, let’s say, three distinct molecular machines within a bacterium that lacks a flagellum. Although all the proteins are there for the flagellum, no flagella are formed. Why? Because genetic regulation within the bacterium targets the proteins to the specific molecular machines within which they occur. It’s not enough for the proteins merely to be formed and then automatically snap together to form a flagellum. The localization probability therefore refers to such regulation.

Similarly with configuration, we can imagine proteins homologous to those of a flagellum all being in a bacterial cell. Moreover, we can imagine genetic regulation targeting all these proteins to the same location in the right order to build a flagellum. And yet, if these proteins are perturbed from their precise amino-acid sequencing in the flagellum, they will in all likelihood not be adapted to each other and therefore fail to form a functioning flagellum. Thus, even though localization and configuration probabilities can be thought to be built into the origination probability, in fact they are separable and a probabilistic analysis rightly takes into account their separability. Miller’s point is indeed of concern to ID enthusiasts, as any charitable reading of our work would make clear.

And that brings us to point (2), in which Miller argues that the probabilistic analysis I offer is irrelevant to calculating the probabilities actually connected with the emergence of the bacterial flagellum. He writes: “By treating the flagellum as a ‘discrete combinatorial object’ [Dembski] has shown only that it is unlikely that the parts [of the] flagellum could assemble spontaneously. Unfortunately for his argument, no scientist has ever proposed that the flagellum or any other complex object evolved that way. Dembski, therefore, has constructed a classic ‘straw man’ and blown it away with an irrelevant calculation. By treating the flagellum as a discrete combinatorial object he has assumed in his calculation that no subset of the 30 or so proteins of the flagellum could have biological activity. As we have already seen, this is wrong. Nearly a third of those proteins are closely related to components of the TTSS, which does indeed have biological activity. A calculation that ignores that fact has no scientific validity.”

First off, it's easy to see that the calculation is indeed relevant, for if the spontaneous formation of the proteins occurring in the flagellum had high joint probability, ID theorists and Darwinians would be agreed that the flagellum would not be a system that required design — if the probability of the parts of the flagellum forming spontaneously were high, the bacterial flagellum's design would be refuted. So Miller's point, presumably, is not that such calculations are irrelevant but that they don't go far enough, namely, that they doesn't treat the probabilities that might arise from a Darwinian pathway leading to the flagellum.

But in fact they do. My point in section 5.10 was not to calculate every conceivable probability connected with the stochastic formation of the flagellum (note that the Darwinian mechanism is a stochastic process). My point, rather, was to sketch out some probabilistic techniques that could then be applied by biologists to the stochastic formation of the flagellum. As I emphasized in *No Free Lunch* (2002, 302): “There is plenty of biological work here to be done. The big challenge is to firm up these numbers and make sure they do not cheat in anybody's favor.”

Miller doesn't like my number $10^{(-1170)}$, which is one improbability that I calculate for the flagellum. Fine. But in pointing out that a third of the proteins in the flagellum are closely related to components of the TTSS, Miller tacitly admits that two-thirds of the proteins in the flagellum are unique. In fact they are (indeed, if they weren't, Miller would be sure to point us to where the homologues could be found). Applied to those remaining two-third of flagellar proteins, my calculation yields something like $10^{(-780)}$, which also falls well below my universal probability bound.

But let's suppose we found several molecular systems like the TTSS that jointly took into account all the flagellar proteins (assume for simplicity no shared or extraneous proteins). Those proteins would be similar but, in all likelihood, not identical to the flagellar proteins (strict identity would itself be vastly improbable). But that then raises the question how those several molecular machines can come together so that proteins from one molecular machine adapt to proteins from another molecular machine to form an integrated functional system like the flagellum. As John Bracht (2003) points out: “The problem is that the proteins which are to become the flagellum are coming from systems that are distinctly non-flagellar in nature (after all, we are discussing the origin of that very system) and being co-modified from their original molecular interactions into an entirely new set of molecular interactions. Old interfaces and binding sites must be removed and new ones must be created. But given the sheer number of flagellar proteins that must co-evolve, [thereby] co-generating all the proteins required for flagellar function (again, this is true *at some point in the flagellum's evolutionary past even if there were earlier steps that were not so tightly constrained*), the Darwinian explanation is really no different from appealing to a miracle.”

We can do the probabilistic analysis at the level of individual proteins as I did in *No Free Lunch*. Or we can do it at higher levels of organization like functional subsystems (e.g., the TTSS). But all such probabilistic analyses still point up vast improbabilities. If Miller is right about Darwinian evolution being responsible for the bacterial flagellum, there had to exist bacterial genomes $A = A_1$ through $A_n = B$ where one genome represents an evolutionary precursor to the next such that $A (= A_1)$ contains no flagellar genes (not even homologues) and $B (= A_n)$

has the operons for a fully functioning flagellum. Moreover, the change from A_i to $A_{(i+1)}$ must in each case be reasonably probable in the light of any selection pressure operating on the organisms containing those genomes. Miller of course has nothing like this — no such sequence and no such probabilistic analysis (i.e., no probabilistic analysis showing $P(A_{(i+1)}|A_i) \gg 0$). He has B (e.g., the genome of *E. coli*) and C (e.g., the genome of *Yersinia pestis*, which codes for the TTSS), and he has no good argument for why C should fall somewhere within the progression A_1 through A_n , much less whether there even is such a progression.

In *No Free Lunch*, I offer a way to try to get a handle on such progressions through what I call perturbation identity and tolerance factors (see section 5.10). The idea is to take a functional system, perturb it, and determine how perturbation affects the probability of retaining function. If the probability of retaining function is high, then this would constitute evidence that a Darwinian pathway could readily lead to the system in question. Essentially the idea here is one used in AI search strategies. Miller's task, to vindicate Darwinism in regard to the flagellum, is to exhibit a *forward chaining* search through genomic space that issues in a genome coding for the flagellum. But neither he nor anyone else in the biological community can do this. So an alternative approach is to try a *backward chaining* search that preserves function. What I show through my perturbation probabilities is that such searches face huge probabilistic hurdles. What this means is that if a forward chaining search succeeds, it does so as a highly specific and isolated path through genomic space. In that case the step-by-step probabilities moving forward from A_i to $A_{(i+1)}$ could still be large enough not to overturn my universal probability bound. But absent a successful forward chaining search, there is no reason to think that success is even possible. Successful forward chaining assumes that a sequence like A_1 through A_n and can be made explicit. There is no evidence of this.

In fact, if we look to human invention, we have all the more reason to think that the Darwinian mechanism cannot account for successful forward chaining searches and thus for systems like the bacterial flagellum. The field of technological evolution broadly distinguishes between routine and innovative problems (see Savransky 2000 as well as Dembski 2001 and Bracht 2001). Routine problems are amenable to trial-and-error problem-solving techniques (of which the Darwinian mechanism constitutes an instance). Innovative problems, by contrast, require conceptual insights that transcend trial-and-error tinkering. Moreover, in human experience, irreducibly complex designed systems are invariably solutions to innovative, not routine, problems. Since we don't expect trial and error to produce irreducible complexity in the human context, why should we expect it to produce it in the biological context? The usual counterargument here is to charge anthropomorphism and invoke deep time — natural selection should not be compared to human activity and natural selection has unimaginably more time to work with than human trial-and-error tinkering. But neither of these criticisms holds water. Humans can mimic undirected selection and they can now do it very fast on the computer, thereby compressing deep time into ordinary time. And nevertheless, it remains the case that no genetic algorithm or evolutionary computation has designed a complex, multipart, functionally integrated, irreducibly complex system without stacking the deck by incorporating the very solution that was supposed to be attained from scratch (Dawkins 1986 and Schneider 2000 are among the worst offenders here).

Bottom line: Calculate the probability of getting a flagellum by stochastic (and that includes Darwinian) means any way you like, *but do calculate it*. All such calculations to date have fallen well below my universal probability bound of $10^{(-150)}$. But for Miller all such calculations are besides the point because a Darwinian pathway, though completely unknown, most assuredly exists and, once made explicit, would produce probabilities above my universal probability bound. To be sure, if a Darwinian pathway exists, the probabilities associated with it would no longer trigger a design inference. But that's just the point, isn't it? Namely, whether such a pathway exists in the first place. Miller, it seems, wants me to calculate probabilities associated with indirect Darwinian pathways leading to the flagellum. But until such paths are made explicit, there's no way to calculate the probabilities. This is all very convenient for Darwinism and allows Darwinists to insulate their theory from critique indefinitely. Over six years after Michael Behe made the bacterial flagellum the mascot of the intelligent design movement, Ken Miller has nothing more than the TTSS to point to as a possible evolutionary precursor. Behe and the ID community have therefore successfully shown that Darwinists don't have a clue how the bacterial flagellum might have arisen. Miller, however, wants more, namely for ID proponents to show that Darwinists don't have a prayer for the naturalistic origination of the flagellum. But as a good Roman Catholic, Miller must realize that no sinner is beyond the reach of prayer, not even the Darwinist. At any rate, prayer is not the issue. The issue is whether design does have a clue about the flagellum. The intelligent design community argues that it does. Miller doesn't like the argument, but don't think for a moment that he has anything equal or better.

Conflating ID with Interventionism:

According to Miller, intelligent design "requires that the source of each and every novelty of life was the direct and active involvement of an outside designer whose work violated the very laws of nature he had fashioned.... The notion at the heart of today's intelligent design movement is that the direct intervention of an outside designer can be demonstrated by the very existence of complex biochemical systems" Miller and I have discussed this criticism in public debate on several occasions. By now he should know better.

Intelligent design does not require organisms to emerge suddenly or be specially created from scratch by the intervention of a designing intelligence. To be sure, intelligent design is compatible with the creationist idea of organisms being suddenly created from scratch. But it is also perfectly compatible with the evolutionist idea of new organisms arising from old by a process of generation. What separates intelligent design from naturalistic evolution is not whether organisms evolved or the extent to which they evolved but what was responsible for their evolution.

Naturalistic evolution holds that material mechanisms alone are responsible for evolution (the chief of these being the Darwinian mechanism of random variation and natural selection). Intelligent design, by contrast, holds that material mechanisms are capable of only limited evolutionary change and that any substantial evolutionary change would require input from a designing intelligence. Moreover, intelligent design maintains that the input of intelligence into biological systems is empirically detectable, that is, it is detectable by observation through the methods of science. For intelligent design the crucial question therefore is not whether organisms

emerged through an evolutionary process or suddenly from scratch, but whether a designing intelligence made a discernible difference regardless how organisms emerged.

For a designing intelligence to make a discernible difference in the emergence of some organism, however, seems to Miller to require that an intelligence intervened at specific times and places to bring about that organism and thus again seems to require some form of special creation. This in turn raises the question: How often and at what places did a designing intelligence intervene in the course of natural history to produce those biological structures that are beyond the power of material mechanisms? Thus, according to Miller, intelligent design draws an unreasonable distinction between material mechanisms and designing intelligences, claiming that material mechanisms are fine most of the time but then on rare (or perhaps not so rare) occasions a designing intelligence is required to get over some hump that material mechanisms can't quite manage. Hence Miller's reference to "an outside designer violat[ing] the very laws of nature he had fashioned."

As I've pointed out to Miller on more than one occasion, this criticism is misconceived. The proper question is not how often or at what places a designing intelligence intervenes but rather at what points do signs of intelligence first become evident. Intelligent design therefore makes an epistemological rather than ontological point. To understand the difference, imagine a computer program that outputs alphanumeric characters on a computer screen. The program runs for a long time and throughout that time outputs what look like random characters. Then abruptly the output changes and the program outputs the most sublime poetry. Now, at what point did a designing intelligence intervene in the output of the program? Clearly, this question misses the mark because the program is deterministic and simply outputs whatever the program dictates.

There was no intervention at all that changed the output of the program from random gibberish to sublime poetry. And yet, the point at which the program starts to output sublime poetry is the point at which we realize that the output is designed and not random. Moreover, it is at that point that we realize that the program itself is designed. But when and where was design introduced into the program? Although this is an interesting question, it is ultimately irrelevant to the more fundamental question whether there was design in the program and its output in the first place. We can tell whether there was design (this is ID's epistemological point) without introducing any doctrine of intervention (ID refuses to speculate about the ontology of design)

Intelligent design is not a theory about the frequency or locality at which a designing intelligence intervenes in the material world. It is not an interventionist theory at all. Indeed, intelligent design is perfectly compatible with all the design in the world being front-loaded in the sense that all design was introduced at the beginning (say at the Big Bang) and then came to expression subsequently over the course of natural history much as a computer program's output becomes evident only when the program is run. This actually is an old idea, and one that Charles Babbage, the inventor of the digital computer, explored in the 1830s in his *Ninth Bridgewater Treatise* (thus predating Darwin's *Origin of Species* by twenty years).

Let's be clear, however, that such preprogrammed evolution would be very different from evolution as it is now conceived. Evolution, as currently presented in biology textbooks, is blind — nonpurposive material mechanisms run the show. Within this naturalistic conception of

evolution, the origin of any species gives no evidence of actual design because mindless material mechanisms do all the work. Within a preprogrammed conception of evolution, by contrast, the origin of some species and biological structures would give evidence of actual design and demonstrate the inadequacy of material mechanisms to do such design work. Thus naturalistic evolution and preprogrammed evolution would have different empirical content and be distinct scientific theories.

Of course, such preprogrammed evolution or front-loaded design is not the only option for the theory of intelligent design. Intelligent design is also compatible with discrete interventions at intermittent times and diverse places. Intelligent design is even compatible with what philosophers call an occasionalist view in which everything that occurs in the world is the intended outcome of a designing intelligence but only some of those outcomes show clear signs of being designed. In that case the distinction between natural causes and intelligent causes would concern the way we make sense of the world rather than how the world actually is (another case of epistemology and ontology diverging).

We may never be able to tell how often or at what places a designing intelligence intervened in the world or even whether there was any intervention in Miller's sense of violating natural laws. But that's okay. What's crucial for the theory of intelligent design is the ability to identify signs of intelligence in the world — and in the biological world in particular — and therewith conclude that a designing intelligence played an indispensable role in the formation of some object or the occurrence of some event. That is the start. Often in biology there will be clear times and locations where we can say that design first became evident. But whether that means a designing intelligence actually intervened at those points will require further investigation and may indeed not be answerable. As the computer analogy above indicates, the place and time at which design first becomes evident need have no connection with the place and time at which design was actually introduced.

In the context of biological evolution, this means that design can be real and discernible in evolutionary change without requiring an explicit “design event,” like a special creation, miracle, or supernatural intervention. At the same time, however, for evolutionary change to exhibit actual design would mean that material mechanisms were inadequate by themselves to produce that change. The question, then, that requires investigation is not simply what are the limits of evolutionary change, but what are the limits of evolutionary change when that change is limited to material mechanisms. This in turn requires examining the material factors within organisms and in their environments capable of effecting evolutionary change. The best evidence to date indicates that these factors are inadequate to drive full-scale macroevolution. Something else is required — intelligence.

Miller's Foray into Theology:

Miller concludes his essay by remarking, “The struggles of the intelligent design movement are best understood as clamorous and disappointing double failures — rejected by science because they do not fit the facts, and having failed religion because they think too little of God.” As for intelligent design's rejection by science, Miller's claim needs to be adjusted as follows: “rejected

by a naturalistic construal of science because it does not fit a dogmatically held theory, to wit, Darwinism.” As for intelligent design’s rejection as bad theology, Miller would do well to review his own theology. In *Finding Darwin’s God*, Miller (1999, 241) writes: “The indeterminate nature of quantum events would allow a clever and subtle God to influence events in ways that are profound, but scientifically undetectable to us. Those events could include the appearance of mutations, the activation of individual neurons in the brain, and even the survival of individual cells and organisms affected by the chance processes of radioactive decay.” As far as Miller is concerned, this presumably is good theology. And as an “orthodox Catholic” (Miller referred to himself that way in the PBS evolution series that aired September 2001), Miller presumably accepts full-blown divine intervention in salvation history even if he repudiates it in natural history. Indeed, what are we to make of this Jesus fellow, who walks on water, multiplies loaves and fishes, gets born of a virgin, and then resurrects after being crucified?

There’s an obvious difficulty with Miller’s theological criticism: Why is it necessary to a good theology that a designing intelligence act in ways that are “scientifically undetectable to us.” It’s certainly prudent, as a matter of maintaining one’s respectability in Western intellectual high culture, to assert the scientific undetectability of design (those crazy fundamentalists, after all, need to be kept at bay). But as a matter of good theology, which presumably means a theology that is at once logically coherent and faithful to the Christian tradition, why in the world should “scientific undetectability” be an issue at all? The detectability of something, after all, does not undercut its freedom of expression. That, after all, is Miller’s main concern, that intelligent design will somehow undercut the freedom of God and creation to be creative. But that intelligent design, by stressing scientific detectability, should undercut divine freedom doesn’t follow at all. What scientific detectability addresses is not the freedom of God or creation, but the completeness of material mechanisms and natural laws to characterize everything that happens in nature. Now that completeness is not part of “good” theology. In fact, when Friedrich Schleiermacher, the father of liberal theology, naturalized Christian theology in this way (cf. Schleiermacher’s emphasis on “the system of nature” in his treatise *The Christian Faith*), it was as a concession to the monism of Spinoza on the one hand and the determinism of Newtonian physics on the other, both of which are themselves problematic.

The charge that ID is bad theology, just as the charge that it is bad science, is a convenient fiction. In the PBS series to which I just adverted, Miller called himself both an “orthodox Catholic” and an “orthodox Darwinian.” If you are an orthodox Darwinian, then the best theology you can come up with is probably something like what Miller sketches in *Finding Darwin’s God*. But intelligent design is making clear that there’s no reason to be an orthodox Darwinian and thus no reason to accept a theology built on Darwinian foundations. At any rate, good theology did not come of age with Darwin. Far from it. Darwinism does just fine without any theology whatsoever. When Richard Dawkins (1986, 6) writes that Darwin made it possible to be an intellectually fulfilled atheist, he’s not far from the master, who thought that no knowledge about God of any sort was possible. Miller’s forced marriage of Darwinism and theology is an unhappy one. In the name of good theology, intelligent design is only too happy to preside over their divorce.

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Appendix 5: “Irreducible Complexity Revisited,” Section 5

article by Wm. A. Dembski, version 2.0, revised 2.23.04, full article available online at http://www.designinference.com/documents/2004.01.Irred_Compl_Revisited.pdf

ABSTRACT: Michael Behe’s concept of irreducible complexity, and in particular his use of this concept to critique Darwinism, continues to come under heavy fire from the biological community. The problem with Behe, so Darwinists inform us, is that he has created a problem where there is no problem. Far from constituting an obstacle to the Darwinian mechanism of random variation and natural selection, irreducible complexity is thus supposed to be eminently explainable by this same mechanism. But is it really? It’s been eight years since Behe introduced irreducible complexity in *Darwin’s Black Box* (a book that continues to sell 15,000 copies per year in English alone). I want in this essay to revisit Behe’s concept of irreducible complexity and indicate why the problem he has raised is, if anything, still more vexing for Darwinism than when he first raised it. The first four sections of this essay review and extend material that I’ve treated elsewhere. The last section contains some novel material.

[sections 1 to 4 omitted]

5 The Connection with Specified Complexity

In my books *The Design Inference* and *No Free Lunch*, I describe a formal criterion for detecting design, namely, specified complexity.⁷⁰ In this essay, we’ve seen that there are no detailed, testable, step-by-step Darwinian accounts for the evolution of any irreducibly complex biochemical machine such as the bacterial flagellum. What’s more, without the bias of speculative Darwinism coloring our conclusions, we are naturally inclined to see such irreducibly complex systems as the products of intelligent design. All our intuitions certainly point in that direction. That’s why Richard Dawkins writes, “Biology is the study of complicated things that give the appearance of having been designed for a purpose.”⁷¹ That’s also why Francis Crick writes, “Biologists must constantly keep in mind that what they see was not designed, but rather evolved.”⁷² Yet for Dawkins, Crick, and fellow Darwinists, the appearance of design in biology cannot be trusted. Accordingly, any intuitions that lead us to see actual design in biological systems are in fact leading us astray.

But intuitions need not lead us astray; they can also lead us aright. In fact, they often lead us to truths that might otherwise elude us. How, then, do scientists differentiate between the sound intuitions that lead us aright and the faulty intuitions that lead us astray? The problem for science with intuitions is that they are informal and imprecise. Hence, to determine whether intuitions are leading us astray or aright, scientists attempt to flesh out intuitions with precise formal analyses. Darwinists claim to have done just that. Thus, they purport to have shown where our intuitions about design in biology break down and how the Darwinian selection mechanism can bring about the appearance of design in biology. But Darwinists have demonstrated no such thing. As we’ve seen in the previous sections, Darwin’s theory offers no insight into the emergence of irreducibly complex molecular machines.

It follows that we need once again to take seriously our intuitions that such systems (notably the bacterial flagellum) are in fact designed. The challenge, then, for the design theorist is to provide precise formal analyses showing that our intuitions about design in biology are indeed justified and, specifically, how various biological systems satisfy the formal criterion for detecting design described in my other writings, namely, the criterion of specified complexity.

What, then, does such a formal, design-theoretic analysis of irreducibly complex systems look like? How does it demonstrate that such systems are indeed complex and specified, therefore exhibit specified complexity, and thus are in fact designed? The details here are technical, but the general logic by which design theorists argue that irreducibly complex systems exhibit specified complexity is straightforward: for a given irreducibly complex system and any putative evolutionary precursor, show that the probability of the Darwinian mechanism evolving that precursor into the irreducibly complex system is small. In such analyses, specification is never a problem—in each instance, the irreducibly complex system, any evolutionary precursor, and any intermediate between the precursor and the final irreducibly complex system are always specified in virtue of their biological function. Also, the probabilities here need not be calculated exactly. It's enough to establish reliable upper bounds on the probabilities and show that they are small. What's more, if the probability of evolving a precursor into a plausible intermediate is small, then the probability of evolving that precursor through the intermediate into the irreducibly complex system will a fortiori be small.

Darwinists object to this approach to establishing the specified complexity of irreducibly complex biochemical systems. They contend that design theorists, in taking this approach, have merely devised a “tornado-in-a-junkyard” strawman. The image of a “tornado in a junkyard” is due to astronomer Fred Hoyle. Hoyle imagined a junkyard with all the pieces for a Boeing 747 strewn in disarray and then a tornado blowing through the junkyard and producing a fully assembled 747 ready to fly.⁷³ Darwinists object that this image has nothing to do with how Darwinian evolution produces biological complexity. Accordingly, in the formation of irreducibly complex systems like the bacterial flagellum, all such arguments are said to show is that these systems could not have formed by purely random assembly. But, Darwinists contend, evolution is not about randomness. Rather, it is about natural selection sifting the effects of randomness.

To be sure, if design theorists were merely arguing that pure randomness cannot bring about irreducibly complex systems, there would be merit to the Darwinists' tornado-in-a-junkyard objection. But that's not what design theorists are arguing. The problem with Hoyle's tornado-in-a-junkyard image is that, from the vantage of probability theory, it made the formation of a fully assembled Boeing 747 from its constituent parts as difficult as possible. But what if the parts were not randomly strewn about in the junkyard? What if, instead, they were arranged in the order in which they needed to be assembled to form a fully functional 747. Furthermore, what if, instead of a tornado, a robot capable of assembling airplane parts were handed the parts in the order of assembly? How much knowledge would need to be programmed into the robot for it to have a reasonable probability of assembling a fully functioning 747? Would it require more knowledge than could reasonably be ascribed to a program simulating Darwinian evolution?

Design theorists, far from trying to make it difficult to evolve irreducibly complex systems like the bacterial flagellum, strive to give the Darwinian selection mechanism every legitimate advantage in evolving such systems. The one advantage that cannot legitimately be given to the Darwinian selection mechanism, however, is prior knowledge of the system whose evolution is in question. That would be endowing the Darwinian mechanism with teleological powers (in this case foresight and planning) that Darwin himself insisted it does not, and indeed cannot, possess if evolutionary theory is effectively to dispense with design. Yet even with the most generous allowance of legitimate advantages, the probabilities computed for the Darwinian mechanism to evolve irreducibly complex biochemical systems like the bacterial flagellum always end up being exceedingly small.⁷⁴

The reason these probabilities always end up being so small is the difficulty of coordinating successive evolutionary changes apart from teleology or goal-directedness. In the Darwinian mechanism, neither selection nor variation operates with reference to future goals (like the goal of evolving a bacterial flagellum from a bacterium lacking this structure). Selection is natural selection, which is solely in the business of conferring immediate benefits on an evolving organism. Likewise, variation is random variation, which is solely in the business of perturbing an evolving organism's heritable structure without regard for how such perturbations might benefit or harm future generations of the organism.

In attempting to coordinate the successive evolutionary changes needed to bring about irreducibly complex biochemical machines, the Darwinian mechanism therefore encounters a number of daunting probabilistic hurdles. These include the following:⁷⁵

- (1) *Availability*. Are the parts needed to evolve an irreducibly complex biochemical system like the bacterial flagellum even available?
- (2) *Synchronization*. Are these parts available at the right time so that they can be incorporated when needed into the evolving structure?
- (3) *Localization*. Even with parts that are available at the right time for inclusion in an evolving system, can the parts break free of the systems in which they are currently integrated and be made available at the "construction site" of the evolving system?
- (4) *Interfering Cross-Reactions*. Given that the right parts can be brought together at the right time in the right place, how can the wrong parts that would otherwise gum up the works be excluded from the "construction site" of the evolving system?
- (5) *Interface Compatibility*. Are the parts that are being recruited for inclusion in an evolving system mutually compatible in the sense of meshing or interfacing tightly so that, once suitably positioned, the parts work together to form a functioning system?
- (6) *Order of Assembly*. Even with all and only the right parts reaching the right place at the right time, and even with full interface compatibility, will they be assembled in the right order to form a functioning system?
- (7) *Configuration*. Even with all the right parts slated to be assembled in the right order, will they be arranged in the right way to form a functioning system?

To see what's at stake in overcoming these hurdles, imagine you are a contractor who has been hired to build a house. If you are going to be successful at building the house, you will need to overcome each of these hurdles. First, you have to determine that all the items you need to build the house (e.g., bricks, wooden beams, electrical wires, glass panes, and pipes) exist and thus are *available* for your use. Second, you need to make sure that you can obtain all these items within a reasonable period of time. If, for instance, crucial items are back-ordered for years on end, then you won't be able to fulfill your contract by completing the house within the appointed time. Thus, the availability of these items needs to be properly *synchronized*. Third, you need to transport all the items to the construction site. In other words, all the items needed to build the house need to be brought to the *location* where the house will be built.

Fourth, you need to keep the construction site clear of items that would ruin the house or interfere with its construction. For instance, dumping radioactive waste or laying high-explosive mines on the construction site would effectively prevent a usable house from ever being built there. Less dramatically, if excessive amounts of junk found their way to the site (items that are

irrelevant to the construction of the house, such as tin cans, broken toys, and discarded newspapers), it might become so difficult to sort through the clutter and thus to find the items necessary to build the house that the house itself might never get built. Items that find their way to the construction site and hinder the construction of a usable house may thus be described as producing *interfering cross-reactions*.

Fifth, procuring the right sorts of materials required for houses in general is not enough. As a contractor you also need to ensure that they are properly adapted to each other. Yes, you'll need nuts and bolts, pipes and fittings, electrical cables and conduits. But unless nuts fit properly with bolts, unless fittings are adapted to pipes, and unless electrical cables fit inside conduits, you won't be able to construct a usable house. To be sure, each part taken by itself can make for a perfectly good building material capable of working successfully in some house or other. But your concern here is not with some house or other but with the house you are actually building. Only if the parts at the construction site are adapted to each other and interface correctly will you be able to build a usable house. In short, as a contractor you need to ensure that the parts you are bringing to the construction site not only are of the type needed to build houses in general but also share *interface compatibility* so that they can work together effectively.

Sixth, even with all and only the right materials at the construction site, you need to make sure that you put the items together in the correct order. Thus in building the house, you need first to lay the foundation. If you try to erect the walls first and then lay the foundation under the walls, your efforts to build the house will fail. The right materials require the right *order of assembly* to produce a usable house. Seventh and last, even if you are assembling the right building materials in the right order, the materials need also to be arranged appropriately. That's why, as a contractor, you hire masons, plumbers, and electricians. You hire these subcontractors not merely to assemble the right building materials in the right order but also to position them in the right way. For instance, it's all fine and well to take bricks and assemble them in the order required to build a wall. But if the bricks are oriented at strange angles or if the wall is built at a slant so that the slightest nudge will cause it to topple over, then no usable house will result even if the order of assembly is correct. In other words, it's not enough for the right items to be assembled in the right order; rather, as they are being assembled, they also need to be properly *configured*.

Now, as a building contractor, you find none of these seven hurdles insurmountable. That's because, as an intelligent agent, you can coordinate all the tasks needed to clear these hurdles. You have an architectural plan for the house. You know what materials are required to build the house. You know how to procure them. You know how to deliver them to the right location at the right time. You know how to secure the location from vandals, thieves, debris, weather and anything else that would spoil your construction efforts. You know how to ensure that the building materials are properly adapted to each other so that they work together effectively once put together. You know the order of assembly for putting the building materials together. And, through the skilled laborers you hire (i.e., the subcontractors), you know how to arrange these materials in the right configuration. All this *know-how* results from intelligence and is the reason you can build a usable house.

But the Darwinian mechanism of random variation and natural selection has none of this know-how. All it knows is how to randomly modify things and then preserve those random modifications that happen to be useful at the moment. The Darwinian mechanism is an instant gratification mechanism. If the Darwinian mechanism were a building contractor, it might put up a wall because of its immediate benefit in keeping out intruders from the construction site even

though by building the wall now, no foundation could be laid later and, in consequence, no usable house could ever be built at all. That's how the Darwinian mechanism works, and that's why it is so limited. It is a trial-and-error tinkerer for which each act of tinkering needs to maintain or enhance present advantage or select for a newly acquired advantage.

Imagine, therefore, what it would mean for the Darwinian mechanism to clear these seven hurdles in evolving a bacterial flagellum. We start with a bacterium that has no flagellum, no genes coding for proteins in the flagellum, and no genes homologous to genes coding for proteins in the flagellum. Such a bacterium is supposed to evolve, over time, into a bacterium with the full complement of genes needed to put together a fully functioning flagellum. Is the Darwinian mechanism adequate for coordinating all the biochemical events needed to clear these seven hurdles and thereby evolve the bacterial flagellum? To answer yes to this question is to attribute creative powers to the Darwinian mechanism that are implausible in the extreme.

To see this, let's run through these seven hurdles in turn, at each hurdle assessing its potential challenge to the Darwinian evolution of the bacterial flagellum. Let's start with availability: can the Darwinian mechanism clear the *availability hurdle*? To clear this hurdle, the Darwinian mechanism needs to be able to form novel proteins from scratch (the bacterial flagellum, if it evolved at all, evolved from a bacterium without any of the genes, exact or homologous, for the proteins constituting the flagellum). Now it's certainly true that the Darwinian mechanism is capable of tinkering with existing proteins or recruiting them wholesale for new uses. But there is no evidence that it can produce complex specified proteins from scratch (the problem of specified complexity thus arises not just at the level of irreducibly complex molecular machines but even at the level of the individual proteins that make up these machines and constitute their elemental constituents). Moreover, recent work on the extreme functional sensitivity of proteins provides strong evidence that certain classes of proteins are in principle unevolvable by gradual means (and thus a fortiori by the Darwinian mechanism) because small perturbations of these proteins destroy all conceivable biological function (and not merely existing biological function).⁷⁶ Thus, it's highly implausible that the Darwinian mechanism can generate the novel proteins (as well as the novel genes coding for them) required in the evolution of the bacterial flagellum.

What about the *synchronization hurdle*? Some hurdles are easier for the Darwinian mechanism to clear than others, and this is perhaps one of them. Natural selection is capable of locking in existing structures that serve some biologically useful purpose. Thus, once available, a biologically useful structure will tend to remain available. What's more, unlike building contractors, who need to complete projects in narrow windows of time, Darwinian evolution works without immediate deadlines (though note that astrophysics imposes long-term deadlines, as with the Sun turning into a red giant in about 5 billion years, causing it to expand and burn up everything in its path, including the Earth⁷⁷). Thus, the timing with which items become available for systems to evolve tends not to be so critical in biological evolution. The only hitch could be that an item that hitherto has served a biologically useful function and is needed in the future evolution of some irreducibly complex system loses its functional advantage somewhere in the middle of the evolutionary process and thus falls into disuse. If that happens, natural selection will tend to eliminate that item, thereby rendering it unavailable.

The *localization hurdle*, on the other hand, seems considerably more difficult for the Darwinian mechanism to clear. The problem here is that items originally assigned to certain systems need to be reassigned and recruited for use in a newly emerging system. This newly emerging system starts as an existing system that then gets modified with items previously

incorporated in other systems. But how likely is it that these items break free and get positioned at the construction site of an existing system, thereby transforming it into a newly emerging system with a novel or enhanced function? Our best evidence suggests that this repositioning of items previously assigned to different systems is improbable and becomes increasingly improbable as more items need to be repositioned simultaneously at the same location. There are two reasons for this. First, the construction site for a given biochemical system tends to maintain its integrity, incorporating only proteins pertinent to the system and keeping out stray proteins that could be disruptive. Second, proteins don't just break free of systems to which they are assigned as a matter of course; rather, a complex set of genetic changes is required, such as gene duplications, regulatory changes, and point mutations.

The *interfering cross-reaction* hurdle intensifies the challenge to the Darwinian mechanism posed by the previous hurdle. If the bacterial flagellum is indeed the result of Darwinian evolution, then evolutionary precursors to the flagellum must have existed along the way. These precursors would have been functional systems in their own right, and in their evolution to the flagellum would have needed to be modified by incorporating items previously assigned to other uses. These items would then need to have been positioned at the construction site of the given precursor. Now, as we just saw with the localization hurdle, there is no reason to think that this is likely. Typically, a construction site for a given biochemical system has an integrity of its own, incorporating only proteins pertinent to the system and keeping out stray proteins that could be disruptive. But suppose the construction site becomes more open to novel proteins (thus lowering the localization hurdle and thereby raising the probability of clearing it). In that case, by welcoming items that could help in the evolution of the bacterial flagellum, the construction site would also welcome items that could hinder its evolution. It follows that to the degree that the localization hurdle is easy to clear, to that degree the interfering cross-reaction hurdle is difficult to clear, and vice versa.

With the *interface-compatibility hurdle*, we come to the gravest difficulty confronting the Darwinian mechanism. The problem is this. For the Darwinian mechanism to evolve a system, it must redeploy parts previously targeted for other systems. But that's not all. It also needs to ensure that those redeployed parts mesh or interface properly. If not, the evolving system will cease functioning and thus no longer confer a selectable advantage. The products of Darwinian evolution are, after all, kludges. In other words, they are systems formed by sticking together items previously assigned to different uses. Now, if these items were built according to common standards or conventions, there might be some reason to think that they could work together effectively. But natural selection is incapable of instituting such standards or conventions.

Think of cars manufactured by different automobile companies—say, a Chevrolet Impala from the United States and a Honda Accord from Japan. Although these cars will be quite similar and have subsystems and parts that perform identical functions in identical ways, the parts will be incompatible. You can't, for instance, swap a piston from one car for a piston in the other or, for that matter, swap bolts, nuts, and screws from the two vehicles. That's because these cars were designed independently according to different standards and conventions. Of course, at the Chevrolet plant that builds the Impala, there will be common standards and conventions ensuring that different parts of the Impala have compatible interfaces. But across automobile manufacturers (e.g., Chevrolet and Honda), there will be no (or very few) common standards and conventions to which the construction of parts must adhere. In fact, common standards and conventions that facilitate the interface compatibility of distinct functional systems points not just to the design of the systems but also to a common design responsible for the common

standards and conventions.

But the Darwinian mechanism is incapable of such common design. As an instant gratification mechanism, its only stake is in bringing about structures that constitute an immediate advantage to an evolving organism. It has no stake in ensuring that such structures also adhere to standards and conventions that will allow them to interface effectively with other structures down the line. Thus, suppose the model proposed in section 4 for the evolution of the bacterial flagellum is, at least in broad strokes, accurate (though, as we saw in that section, this model is neither detailed nor testable nor step-by-step). Hence, at a crucial stage in the evolution of the bacterial flagellum, a pilus got redeployed and attached to a type III secretory system (TTSS). Yet prior to their juxtaposition, these two systems had evolved independently. Consequently, short of invoking sheer blind luck, there is no reason to think that these systems should work together—any more than there is to think that independently designed cars would have swappable parts. This weakness of Darwinian theory can be tested experimentally: take an arbitrary TTSS and pilus and determine the extent of the genetic modifications needed for the pilus to extrude through the TTSS's protein delivery system. At present, there is no evidence, whether theoretical or experimental, that the Darwinian mechanism can clear the interface compatibility hurdle.

For the Darwinian mechanism to clear the *order-of-assembly hurdle* is also a stretch. The Darwinian mechanism works by accretion and modification: it adds novel parts to already functioning systems as well as modifies existing parts in them. In this way, new systems with enhanced or novel functions are formed. Now, consider what happens when novel parts are first added to an already functioning system. In that case, the earlier system becomes a subsystem of a newly formed supersystem. What's more, the order of assembly of the subsystem will, at least initially (before subsequent modifications), be the same as when the subsystem was a standalone system. In general, however, just because the parts of a subsystem can be put together in a given order doesn't mean those parts can be put together in the same order once it is embedded in a supersystem. In fact, in the evolution of systems like the bacterial flagellum, we can expect the order of assembly of parts to undergo substantial permutations (certainly, this is the case with the model for the evolution of the bacterial flagellum discussed in section 4). How, then, does the order of assembly undergo the right permutations? For most biological systems, the order of assembly is entrenched and does not permit substantial deviations. The burden of evidence is therefore on the Darwinist to show that for an evolving system, the Darwinian mechanism coordinates not only the emergence of the right parts but also their assembly in the right order. Darwinists have done nothing like this.

Finally, we consider the *configuration hurdle*. In the design and construction of human artifacts, this hurdle is one of the more difficult to clear. Nevertheless, in the evolution of irreducibly complex biochemical systems like the bacterial flagellum, this is one of the easier hurdles to clear. That's because in the actual assembly of the flagellum and systems like it, the biochemical parts do not come together haphazardly. Rather, they self-assemble in the right configuration when chance collisions allow specific, cooperative, local electrostatic interactions to lock the flagellum together, one piece at a time. Thus, in the evolution of the bacterial flagellum, once the interface-compatibility and order-of-assembly hurdles are cleared, so is the configuration hurdle. There's a general principle here: for self-assembling structures, such as biological systems, configuration is a byproduct of other constraints (like interface compatibility and order of assembly). But note, this is not to say that the configuration of these systems comes for free. Rather, it is to say that the cost of their configuration is included in other costs.

The seven hurdles that I've just described should not be construed as merely subjective or purely qualitative challenges to the Darwinian mechanism. It is possible to assess objectively and quantitatively the challenge these hurdles pose to the Darwinian mechanism. Associated with each hurdle is a probability:

- p_{avail} The probability that the types of parts needed to evolve a given irreducibly complex biochemical system become available (the *availability probability*).
- p_{synch} The probability that these parts become available at the right time so that they can be incorporated when needed into the evolving system (the *synchronization probability*).
- p_{local} The probability that these parts, given their availability at the right time, can break free of the systems in which they are currently integrated and be localized at the appropriate site for assembly (the *localization probability*).
- $p_{\text{i-c-r}}$ The probability that other parts, which would produce interfering cross-reactions and thereby block the formation of the irreducibly complex system in question, get excluded from the site where the system will be assembled (the *interfering-cross-reaction probability*).
- $p_{\text{i-f-c}}$ The probability that the parts recruited for inclusion in an evolving system interface compatibly so that they can work together to form a functioning system (the *interface-compatibility probability*).
- $p_{\text{o-o-a}}$ The probability that even with the right parts reaching the right place at the right time, and even with full interface compatibility, they will be assembled in the right order to form a functioning system (the *order-of-assembly probability*).
- p_{config} The probability that even with all the right parts being assembled in the right order, they will be arranged in the right way to form a functioning system (the *configuration probability*).

Note that each of these probabilities is conditional on the preceding ones. Thus, the synchronization probability assesses the probability of synchronization *on condition that* the needed parts are available. Thus, the order-of-assembly probability assesses the probability that assembly can be performed in the right order *on condition that* all the parts are available (availability) at the right time (synchronization) at the right place (localization) without interfering cross-reactions and with full interface compatibility. As a consequence, the probability of an irreducibly complex system arising by Darwinian means cannot exceed the following product (note that because the probabilities are conditional on the preceding ones, in forming this product no unwarranted assumption about probabilistic independence is being slipped in here):

$$p_{\text{avail}} \times p_{\text{synch}} \times p_{\text{local}} \times p_{\text{i-c-r}} \times p_{\text{i-f-c}} \times p_{\text{o-o-a}} \times p_{\text{config}}$$

If we now define p_{origin} as the probability of an irreducibly complex system originating by Darwinian means (the *origination probability*), then the following inequality holds (the *origination inequality*):

$$p_{\text{origin}} \leq p_{\text{avail}} \times p_{\text{synch}} \times p_{\text{local}} \times p_{\text{i-c-r}} \times p_{\text{i-f-c}} \times p_{\text{o-o-a}} \times p_{\text{config}}^{78}$$

The origination inequality has far-reaching implications. Because probabilities are numbers between zero and one, this inequality tells us that if even one of the probabilities to the right of the inequality sign is small, then the origination probability must itself be small (indeed, no

bigger than any of the probabilities on the right). It follows that we don't have to calculate all seven probabilities to the right of the inequality sign to ensure that p_{origin} is small. It also follows that none of these probabilities needs to be calculated exactly. It is enough to have reliable upper bounds on these probabilities. If any of these upper bounds is small, then so is the associated probability and so is the origination probability. And if the origination probability is small, then the irreducibly complex system in question is both highly improbable and specified (all these irreducibly complex systems are specified in virtue of their biological function). It follows that if the origination probability is small, then the system in question exhibits specified complexity; and since specified complexity is a reliable empirical marker of actual design, it follows that the system itself is designed.

It will be helpful here to contrast the origination inequality with the Drake equation, which arises in the search for extraterrestrial intelligence (SETI). In 1960, an astrophysicist named Frank Drake organized the first SETI conference and introduced the now-famous Drake equation:

$$N = N_* \times f_p \times n_e \times f_i \times f_i \times f_c \times f_L.^{79}$$

Here are what the terms of this equation mean:

- N** The number of technologically advanced civilizations in the Milky Way Galaxy capable of communicating with Earth.
- N*** The number of stars in the Milky Way Galaxy.
- f_p** The fraction of stars that have planetary systems.
- n_e** The average number of planets per star capable of supporting life.
- f_i** The fraction of those planets in turn where life evolves.
- f_i** The fraction of those planets in turn where intelligent life evolves.
- f_c** The fraction of those planets in turn with civilizations that invent advanced communications technology.
- f_L** The fraction of a planetary lifetime during which communicating civilizations exist.

The Drake equation gauges how likely the search for extraterrestrial intelligence is to succeed: the bigger **N**, the more likely SETI researchers are to find signs of intelligence from distant space.

As with the origination inequality, seven terms determine the Drake equation, namely, the seven terms on the right side of the equality. What's more, these seven terms, as with the seven terms on the right side of the origination inequality, depend on each other successively. For instance, the fraction of planets where intelligent life evolves is defined in terms of the fraction of planets on which life simpliciter evolves.

Despite these interesting parallels between the Drake equation and the origination inequality—not least that both are used for discovering signs of intelligence—there is also a sharp difference. For the Drake equation to convince us that the search for extraterrestrial intelligence is likely to succeed, *none of the terms* on the right side of that equation must get too small. Only then will SETI researchers stand a reasonable chance of discovering signs of extraterrestrial intelligence. By contrast, with the origination inequality, to guarantee the specified complexity, and therefore design, of an irreducibly complex system, it is enough to show that *even one term* on the right side of the inequality is sufficiently small. With regard to

the practical application of these formulas, this difference makes all the difference in the world.

The problem with the Drake equation is that most of the terms cannot be estimated. As Michael Crichton observed in a widely publicized Caltech lecture,

The only way to work the equation is to fill in with guesses. And guesses—just so we’re clear—are merely expressions of prejudice. Nor can there be “informed guesses.” If you need to state how many planets with life choose to communicate, there is simply no way to make an informed guess. It’s simply prejudice. As a result, the Drake equation can have any value from “billions and billions” to zero. An expression that can mean anything means nothing.... I take the hard view that science involves the creation of testable hypotheses. The Drake equation cannot be tested.... There is not a single shred of evidence for any other life forms, and in forty years of searching, none has been discovered.⁸⁰

For the Drake equation to be testable, it must be possible to estimate its terms with confidence. Accordingly, the Drake equation can confirm extraterrestrial intelligence only if *all* its terms can be estimated with confidence (which, for now, they cannot) and turn out to be large.⁸¹ By contrast, the origination inequality confirms an intelligence active in the formation of irreducibly complex biological structures provided that *even one* of its terms can be estimated with confidence and turns out to be small. That’s because as soon as even one term on the right side of the origination inequality is small, the origination probability itself must be at least that small.

Nor is the origination inequality testable only in principle. Take, for instance, the interface-compatibility probability. It is possible to join existing biochemical systems (anything from individual proteins to complex biochemical machines) and determine experimentally the degree to which their interfaces are compatible. It is also possible to take apart existing biochemical systems, perturb them, and then put them back together. To the degree that these systems tolerate perturbation, they are evolvable by Darwinian means. Conversely, to the degree that these systems are sensitive to perturbation, they are unevolvable by Darwinian means. Experiments like this can be conducted on actual biochemical systems. Alternatively, they can be conducted using computer simulations that model biochemical processes. The point is, with the interface-compatibility probability and the other probabilities in the origination inequality, there is no inherent obstacle to deriving reliable, experimentally confirmed estimates for them. Both Darwinists and design theorists have a significant stake in estimating these probabilities, research on which is only now beginning.

The origination inequality has no inherent bias. It does not predetermine whether a given irreducibly complex biochemical system is designed. So long as each of its probabilities is large or remains unestimated, the presumption is against the system exhibiting specified complexity and therefore against it being designed. On the other hand, should any of the probabilities become sufficiently small, then the presumption shifts to the system exhibiting specified complexity and being designed. In this way, the origination inequality makes for a level playing field in deciding between Darwinian and intelligent design theories. Darwinists tacitly consent to the origination inequality whenever they invoke high probability events to support their theory. For instance, in seeking confirmation that antibiotic resistance in bacteria results from the Darwinian mechanism and not intelligent design, Darwinists are happy to note that the probability of the point mutations needed for antibiotic resistance is large.

But having tacitly consented to the origination inequality whenever it confirms Darwinian theory, Darwinists are quick to deny that this inequality can legitimately be employed to

disconfirm Darwinian theory. The double-standard here goes right back to Darwin himself. In the *Origin of Species* Darwin issued the following challenge: “If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down. But I can find out no such case.”⁸² Darwin is here offering one of those heads-I-win-tails-you-lose challenges. Indeed, his challenge is no challenge at all—it guarantees that Darwinian theory will not, and indeed cannot, be subjected to critical scrutiny. As Robert Koons points out,

How could it be proved that something could not possibly have been formed by a process specified no more fully than as a process of “numerous, successive, slight modifications”? And why should the critic [of Darwin’s theory] have to prove any such thing? The burden is on Darwin and his defenders to demonstrate that at least some complex organs we find in nature really can possibly be formed in this way, that is, by some specific, fully articulated series of slight modifications.⁸³

In order even to use the origination inequality, one must first propose specific evolutionary pathways leading to irreducibly complex biochemical systems like the bacterial flagellum. Only with such proposals in hand can one begin to estimate the probabilities that appear in the origination inequality. Moreover, once such proposals are made, they invariably point up the inadequacy of the Darwinian mechanism because the origination probabilities associated with irreducibly complex biochemical systems have, to date, always proven to be small. Design theorists take this as strong confirmation that these systems exhibit specified complexity and are in fact designed. Darwinists, by contrast, take this as simply showing that evolutionary biology has yet to come up with the right evolutionary pathways by which the Darwinian mechanism produced the systems in question.

Who’s right? By now it’s clear that neither party to this controversy is going to give way any time soon. From the vantage of the design theorist, the Darwinist has artificially insulated Darwinian theory and rendered it immune to disconfirmation in principle because the universe of unknown Darwinian pathways can never be exhausted. From the vantage of the Darwinist, on the other hand, nothing less than an in-principle exclusion and exhaustion of all conceivable Darwinian pathways suffices to shift the burden of evidence onto the Darwinist. To an outsider, with no stake in the outcome of this controversy, the asymmetry of these positions will be obvious. Intelligent design allows the evidence of biology both to confirm and to disconfirm it. Darwinism, by contrast, assumes no corresponding burden of evidence—it declares itself the winner against intelligent design by default.

This unwillingness of Darwinism to assume its due evidential burden is unworthy of science. Science, if it is to constitute an unbiased investigation into nature, must give the full range of logically possible explanations a fair chance to succeed. In particular, science may not by arbitrary decree rule out logical possibilities. Evolutionary biology, by unfairly privileging Darwinian explanations, has settled in advance which biological explanations must be true as well as which must be false apart from any consideration of empirical evidence. This is not science. This is arm-chair philosophy. Even if intelligent design is not the correct theory of biological origins, the only way science could discover that is by admitting design as a live possibility rather than by ruling it out in advance. Darwin unfairly stacked the deck in favor of his theory. Notwithstanding, elsewhere in the *Origin of Species*, he wrote: “A fair result can be obtained only by fully stating and balancing the facts and arguments on both sides of each question.”⁸⁴ That balance is now shifting away from Darwinism and toward intelligent design.

Endnotes

¹ Arnhart made this point with special clarity at a several-day symposium devoted to intelligent design at Hillsdale College. The symposium was titled “The Debate over Intelligent Design” and took place November 10-13, 2002. For details, see <http://www.hillsdale.edu/cca/2002/IntelligentDesign/default.htm> (last accessed March 28, 2005). Representing the Darwinian side at this symposium were Larry Arnhart, Michael Ruse, Mano Singham, and Niles Eldredge. Representing the intelligent design side at this symposium were Michael Behe, Jonathan Wells, and William Dembski.

²See Larry Arnhart, *Darwinian Natural Right: The Biological Ethics of Human Nature* (Albany, N.Y.: State University of New York Press, 1998).

³The reference here is to the first verse in John’s Gospel. For the transcript of the debate, go to <http://www.bringyou.to/apologetics/FiringLineDebateCreationEvolution.PDF> (last accessed April 25, 2005). Michael Kinsley moderated this debate. On the pro-ID side were Michael Behe, Phillip Johnson, David Berlinski, and William Buckley. On the pro-evolution side were Kenneth Miller, Eugenie Scott, Michael Ruse, and Barry Lynn.

⁴Raymond E. Brown and Francis J. Maloney, *An Introduction to the Gospel of John* (New York: Doubleday, 2003).

⁵For example, *Intelligent Design: The Bridge Between Science and Theology* (Downers Grove, Ill.: InterVarsity, 1999). Note the subtitle and the religious publisher.

⁶S. Morris Engel, *With Good Reason: An Introduction to Informal Fallacies*, 5th ed. (New York: St. Martin’s Press, 1994), 198.

⁷See <http://www.playboyenterprises.com/foundation/1999winners.html> (last accessed April 25, 2005).

⁸Darwin’s *Descent of Man* is available online. See <http://charles-darwin.classic-literature.co.uk/the-descent-of-man/ebook-page-105.asp> (last accessed April 25, 2005).

⁹Peter Singer, “Heavy Petting,” review of *Dearest Pet: On Bestiality*, by Midas Dekkers, at <http://www.nerve.com/Opinions/Singer/heavyPetting/main.asp>.

¹⁰Randy Thornhill and Craig Palmer, “Why Men Rape,” *The Sciences* (Jan/Feb 2000): 20-28; see also their more extended work on this topic, *The Natural History of Rape: Biological Bases of Sexual Coercion* (Cambridge, Mass.: MIT Press, 2000).

¹¹Michael Ruse and E. O. Wilson, “The Evolution of Ethics,” in *Religion and the Natural Sciences: The Range of Engagement*, ed. J. E. Hutchingson (Orlando, Fl.: Harcourt and Brace, 1991), 310.

¹²See <http://charles-darwin.classic-literature.co.uk/the-descent-of-man/ebook-page-65.asp> (last accessed April 25, 2005).

¹³Richard Dawkins, *The Blind Watchmaker* (New York: Norton, 1986). The first quote is actually the subtitle of this book. The second is taken from page 6.

¹⁴See <http://ffrf.org/ftoday/2000/april2000/weinberg.html> (last accessed April 25, 2005).

¹⁵I personally attended one of those debates in October 1998 at the University of Texas at Austin. Weinberg, Johnson, and I even went out to dineer afterward.

¹⁶Lewontin, “Billions and Billions of Demons,” in the *New York Review of Books*, January 9, 1997.

¹⁷See <http://nosha.secularhumanism.net/whoswho.html> (last accessed April 26, 2005).

¹⁸See http://www.secularhumanism.org/library/fi/cherry_18_1.01.html, point 3 (last accessed April 26, 2005).

¹⁹See <http://www.secularhumanism.org/intro/declaration.html>, point 6 (last accessed April 26, 2005).

²⁰See <http://www.secularhumanism.org/intro/declaration.html>, point 9 (last accessed April 26, 2005).

²¹Ronald L. Numbers, *Darwinism Comes to America* (Cambridge, Mass.: Harvard University Press, 1998), 9, 11.

²²See http://fp.bio.utk.edu/darwin/1998/provine_abstract.html (last accessed April 26, 2005).

²³With regard to evolution functioning as a religion, Darwinist Michael Ruse has been drawing attention to this fact for several years now. See, for instance, the recent piece about Ruse's views in the *Boston Globe* by Peter Dizikes (May 1, 2005): http://www.boston.com/news/globe/ideas/articles/2005/05/01/evolutionary_war/ (last accessed May 12, 2005).

²⁴Semyon Savransky, *Engineering of Creativity: Introduction to TRIZ Methodology of Inventive Problem Solving* (Boca Raton, Fl.: CRC Press, 2000).

²⁵Wallace Arthur, *Biased Embryos and Evolution* (Cambridge: Cambridge University Press, 2004), 36.

²⁶From Berlinski's responses to critics in "A Scientific Scandal?" *Commentary* (June 8, 2003), available online at <http://www.discovery.org/scripts/viewDB/index.php?program=CRSC&command=view&id=1509> (last accessed May 12, 2005).

²⁷For a description of the conference, see <http://www.origins.org/mc> (last accessed April 28, 2005).

²⁸Eugenie Scott, "'Science and Religion', 'Christian Scholarship', and 'Theistic Science': Some Comparisons," *Reports of the National Center for Science Education* 18(2) (1998): 30–32. Available online at http://www.ncseweb.org/resources/articles/6149_science_and_religion_chris_3_1_1998.asp (last accessed March 29, 2005).

²⁹E.g., Jacques Monod, *Chance and Necessity* (New York: Vintage, 1972).

³⁰William A. Dembski, *No Free Lunch* (Lanham, Md.: Rowman and Littlefield, 2002), xiii–xiv.

³¹See http://www.designinference.com/documents/2002.10.27.Disciplined_Science.htm (last accessed April 28, 2005).

³²Stuart Kauffman, "The Emergence of Autonomous Agents," pp. 47-71, in Niels Henrik Gregersen, ed., *From Complexity to Life* (Oxford: Oxford University Press), 68.

³³Mary Jane West-Eberhard, *Developmental Plasticity and Evolution* (Oxford: Oxford University Press, 2003), 16.

³⁴J. A. Scott Kelso and Hermann Haken, "New Laws to Be Expected in the Organism: Synergetics of Brain and Behavior," pp. 137-160, in Michael P. Murphy and Luke A. J. O'Neill, eds., *What Is Life? The Next Fifty Years* (Cambridge: Cambridge University Press, 1995), 141.

³⁵Robert Rosen, *Life Itself: A Comprehensive Inquiry into the Nature, Origin, and Fabrication of Life* (New York: Columbia University Press, 1991), 19, emphasis in the original.

³⁶René Thom, "Darwin Cent Ans Après," pp. 599-605, in René Thom, *Apologie du logos* (Paris: Hachette, 1990), 599.

³⁷Robert G. B. Reid, *Evolutionary Theory: The Unfinished Synthesis* (Ithaca, N.Y.: Cornell University Press, 1985), 360.

³⁸Thomas Kuhn, *The Structure of Scientific Revolutions*, 2nd ed. (Chicago: University of Chicago Press, 1970), 151.

³⁹R. H. Thornhill and D. W. Ussery, "A Classification of Possible Routes of Darwinian Evolution," *Journal of Theoretical Biology* 203 (2000): 111–116.

⁴⁰D.K.Y. Chiu & T.H. Lui, "Integrated Use of Multiple Interdependent Patterns for Biomolecular Sequence Analysis," *International Journal of Fuzzy Systems*, 4(3) (September 2002): 766–775.

⁴¹For a good biography in which all of this is recounted, see Abraham Pais, *Subtle Is the Lord: The Science and the Life of Albert Einstein* (Oxford: Oxford University Press, 1983).

⁴²Quoted in Constance Reid, *Hilbert–Courant* (New York: Springer-Verlag, 1986), 105.

⁴³The quote originally appears in Arthur Koestler and J. R. Smithies, eds., *Beyond Reductionism: New Perspectives in the Life Sciences, Proceedings of the 1968 Alpbach Symposium* (London: Hutchinson, 1969). It is widely available on the web — <http://www.whitehat.com.au/Australia/People/Bragg.asp> (last accessed March 28, 2005).

⁴⁴Richard E. Lenski, “Phenotypic and Genomic Evolution during a 20,000-Generation Experiment with the Bacterium *Escherichia coli*,” *Plant Breeding Reviews* 24 (2004): 225-265.

⁴⁵Francisco J. Ayala, “Darwin’s Revolution,” in *Creative Evolution?!*, eds. J. H. Campbell and J. W. Schopf (Boston: Jones and Bartlett, 1994), 4. The subsection from which this quote is taken is titled “Darwin’s Discovery: Design without Designer.”

⁴⁶See <http://www.seti.org/site/pp.asp?c=ktJ2J9MMIsE&b=179781> (last accessed May 7, 2005).

⁴⁷John Polkinghorne, “God in Relation to Nature,” 1998 *Witherspoon Lecture* (Princeton N.J.: Center for Theological Inquiry), available online at http://www.ctinquiry.org/publications/reflections_volume_2/polkinghorne.htm (last accessed May 7, 2005).

⁴⁸Scientific American Book Club review of *What Makes Biology Unique?* See http://www.sciambookclub.com/doc/full_site_enrollment/detail/fse_product_detail.jhtml?repositoryId=691253050 (last accessed May 5, 2005).

⁴⁹Ernst Mayr, *What Makes Biology Unique? Considerations on the Autonomy of a Scientific Discipline* (Cambridge: Cambridge University Press, 2004), 24–25. Emphasis in the original.

⁵⁰A. C. Burke and A. Feduccia, “Developmental Patterns and the Identification of Homologies in the Avian Hand,” *Science* 278 (October 24, 1997): 666–8, with a perspective by R. Hinchliffe, “The Forward March of the Bird-Dinosaurs Halted?” pp. 596–597.

⁵¹Cited in V. Morell, “*Archaeopteryx*: Early Bird Catches a Can of Worms,” *Science* 259 (February 5, 1993): 764–765.

⁵²Cited in P. Shipman, “Birds Do It... Did Dinosaurs?” *New Scientist* 153 (February 1, 1997): 27–31.

⁵³Sylvia Mader, *Biology*, 6th ed. (Boston, Mass.: McGraw-Hill, 1968), 296.

⁵⁴Elliott Sober, *Reconstructing the Past: Parsimony, Evolution, and Inference* (Boston, Mass.: MIT Press, 1991).

⁵⁵Evolutionary convergence is the topic of an important recent book by one of the world’s leading paleontologists, Cambridge University’s Simon Conway Morris: *Life’s Solution* (Cambridge: Cambridge University Press, 2003).

⁵⁶Consider first Ji Qiang, P. J. Currie, M. A. Norell, and Ji Shu-An, “Two Feathered Dinosaurs from Northeastern China,” *Nature* 393 (June 25, 1998): 753–761 (perspective by K. Padian, same issue, pp. 729–730). Then compare it to the geologic time chronology at <http://www.physicalgeography.net/fundamentals/10b.html> (last accessed May 5, 2005).

⁵⁷Jonathan Wells, *Icons of Evolution* (Washington, DC: Regnery, 2000), 118–120.

⁵⁸See Watson’s autobiographical account of his work on elucidating the structure of DNA in *The Double Helix: A Personal Account of the Discovery of the Structure of DNA* (New York: Atheneum, 1968), in which he cites Schroedinger’s pivotal influence on him.

⁵⁹See Horace Freeland Judson, *The Eighth Day of Creation: The Makers of the Revolution in Biology* (New York: Simon & Schuster, 1979). 50–62.

⁶⁰William A. Dembski, *The Design Inference: Eliminating Chance through Small Probabilities* (Cambridge: Cambridge University Press, 1998), 46.

⁶¹Endorsement on jacket cover of first printing of *The Design Inference*. For whatever reason, current printings of *The Design Inference* omit the jacket cover.

⁶²See http://www.biolsocwash.org/id_statement.html (last accessed May 12, 2005).

⁶³This he did on the PBS evolution series that aired September 2001 — for information on this program see <http://www.reviewevolution.com>.

⁶⁴Peter Douglas Ward, *On Methuselah's Trail: Living Fossils and the Great Extinctions* (New York: W. H. Freeman, 1992), 29.

⁶⁵See Simon Conway Morris, *The Crucible of Creation: The Burgess Shale and the Rise of Animals* (Oxford: Oxford University Press, 1998), 30 as well as National Museum of Natural History's hesitant raising of the possibility that there is an Ediacaran link with the Cambrian Explosion — <http://www.nmnh.si.edu/paleo/shale/pthau.htm> (last accessed May 12, 2005).

⁶⁶Stephen Jay Gould, *Ever Since Darwin: Reflections in Natural History* (New York: W. W. Norton 1977), 121. The situation has not changed since this passage was written.

⁶⁷Michael Ruse, for instance, estimates that at least 90 percent of “active evolutionists” are Darwinian (interview with Lou Dobbs on CNN, May 12, 2005, <http://transcripts.cnn.com/TRANSCRIPTS/0505/12/ldt.01.html> — last accessed May 13, 2005). The percentage is therefore likely to be less among biologists whose area of specialization is not evolution.

⁶⁸Simon Conway Morris, “Evolution: Bringing Molecules into the Fold,” *Cell* 100 (Jan. 7, 2000): 1–11.

⁶⁹Lynn Margulis and Dorion Sagan, *Acquiring Genomes: A Theory of the Origins of Species* (New York: BasicBooks, 2002), 103.

⁷⁰William Dembski, *The Design Inference: Eliminating Chance through Small Probabilities* (Cambridge: Cambridge University Press, 1998); William Dembski, *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence* (Lanham, Md.: Rowman and Littlefield, 2002).

⁷¹Richard Dawkins, *The Blind Watchmaker* (New York: Norton, 1987), 1.

⁷²Francis Crick, *What Mad Pursuit* (New York: Basic Books, 1988), 138.

⁷³Fred Hoyle, *The Intelligent Universe* (New York: Holt, Reinhart, and Winston, 1984), 19.

⁷⁴See, for instance, Dembski, *No Free Lunch*, sec. 5.10.

⁷⁵Ibid. See also Angus Menuge, *Agents Under Fire: Materialism and the Rationality of Science* (Lanham, Md.: Rowman and Littlefield, forthcoming 2004), ch. 4.

⁷⁶Douglas Axe, “Extreme Functional Sensitivity to Conservative Amino Acid Changes on Enzyme Exteriors,” *Journal of Molecular Biology* 301 (2000): 585–595.

⁷⁷Hubert P. Yockey, *Information Theory and Molecular Biology* (Cambridge: Cambridge University Press, 1992), 220–221.

⁷⁸Note that this inequality need not be a strict equality because it can be refined with additional terms. For instance, consider the *retention probability* p_{reten} , the probability that items available at the right time and in the right place stay at the right place long enough (i.e., are retained) for the bacterial flagellum (or whatever irreducibly complex system is in question) to be properly constructed. The retention probability is thus conditional on the availability, synchronization, and localization probabilities and could be inserted as a factor after these terms in the origination inequality.

Or consider the *proportionality probability* p_{propor} , the probability that items available at the right time, in the right place, and long enough occur in the right proportion for the bacterial flagellum to be properly constructed. The protein that goes into the flagellum's whip-like tale requires tens of thousands of subunits; proteins for other parts of the flagellum require only a few hundred subunits. Without the right proportion of suitable parts (subunits), no functioning flagellum can be built. The proportionality probability is conditional on availability, synchronization,

localization, and retention probabilities and could be inserted as a factor after these terms in the origination inequality.

⁷⁹Carl Sagan, *Cosmos* (New York: Random House, 1980), 299.

⁸⁰Michael Crichton, "Aliens Cause Global Warming," Caltech Michelin Lecture, January 17, 2003, available online at http://www.crichton-official.com/speeches/spee-ches_quote04.html (last accessed January 3, 2004).

⁸¹But note, the Drake equation can readily disconfirm the presence of extraterrestrial intelligence: it's enough that even one of the equation's terms can be reasonably estimated and turns out to be small. It follows that with the Drake equation, it is in principle much easier to test the likely failure of the search for extraterrestrial intelligence than its likely success.

⁸²Darwin, *Origin of Species*, 189.

⁸³Robert Koons, "The Check Is in the Mail: Why Darwinism Fails to Inspire Confidence," in W. A. Dembski, ed., *Uncommon Dissent: Intellectuals Who Find Darwinism Unconvincing* (Wilmington, Del.: ISI Books, 2004).

⁸⁴Darwin, *Origin of Species*, 2.