New Yorker May 30, 2005, pp 40-52

ANNALS OF SCIENCE

DEVOLUTION

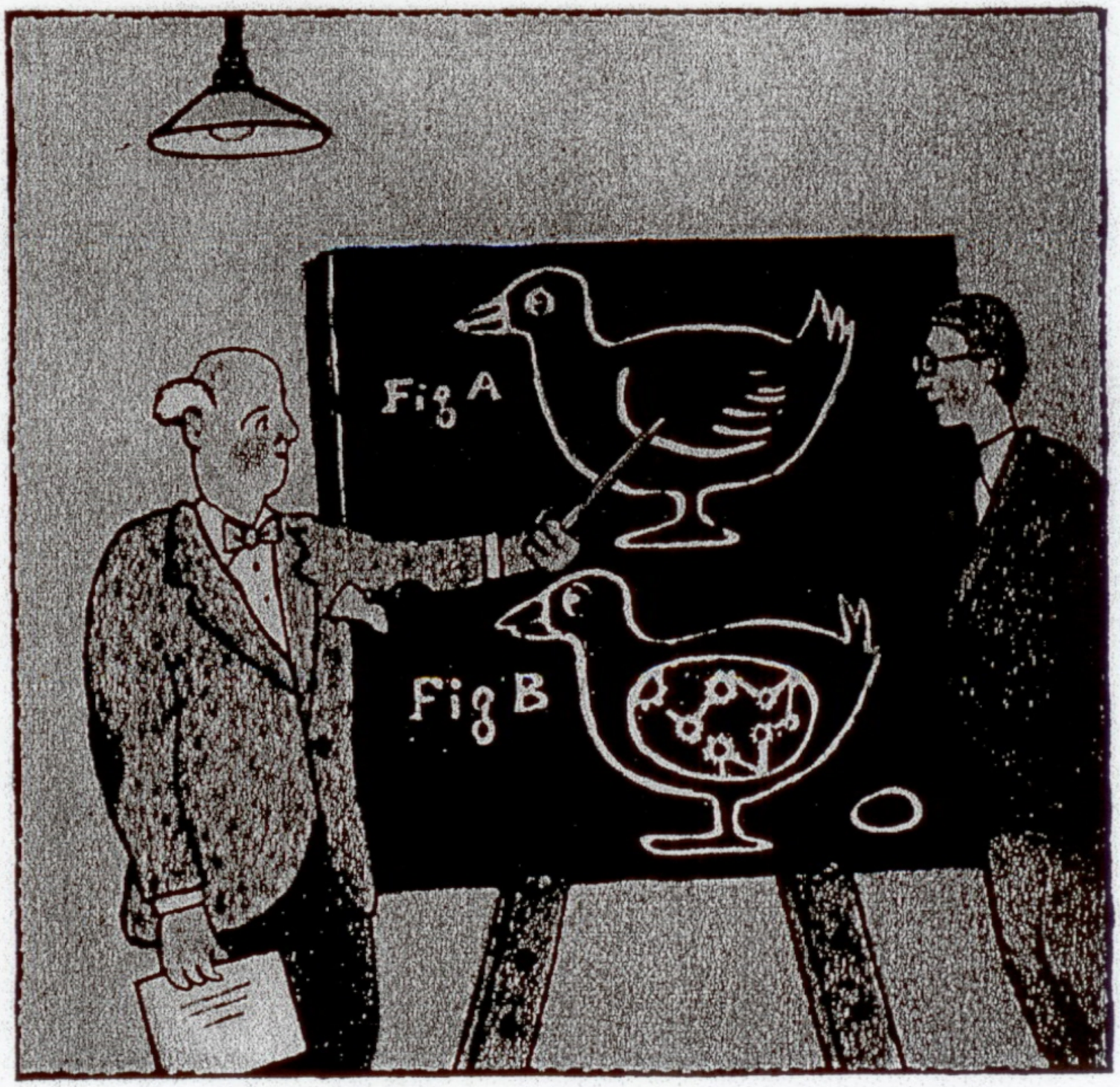
Why intelligent design isn't.

BY H. ALLEN ORR

If you are in ninth grade and live in Dover, Pennsylvania, you are learning things in your biology class that differ considerably from what your peers just a few miles away are learning. In particular, you are learning that Darwin's theory of evolution provides just one possible explanation of life, and that another is provided by something called intelligent design. You are being taught this not because of a recent breakthrough in some scientist's laboratory but because the Dover Area School District's board mandates it. In October, 2004, the board decreed that "students will be made aware of gaps/problems in Darwin's theory and of other theories of evolution including, but not limited to, intelligent design."

While the events in Dover have received a good deal of attention as a sign of the political times, there has been surprisingly little discussion of the science that's said to underlie the theory of intelligent design, often called I.D. Many scientists avoid discussing I.D. for strategic reasons. If a scientific claim can be loosely defined as one that scientists take seriously enough to debate, then engaging the intelligent-design movement on scientific grounds, they worry, cedes what it most desires: recognition that its claims are legitimate scientific ones.

Meanwhile, proposals hostile to evolution are being considered in more than twenty states; earlier this month, a bill was introduced into the New York State Assembly calling for instruction in intelligent design for all public-school students. The Kansas State Board of Education is weighing new standards, drafted by supporters of intelligent design, that would encourage schoolteachers to challenge Darwinism. Senator Rick Santorum, a Pennsylvania Republican, has argued that "intelligent design is a legitimate scientific theory that should be taught in science classes." An I.D.-friendly amendment that he sponsored to the No Child Left Behind Act—requiring public schools to help students understand why evolution "generates so much continuing controversy"—was overwhelmingly approved in the Senate. (The amendment was not included in the version of the bill that was signed into law, but similar language did appear in a conference report that accompanied it.) In the past few years, college students across the country have formed Intelligent Design and Evolution Awareness chapters. Clearly, a policy of limited scientific engagement has failed. So just what is this movement?



The complexity of living things, I.D.'s defenders say, can't be explained by Darwin.

GLEN BAXTER

First of all, intelligent design is not what people often assume it is. For one thing, I.D. is not Biblical literalism. Unlike earlier generations of creationists—the so-called Young Earthers and scientific creationists—proponents of intelligent design do not believe that the universe was created in six days, that Earth is ten thousand years old, or that the fossil record was deposited during Noah's flood. (Indeed, they shun the label "creationism" altogether.) Nor does I.D. flatly reject evolution: adherents freely admit that some evolutionary change occurred during the history of life on Earth. Although the movement is loosely allied with, and heavily funded by, various conservative Christian groups—and although I.D. plainly maintains that life was created—it is generally silent about the identity of the creator.

The movement's main positive claim is that there are things in the world, most notably life, that cannot be accounted for by known natural causes and show features that, in any other context, we would attribute to intelligence. Living organisms are too complex to be explained by any natural—or, more precisely, by any mindless—pro-

cess. Instead, the design inherent in organisms can be accounted for only by invoking a designer, and one who is very, very smart.

All of which puts I.D. squarely at odds with Darwin. Darwin's theory of evolution was meant to show how the fantastically complex features of organisms—eyes, beaks, brains—could arise without the intervention of a designing mind. According to Darwinism, evolution largely reflects the combined action of random mutation and natural selection. A random mutation in an organism, like a random change in any finely tuned machine, is almost always bad. That's why you don't, screwdriver in hand, make arbitrary changes to the insides of your television. But, once in a great while, a random mutation in the DNA that makes up an organism's genes slightly improves the function of some organ and thus the survival of the organism. In a species whose eye amounts to nothing more than a primitive patch of light-sensitive cells, a mutation that causes this patch to fold into a cup shape might have a survival advantage. While the old type of organism can tell only if the lights are on, the new type can detect the *direction* of any source of light or shadow. Since shadows sometimes mean predators, that can be valuable information. The new, improved type of organism will, therefore, be more common in the next generation. That's natural selection. Repeated over billions of years, this process of incremental improvement should allow for the gradual emergence of organisms that are exquisitely adapted to their environments and that look for all the world as though they were designed. By 1870, about a decade after "The Origin of Species" was published, nearly all biologists agreed that life had evolved, and by 1940 or so most agreed that natural selection was a key force driving this evolution.

Advocates of intelligent design point to two developments that in their view undermine Darwinism. The first is the molecular revolution in biology. Beginning in the nineteen-fifties, molecular biologists revealed a staggering and unsuspected degree of complexity within the cells that make up all life. This complexity, I.D.'s defenders argue, lies beyond the abilities of Darwinism to explain. Second, they claim that new mathematical findings cast doubt on the power of natural selection. Selection may play a role in evolution, but it cannot accomplish what biologists suppose it can.

These claims have been championed by a tireless group of writers, most of them associated with the Center for Science and Culture at the Discovery Institute, a Seattle-based think tank that sponsors projects in science, religion, and national defense, among other areas. The center's fellows and advisers—including the emeritus law professor Phillip E. Johnson, the philosopher Stephen C. Meyer, and the biologist Jonathan Wells—have published an astonishing number of articles and books that decry the ostensibly sad state of Darwinism and extoll the virtues of the design alternative. But Johnson, Meyer, and Wells, while highly visible, are mainly strategists and popularizers. The scientific leaders of the design movement are two scholars, one a biochemist and the other a mathematician. To assess intelligent design is to assess their arguments.

Michael J. Behe, a professor of biological sciences at Lehigh University (and a senior fellow at the Discovery Institute), is a biochemist who writes technical papers on the structure of DNA. He is the most prominent of the small circle of scientists working on intelligent design, and his arguments are by far the best known. His book "Darwin's Black Box" (1996) was a surprise best-seller and was named by *National Review* as one of the hundred best nonfiction books of the twentieth century. (A little calibration may be useful here; "The Starr Report" also made the list.)

Not surprisingly, Behe's doubts about Darwinism begin with biochemistry. Fifty years ago, he says, any biologist could tell stories like the one about the eye's evolution. But such stories, Behe notes, invariably began with cells, whose own evolutionary origins were essentially left unexplained. This was harmless enough as long as cells weren't qualitatively more complex than the larger, more visible aspects of the eye. Yet when biochemists began to dissect the inner workings of the cell, what they

found floored them. A cell is packed full of exceedingly complex structures—hundreds of microscopic machines, each performing a specific job. The "Give me a cell and I'll give you an eye" story told by Darwinists, he says, began to seem suspect: starting with a cell was starting ninety per cent of the way to the finish line.

Behe's main claim is that cells are complex not just in degree but in kind. Cells contain structures that are "irreducibly complex." This means that if you remove any single part from such a structure, the structure no longer functions. Behe offers a simple, nonbiological example of an irreducibly complex object: the mousetrap. A mousetrap has several parts—platform, spring, catch, hammer, and hold-down bar—and all of them have to be in place for the trap to work. If you remove the spring from a mousetrap, it isn't slightly worse at killing mice; it doesn't kill them at all. So, too, with the bacterial flagellum, Behe argues. This flagellum is a tiny propeller attached to the back of some bacteria. Spinning at more than twenty thousand r.p.m.s, it motors the bacterium through its aquatic world. The flagellum comprises roughly thirty different proteins, all precisely arranged, and if any one of them is removed the flagellum stops spinning.

In "Darwin's Black Box," Behe maintained that irreducible complexity presents Darwinism with "unbridgeable chasms." How, after all, could a gradual process of incremental improvement build something like a flagellum, which needs *all* its parts in order to work? Scientists, he argued, must face up to the fact that "many biochemical systems cannot be built by natural selection working on mutations." In the end, Behe concluded that irreducibly complex cells arise the same way as irreducibly complex mousetraps—someone designs them. As he put it in a recent *Times* Op-Ed piece: "If it looks, walks, and quacks like a duck, then, absent compelling evidence to the contrary, we have warrant to conclude it's a duck. Design should not be overlooked simply because it's so obvious." In "Darwin's Black Box," Behe speculated that the designer might have assembled the first cell, essentially solving the problem of irreducible complexity, after which evolution might well have proceeded by more or less conventional means. Under Behe's brand of creationism, you might still be an ape that evolved on the African savanna; it's just that your cells harbor micro-machines engineered by an unnamed intelligence some four billion years ago.

But Behe's principal argument soon ran into trouble. As biologists pointed out, there are several different ways that Darwinian evolution can build irreducibly complex systems. In one, elaborate structures may evolve for one reason and then get co-opted for some entirely different, irreducibly complex function. Who says those thirty flagellar proteins weren't present in bacteria long before bacteria sported flagella? They may have been performing other jobs in the cell and only later got drafted into flagellum-building. Indeed, there's now strong evidence that several flagellar proteins once played roles in a type of molecular pump found in the membranes of bacterial cells.

Behe doesn't consider this sort of "indirect" path to irreducible complexity—in which parts perform one function and then switch to another—terribly plausible. And he essentially rules out the alternative possibility of a direct Darwinian path: a path, that is, in which Darwinism builds an irreducibly complex structure while selecting all along for the same biological function. But biologists have shown that direct paths to irreducible complexity are possible, too. Suppose a part gets added to a system merely because the part improves the system's performance; the part is not, at this stage, essential for function. But, because subsequent evolution builds on this addition, a part that was at first just advantageous might *become* essential. As this process is repeated through evolutionary time, more and more parts that were once merely beneficial become necessary. This idea was first set forth by H. J. Muller, the Nobel Prize-winning geneticist, in 1939, but it's a familiar process in the development of human technologies. We add new parts like global-positioning systems to cars not because they're necessary but because they're nice. But no one would be surprised if, in fifty years, computers that rely on G.P.S. actually drove our cars. At that point, G.P.S. would no longer be an attractive option; it would be an essential piece of automotive technology. It's important to see that this process is thoroughly Dar-

"I brought out the grill and Henry, but I haven't uncovered them yet."

winian: each change might well be small and each represents an improvement.

Design theorists have made some concessions to these criticisms. Behe has confessed to "sloppy prose" and said he hadn't meant to imply that irreducibly complex systems "by definition" cannot evolve gradually. "I quite agree that my argument against Darwinism does not add up to a logical proof," he says—though he continues to believe that Darwinian paths to irreducible complexity are exceedingly unlikely. Behe and his followers now emphasize that, while irreducibly complex systems can in principle evolve, biologists can't reconstruct in convincing detail just how any such system did evolve.

What counts as a sufficiently detailed historical narrative, though, is altogether subjective. Biologists actually know a great deal about the evolution of biochemical systems, irreducibly complex or not. It's significant, for instance, that the proteins that typically make up the parts of these systems are often similar to one another. (Blood clotting—another of Behe's examples of irreducible complexity—involves at least twenty proteins, several of which are similar, and all of which are needed to make clots, to localize or remove clots, or to prevent the runaway clotting of all blood.) And biologists understand why these proteins are so similar. Each gene in an organism's genome encodes a particular protein. Occasionally, the stretch of DNA that makes up a particular gene will get accidentally copied, yielding a genome that includes two versions of the gene. Over many generations, one version of the gene will often keep its original function while the other one slowly changes by mutation and natural selection, picking up a new, though usually related, function. This process of "gene duplication" has given rise to entire families of proteins that have similar functions; they often act in the same biochemical pathway or sit in the same cellular structure. There's no doubt that gene duplication plays an extremely important role in the evolution of biological complexity.

It's true that when you confront biologists with a particular complex structure like the flagellum they sometimes have a hard time saying which part appeared before which other parts. But then it can be hard, with any complex historical process, to reconstruct the exact order in which events occurred, especially when, as in evolution, the addition of new parts encourages the modification of old ones. When you're looking at a bustling urban street, for example, you probably can't tell which shop went into business first. This is partly because many businesses now depend on each other and partly because new shops trigger changes in old ones (the new sushi place draws twenty-somethings who demand wireless Internet at the café next door). But it would be a little rash to conclude that all the shops must have begun business on the same day or that some Unseen Urban Planner had carefully determined just which business went where.

The other leading theorist of the new creationism, William A. Dembski, holds a Ph.D. in mathematics, another in philosophy, and a master of divinity in theology. He has been a research professor in the conceptual foundations of science at Baylor University, and was recently appointed to the new Center for Science and Theology at Southern Baptist Theological Seminary. (He is a longtime senior fellow at the Discovery Institute as well.) Dembski publishes at a staggering pace. His books—including "The Design Inference," "Intelligent Design," "No Free Lunch," and "The Design Revolution"—are generally well written and packed with provocative ideas.

According to Dembski, a complex object must be the result of intelligence if it was the product neither of chance nor of necessity. The novel "Moby Dick," for example, didn't arise by chance (Melville didn't scribble random letters), and it wasn't the necessary consequence of a physical law (unlike, say, the fall of an apple). It was, instead, the result of Melville's intelligence. Dembski argues that there is a reliable way to recognize such products of intelligence in the natural world. We can conclude that an object was intelligently designed, he says, if it shows "specified complexity"—complexity that matches an "independently given pattern." The sequence of letters "JKXVCJUDOPLVM" is certainly complex: if you randomly type thirteen letters, you are very unlikely to arrive at this particular sequence. But it isn't *specified:* it doesn't match any independently given sequence of letters. If, on the other hand, I ask you for the first sentence of "Moby Dick" and you type the letters "CALLMEISHMAEL," you have produced something that is both complex and specified. The sequence you

TENNIS BALL

I parked by the grave in September, under oaks and birches,
and said hello again, and went walking with Gussie

past markers, roses, and the grave with plastic chickens.
(Somebody loved somebody who loved chickens.)

Gus stopped and stared: a woman's long bare legs
stretched up at the edge of the graveyard, a man's body

heaving between them. Gus considered checking them out,
so I clicked my fingers, softly as I could, to distract him,

and became the unintending source of coitus interruptus.
Walking to the car, I peeked. She was re-starting him, her

head riding up and down. It was a fine day, leaves red,
Gus healthy and gay, refusing to give up his tennis ball.

—Donald Hall

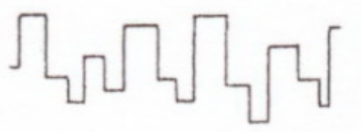
typed is unlikely to arise by chance alone, and it matches an independent target sequence (the one written by Melville). Dembski argues that specified complexity, when expressed mathematically, provides an unmistakable signature of intelligence. Things like "CALLMEISHMAEL," he points out, just don't arise in the real world without acts of intelligence. If organisms show specified complexity, therefore, we can conclude that they are the handiwork of an intelligent agent.

For Dembski, it's telling that the sophisticated machines we find in organisms match up in astonishingly precise ways with recognizable human technologies. The eye, for example, has a familiar, cameralike design, with recognizable parts—a pinhole opening for light, a lens, and a surface on which to project an image—all arranged just as a human engineer would arrange them. And the flagellum has a motor design, one that features recognizable O-rings, a rotor, and a drive shaft. Specified complexity, he says, is there for all to see.

Dembski's second major claim is that certain mathematical results cast doubt on Darwinism at the most basic conceptual level. In 2002, he focussed on so-called No Free Lunch, or N.F.L., theorems, which were derived in the late nineties by the physicists David H. Wolpert and William G. Macready. These theorems relate to the efficiency of different "search algorithms." Consider a search for high ground on some unfamiliar, hilly terrain. You're on foot and it's a moonless night; you've got two hours to reach the highest place you can. How to proceed? One sensible search algorithm might say, "Walk uphill in the steepest possible direction; if no direction uphill is available, take a couple of steps to the left and try again." This algorithm insures that you're generally moving upward. Another search algorithm—a so-called blind search algorithm—might say, "Walk in a random direction." This would sometimes take you uphill but sometimes down. Roughly, the N.F.L. theorems prove the surprising fact that, averaged over all possible terrains, no search algorithm is better than any other. In some landscapes, moving uphill gets you to higher ground in the allotted time, while in other landscapes moving randomly does, but on average neither outperforms the other.

Now, Darwinism can be thought of as a search algorithm. Given a problem—adapting to a new disease, for instance—a population uses the Darwinian algorithm of random mutation plus natural selection to search for a solution (in this case, disease resistance). But, according to Dembski, the N.F.L. theorems prove that this Darwinian algorithm is no better than any other when confronting all possible problems. It follows that, over all, Darwinism is no better than blind search, a process of utterly random change unaided by any guiding force like natural selection. Since we don't expect blind change to build elaborate machines showing an exquisite coördination of parts, we have no right to expect Darwinism to do so, either. Attempts to sidestep this problem by, say, carefully constraining the class of challenges faced by organisms inevitably involve sneaking in the very kind of order that we're trying to explain—something Dembski calls the displacement problem. In the end, he argues, the N.F.L. theorems and the displacement problem mean that there's only one plausible source for the design we find in organisms: intelligence. Although Dembski is somewhat noncommittal, he seems to favor a design theory in which an intelligent agent programmed design into early life, or even into the early universe. This design then unfolded through the long course of evolutionary time, as microbes slowly morphed into man.

Dembski's arguments have been met with tremendous enthusiasm in the I.D. movement. In part, that's because an innumerate public is easily impressed by a bit of mathematics. Also, when Dembski is wielding his equations, he gets to play the part of the hard scientist busily correcting the errors of those soft-headed biologists. (Evolutionary biology actually features an extraordinarily sophisticated body of mathematical theory, a fact not widely known because neither of evolution's great popularizers—Richard Dawkins and the late Stephen Jay Gould—did much math.) Despite all the attention, Dembski's mathematical claims about design and Darwin are almost entirely beside the point.



The most serious problem in Dembski's account involves specified complexity. Organisms aren't trying to match any "independently given pattern": evolution has no goal, and the history of life isn't trying to get anywhere. If building a sophisticated structure like an eye increases the number of children produced, evolution may well build an eye. But if destroying a sophisticated structure like the eye increases the number of children produced, evolution will just as happily destroy the eye. Species of fish and crustaceans that have moved into the total darkness of caves, where eyes are both unnecessary and costly, often have degenerate eyes, or eyes that begin to form only to be covered by skin—crazy contraptions that no intelligent agent would design. Despite all the loose talk about design and machines, organisms aren't striving to realize some engineer's blueprint; they're striving (if they can be said to strive at all) only to have more offspring than the next fellow.

Another problem with Dembski's arguments concerns the N.F.L. theorems. Recent work shows that these theorems don't hold in the case of co-evolution, when two or more species evolve in response to one another. And most evolution is surely co-evolution. Organisms do not spend most of their time adapting to rocks; they are perpetually challenged by, and adapting to, a rapidly changing suite of viruses, parasites, predators, and prey. A theorem that doesn't apply to these situations is a theorem whose relevance to biology is unclear. As it happens, David Wolpert, one of the authors of the N.F.L. theorems, recently denounced Dembski's use of those theorems as "fatally informal and imprecise." Dembski's apparent response has been a tactical retreat. In 2002, Dembski triumphantly proclaimed, "The No Free Lunch theorems dash any hope of generating specified complexity via evolutionary algorithms." Now he says, "I certainly never argued that the N.F.L. theorems provide a direct refutation of Darwinism."

Those of us who have argued with I.D. in the past are used to such shifts of emphasis. But it's striking that Demb-

ski's views on the history of life contradict Behe's. Dembski believes that Darwinism is incapable of building anything interesting; Behe seems to believe that, given a cell, Darwinism might well have built you and me. Although proponents of I.D. routinely inflate the significance of minor squabbles among evolutionary biologists (did the peppered moth evolve dark color as a defense against birds or for other reasons?), they seldom acknowledge their own, often major differences of opinion. In the end, it's hard to view intelligent design as a coherent movement in any but a political sense.

It's also hard to view it as a real research program. Though people often picture science as a collection of clever theories, scientists are generally staunch pragmatists: to scientists, a good theory is one that inspires new experiments and provides unexpected insights into familiar phenomena. By this standard, Darwinism is one of the best theories in the history of science: it has produced countless important experiments (let's re-create a natural species in the lab—yes, that's been done) and sudden insight into once puzzling patterns (*that's* why there are no native land mammals on oceanic islands). In the nearly ten years since the publication of Behe's book, by contrast, I.D. has inspired no nontrivial experiments and has provided no surprising insights into biology. As the years pass, intelligent design looks less and less like the science it claimed to be and more and more like an extended exercise in polemics.

In 1999, a document from the Discovery Institute was posted, anonymously, on the Internet. This Wedge Document, as it came to be called, described not only the institute's long-term goals but its strategies for accomplishing them. The document begins by labelling the idea that human beings are created in the image of God "one of the bedrock principles on which Western civilization was built." It goes on to decry the catastrophic legacy of Darwin, Marx, and Freud—the alleged fathers of a "materialistic conception of reality" that eventually "infected virtually every area of our culture." The mission of the Discovery Institute's scientific wing is then spelled out: "nothing less than the overthrow of materialism and its cultural legacies." It seems fair to conclude that the Discovery Institute has set its sights a bit higher than, say, reconstructing the origins of the bacterial flagellum.

The intelligent-design community is usually far more circumspect in its pronouncements. This is not to say that it eschews discussion of religion; indeed, the intelligent-design literature regularly insists that Darwinism represents a thinly veiled attempt to foist a secular religion—godless materialism—on Western culture. As it happens, the idea that Darwinism is yoked to atheism, though popular, is also wrong. Of the five founding fathers of twentieth-century evolutionary biology—Ronald Fisher, Sewall Wright, J. B. S. Haldane, Ernst Mayr, and Theodosius Dobzhansky—one was a devout Anglican who preached sermons and published articles in church magazines, one a practicing Unitarian, one a dabbler in Eastern mysticism, one an apparent atheist, and one a member of the Russian Orthodox Church and the author of a book on religion and science. Pope John Paul II himself acknowledged, in a 1996 address to the Pontifical Academy of Sciences, that new research "leads to the recognition of the theory of evolution as more than a hypothesis." Whatever larger conclusions one thinks *should* follow from Darwinism, the historical fact is that evolution and religion have often coexisted. As the philosopher Michael Ruse observes, "It is simply not the case that people take up evolution in the morning, and become atheists as an encore in the afternoon."

Biologists aren't alarmed by intelligent design's arrival in Dover and elsewhere because they have all sworn allegiance to atheistic materialism; they're alarmed because intelligent design is junk science. Meanwhile, more than eighty per cent of Americans say that God either created human beings in their present form or guided their development. As a succession of intelligent-design proponents appeared before the Kansas State Board of Education earlier this month, it was possible to wonder whether the movement's scientific coherence was beside the point. Intelligent design has come this far by faith. ♦