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# Darwin v. Intelligent Design (Again)

The latest attack on evolution is cleverly argued, biologically informed—and wrong

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*Darwin's Black Box: The Biochemical Challenge to Evolution*
Michael J. Behe
Free Press, $25

Just don't pull the knot tight before being certain that you have got hold of the right end.
—Wittgenstein[1]

⏩ The pages of this magazine are not often taken up with reviews of creationist screeds. The stuff is, after all, intellectual junk food, served up with a transparent evangelical agenda. But now and then a reputable, or even esteemed, scientist launches an assault on evolution. These attacks are potentially important and, whether sound or not, are invariably great head-turners. A generation ago, for instance, the astronomer Sir Fred Hoyle announced that the theory of natural selection was deeply flawed and could never account for the existence of complex organisms like you and me. Hoyle's objections were frankly silly, reflecting an embarrassing misunderstanding of Darwinian logic. In retrospect, there was only one reason anyone listened: Hoyle was a physicist. And as everyone—including biologists—then knew, physicists are smarter than the rest of us.

But the days of biologists suffering physics envy are long gone. We biologists have discovered the structure of DNA, broken the genetic code, sequenced the entire genome of some species, and, to a remarkable extent, figured out how a little egg turns into a big person (the last in a breathtaking decade). If a Hoyle were to now announce that biologists are deeply confused about natural selection or neurobiology, he'd be greeted, if at all, with a big yawn. There's only one way to shake up biologists now—the attack has to come from within.

Well, ask and ye shall receive. Michael J. Behe, a biochemist at Lehigh University, has published a (seemingly) sophisticated insider's attack on Darwinism. His book, Darwin's Black Box, is well-written, cleverly argued, and biologically informed. No one

can deny Behe's grasp of biochemistry. Unlike a few previous "biologists" who have taken aim at Darwin, Behe is the real thing: a research scientist, someone who does experiments, gets grants, and publishes papers. Behe's work may well represent the most sophisticated—and the most seductive—creationist attack on evolution in a quarter century. But Behe, it turns out, differs from his less-sophisticated brethren in an important way: he does not wholly deny evolution. He has no problem with stories of moths evolving dark coloration so as to hide on polluted trees or of streptococci outwitting antibiotics. Nor does he deny common descent, the notion that all species, including humans, are derived from one or a few common ancestors. But Behe's chief claim remains deeply revolutionary: evolution, he says, cannot account for the cell, the very basis of life. Instead the cell shows unequivocal signs of design by an intelligent agent.

Not surprisingly, Behe has gotten a bit of attention. His book is, after all, a creationist's dream come true. His challenge to Darwin has been talked up in Newsweek, U.S. News & World Report, the New York Times, and National Review. Even Judge Bork has chimed in, proclaiming that Behe "has shown that Darwinism cannot explain life as we know it."[2] (Revealing his expertise on such things, Bork misidentifies Behe as a "microbiologist," not a biochemist.) Whether or not Behe wanted such company, it is obvious that the Christian Right and allied conservative forces will make much ado of his book. There's a brand new weapon in the creationist arsenal—a real biologist says we're right.

Although Behe discusses his religious sentiments—he notes his Roman Catholicism, is disturbed by the ill will between science and theology, and is subtly (but clearly) offended by biologist Richard Dawkins's atheism—he never places himself squarely in the creationist camp.[3] He maintains that his position is strictly scientific and that the data have driven him ineluctably to his views. As though to prove his scientific restraint, Behe even refuses to speculate on the identity of the designer. Although his last chapter offers many hints of the designer's divinity, the door is left open ever so slightly to some variety of alien intervention (although one wonders who designed them). It's hard to say if Behe's reluctance to utter "God did it" is tactical or sincere. On the one hand, creationists learned long ago to be discreet about religious motive. But on the other, Behe seems sophisticated enough to see that Darwinism never threatened any but the most literal-minded of religious creeds anyway (as dramatically confirmed by Pope John Paul II's recent acceptance of evolution as "more than just a hypothesis").[4]

In any case, I will take Behe at his word. His arguments should and must be dealt with on scientific grounds, just as he has requested. For, in the end, Behe is simply right or wrong. And I am convinced that he is very wrong.

## Irreducible Complexity

Until recently, we had no inkling of what went on inside a cell. Although biology had made great strides in anatomy and physiology, the cell remained a tightly shut black box. Behe argues that this black box proved very convenient to evolutionists: when explaining, say, the evolution of the eye, biologists could start their story with a light-sensitive cell of the sort that lines our retinas. Evolutionists then merely tried to explain how the gross morphology of the eye—a curved retina, a properly shaped lens—evolved. No one interrupted such tales to ask, "But how do you get a light-sensitive cell in the first place?" The question was not asked, Behe argues, because everyone believed the inner workings of the cell to be trivially simple—certainly nothing that might pull the rug out from under Darwinism.

But in the early 1950s, the heroes of Behe's book, the biochemists, began to pry open the black box, working out the structure and function of molecules residing in the cell. Decades of such work have unearthed two findings that Behe claims are of capital importance to evolution. First, the cell is horrendously complicated. Indeed Behe spends a third of his book trying to convince you of just how complicated it is. Take your pick—blood clotting, intracellular transport, the immune response (a chapter each)—they're all Rube Goldberg machines of dizzying complexity.

As Behe tells it, the complexity of the cell came as a big surprise. But his display of shock is, I think, a bit disingenuous, an attempt to create a crisis atmosphere. To anyone paying attention over the last century, the revelation of complexity is no revelation at all. Geneticists, for instance, have known for sixty years that the modest fruitfly sports at least five thousand genes. So how could it not be complicated? You don't need a script to know that a play featuring five thousand speaking parts is going to be a tad complicated. Moreover, evolutionists all know that, from the time the earth formed, it took three billion years to evolve the first true cell but only half as long to get human beings from this cell. And we all interpret this the same way: it's harder to evolve a cell than a human given a cell. But, surprise or no, Behe's talk of complexity is utterly beside the point. As he well knows, Darwinism has no trouble explaining sheer complexity: four billion years is an unimaginably long time for things to get complicated.

Behe's second point is far more important. Biochemistry, he claims, has revealed not just complexity, but a special kind of complexity: many biochemical systems are irreducibly complex. Because it represents the central argument of his book—and the key to his attack on Darwinism—it is important to see what Behe means here. "By irreducibly complex I mean a single system composed of several well-matched, interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively stop functioning."

Consider Behe's favorite example: the mousetrap. A mousetrap has a clear function (crushing mice) and is made of several parts (a platform, a spring, a bar that does the crushing). If any of these parts is removed, the trap doesn't work. Hence it's irreducibly complex. This is different from, say, a car, which continues to run after a headlight burns out or a spark plug stops firing.

One of Behe's goals is to show that irreducible complexity is not confined to the inanimate world: some biochemical systems are also irreducibly complex. Here he succeeds. Certain biochemical systems show exactly the properties Behe attributes to them. His description of the mind-boggling cascade of reactions that occurs during blood-clotting is particularly persuasive: thrombin activates accelerin, which, with Stuart factor, cleaves prothrombin; the resulting thrombin cleaves fibrinogen, making fibrin, etc. Knock out any of these innumerable steps and the animal either bleeds or clots to death.

To Behe, an extraordinary conclusion follows on the heels of irreducible complexity: Darwinism cannot explain such systems. The reason, he says, is simple: An irreducibly complex system "cannot be produced directly . . . by slight, successive modifications of a precursor system, because any precursor to an irreducibly complex system that is missing a part is by definition nonfunctional." You cannot, in other words, gradually improve a mousetrap by adding one part and then the next. A trap having half its parts doesn't function half as well as a real trap; it doesn't function at all. So Darwinism's problem is obvious: it requires that each step in the evolution of a system be functional and adaptive. Biochemistry has, then, found an "unbridgeable chasm"—evolution just can't get here from there. Indeed Darwinism is rendered so impotent before irreducible complexity that Behe feels obliged to resurrect a notion that, since Darwin, has been the greatest of all biological taboos—intelligent design. The cell, he argues, is a mousetrap: a complex machine bearing the unmistakable signature of an intelligent designer.[5]

So the question facing biologists is clear: Do irreducibly complex systems represent an unbridgeable evolutionary chasm? If so, Darwinism is in a bad way and Behe has made an astonishing discovery. If not, Behe's case collapses and he has succeeded only in misleading large numbers of people. Behe, never shy, has already cast his vote: the discovery of design, he assures us, is "so significant that it must be ranked as one of the greatest achievements in the history of science," rivaling "those of Newton and Einstein, Lavoisier and Schrodinger, Pasteur, and Darwin."

### Reducible Complexity

The first thing you need to understand about Behe's argument is that it's just plain wrong. It's not that he botched some stray fact about evolution, or that he doesn't know his biochemistry, but that his argument—as an argument—is fatally flawed. To see this

we need to first get clear about what kinds of solutions to irreducible complexity are not open to Darwinism.

First it will do no good to suggest that all the required parts of some biochemical pathway popped up simultaneously by mutation. Although this "solution" yields a functioning system in one fell swoop, it's so hopelessly unlikely that no Darwinian takes it seriously. As Behe rightly says, we gain nothing by replacing a problem with a miracle. Second, we might think that some of the parts of an irreducibly complex system evolved step by step for some other purpose and were then recruited wholesale to a new function. But this is also unlikely. You may as well hope that half your car's transmission will suddenly help out in the airbag department. Such things might happen very, very rarely, but they surely do not offer a general solution to irreducible complexity.

Behe's colossal mistake is that, in rejecting these possibilities, he concludes that no Darwinian solution remains. But one does. It is this: An irreducibly complex system can be built gradually by adding parts that, while initially just advantageous, become—because of later changes—essential. The logic is very simple. Some part (A) initially does some job (and not very well, perhaps). Another part (B) later gets added because it helps A. This new part isn't essential, it merely improves things. But later on, A (or something else) may change in such a way that B now becomes indispensable. This process continues as further parts get folded into the system. And at the end of the day, many parts may all be required.

The point is there's no guarantee that improvements will remain mere improvements. Indeed because later changes build on previous ones, there's every reason to think that earlier refinements might become necessary. The transformation of air bladders into lungs that allowed animals to breathe atmospheric oxygen was initially just advantageous: such beasts could explore open niches—like dry land—that were unavailable to their lungless peers. But as evolution built on this adaptation (modifying limbs for walking, for instance), we grew thoroughly terrestrial and lungs, consequently, are no longer luxuries—they are essential. The punch line is, I think, obvious: although this process is thoroughly Darwinian, we are often left with a system that is irreducibly complex. I'm afraid there's no room for compromise here: Behe's key claim that all the components of an irreducibly complex system "have to be there from the beginning" is dead wrong.

It's worth noting that our scenario is neither hypothetical nor confined to the often irretrievable world of biological history. Indeed it's a common experience among computer programmers. Anyone who programs knows how easy it is to write yourself into a corner: a change one makes because it improves efficiency may become, after further changes, indispensable. Improvements might be made one line of code at a time and, at all stages, the

program does its job. But, by the end, all the lines may be required. This programming analogy captures another important point: If I were to hand you the final program, it's entirely possible that you would not be able to reconstruct its history—that this line was added last and that, in a previous version, some other line sat between these two. Indeed, because the very act of revising a program has a way of wiping out clues to its history, it may be impossible to reconstruct the path taken. Similarly, we have no guarantee that we can reconstruct the history of a biochemical pathway. But even if we can't, its irreducible complexity cannot count against its gradual evolution any more than the irreducible complexity of a program does—which is to say, not at all.

I wish I could claim credit for this Darwinian model of irreducible complexity, but I'm afraid I've been scooped by eighty years. This scenario was first hinted at by the geneticist H. J. Muller in 1918 and worked out in some detail in 1939.[6] Indeed, Muller gives reasons for thinking that genes which at first improved function will routinely become essential parts of a pathway. So the gradual evolution of irreducibly complex systems is not only possible, it's expected. For those who aren't biologists, let me assure you that I haven't dug up the half-baked lucubrations of some obscure amateur. Muller, awarded the Nobel Prize in 1946, was a giant in evolution and genetics.

Although Muller's essay isn't as well known as it should be, the gist of his idea is common wisdom in evolutionary biology. Here's an important application: Molecular evolutionists have shown that some genes are duplications of others. In other words, at some point in time an extra copy of a gene got made. The copy wasn't essential—the organism obviously got along fine without it. But through time this copy changed, picking up a new, and often related, function. After further evolution, this duplicate gene will have become essential. (We're loaded with duplicate genes that are required: myoglobin, for instance, which carries oxygen in muscles, is related to hemoglobin, which carries oxygen in blood. Both are now necessary.) The story of gene duplication—which can be found in every evolution text—is just a special case of Muller's theory. But it's an immensely important case: it explains how new genes arise and, thus, ultimately, how biochemical pathways get built.

So how does Behe explain duplicate genes? He doesn't. He reluctantly admits that different genes often have similar sequences. He even admits that some genes in his favorite pathway—blood clotting—are similar.[7] But he refuses to draw the obvious conclusion: some genes are copies of others. Does Behe think their similarity is a coincidence—they just happen to look alike? It is, I think, clear why Behe fails to face up to duplicate genes: were he to admit that one gene is a copy of another, he'd have to admit that a copy was made at some point in time and

thus that the organism once got along without it. But this implies that such systems can arise step by step. Behe avoids this conclusion only by sheer evasion: he brands gene duplication a "hypothesis," leaves the similarity of his favorite genes unexplained, and quickly moves on to safer turf.

## Irreducible Confusion

In truth, we're done. Behe's chief objection to Darwinism is flat wrong, and, bereft of this, he's got little to say. But when you do look at what else he says, you find a bizarre string of confusions and contradictions.

For instance, while Behe claims that evidence for design had to await the new science of biochemistry, he never really explains what's so special about biochemistry. It's true that molecules provide some nice examples of irreducible complexity, but why can't we find such complexity at other levels? The answer is we can. Here's one: the heart. The human heart is built of a pump and valves. Remove either one and you're dead. But Behe seems terribly unclear about whether such non-molecular examples are kosher. In one breath, he tells us that "one has to examine molecular systems for evidence of design," but in the next, he assures us that the theologian William Paley's description of the heart as irreducibly complex was right on the money. So which is it? If Paley's example is "exactly correct," why did we have to await biochemistry? The issue is not trivial. For if anatomy didn't topple Darwinism (and it seems not to have), why should biochemistry?

Behe's one attempt to explain what's so special about molecules only hurls us into deeper confusion. He suggests that biochemical examples are best because they're simpler and thus clearer. But I, for one, have a hard time reconciling this argument with Behe's main claim—that biochemistry is very, very complicated. I suspect the real reason Behe finds biochemistry so special is that he has confused two senses of "reducible." Irreducible complexity is a formal property of a system, having nothing to do with physical scale. You might say we can't "reduce" the function of the system to its parts if they're all required. But if we like, we can always "reduce" such a system into its molecular bits and pieces (the heart is made of myosin, etc.). When Behe worries that an anatomical structure is made of so many different molecules that it's hard to know if it's irreducibly complex, he is mixing up these two senses of reducible. There is absolutely no reason to think we get truer irreducible complexity at the micro than macro scale. This is made perfectly clear by Behe's own example: to see that a mousetrap is irreducibly complex, we don't have to work out its chemistry! It remains irreducibly complex whether made of one kind of molecule or one million. The upshot is that Behe's grand claim that biochemistry poses some qualitatively new challenge to Darwinism just doesn't make sense. Irreducible complexity lives at all scales.

Behe offers up yet another contradiction when he tells us that he finds the descent of all species from a common ancestor "fairly convincing" but that he's not so sure about macroevolution.[8] Now macroevolution is the process of getting species from a common ancestor. You can no more believe in one but not the other than you can believe in beer but not brewing. The strange thing is that Behe seems to understand the meaning of both words. He says sensible things about common descent and then about macroevolution. He just doesn't see that the two sets of statements are flatly contradictory.

Last, in one of the stranger passages of his book, Behe speculates that the designer provided the Primal Cell with all the genes modern organisms might need (i.e., the first bacterium carried genes for human speech centers). If a lineage didn't need some genes, they got lost or silenced. This notion leaves so much of molecular evolution unexplained that it's hard to know where to start. Here's just one problem: Although some genes do get killed or silenced over time (producing non-functional "pseudogenes"), how come we only carry pseudogenes that are wrecked copies of our real genes? In other words, why don't I carry pseudogenes for chlorophyll or flower structure? Why don't azaleas carry pseudogenes for brain cells? Behe's it-was-all-there-from-day-one hypothesis is flatly falsified by this and every other known pattern in molecular evolution.

I'll be the first to admit that such non sequiturs are not fatal to Behe's central argument. But they do betray remarkable confusion or, worse, a powerful tendency to see what he wants, contradictions be damned. In any case, strings of such contradictions eat away at Behe's case, and, in the end, make it hard to believe that Darwin will be getting company in Westminster Abbey any time soon.

## Know Thy Enemy

One of the most interesting questions about Behe's book is why he feels especially qualified to critique Darwinism. (And not just to quibble over details, but to announce that "Darwinism is not science," as he did in a recent letter to Commentary.)[9] To a historian or electrician, Behe certainly looks qualified. He is a biologist. But it's not that simple, as can be seen by turning the tables for a moment. If I, an evolutionary biologist, were to announce that biochemistry is deeply flawed—I've shown, for instance, that enzymes are not catalysts—I doubt I'd get a listen. I surely wouldn't get a publisher. Nor would any jurist consider my ruminations worthy of attention. But Behe stars in public debates, has a fancy publisher (Free Press, a division of Simon & Schuster) and the ear of the likes of Judge Bork. Why the difference? Why is everyone an expert witness when the topic is Darwinism but not when it's biochemistry?

The answer is complicated, but a few things are clear. First,

Darwinism matters. Many people will inevitably have questions about Darwinism because many people will inevitably think about it. By comparison, I doubt many Sunday school classes get worked up over enzyme kinetics. Second—and this has more to do with attacks from scientists such as Behe's—there's a striking asymmetry in molecular versus evolutionary education in American universities. Although many science, and all biology, students are required to endure molecular courses, evolution—even introductory evolution—is often an elective. The reason is simple: biochemistry and cell biology get Junior into med school, evolution doesn't. Consequently, many professional scientists know surprisingly little about evolution.

Now I don't pretend to know the details of Behe's education, but I do know this: he is not at home in the technical evolution literature. His book reveals that his grasp of evolution derives mostly from the pop literature (Gould, Dawkins—good stuff, but no stand-in for the real thing) and from computer searches of the scientific literature that he strangely makes a big deal of. While I have utter confidence in Behe's biochemistry, I am less confident that he can say what soft selection, or Muller's ratchet, or the Fundamental Theorem of Natural Selection is—all bread and butter of evolutionary biology. It would be easy, of course, to get carried away here, and I want to emphasize that I'm not saying that outsiders can offer nothing of value (it's worth remembering that Darwin himself was trained primarily as a geologist, not a biologist). I'm simply saying that any would-be critic of Darwinism should know as much about evolution as any critic of biochemistry must know about molecules. (An idea that apparently never occurred to Free Press, who presumably will next treat us to a botanist's musings on the flat earth.)

Finally, Behe and others may feel obliged to sling mud Darwin's way because they suspect evolutionary biologists won't do so. Evolutionists are widely perceived as uncritical ideologues, devoted to suppressing all doubt about evolution. It's easy to see how this impression arose: evolutionists, after all, spend most of their public lives defending Darwin against endlessly recycled creationist arguments. So of course we appear hide-bound reactionaries. (So would physicists if the theory of gravity were dragged into court every other year.) But the truth is, I think, quite different. It would be fatuous to deny that scientists can be intellectually conservative or prone to hero worship. And it would be equally absurd to suggest that evolutionists have resolved every major problem facing us; many remain. But the fact is that, as in any science, evolutionists often sharply disagree. And, as in any science, these disagreements sometimes concern fundamentals. In the 1930s, for example, Sewall Wright championed the role of "genetic drift" in evolution. Parting with accepted wisdom, he argued that random changes in the genetic composition of populations—not natural selection—account for many of the differences we see between species. More recently, Motoo Kimura championed the neutral theory, arguing that a good deal of

evolution at the molecular level does not reflect natural selection. Here were overt attempts to circumscribe the role of selection. And the attempts were largely successful: Wright and Kimura were not hooted down, gagged or shot. Instead genetic drift and the neutral theory are now enshrined in every evolution text.

So when the Christian Right tries to tell you that evolutionists instinctively circle the wagons whenever anyone dares question the Darwinian status quo, you should ask yourself why Wright and Kimura got through, but Behe not. The answer is, I think, straightforward: Wright and Kimura knew what they were talking about. ■

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1 *Notebooks, 1914–16*, ed. G. H. von Wright and G. E. M. Anscombe (Oxford: Blackwell, 1961), p. 47.

2 Robert H. Bork, *Slouching Towards Gomorrah: Modern Liberalism and American Decline* (New York: Regan Books, 1996), p. 294.

3 Also see Behe's *New York Times* op-ed (October 26,1996, p. A25), where he speaks more plainly about his religion.

4 *New York Times*, October 25, 1996, p. A1.

5 Behe waffles a bit here. He typically claims that irreducibly complex systems "cannot" by natural selection as all the parts *have* to be there from the beginning. But, once or twice, he contradicts these strong claims, asserting that no Darwinian explanation *seems* possible. The same waffling shows up in his *New York Times* op-ed, where he boldly states that we know of "no other mechanism [besides design], including Darwin's, which produces such complexity," and that "such a system*probably* cannot be put together in a Darwinian manner" (my italics). For present purposes, the distinction doesn't matter much: we'll see that it's neither impossible nor difficult to gradually evolve irreducible complexity.

6 H. J. Muller, "Reversibility in Evolution Considered from the Standpoint of Genetics," *Biological Reviews* 14 (1939): 261–80. Muller does not, of course, use Behe's term "irreducible complexity." Rather he speaks in terms of irreversibility: you can add something extra because it's merely advantageous. But, once it becomes essential, you can't remove it. Irreducible complexity means that evolution is not reversible.

7 The situation is slightly more complex than this applies. Sometimes just *parts* of genes get duplicated. But the point remains: parts of some genes in the blood-clotting pathway are copies of parts of other genes. See W.-H. Li and D. Graur, *Fundamentals of Molecular Evolution* (Sunderland, MA: Sinauer, 1991) for a discussion of partial *v*. complete gene duplicaion and the evolution of new gene function.

8 See J. A. Coyne, "God in the Details," *Nature* 383 (1996): 227–28. Coyne also emphasizes that Behe's theory is unfalsifiable: Since Behe admits both evolution and design, proof that a pathway was built gradually can't stump him. He can always claim that some *other* pathway was designed.

9 *Commentary* (September 1996), p. 22.

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