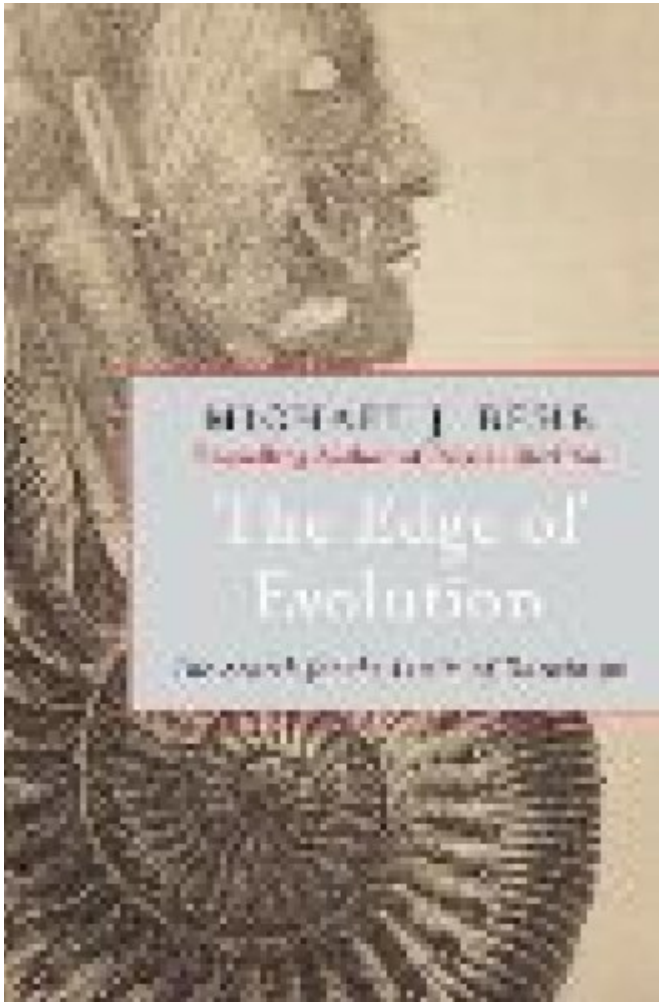


A matter of mutation

By [Joan Roughgarden](#) in the [October 30, 2007](#) issue

In Review



The Edge of Evolution: The Search for the Limits of Darwinism

Michael J. Behe

Free Press

Michael Behe, a biochemistry professor at Leigh University and one of the chief advocates for intelligent design (ID), has written a sequel to *Darwin's Black Box*

(1998). In his earlier work Behe argued that organisms possess some features that cannot result from Darwinian evolution because they are “irreducibly complex.” Such structures can function only when all their pieces are in place, and therefore, he maintained, they could not have been assembled through the gradual modification of preexisting structures as the standard Darwinian evolutionary narrative envisions.

Behe’s key example of an irreducibly complex structure was the bacterial flagellum, the “tail” that a bacterium wiggles for its propulsion. Behe concluded that structures like the bacterial flagellum must have been designed and somehow placed there by an intelligent designer, whom he acknowledged might be God or some other entity, depending on one’s theological inclination.

Behe’s position has been criticized scientifically and theologically. The structures thought to be irreducibly complex aren’t; precursor structures can be identified whose modification can lead to a flagellum—or any other trait, for that matter. Furthermore, ID advocates don’t offer any hypothesis about what happened in the evolutionary past—where, when and how did the designer give bacteria their flagella?

The ID position wound up being a litany of complaints against Darwin rather than a scientific hypothesis in its own right.

ID is commingled with creationism, even though it is different. Unlike creationists, ID proponents accept the old age of the earth, acknowledge that all life—including humans and apes—share descent from common ancestry, reject the idea that species are specially created, and do not regard the Bible as scientifically meaningful. Nonetheless, ID and creationism are joined at the hip because ID proponents ally themselves with creationists for fund-raising, publicity, politics and legal strategizing.

Behe’s new book recasts the ID position. Gone is the focus on irreducibly complex structures; in its place is a concern for the rate and randomness of genetic mutation. Most of the book is about the implications of genetic mutation. Behe argues that the occurrence of structures with three or more different kinds of proteins is beyond “what is biologically reasonable to expect Darwinian evolution to have accomplished in all of life in all of the billion-year history of the world.”

To illustrate, Behe develops the case of the evolution of malaria parasites in response to drugs. One mutation in the malaria parasite makes it resistant to atovaquone, whereas two mutations are needed to make it resistant to chloroquine. The malarial parasite is 10^{-8} less likely to develop resistance to chloroquine than to atovaquone because two mutations are needed instead of one. If an antibiotic could be developed that required malarial parasites to undergo three mutations to be able to resist it, then such drugs would “*never* lose their effectiveness,” predicts Behe.

He computes that the waiting time for the first occurrence of a triple-mutated structure, formed through random mutation, would exceed the age of the earth. Because all living things possess many structures, pathways, regulatory systems and so forth that involve more than three proteins working together, Behe concludes that most of these features are not the product of Darwinian evolution but instead represent evidence of intelligent design.

Behe doesn't spell out exactly what he is assuming in his calculations, but evidently he is supposing that the resistance to chloroquine requires two unique mutations that must occur simultaneously to be effective. The waiting time for two mutations to appear simultaneously in the same individual is the product of the waiting times for each mutation by itself.

On the other hand, if each mutation is helpful in its own right, as postulated in Darwinian evolution, then the mutations can enter the population consecutively. In that case the waiting time for the appearance of a double mutant is the sum rather than the product of the times for each mutation—a much shorter span.

Behe cites the long-term studies of evolution in bacteria by Richard Lenski of Michigan State University. Lenski has maintained a culture of bacteria for over 30,000 generations, in population sizes of about 500 million. Over 10 trillion individual bacteria have been produced during the experiment, a number “probably more than the number of primates on the line from chimp to human.” Behe observes that during the experiment “nothing fundamentally new has been produced. No new protein-protein interactions, no new molecular machines.” After a while, even small beneficial changes petered out—“that's all Darwinism can do.” To Behe, Darwinism is fine as far as it goes, but it doesn't go very far.

Contrary to Behe's insistence, the concept of random genetic mutation is not fundamental to evolutionary biology. Darwin never used the term *random* in the

Origin of Species. From its beginning, Darwinism has focused on the natural-selection component of the evolutionary process, and Darwin's theory accommodates whatever information genetics supplies for the mechanism of inheritance. So I'm puzzled by Behe's fervent identifying of Darwinism with "random" mutation, as in sentences such as: "Darwin's proposed mechanism of evolution—*random* variation and natural selection—. . . sought to explain the development of life explicitly without recourse to guidance or planning by anyone or anything at any time."

Darwin does not say that evolution is unguided. In Darwin's theory, the guidance for evolution comes from the natural-selection component of the evolutionary process, not from the mutation component. What *random* means in evolutionary theory is that the mutations that occur are independent of whether they might prove subsequently useful; their usefulness is for natural selection to determine.

The genetics of development has moved far beyond a focus on individual mutations and instead is focusing on groups of genes. Behe cites this new work but overlooks its significance. He acknowledges the discoveries over the past 20 years that "animals as disparate as mice, flies, and worms rely to a very surprising degree on similar developmental programs that use similar components." He notes that "genetic programs to build organs such as eyes, limbs, and body segments seem to occur in discrete modules." Therefore, natural selection can produce new adaptations by drawing on the rearrangement and repackaging of genetic modules, rather than needing to await the appearance of a brand new set of individual genes.

Anyone who has tried to program computers knows that stupendously complicated tasks can be accomplished provided that the task is broken into programming modules, or subroutines. Programmers would abandon gigantic tasks in despair if they attempted each as one giant single program. Also, a new program can reuse old subroutines and put them to a new purpose. This is why computer programmers keep libraries of subroutines for regular use, and it is what makes the user interface of all the programs running under Microsoft Windows look the same; they are built from a common set of subroutines that Microsoft has released to programmers.

Accordingly, the reason Richard Lenski's long-term laboratory experiment with bacterial evolution failed to produce decidedly novel structures (a difference as large as the difference between humans and chimps) is that the bacterial cell, lacking even a distinct nucleus, doesn't have any modules to work with. It's like a huge

nonmodular computer program. But mammals do have loads of modules throughout their cells, and this has evidently allowed the variation needed for natural selection to cause the many conspicuous changes seen in the hominid line since its recent split from other primates.

Behe doesn't avail himself of the explanatory power that genetic modularity potentially provides for resolving his mathematical conundrums on the basis of simultaneous random-point mutation. Instead, he dismisses modularity concepts as "a further layer of complexity" and claims that because of modularity the case for Darwinian evolution "only gets worse." I suggest that ID proponents should reconsider their hasty dismissal of new research in developmental genetics. This research may show them that evolution by natural selection does not stall out while waiting eternally for new genetic variations.

Discussion of these issues is certain to be eclipsed by the gladiatorial spectacle of scientists behaving badly. Behe attacks by name biologists Kenneth Miller, Sean Carroll, Jerry Coyne and Richard Dawkins, among others. Perhaps not surprisingly, these scientists have responded vehemently in their reviews of Behe's book. This conduct cannot increase respect and appreciation for science in the general public. Dawkins has yet to acknowledge his own direct responsibility for the existence of the ID theory. Phillip Johnson founded the present-day ID movement by writing *Darwin on Trial* (1993) in response to the ideology of selfishness and militant atheism that Dawkins preaches in *The Selfish Gene* (1976) and more recently in *The God Delusion* (2006). With both sides poisoning each other's wells, it's tempting to run away lest one be slaughtered as collateral damage.

Flawed as it is, Behe's book makes four constructive points. First, Behe makes it clear that all of life is united through descent from common ancestors—evolution is real and true. I imagine that one could even introduce this book as testimony at a curriculum hearing in Kansas to show that creationism is not a viable alternative to evolution. Second, he has replaced his early naive claims about irreducible complexity with a more sophisticated argument about whether sufficient genetic variation exists upon which natural selection can act. (I would argue, however, that sufficient variation almost surely does exist, especially when mutations accumulate consecutively and genetic modules are rearranged and repackaged.)

Third, Behe has introduced a glimmer of an idea of how to test the ID theory by arguing that the moments in history when the higher organisms (according to the

Linnaean classification system) originated were marked by bursts of nonrandom mutation. This is an empirical claim that can be tested, although not easily. (Discovering that the emergence of higher organisms coincides with anomalous bursts of directed mutation would support the ID position without falsifying Darwinism, because Darwinism takes no position on what causes the variations on which natural selection acts.) Fourth, Behe endorses a strong version of theistic evolution, one that many scientists will find innocuous: “The purposeful design of life to any degree is easily compatible with the idea that, after its initiation, the universe unfolded exclusively by the intended playing out of natural laws.” Thus Behe rejects the need for miracles or any other divine intervention during the course of evolution according to ID. Indeed, some Christians will find this position too hands-off—one that views God as too remote to matter in our everyday lives.

At this point, one might wonder what all the fuss is about. If Behe is not claiming either divine intervention or miracles, then the dispute between ID and Darwinism comes down to arguing about genetic details of interest mainly to professional biologists. I'd like to think that *The Edge of Evolution* marks the beginning of a midcourse correction for ID proponents. If so, I welcome it.