BOOKS & ARTS

# Falling over the edge

**Claims that an intelligent designer is needed to explain evolution of complex systems are deeply flawed.**

**The Edge of Evolution: The Search for the Limits of Darwinism**
by Michael Behe
Free Press: 2007. 336 pp. $28

**Kenneth R. Miller**

Michael Behe's new book, *The Edge of Evolution*, is an attempt to give the intelligent-design movement a bit of badly needed scientific support. After a spectacular setback in the 2005 Dover, Pennsylvania, intelligent-design trial (*Nature* **439,** 6–7; 2006), and the 2006 electoral losses in Ohio and Kansas, the movement could use some help — and Behe is eager to provide it.

Knowing how easy it is to demonstrate the workings of evolution in the development of drug resistance in viruses, bacteria and protozoan parasites, Behe concedes the point that evolution works very well at this level. His case study, repeated almost to the point of tedium, is malaria. Resistance to drugs such as chloroquine has indeed arisen within the parasite population, and so has genetic resistance to the parasite in humans. But if the interspecies genetic warfare between *Homo sapiens* and *Plasmodium* is actually a prime example of evolution, how can it then be used to make the case for 'design'?

The reason can be found in the book's title. To Behe, the genetic changes in both parasite and host represent the absolute limit of what darwinian processes can accomplish, and mark the "edge of evolution". He describes these well-understood mutations as a kind of "trench warfare" in which parasite and host endure a series of destructive mutations in key elements of cellular machinery. These changes produce nothing genuinely new, serving only to block the parasite or render widely used drugs ineffective by altering target proteins or clearing damaged cells. The fact that centuries of conflict between parasite and host have produced nothing in the way of new, complex systems in either species is proof that this is all that evolution can do. They mark the "limits of darwinism".

Where does this leave evolutionary explanations of more complex systems? Behe tells us frankly that darwinism cannot account for even a modest share of the complexity of life, and therefore design is absolutely required as an explanation. Yet, at the heart of his anti-darwinian calculus are numbers not merely incorrect, but so spectacularly wrong that this badly designed argument collapses under its own weight.

Far from finding a clean edge to evolution, Behe's poorly designed arguments crumble away.

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Behe cites the malaria literature to note that two amino-acid changes in the digestive-vacuole membrane protein PfCRT (at positions 76 and 220) of *Plasmodium* are required to confer chloroquine resistance. From a report that spontaneous resistance to the drug can be found in roughly 1 parasite in $10^{20}$, he asserts that these are the odds of both mutations arising in a single organism, and uses them to make this sweeping assertion:

> *"On average, for humans to achieve a mutation like this by chance, we would need to wait a hundred million times ten million years. Since that is many times the age of the universe, it's reasonable to conclude the following: No mutation that is of the same complexity as chloroquine resistance in malaria arose by Darwinian evolution in the line leading to humans in the past ten million years."*

Behe, incredibly, thinks he has determined the odds of a mutation "of the same complexity" occurring in the human line. He hasn't. What he has actually done is to determine the odds of these two exact mutations occurring simultaneously at precisely the same position in exactly the same gene in a single individual. He then leads his unsuspecting readers to believe that this spurious calculation is a hard and fast statistical barrier to the accumulation of enough variation to drive darwinian evolution.

It would be difficult to imagine a more breathtaking abuse of statistical genetics.

Behe obtains his probabilities by considering each mutation as an independent event, ruling out any role for cumulative selection, and requiring evolution to achieve an exact, predetermined result. Not only are each of these conditions unrealistic, but they do not apply even in the case of his chosen example. First, he overlooks the existence of chloroquine-resistant strains of malaria lacking one of the mutations he claims to be essential (at position 220). This matters, because it shows that there are several mutational routes to effective drug resistance. Second, and more importantly, Behe waves away evidence suggesting that chloroquine resistance may be the result of sequential, not simultaneous, mutations (*Science* **298,** 74–75; 2002), boosted by the so-called ARMD (accelerated resistance to multiple drugs) phenotype, which is itself drug induced.

A mistake of this magnitude anywhere in a book on science is bad enough, but Behe has built his entire thesis on this error. Telling his readers that the production of so much as a single new protein-to-protein binding site is "beyond the edge of evolution", he proclaims darwinian evolution to be a hopeless failure. Apparently he has not followed recent studies exploring the evolution of hormone-receptor complexes by sequential mutations (*Science* **312,** 97–101; 2006), the 'evolvability' of new functions in existing proteins — studies on serum paraxonase (PON1) traced the evolution of several new catalytic functions (*Nature Genet.* **37,** 73–76; 2005) — or the modular evolution of cellular signalling circuitry (*Annu. Rev. Biochem.* **75,** 655–680; 2006). Instead, he tells his readers that there is just one explanation that "encompasses the cellular foundation of life as a whole". That explanation, of course, is intelligent design.

The sad mistake at the logical centre of this book is eerily reminiscent of a similar claim in Behe's 1996 book *Darwin's Black Box*. In this work he claimed that complex biochemical systems have a property he called "irreducible complexity". Irreducibly complex structures, such as the bacterial flagellum, could not have evolved because they lack any selectable function until all of their component parts are in place. As he wrote, "any precursor to an irreducibly complex system is by definition nonfunctional", since every part of such a system had to be in place for natural selection to favour it. Therefore, such structures must have been designed. A nice argument, except for the annoying fact that it is wrong. Subsets of proteins nearly identical to those in the flagellum do indeed have selectable functions (*Nature Rev. Microbiol.* **4,** 784–790; 2006), and the argument fails. In the same book, Behe also claimed that every component of the irreducibly complex vertebrate blood-clotting system had to be present for the system to work properly. That argument collapsed when Russell Doolittle's laboratory (*Proc. Natl Acad. Sci.* **100,** 7527–7532; 2003) showed that the puffer fish, *Fugu,* lacks at least three clotting factors and still has a workable system. Such failures in the science of the argument helped to send intelligent design to a defeat in the Dover trial, and they haunt it still.

No doubt creationists who long for a scientific champion will overlook the parts of this deeply flawed book that might trouble them, including Behe's admission that "common descent is true", and that our species shares a common ancestor with the chimpanzee. Instead, they will cling to Behe's mistaken calculations, and proclaim that the end of evolution is at hand. What this book actually demonstrates, however, is the intellectual desperation of the intelligent-design movement as it struggles to survive in the absence of even a shred of scientific data in its favour. ■

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EXHIBITION

# A Wellcome addition

**The Wellcome Collection**
by the Wellcome Trust
183 Euston Road, London
www.wellcomecollection.org

**Sara Abdulla**

A unique cultural venue opened in London this month. The Wellcome Collection is the first permanent home for the massive, maverick history-of-medicine collection that pharmaceutical entrepreneur Sir Henry Wellcome (1853–1936) gathered throughout his life. Thirty million pounds (US$60 million) and decades in the making, the free venue has three galleries, one of the world's most important history-of-medicine libraries, an original programme of live events, a members' club, a bookshop, a café, a conference centre and Pablo Picasso's Bernal mural.

Wellcome's fortune also created the Wellcome Trust, Britain's main bioscience research funding agency. The trust has now remodelled the compact 1930s building it recently vacated to realize Sir Henry's vision of a 'Museum of Man' and to extend its public engagement activities.

The scholarly heat rises with each floor. Street level lures in passers-by from the thundering road outside with a chic café and striking large-scale works — including a pendulous Antony Gormley cast. Here temporary exhibitions will explore the interplay between advances in medical science and our view of ourselves. The opening show, The Heart, runs until 14 September 2007; it features Andy Warhol prints, Leonardo da Vinci anatomical drawings and a wall of fixed animal hearts.

The next floor boasts two permanent galleries charting the evolution of our cultural response to health, sickness and discovery. Medicine Man displays some of Sir Henry's extraordinary anthropological and ethnographic haul, such as these Chinese porcelain fruits containing couples engaged in sexual foreplay (pictured). Medicine Man has been seen in public just once before, at the British Museum in 2003 (*Nature* **423,** 805; 2003). Looking like a cross between the Horniman Museum and a Hollywood humidor, its handsome walnut cases, drawers and hidden cabinets reveal a telling fraction of the objects Sir Henry amassed. There are amputation saws, birthing tools, diagnostic dolls, arresting paintings and glassware galore. Medicine Now brings the story of 'what it means to be human' up to date, in a bright white and red journey through malaria, obesity, genomics and more.

Throughout the building, subtle curation and sumptuous display invite visitors to reflect on our knowledge, hopes, fears and beliefs about the body. This dialogue will continue in The Forum, an auditorium for debates, workshops, lectures and performances. Some of these will engage with themes of the temporary exhibitions. For example on 5 July, the audience can watch a live video link to a heart-valve operation, ask questions of the surgeon and examine instruments akin to those being used. Other events, such as the Islam and medicine panel on 19 July, will respond to current affairs.

The second floor brings the trust's vast library into the twenty-first century. Virtual browsing stations and WiFi now complement the graceful galleries long beloved by science-and-society scholars (and TV crews in search of instant gravitas). The top floors house The Wellcome Trust Centre for the History of Medicine at University College London, where much of this thoughtful activity starts.

And what of the members' club? Will it become biology's Algonquin Hotel? Quite possibly: it is inside a thrilling new museum, beside a leading medical school, opposite London's new European rail terminus and encircled by scientific publishers. What better place to raise a glass to humane curiosity, the legacy of Sir Henry Wellcome. ■

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