Holy Phylogeny! Did Bats Evolve Twice?

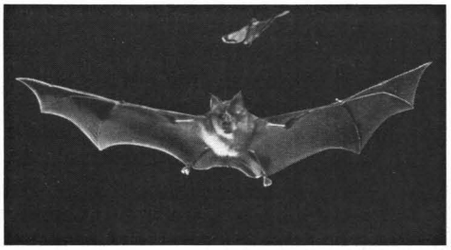
Yes, says an Australian neuroanatomist—calling forth much skepticism from the zoological establishment

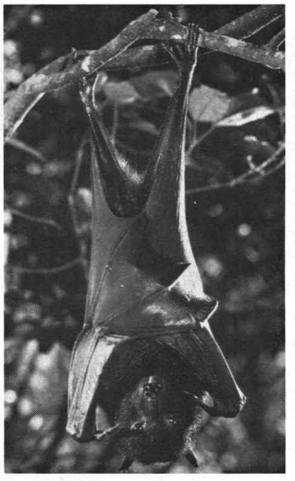
BATS ARE SUCH UNUSUAL CREATURES THAT it seems unlikely that even evolution, with all its resourcefulness, could have brought them into being twice. Yet just such an idea, known as the "diphyletic hypothesis," is getting a hard look these days, thanks to controversial neuroanatomist John Pettigrew of the University of Queensland in Australia. On the basis of brain characteristics that he was the first to observe, Pettigrew contends that the two orders of bats—the *Megachiroptera*, or megabats, and the *Microchiroptera*, or microbats—are not each other's closest relatives. In fact, Pettigrew argues provocatively, the megabats are actually an early offshoot of the primate family tree.

This contention, which he first raised several years ago in *Science*, caused a fuss among many experts on bats who held to the "monophyletic" hypothesis; a debate has simmered ever since. Now Pettigrew and a trio of opponents have turned up the burners with a set of papers in the June issue of the quarterly *Systematic Zoology*. First, Pettigrew reviews the evidence for his argument that megabats are the sister group of primates. In the same issue, Robert Baker of Texas Tech University and Michael Novacek and Nancy Simmons of the American Museum of Natural History review much the same evidence—and come to precisely the opposite conclusion.

Many systematists find the style of argument adopted by Pettigrew (who wasn't trained as a systematist) frustrating. Yet they concede that the evolutionary origins of the bats remain an open question. According to bat biologist Brock Fenton of Toronto's York University, microbats (small, echolocating bats with diverse life histories and diets) and megabats (larger "flying foxes" that live in the Old World tropics, eat fruit and nectar, and rely on vision rather than echolocation) "have an interesting blend of similarities and differences. You're left with the age-old question: Which are more important, the similarities or the differences?" It seems that even if Pettigrew turns out to be wrong, he has stimulated research that could help bring the age-old question to a resolution.

Pettigrew didn't start off to analyze bat systematics. In fact, he's an expert on the brain's system for processing visual information who knew nothing about bat phylogeny when he started examining brain tissue from flying foxes. "When I looked in the microscope," he says, "I got a rude shock." The shocker: The megabat brain displayed visual pathway traits thought to be unique to primates.





Animals, Animals

Brothers—or distant cousins? *Greater horseshoe bat* (Rhinolopus ferrum equinum) *is a microbat* (above)*; black flying fox* (Pteropus alecto) *is a megabat.*

Since first publishing those findings (see *Science*, 14 March 1986, p. 1304), Pettigrew has identified other characteristics he says link megabats and primates, many of them aspects of nervous-system pathways. Those identical wiring patterns provide evidence for a common descent, he argues. If the nervous systems of megabats and primates had evolved by convergence to perform similar functions, he claims, the wiring patterns would likely be different.

Yet when it comes to the striking similarities in the wings of the two kinds of bats (the only flying mammals), Pettigrew looks at things differently—seeing convergent evolution rather than common descent. "The two lineages of bats," he writes, "had only one support option available, so the use of all digits by both [to support the wing membrane] is not surprising." Other similarities of megabat and microbat wings are, Pettigrew adds, "inescapable features of any mammalian wing."

Pettigrew's opponents are endlessly irritated by his invocation of convergence rather than common descent to explain these shared wing characteristics. Convergence is "not something you can decide upon by degree of similarity," Novacek told *Science*. "We know whales are not fish, not based on differences in flippers, but essentially because whales are mammals," possessing an entire suite of characteristics, such as mammary glands and live birth, that identify them as mammals.

Novacek and Simmons don't dispute Pettigrew's analysis of the neural systems—but they offer an alternative hypothesis for how megabats and primates came to share many neural characteristics microbats don't have. They believe primates and megabats share an evolved form of the mammalian visual system, which the microbats lost when they evolved echolocation. Such evolutionary reversal, they write, "has played a significant role in many evolutionary explanations of differences among taxa."

Both sides concede that what's needed to end the great bat shoot-out is a careful review of the existing evidence—and a lot more data. Some of that data is bound to be molecular. In their *Systematic Zoology* papers, both sides term the existing molecular evidence equivocal, but that could soon change. Rodney Honeycutt and Ronald Adkins of Texas A&M University have sequenced the mitochondrial gene for the protein called cytochrome oxidase subunit II; their manuscript is being reviewed by a major journal. "We found that bats are monophyletic," says Honeycutt, "but they have very deep branches—meaning they are pretty divergent from one another." Others whose unpublished molecular results tend to support the monophyletic hypothesis include John Kirsch of the University of Wisconsin, Loren Ammerman and David Hillis at the University of Texas, Vincent Sarich of the University of California at Berkeley, and Morris Goodman at Wayne State University.

Yet many systematists think Pettigrew's contrarian analysis has been fruitful. Ross MacPhee of the American Museum of Natural History calls him "a damned good neuroanatomist" who has come up with similarities between megabats and primates that demand explanation. And if Pettigrew is correct, his work will have thrown light not only on the evolution of the bats—but also on that of our closest living nonprimate relatives. ■ BILLY GOODMAN

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