Huge genome-scale phylogenetic study of birds rewrites evolutionary tree-of-life

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The largest ever study of bird genetics has not only shaken up but completely redrawn the avian evolutionary tree. The study challenges current classifications, alters our understanding of avian evolution, and provides a valuable resource for phylogenetic and comparative studies in birds.

Birds are among the most studied and loved animals, and much of what we know about animal biology – from natural history to ecology, speciation, reproduction, etc. – is based on birds. Nevertheless, the avian tree-of-life has remained controversial and elusive – until now.

For more than five years, the Early Bird Assembling the Tree-of-Life Research Project, centered at The Field Museum, has been examining DNA from all major living groups of birds. Thus far, scientists have built and analyzed a dataset of more than 32 kilobases of nuclear DNA sequences from 19 different locations on the DNA of each of 169 bird species. The results of this massive research, which is equivalent to a small genome project, will be published in Science on June 27, 2008.

"Our study and the remarkable new understanding of the evolutionary relationships of birds that it affords was possible only because of the technological advances of the last few years that have enabled us to sample larger portions of genomes," said Shannon Hackett, one of three lead authors and associate curator of birds at The Field Museum. "Our study yielded robust results and illustrates the power of collecting genome-scale data to reconstruct difficult evolutionary trees."

The results of the study are so broad that the scientific names of dozens of birds will have to be changed, and biology textbooks and birdwatchers' field guides will have to be revised. For example, we now know that:

-- Birds adapted to the diverse environments several distinct times because many birds that now live on water (such as flamingos, tropicbirds and grebes) did not evolve from a different waterbird group, and many birds that now live on land (such as turacos, doves, sandgrouse and cuckoos) did not evolve from a different landbird group.
-- Similarly, distinctive lifestyles (such as nocturnal, raptorial and pelagic, i.e., living on the ocean or open seas) evolved several times. For example, contrary to conventional thinking, colorful, daytime hummingbirds evolved from drab nocturnal nightjars; falcons are not closely related to hawks and eagles; and tropicbirds (white, swift-flying ocean birds) are not closely related to pelicans and other waterbirds.
-- Shorebirds are not a basal evolutionary group, which refutes the widely held view that shorebirds gave rise to all modern birds.

"With this study, we learned two major things," said Sushma Reddy, another lead author and Bucksbaum Postdoctoral Fellow at The Field Museum. "First, appearances can be deceiving. Birds that look or act similar are not necessarily related. Second, much of bird classification and conventional wisdom on the evolutionary relationships of birds is wrong."

Avian evolution

The evolution of birds has been notoriously difficult to determine. This is probably because modern birds arose relatively quickly (within a few million years) during an explosive radiation that occurred sometime between 65 million and 100 million years ago. The result of this rapid divergence early in the evolutionary history of birds is the fact that many

groups of similar-looking birds (for example, owls, parrots and doves) have few, if any, living intermediary forms linking them to other well-defined groups of birds. This makes it very difficult to determine how some of these groups are evolutionarily related.

Many previous studies of avian evolution yielded conflicting results. This new study, however, is more robust because of the use of large amounts of sequence data from across the genome. The Early Bird group sequenced approximately 32 kilobases of aligned data per species, which is about five times more nuclear data than any previous study. Furthermore, the data were analyzed using several different methods and programs.

"Unlike other studies, we consistently found several well-supported, deep divisions within Neoaves (a basal division of birds that includes 95% of all living birds), and this signal was persistent across analyses," said Rebecca Kimball, the third lead author of the study and [associate professor of zoology] at the University of Florida, Gainesville.

The other co-authors of this study include scientists from the University of California, Berkeley; Smithsonian Institution; Stellenbosch University (South Africa); University of Maryland; Louisiana State University; Wayne State University; and the University of New Mexico. More than half of the people who worked on or trained in this project were women.

At The Field Museum, much of the DNA sequencing and analysis was conducted in the Pritzker Laboratory for Molecular Systematics and Evolution. The lab was established in 1974 for genetic research and to study and help preserve the world's biodiversity. Since 2000, over 190 scientists from 29 countries have trained in the lab. Today, there are more than 60 active projects in the Pritzker Lab, examining everything from sharks to plants to lichens, and from owls to flamingos.

Just last month, The Field Museum opened the Daniel F. and Ada L. Rice DNA Discovery Center, which puts a public face on the Pritzker Lab. The center opens up a working state-of-the-art laboratory to Museum visitors, who will be able to observe researchers extracting, sequencing, and analyzing DNA for several projects, including the Early Bird research. In addition, they will be able to speak with scientists at set times as they work.

In addition to the viewing area, the 1,850-square-foot DNA Discovery Center includes videos, hands-on interactives, and informative displays. The exhibition is intended for adults and students in junior high school and above. Located on the mezzanine overlooking Stanley Field Hall, the DNA Discovery Center is free with general admission.

There are an estimated 82 million birdwatchers in the United States alone, making it the country's second (to gardening) most popular hobby. Therefore, interest in the results of the Early Bird research project will be far reaching.

"We now have a robust evolutionary tree from which to study the evolution of birds and all their interesting features that have fascinated so many scientists and amateurs for centuries," Reddy said. "Birds exhibit substantial diversity (largest of the tetrapod groups), and using this 'family tree' we can begin to understand how this diversity originated as well as how different bird groups are interrelated."

Source: Field Museum