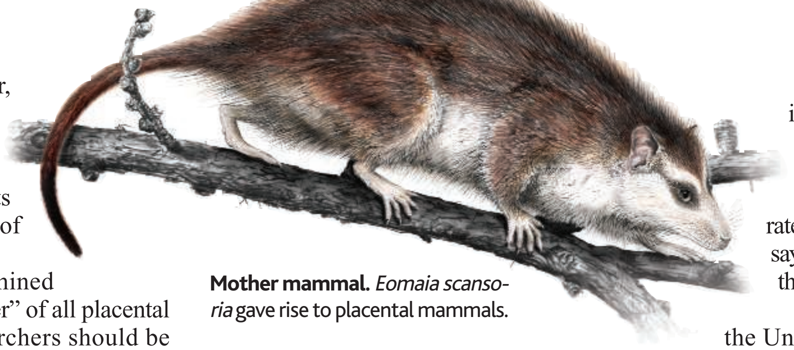


Mother mammal. *Eomaia scansoria* gave rise to placental mammals.

animals' common ancestor, which lived an estimated 100 million years ago, and the two groups hope to know the sequence of its entire genome by the end of the year.

Once they have determined the sequence of the "mother" of all placental mammal genomes, researchers should be able to make evolutionary sense of the genetic differences between species, especially as the data stream in from the more than a dozen vertebrate genomes now slated for partial sequencing. "Reconstructing mammalian sequence to the base [level]—this is amazing," says Francis Collins, director of the National Human Genome Research Institute (NHGRI) in Bethesda, Maryland.

Haussler and Miller focused on placental mammals because the various subgroups alive today arose at basically the same time, from a shrewlike ancestor. The rapid subsequent evolution of these groups makes it easier to verify base changes through time. In contrast, determining the ancestral genome of all mammals would be much more difficult, if not impossible, because marsupials and monotremes branched off at very different times, making DNA comparisons less reliable.

The approach Haussler, Miller, and their colleagues took resembles that of molecular evolutionists, who for decades have used DNA differences to build evolutionary trees. Typically, those researchers focus on one gene, such as that for a ribosomal RNA. They count the number and type of base changes in that gene: The more changes between two species, the more distant the kinship. Those DNA bases shared by all the species under consideration likely represent ancestral ones.

With new computer programs and sophisticated simulations of genome evolution, Haussler's and Miller's groups have taken this approach considerably further by looking across the whole genome and not just at one gene. The computers search among the DNA of many species for common sequences in large stretches of chromosomes and then check individual bases for changes in each species. The group validated the accuracy of the reconstructed genome by crosschecking the simulations with phylogenetic trees derived from modern DNA.

Last year, Haussler's postdoctoral fellow Mathieu Blanchette, now at McGill University in Montreal, Canada, did a test run analyzing a 1-million-base piece of chromosome 7, the region that contains the cystic fibrosis gene, from 19 placental mammals. The simulations indicated the ancestral sequence of that region is about 98% right.

Miller's graduate student Jian Ma has now taken on the task of reconstructing a much bigger chunk of DNA, the ancestral chromosome 15. Although it remains fairly intact in some living mammals, in others it has become quite chopped up and redistributed. In both mice and rats, this ancient DNA is now scattered among five chromosomes, she reported. In humans, however, most of the sequence of the reconstructed ancestral chromosome 15 now appears to make up one arm of human chromosome 13. In dogs, it's divided up between chromosomes 22 and 25.

These whole-chromosome studies include just nine placental species, leading Blanchette to estimate that the ancestral chromosome 15 is only about 90% accurate. But that percentage will improve, says Ma: "The more species we have, the more accuracy we can get."

Robert Waterston, a geneticist at the University of Washington, Seattle, believes the goal of rebuilding the entire genome within a year is achievable. "[They] will be able to reconstruct most of it," he predicts. Researchers will then be able to work from these reconstructed chromosomes to determine how long a particular base has been part of the human genome and how it has changed, says Haussler. Geneticists will also learn more about how chromosomes evolve, says Waterston: "It provides a chance to think about genome evolution systematically and to look at all that's happened." **–ELIZABETH PENNISI**

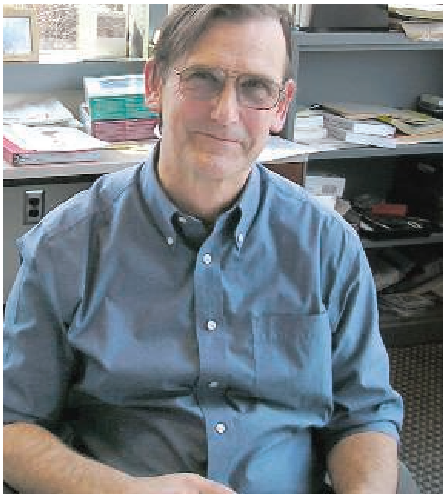
Ornithology

Citizen Scientists Supplement Work of Cornell Researchers

A half-century of interaction with bird watchers has evolved into a robust and growing collaboration between volunteers and a leading ornithology lab

BOYCE, VIRGINIA—On a sunny April morning, Kaycee Lichter has driven 32 kilometers to the Virginia State Arboretum here in the Shenandoah Valley to meet her friend Greg Baruffi. Walking to the edge of a meadow, the two open a box containing a bluebird nest and place an electronic device no larger than a coat button under the five eggs inside. The button will record the fluctuating temperature inside the nest as the female bluebird departs and returns periodically in search of food. In 3 days, Lichter and Baruffi will download the data to a computer and reset the button.

Lichter, 46, is a medical transcriptionist at a nearby mental health clinic and Baruffi, 50, is a carpenter. They are not scientists, but their work is crucial to a study by researchers at the Cornell Lab of Ornithology in Ithaca, New York, of whether birds lay fewer eggs in cooler climates because of the energy costs of incubation. The results could provide insights into how environmental factors affect the number of hatchlings in a brood.



Group think. Cornell's Andre Dhondt says a volunteer network allows him to ask large-scale ecological questions.

Over the past decade, Cornell has harnessed the enthusiasm of such volunteers—or citizen scientists, as they are known—to explore questions such as the dynamics of infectious disease in bird populations and the impact of acid rain on their reproductive success. Those efforts have resulted in a long list of peer-reviewed publications, demonstrating the value of citizen science as a research tool. "Having an army of assistants on the ground allows you to ask questions that require simultaneous observation across

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large spatial and temporal scales," says Andre Dhondt, an ecologist at Cornell. "It opens up a world of scientific possibilities."

Nobody has pursued those possibilities as seriously and successfully as Dhondt and his colleagues at Cornell. "There are 15 million citizens in the U.S. alone who spend untold amounts of time and money on bird watching. The Lab of Ornithology has capitalized on this public interest to produce some very good science," says Peter Marra, an ecologist at the Smithsonian Environmental Research Center in Edgewater, Maryland. Cornell has even created an endowed professorship dedicated to citizen science—the first position of its kind in the country—that it hopes to fill this year.

Helping hands

Cornell's tradition of engaging citizens in bird studies dates to the 1950s, when lab founder Arthur Allen conducted informal Monday evening seminars to raise public awareness about ornithology. At those sessions, Allen would read out a list of birds and ask for a show of hands indicating how many people in the audience had sighted each species. He logged the results of the weekly poll in a register, providing a rough picture of the relative abundance of different birds over time.

Decades later, lab researchers thumbing through those registers wondered if they could get volunteers to be more scientific. That idea led to Project Tanager, a large-scale experiment begun in 1994 to study the impact of forest fragmentation on tanager populations and their nesting success. Over 3 years, nearly 1500 volunteers around the country took a census of four tanager species—often by playing taped calls supplied by the lab—and recorded signs of predation in their nests. Researchers found that tanagers in fragmented habitats were more likely to thrive in regions that had a high percentage of forest cover.

Volunteers also played a key role in helping scientists understand an epidemic of conjunctivitis among house finches in the mid-1990s. Following up on sightings in Maryland of finches with red, crusty eyes, Dhondt printed and distributed 60,000 computer-scannable forms to 9000 volunteers to record daily sightings of both healthy and sick birds. Within months, researchers had documented the spread of the disease across the Northeast and Midwest.

"The speed at which we were able to track the epidemic was simply amazing; we couldn't have dreamed of doing it without a volunteer network," says Dhondt. Over the next 5 years, more data revealed patterns showing seasonal and geographical variations in the spread of the disease. In 2000, Dhondt and his colleagues used those data to win a $2.4 million grant from the National Institutes of Health and the National Science Foundation (NSF) under a joint program on the ecology of infectious diseases. The team developed predictive models of the spread of aerially transmitted bacterial diseases.

The grant marked a coming of age for Cornell's citizen science efforts, which had previously been supported through NSF's informal science education program. Dhondt says NSF reviewers had rejected earlier proposals because of doubts that volunteer-generated data could be trusted. But the publications from the house finch survey "countered that skepticism effectively," says NSF program director Samuel Scheiner.

Cornell researchers have also studied the reliability of citizen scientists. During the pilot phase of Project Tanager, for example, ornithologist Ken Rosenberg and his colleagues compared observations made by volunteers to data collected by researchers themselves. At 17 of the 19 sites where this comparison was made, the data were identical. "Volunteers are extra-careful because they aren't professionally trained," says Rosenberg. "They doubt themselves."

By using statistical tools to look at broad patterns, the Cornell researchers are able to detect and discard individual data points that appear suspect. And although there are differences between volunteers in their ability to see and hear birds, "the variation tends to be random," says ecologist Wesley Hochachka. "The larger the data set, the greater the chances of detecting a signal."

Even so, Cornell researchers face constant reminders that volunteers are not trained scientists. Dhondt remembers a lament from one despondent volunteer in Quebec, who wrote him that "I've been reporting for 48 months, and I've yet to see a sick house finch." Dhondt used his reply as an instructional tool. "Your data are so valuable," Dhondt wrote back. "As soon as you have seen your feeder and recorded your observation, you've made your contribution. Not seeing birds is biologically important information."


Fieldworkers. Citizen scientists Kaycee Lichter and Greg Baruffi of Virginia devote up to 15 hours a week to Cornell-based projects.

CREDIT: Y. BHATTACHARJEE/SCIENCE

The lab thinks citizen scientists are capable of even more sophisticated observations. For example, Stefan Hames is using volunteers to investigate the mechanism by which acid rain affects wood thrush populations. The protocol asks them to soak a square piece of cardboard in unchlorinated water and place it on a patch of earth covered with twigs and fallen leaves. The next day they record the number of snails and other invertebrates found under the cardboard. Eating these calcium-rich animals helps the birds lay eggs with secure shells. Knowing that acid rain takes a toll on these invertebrates, Hames and his colleagues hope to find out whether the scarcity of calcium-rich prey explains the decline of wood thrushes at sites with high levels of acid rain.

The lab also hopes to expand its network of volunteers. "Right now, the northeastern seaboard is well covered," says lab director John Fitzpatrick. "We'd like more observers on the ground in states like Arizona and Nevada. Eventually, we'd like to test hypotheses and conduct experiments on a continental scale."

–YUDHIJIT BHATTACHARJEE

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