Decoding Chimp Genes and Lives

For years, the genes of wild chimps have eluded scientific scrutiny. Now researchers have extracted DNA from chimp hairs, revealing kinship patterns and—possibly—a new species

A slender strand of chimpanzee hair isn't much to look at, and it's very disposable: Chimps lose hundreds every day. But within the DNA of these strands are clues to a complex social world, in which half-brothers form alliances to gain power and the desire of powerful males to sire offspring may be thwarted by their subordinates. Within the hairs, too, are hints that while many chimpanzees may look alike, some may turn out to have marked molecular differences—perhaps even forming a new species.

As a team of researchers report on page 1193 of this issue, it is now possible to use a handful of chimp hair to provide information about chimpanzee behavior and kin relationships that could previously only be inferred from years of observation in the wild. "We believe it opens up all sorts of possibilities and not just for primatologists, but for every wildlife biologist," says David S. Woodruff, one of the researchers behind this work and an evolutionary biologist at the University of California, San Diego. "It shows that we can study an animal's pedigree without ever touching or even seeing them—all we need is their hair."

In their paper, Woodruff and his colleagues used DNA from the nucleus of hair cells to verify researchers' ideas about an unusual behavioral pattern: female exogamy. Among most social mammals, the young males tend to leave the groups in which they are born to find mates and their own territories. Among chimps, however, it is the females who often leave—a pattern that has a profound effect on chimp social structure.

The scientists used another type of DNA—from the energy-producing organelles called mitochondria—to explore the animals' genetic diversity. This mtDNA, inherited only from the mother, is not scrambled by sexual recombination, and is therefore useful for establishing lineages stretching far back in time. The researchers used this material to suggest that the West African chimpanzee (*Pan troglodytes verus*) could be a third species of chimpanzee, distinct from *Pan troglodytes* and *Pan paniscus*, the two chimp species everyone agrees upon. In doing so the researchers have wandered into one of biology's touchiest areas, for few scientists can agree on just what constitutes a species. "It's a very hotly debated topic," says James L. Patton, an evolutionary biologist at the University of California, Berkeley, noting that species definition can involve morphological, behavioral, genetic, and geographic elements.

Many strands of data

The controversy over whether there is a third species of chimp hasn't taken the luster off the hairs' tales. "They've addressed such a diversity of questions with their [genetic] data," says Patton, who has used genetics to analyze speciation of animals in the Amazon Basin. "It certainly shows the power of this approach." Says Anne Pusey, a behavioral ecologist at the University of Minnesota: "The fact that we can now look at chimp genetics and see who is related to who, and from that draw new insights about their social relationships, is excellent."

JANETTE WALLIS

Plucking hairs. Biologist Phillip Morin searches for chimp hairs among the leaves of a chimp's night nest.

Previously, primatologists gathered information about chimp kinship, social relations, and phylogeny only after years of patient observation, noting which infants were born to particular mothers and observing the males that sexually monopolized females. Obviously, genetic data would have resolved many of these issues quickly and accurately, but primatologists balked at the idea, because blood samples had to be taken, and that posed a risk to the chimps from tranquilizer darts and potentially dangerous falls from tall trees. "You can't expect chimps to let you follow them around the forest if you start messing them about like that, darting them and knocking them out of the trees," says Jane Goodall, the renowned chimp-watcher and a co-author of the paper.

Woodruff and Phillip A. Morin, a conservation biologist at the University of California, Davis, hit on the idea of analyzing DNA in chimpanzee hair after reading a 1987 study by molecular biologist Cecilia von Beroldingen, who reported that small amounts of DNA could be retrieved from human hair, particularly if the root was intact. "There's tissue, hair growth cells, in the root end of naturally shed hair," explains Morin, who first extracted and analyzed genetic sequences from captive chimps' hair, specifically targeting two mtDNA loci and eight nuclear DNA loci. When that worked, the researchers turned to Goodall's chimps at Tanzania's Gombe Stream Research Centre. "That's a dream site for a pedigree study like this, because of the more than 30 years of [behavioral] data Jane has collected," says Woodruff.

The next step was to check the DNA method by matching the genetic data to information the primatologists already had about family relationships. That meant getting to the chimps' night nests. Individual chimps make new nests each night, bending down tree branches to form comfortable beds among the leaves. After the chimps had departed on their morning treks, Morin and UC San Diego primatologist James J. Moore climbed into the nests and picked up hairs the animals had shed during the night. The scientists were thus able to link the hairs they recovered to their owners—and so secure a positive genetic ID for each animal.

Of 43 chimpanzees whose hairs they collected, Morin eventually genotyped 37 individuals by comparing degrees of similarity among the eight nuclear genetic loci, known as simple sequence repeats, and then used that information to analyze the animals' genetic relationships. Mothers and offspring were highly similar; half-siblings (those with the same mother and different fathers) were less so; and chimps with different mothers were most distinct from one another.

Where's Poppa?

Having established the reliability of the DNA data by matching it with observational data, the researchers began to go beyond what others had learned by watching the apes. The first step was to establish paternity. Since sexually receptive females often mate with all the adult males, picking out the father by observation in the wild is impossible. "That's what we really wanted to figure out, since by simply watching the chimps it's hard to know who actually fathers the offspring," says Moore. By establishing the genetic similarity among captive fathers and offspring as a benchmark, and comparing the DNA of the wild offspring to that of the males in the Gombe group, the researchers were able to single out the fathers of two young males.

Morin had hoped to identify the paternity of most of the chimps in the group, but he discovered that, in fact, nearly all the fathers were missing—apparently having died during a viral epidemic in the late 1980s. Nevertheless, Morin thinks he may eventually be able to pinpoint some of these dead fathers by extracting DNA from their skeletal remains—a possibility that William McGrew, a primatologist at Miami University of Ohio finds "absolutely fascinating...because once we know the paternity, there are many [behavioral] hypotheses we can actually test."

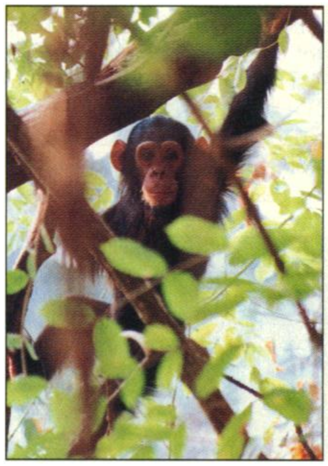
One of those hypotheses is the social consequences of female exogamy. Primatologists had hypothesized that such a practice means males in a group are more closely related than females—and that the genetically related males might therefore cooperate more closely than the unrelated females. Males at Gombe, for instance, form tight bonds and cooperate to defend their territory. And Morin's data show that, indeed, males at Gombe are related at the level of half-brothers, on average. "The study does the hard work of testing that hypothesis, and is nicely congruent with it," says McGrew. On the other hand, the genetically distant females in a community show little inclination to help or support one another.


JIM MOORE

Genetic family portrait. DNA from hair reveals the relations in this group: a youngster *(left)*, his mother *(rear)*, and his uncle.

Male cooperation lies behind numerous political dramas that Goodall and her assistants have observed over the years at Gombe. Perhaps the best example is the rise of a young chimp named Figan to the status of alpha—or most dominant—male in the mid-1970s, says Goodall. "Figan got to be the top-ranking male because of his [half-brother] Faben's support," she notes. "Theirs was really a double-display against the other males, who were very intimidated."

Although the new study may help explain how some males rise to alpha status, it also raises questions about why a chimpanzee would aspire to be top banana at all. The two fathers that were identified by the DNA testing were not alpha males. Instead they were "brash young guys on their way up," as Moore puts it. "We've often wondered about what is the most successful mating strategy," he continues, as chimpanzees engage in a variety of tactics from group sex to monogamous "consortships."


PHILLIP MORIN

Babe in the woods. The paternity of Tanga, a 2-year-old female, may be established as more chimp genotypes are added to the Gombe database.

Primatologists have tended to assume that males who persuade a female to join them as consorts probably have a better chance at actually fathering an infant than do males who stay with the group—usually the alpha male—and mate whenever they get the chance. "Once this paternity data comes in, we can determine which is the better strategy," says McGrew. "And then we'll be in a better position to understand female choice, and whether they are able to choose a particular male as the father." New chimp DNA studies will also help primatologists track females who transfer out of known communities, which has never been done.

More hair research may also help scientists sort out a speciation muddle. The mtDNA lineages from 20 different chimp sites revealed that the West African chimpanzee, now regarded as one of three subspecies of *Pan troglodytes*, is actually "genetically distinct" from the East and Central African subspecies, says Morin. Specifically, Morin's analysis revealed DNA sequence differences peculiar only to the West African chimps; they are not found at all in either the East or Central populations—"a substantial difference," says Morin.

A new species?

The time needed for this marked genetic difference to evolve between two populations splitting off from a common ancestor is about 1.6 million years, the team calculates. "This is the first clue that *P.t. verus* [the western chimp] might actually be a separate species," says Morin, adding the caveat that "genetics alone, of course, does not determine a species." To conclusively move *P.t. verus* up one taxonomic notch, he says, would require finding similarly strong genetic differences in nuclear DNA, as well as recording any distinctive ecological or behavioral differences.

Still, the mere suggestion that there is a third chimpanzee species is certain to fan the "what makes a species" debate. "In the past," explains evolutionary biologist Patton, "species were defined biologically: by their morphology and their ability to interbreed. But that's been challenged by the phylogenetic species concept." According to this hypothesis, if a population of animals has one or more features that uniquely differentiates them from all other populations, then they should be recognized as a species. Thus, for Patton, the western chimp's unique mtDNA suffices for "treating *P.t. verus* as a unique species."

Others, however, are not so easily persuaded. Primatologists seem reluctant to rework the chimps' taxonomy because, as Janette Wallis of the University of Oklahoma notes, "the subspecies have so many similar behaviors; when you're with them, you don't get a strong feeling of species' differences."

Yet if the three-species hypothesis is borne out, it may help to explain certain behavioral differences that primatologists have observed between the western and eastern populations. For instance, certain western populations use stone tools to crack open nuts; eastern chimps have never been observed doing this, notes McGrew. On the other hand, all chimpanzees, from east to west, use twigs or other tools to fish for termites. "It's tempting to see a correlation here," says McGrew. "Perhaps the [western] chimps invented nut-cracking after the 1.6-million-year split, so that behavior never had a chance to diffuse to the other species."

It's an inviting argument. Great apes, after all, have shown the ability to constantly invent new technologies. A subgroup of one ape species, for instance, has recently figured out how to use hair to glean knowledge about their cousins. Early betting among other members of that small subgroup is that this hairy technology will soon be widely spread.

–Virginia Morell