Our closest primate relatives exhibit traditions of grooming, calling, and tool use that a growing number of researchers say add up to a primitive form of culture

Chimps in the Wild Show Stirrings of Culture

TAÏ NATIONAL FOREST, CÔTE D'IVOIRE, WEST AFRICA—At the foot of a buttress tree, in the dappled sunlight of the rainforest floor, a young chimpanzee named Lefkas is working hard for his lunch. He holds a rock with both hands and a foot and slams it down with a sharp crack on a round coula nut, a bit smaller than a golf ball, which is balanced on a flat rock on the ground. After a few tries the nut cracks. The chimp pops the meat in his mouth and scampers off.

PRIMATE ABILITIES

What separates humans from animals? This special Focus looks at two possible answers: culture and consciousness. New research suggests that rudimentary aspects of both may be found in our primate cousins.

▶ CULTURE

CONSCIOUSNESS

The ground where Lefkas was sitting is strewn with coula nut shells, the leavings of other chimpanzees' meals. Indeed, from December through February, coula nut cracking is one of these chimps' main pastimes; primatologist Christophe Boesch, who has studied Lefkas's group at Taï for 20 years, says he watched another young chimp crack nuts nonstop for 5 hours.

But chimps from just a few hundred kilometers away would probably stroll right past Lefkas's dining site. In a survey of chimps throughout Côte d'Ivoire, Boesch found no evidence for nutcracking anywhere east of a river called the Sassandra-N'Zo, even though both nuts and rocks are readily available throughout the forest. To Boesch, who is director of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, such differences in customs are akin to the use of chopsticks in Japan and forks in France: signs of distinct cultures, in which groups develop their own sets of behaviors based on social ties and shared history.

Most people think of culture as encompassing such uniquely human skills as language, music, art, and clothing styles. But some biologists have a simpler definition: any behaviors common to a population that are learned from fellow group members rather than inherited through genes. By this generous definition, bird song dialects and the calls of whales might qualify as animal "culture" (*Science*, 27 November 1998, p. 1616).

How does mom do it? A mother chimpanzee in the Taï forest smashes open a coula nut; eventually her son Lefkas will catch on.

Most anthropologists stick to a narrower definition, requiring culture to include language and whole systems of behavior. But in the past decade, a growing number of primatologists and psychologists have sought to approach the question more rigorously, defining specific elements of culture that could potentially be observed in animals, then seeking these behaviors in the wild and in labs. They are turning up increasing evidence that nonhuman primates, in particular chimpanzees, may have a primitive type of culture that bridges the gap between the two definitions. Their argument rests on two main kinds of evidence: examples in which one chimp learns from another, and the results of such learning—the seemingly arbitrary differences in habits between chimpanzee groups at different sites. Although most examples of "culture" among animals involve just one or two behaviors, chimpanzees have dozens of learned behaviors involving tool use, social customs, and calls, says Andrew Whiten of the University of St. Andrews in Fife, Scotland.

Of course, no primate society can build a mud hut or do any number of other tasks that are relatively easy for humans to master. Some researchers argue that that is because our primate cousins do not learn as we do, by imitation and instruction. And most agree that primates don't seem to be able to build on previous inventions, an ability that "is the hallmark of human culture" and that allows us to develop complex technologies and rituals, notes psychologist Bennett Galef of McMaster University in Hamilton, Ontario. Even so, Boesch and others argue that the nascent cultural stirrings of our primate cousins may help uncover the roots of human culture, showing that, for example, gregariousness—hunting and foraging together rather than alone—may have spurred cultural development. To see the beginnings of culture in other species, says Boesch, "helps us to see what is unique about humans."

Multicultural chimps

Some of the best evidence for primate culture has come from field studies comparing the repertoire of chimpanzee skills and behaviors in groups around Africa. For example, in 1974 William McGrew of Miami University in Oxford, Ohio, detailed how chimps at Jane Goodall's Gombe site in Tanzania used sticks to fish driver ants out of their nests. A decade later at Taï, Boesch and his colleagues noticed a slightly different technique. At Gombe, chimps use 60-centimeter-long sticks to probe an ant nest. They wait for the insects to swarm halfway up the stick, then withdraw the tool and sweep ants off with their free hand, gathering a crunchy mouthful of hundreds of ants. At Taï, chimps use sticks about half as long, wait only a few seconds, then use their lips to sweep about a dozen ants directly into their mouth. The Taï method, analogous to eating

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Life—and Death—in the Forest

TAÏ NATIONAL FOREST, CÔTE D'IVOIRE—A day spent watching chimpanzees here begins before sunrise, with a headlong crash through tangled forest to the trees where researchers watched the 32-member group nest the night before. Later there may be another dash through the jungle, trying to keep up with a hunting party as they race through the treetops chasing their favorite prey, red colobus monkeys. There are quiet moments as well, of patient watching and waiting as the animals nap, notes veteran chimp watcher Christophe Boesch of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. But often the forest seems to be crawling with chimps—three or four juveniles swing in trees, adult females sit with young ones eating fruit, and an adolescent male doggedly follows his latest crush, a female currently in heat. Keeping track of who is doing what with whom sometimes seems like trying to keep track of a kindergarten class on a field trip.

It's an exhausting way to gather data. But for researchers seeking to test theories about chimpanzee behavior, including the idea that the animals have a sort of rudimentary culture (see main text), watching the animals in the wild is the only way. So scientists rearrange their work and lives to accommodate the chimpanzee rhythms, spending several months a year in remote jungles, largely out of contact with the rest of the world.

The first lesson for wannabe chimp observers is patience. Chimpanzees are wary creatures and flee the moment they spot an intruder. It can take as long as 5 years to accustom a group to the presence of note-taking humans, a process called habituation. When Boesch began to work here as part of his graduate studies back in 1979, he spent endless hours just chasing dark shadows in the forest. "In the first 2 months, we never saw a chimp. We only heard them running away," recalls Boesch, who worked with his wife, Hedwidge Boesch-Achermann, to habituate the chimps. "In the first 2 years, we spent full days in the forest and saw chimps only 1% of the time. In the third year, we had a dramatic increase—to 5%," he says. It was 5 years before a chimp first looked at a researcher without running away or otherwise changing its behavior.

In order to get his thesis done before his adviser and funders lost patience, Boesch studied nut-cracking behavior, in part because the sharp, rhythmic ring of rock on nut can be heard throughout a forest even when no chimps are in sight. By the time his thesis was done, the chimpanzees were nearly habituated, and he could move on to more firsthand studies.

After 20 years, the data-gathering is highly systematic. Boesch still takes notes by hand in a spiral notebook kept in a plastic bag in his breast pocket, but several of his students and assistants type three-letter codes for behaviors into handheld computers, then download the data directly to a laptop back at camp. Often a researcher will follow one animal for the whole day, noting its behavior and interactions and photographing and videotaping it.

Crunchy snack. A young chimp eats ants Taï-style.

Still, even after a group is habituated and has been studied for years, the entire research program is vulnerable to everything that threatens the chimps themselves, from poaching to disease. The group here has suffered two epidemics of Ebola, and last month, a suspected measles outbreak killed another eight chimpanzees, leaving the group's survival in question. Boesch and his colleagues have successfully habituated another group in the southern part of the forest and are working on a third, but studies of family relationships and social structures in the first group have been crippled. "It is the way of nature," Boesch says sadly, "but that does not make it easier."

–G.V.

CREDITS: (TOP TO BOTTOM) CHRISTOPHE BOESCH; ANDREW WHITEN

soup with a tiny sugar spoon, collects only one-fourth as many ants per minute, but in 2 decades of observation, no animals at Taï have ever eaten ants Gombe-style, presumably because no chimp there ever discovered it. "A Gombe chimp would laugh at [the Taï chimps]" for their "primitive" method of ant fishing, says McGrew.

Social interactions vary among groups, too. For example, McGrew, primatologist Linda Marchant, and their colleagues have recently documented a new behavior they call "social scratch," in which one chimp rakes its hand up and down another's back after grooming. The behavior is common at Mahale in Tanzania but never seen elsewhere. Like some human fads and fashions, the behavior isn't utilitarian, but a part of social etiquette that apparently caught on simply because it feels good. "It's unlikely to be related to functional significance of grooming," McGrew says, but rather helps to reinforce the social hierarchy. In preliminary studies, higher ranking chimpanzees received more social scratches per grooming session.

Twist, then pull. An "artificial fruit" that opens several different ways allows researchers to test whether chimpanzees imitate specific actions.

Such examples add up to an impressive list. In last week's issue of *Nature*, researchers from the seven longest established chimpanzee field studies combined observations and listed 39 behaviors, from tool design to grooming to mating displays, that are distinct to particular groups and not readily explained by ecological differences. "We now have, in a sense, an ethnographic record" of chimp populations, McGrew says. "We have enough data in enough populations that we can start doing the sorts of comparisons that cultural anthropologists do across human populations."

Such geographical differences suggest that a chimpanzee's specific behavior and skills are shaped by where it is raised. That idea "is the most exciting finding" in chimpanzee field research this decade, says primatologist Tetsuro Matsuzawa of the Primate Research Institute at Kyoto University in Japan. Yet simply noting these geographical differences begs the question of how they develop and how they are maintained.

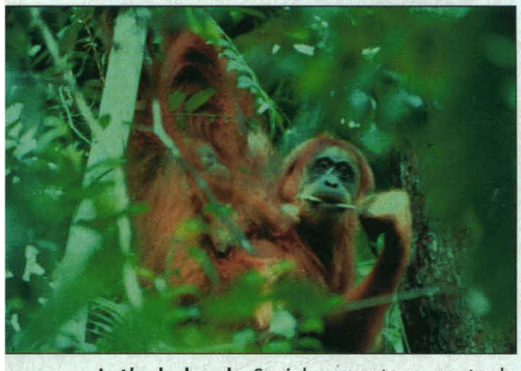
Do apes ape?

A chimpanzee pant-hoot sounds like nothing else in the forest: who-ho-who-ho-who AH

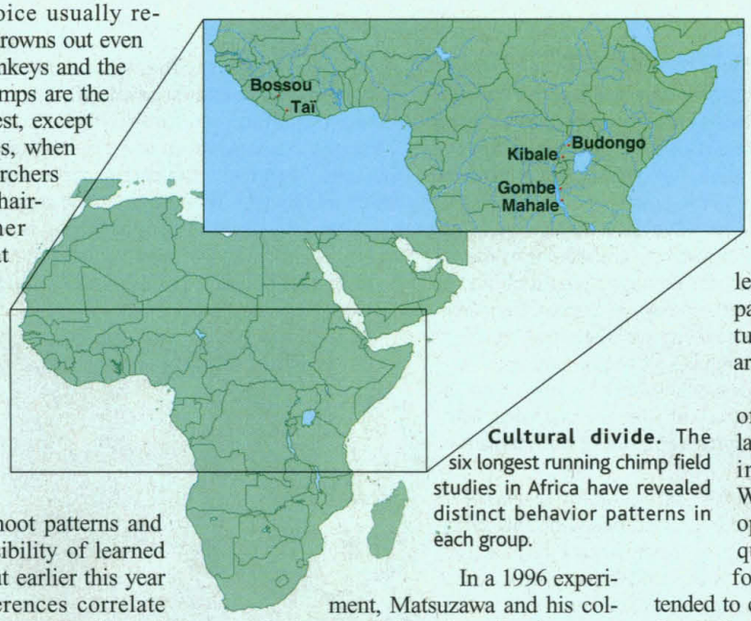
AH AH AH. Another voice usually responds, and soon the din drowns out even the copulation cries of monkeys and the screech of the hyrax. "Chimps are the loudest animals in the forest, except for humans," Boesch notes, when the din dies down. Researchers are now analyzing these hair-raising hoots for another proof of culture, one that helps explain the origin of geographical customs: that chimps learn from one another.

In 1992, primatologist John Mitani of the University of Michigan, Ann Arbor, reported that different chimpanzee groups had distinct pant-hoot patterns and pitch, suggesting the possibility of learned chimpanzee "dialects." But earlier this year he noted that those differences correlate with factors such as average body size and so might be genetic rather than "cultural" in origin. To find out, anthropologist Richard Wrangham of Harvard University and his colleagues studied calls in two captive groups where chimps from a mix of wild populations live together. In spite of the mixture of genetic backgrounds, each colony had a characteristic style of pant-hoot. "This is some of the best evidence for learning" of vocalizations, says Wrangham. "It's very difficult to think of an alternative hypothesis here."

Evidence that chimp behaviors can spread from one group to another would also strengthen the case that they are learned. Successful human practices tend to spread when people travel, and Matsuzawa has shown that in at least one case, a chimp skill spread the same way. He studies a community near the village of Bossou, Guinea, where the chimps are skilled tool users and frequently use rock hammers and anvils to crack the hard shells of oil palm nuts to get at the fatty meat inside; coula nuts do not grow here, although they are found on nearby Mount Nimba.



Let's do lunch. Social orangutans use tools more frequently than their solitary cousins.



Cultural divide. The six longest running chimp field studies in Africa have revealed distinct behavior patterns in each group.

In a 1996 experiment, Matsuzawa and his colleagues left rocks, oil palm nuts, and the unfamiliar coula nuts in a clearing, then hid behind a grass screen and videotaped the chimps. Several chimps picked up the unfamiliar nuts, but only an adult female named Yo cracked and ate them. Although other adults ignored Yo's nutcracking, a few young chimps watched her intently and later picked up and cracked nuts themselves. Matsuzawa suspects that Yo, who joined the group as an adolescent and may have been raised in the coula-rich Mount Nimba area, remembered the skill from her childhood. The fact that she passed it on to other young chimps shows, he says, that chimpanzee behaviors can spread from one group to another throughout a region, just as human cultural behaviors do.

But the field is divided over whether monkeys and apes learn from one another the same way humans do, and researchers interpret the same experimental results in very different ways. For example, in the very first evidence of possible primate culture, reported in 1958, primatologists Shunzo Kawamura and Masao Kawai of Kyoto University observed as a young female macaque living on the small island of Koshima discovered how to wash sandy sweet potatoes (provided by the researchers) in a nearby stream. Eventually most of her group was doing it too. Kawamura suggested that this was a "precultural" behavior, and the observations were touted in textbooks for decades as evidence for culture among animals.

But in the early 1990s McMaster's Galef and other animal behaviorists pointed out that the skill took several years to spread through the group and suggested that troop members, once they paid attention to the potatoes, discovered on their own how to wash them—essentially reinventing the wheel. In contrast, humans learning a new skill tend to carefully mimic the exact movements they see in an expert and are often deliberately taught by another person. Although reinvention might work for learning to crack nuts or fish for ants, says psychologist Celia Heyes of University College London, it wouldn't work for passing on more sophisticated cultural behaviors such as chipping arrowheads or weaving baskets.

Such critiques sparked a flurry of new work in both the field and lab to discern whether great apes do in fact imitate. St. Andrews's Whiten and his colleagues developed "artificial fruits," which required several steps to open, and found in 1996 that chimpanzees tended to complete the steps in the same order as the demonstrator. Primatologists such as McGrew say that the experiments have "nailed down" the point: "In the right sorts of circumstances, chimps imitate." The observations of the different ant-dipping methods offer an example in the wild, adds Whiten. "It's difficult to see how such consistent behaviors could come about with anything but imitation," he says.

But the animal behaviorists aren't so sure. Following the order of simple actions is not the same as humans' imitation of fine motor movements such as dance steps, says Heyes. And Matsuzawa cautions that chimp imitation is rare in the wild. "Imitation is much more difficult than we expected," he says. "Yes, there is imitation, but it is very, very difficult for the chimpanzee." He and others also note that active, deliberate teaching, which some claim is a prerequisite for culture, is also rare among chimpanzees. Boesch has described two instances of mothers helping their offspring with the fine details of nutcracking, but as Galef points out, only two clear examples in 20 years of observation suggests that teaching is very rare. "The primatologists are pushing very hard for a rich interpretation of the data that are available," he says. "Given that imitation is rare in nonhuman primates and teaching is essentially nonexistent, it's hard to see how you're going to get the cumulative culture which is the hallmark of our culture."

The benefits of tolerance

Whether you call primate behaviors "culture" or not, researchers say that primate traditions may offer insight into the origins of human culture. Take orangutans, which love to eat the high-fat seeds of the neesia fruit. "It's like chocolate; they eat it for hours," says Duke University biological anthropologist Carel

CREDIT: (BOTTOM) PERRY VAN DUYNHOVEN/WILDLIFE CONSERVATION SOCIETY (NYZS)

van Schaik. Most orangs won't touch the fruit after it ripens, however, because the seeds are then surrounded by stinging hairs. But one population, in Sumatra, uses sticks to scrape out the hairs and get at the seeds. "The whole population knows the trick," van Schaik says. "It's very similar to what we see in some chimp populations." And it's the only case in which orangs—skilled tool users in captivity—have been spotted using tools in the wild.

Orangs that avoid ripe neesia have the same sticks available for tools, so lack of materials can't explain why their behavior differs, van Schaik says. The key difference, he and his colleagues found, is that whereas most orangs are solitary, the Sumatran tool-using animals travel and feed close together, perhaps because there is plenty of food to go around. In most environments, food is thinly distributed and the animals "can't afford" to forage together, says van Schaik. The extra interaction in Sumatra allows an invention by one animal to spread when its compatriots observe it, he adds.

The pattern also holds for chimpanzees, as van Schaik and his colleagues report in this month's issue of the *Journal of Human Evolution*. In a survey of the behaviors reported at the five longest running chimp field studies, the researchers found that those with higher "social tolerance" (measured by the amount of meat sharing, female-female grooming, and similar indicators) have more varied tool use. The theory could help to explain why captive primates are better at using tools than wild ones, as animals in captivity have more chances to observe one another and have plenty of food, van Schaik says.

The correlation might help explain the rise of human tool use as well. The earliest tool-using hominids "didn't have a much bigger brain yet, so we shouldn't look for major cognitive advances," van Schaik says. "I hypothesize that there was a social change that made them tolerate each other," which led to increased opportunities to learn and build on each other's inventions.

The fossil record might support such a theory, says anthropologist John Fleagle of the State University of New York, Stony Brook. Ancient humans have small canine teeth and lots of tools compared to other apes, he notes, and "when you look at the fossil record, you see reduction of canines early and tools later." He thinks smaller teeth might be a sign of increased tolerance, as canines are often used in fighting among group members. "And once you have tolerance, you have bigger tool kits."

But the researchers attempting to learn the roots of culture by studying wild primates worry that they are running out of time. Habitat loss and increased hunting are pushing many great ape populations to the brink of extinction. Illegal loggers are threatening the Sumatran orangutans that van Schaik studies. And on a recent market day at the village of Taï, just outside the park where Boesch works, three chimpanzee heads were stashed in the game warden's office, confiscated from poachers. If Boesch and his colleagues are correct, says Whiten, such sights mean "we're not just losing chimpanzees; we're losing lots of different chimpanzee cultures." That, he says, would be a major loss for humans. "If we want to understand how humans came to have the minds we have and the cultures we have, then we're only going to learn about that by looking for similar characteristics in our close relatives"—close relatives who are fast disappearing.

–GRETCHEN VOGEL

PRIMATE ABILITIES
▶ CONSCIOUSNESS

Are Our Primate Cousins 'Conscious'?

With animals brandishing both tools and symbols, consciousness seems the last stronghold of human uniqueness. But might primates also have some elements of self-awareness? A new generation of researchers seeks to find out

Know thyself? Female baboons behave as if fully aware of their own social status as well as the status and kinship of others in their group.

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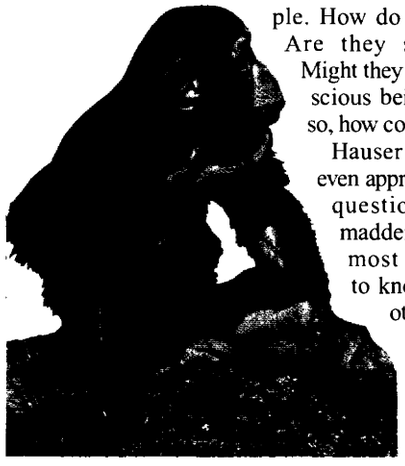

When Marc Hauser sat down to write his soon-to-be-published book, *Wild Minds*, he knew he was in for a wild ride. The Harvard University cognitive neuroscientist was about to ask questions that philosophers have struggled with for millennia—and he was asking them about animals, not people. How do they think? Are they self-aware? Might they even be conscious beings—and if so, how could we tell?

Hauser admits that even approaching such questions can be maddening. It's almost impossible to know what another person is experiencing unless they tell you, so how can scientists ever know what nonverbal animals are thinking? And there's no consensus on exactly what consciousness is, much less how to test for it. All the same, Hauser and increasing numbers of neuroscientists, psychologists, and ethologists hope to yank such questions out of the realm of philosophy and into empirical science. They seek to create a scientific foundation for understanding just what it is that makes the human mind so different from those of our hairier cousins.

Researchers are designing clever new ways to test primates for some of the concrete abilities long considered to be prerequisites for consciousness, such as overcoming instinctive behavior; being aware of oneself and of others (and knowing the difference); and, most sophisticated, understanding that others also have mental states and thoughts. By borrowing from studies of infants and comparing results among primates and children of various ages, these scientists are beginning to understand where on the continuum of intelligent beings chimps and monkeys fall. Less advanced primates are turning out to be capable of sophisticated activities such as tool use (see sidebar on p. 2075), while other primates appear to be closer to humans than has often been assumed.

For example, some monkeys can overcome instinctive behavior to solve a problem more easily than can 2-year-old children. Other experiments seem to show that chimpanzees can attribute thoughts and intentions to each other. Species "have conscious behavior attuned to their ecological niches and show different levels of conscious behavior depending on the situation," says ethologist Irene Pepperberg of the Uni-