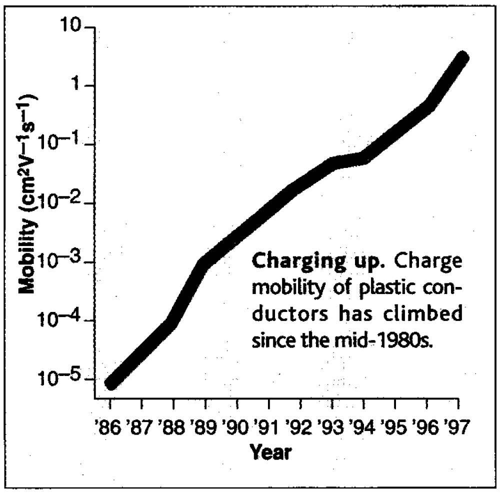


Charging up. Charge mobility of plastic conductors has climbed since the mid-1980s.

standing problem in polymer electronics. Polymers suffer from low mobility—essentially the speed at which charges, either electrons or electron gaps called holes, move through the material when a voltage is applied. By tweaking polymers' chemical structure, researchers had managed to improve their mobility by five orders of magnitude—enough to make plastic semiconductors. That development, in turn, opened the way to polymer transistors.

The basic design starts with a substrate carrying a metal electrode called a gate. Over the gate and substrate goes a layer of insulator followed by a layer of organic semiconductor such as pentacene, topped off by two more contacts, one on either side of the buried gate, known as the source and the drain. Normally, a voltage between the source and drain will produce only a trickle of current because charge carriers get caught in "traps," current-impeding locations in the polymer. "We expect that these traps are related to structural defects, such as grain boundaries or dislocations, and to impurities," says Dimitrakopoulos.

Applying a voltage to the gate, however, attracts charge carriers—holes in pentacene's case—from elsewhere in the semiconductor layer into the region above the gate, where they fill up some of the traps, allowing a freer flow of charge carriers from the source to the drain. Although this gate voltage effectively "switches on" the transistor, it still requires voltages in the region of 100 volts at all three electrodes to achieve this result, because the mobility of charge carriers is so low in a polymer. "Such voltages are incompatible with real applications," says Garnier.

So Dimitrakopoulos's team dodged the problem: Instead of trying to improve the mobility of the pentacene semiconductor directly, they sought to fill more traps by changing the insulating layer. "We replaced silicon dioxide, which was the gate insulator used, with an insulator with a much higher dielectric constant," says Dimitrakopoulos. The team used barium zirconate titanate, which has a dielectric constant of 17.3 compared to the 3.9 of silicon dioxide. Dielectric constant is a measure of a material's ability to transmit an electric field. A higher constant will channel more of the gate's electric field to the semiconductor and so pull in many more holes—"enough to fill [all] the trapping states [and leave] extra carriers that are free to travel," says Dimitrakopoulos.

With the new insulator, it took a change in gate voltage of just a few volts, rather than a few hundred volts, to alter the source-drain current by more than five orders of magnitude. The performance of these transistors now rivals that of the amorphous-silicon transistors, the type of low-cost transistor used in active-matrix displays, says Dimitrakopoulos, who adds that his group now hopes to integrate their transistors into similar displays. Friend says such work can only heighten industry's interest. "The level of interest is of an entirely different order than it was 2 years ago."

—**Alexander Hellemans**

Alexander Hellemans is a writer in Naples, Italy.

VIROLOGY

AIDS Virus Traced to Chimp Subspecies

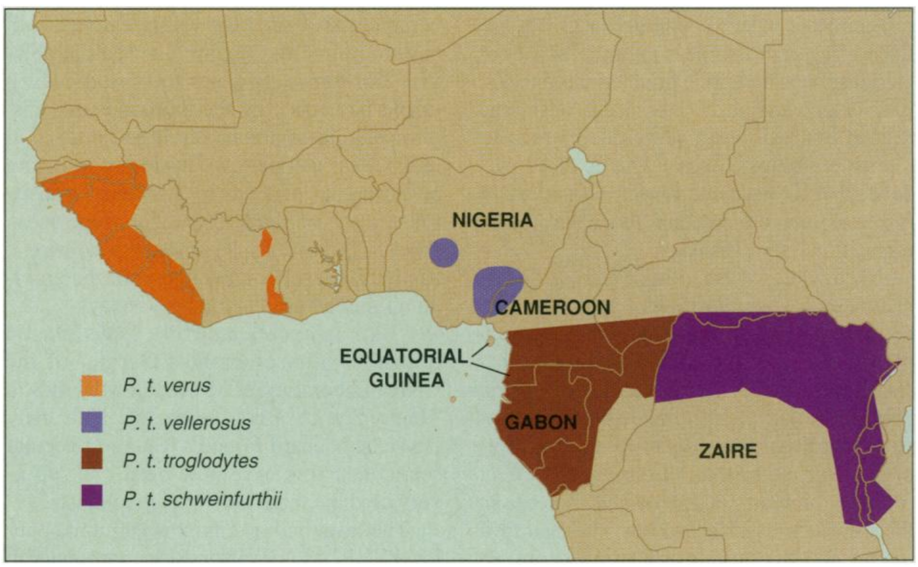
Chicago, Illinois—Most AIDS researchers have long believed that HIV-1, the main form of the AIDS virus, jumped from chimpanzees into humans. But there have been scant data to support this thesis, which has allowed theories to flourish ranging from the ridiculous (the government made the virus) to the scientifically implausible (a poliovirus vaccine introduced it) to the highly speculative (an unidentified species is the main host). Now Beatrice Hahn from the University of Alabama, Birmingham, and co-workers have pieced together what is being hailed as the best case yet for the chimpanzee connection.

Hahn's genetic detective work—which she described in the keynote speech here at the opening of the largest annual AIDS conference held in the United States* and is published in this week's issue of *Nature*—indicates that different subspecies of chimps harbor different strains of HIV-like viruses, and that one particular chimp subspecies found in a region that includes Gabon, Cameroon, and Equatorial Guinea is the source of human HIV-1 infections.

That region had been identified before as the likely epicenter of the human disease (*Science*, 15 May 1992, p. 966). But some researchers, including Hahn, doubted that chimps were the original reservoir of HIV-1 because a virus isolated from one chimp bore little resemblance to human strains, and some regions where chimps live do not have HIV-1 epidemics. The new analysis changed her mind: She now argues that some subspecies may not harbor the virus, and others may be infected with a strain that is not as likely to spread epidemically in humans. Furthering the case, Hahn noted in her talk that a French group led by the Pasteur Institute's Françoise Barre-Sinoussi will report later at the meeting that they have found three chimps from Cameroon infected with an HIV-like virus.

Vanessa Hirsch, a primate researcher at the U.S. National Institute of Allergy and Infectious Diseases who, like Hahn, helped establish the link between HIV-2—a much rarer

* Sixth Conference on Retroviruses and Opportunistic Infections, 31 January to 4 February 1999, Chicago, Illinois.



Chimp ranges. All three close relatives of HIV-1 were found in *P. t. troglodytes*.

CREDIT: (TOP) IBM; SOURCE (BOTTOM) B. HAHN *ET AL.*

cause of human AIDS—and sooty mangabey monkeys, is impressed by the data. "Everyone has kind of been pussyfooting around the question of whether chimps were the origin," says Hirsch. "As more isolates are studied, it becomes more believable."

Hahn began studying HIV-1's origins in 1995 when she received a call from Larry Arthur at the National Cancer Institute. A decade earlier, Arthur had tested 98 captive chimps in the United States to make sure they did not harbor HIV-1. He found that one animal, a pregnant 26-year-old named Marilyn, had antibodies against HIV-1, but she died in childbirth a few days later. Arthur put tissue samples from the chimp aside and forgot about them until he cleaned out his freezer. Did Hahn want to study Marilyn? he asked.

Hahn jumped at the chance. Scientists until then had found HIV-like viruses in only three chimps, two of which came from Gabon and the third from what was then Zaire. (The viruses do not appear to cause disease in the animals.) An analysis of the genetic sequence of these isolates, named SIVcpz, had revealed that the two Gabonese strains were closely related to HIV-1 strains found in humans, but the Zairian strain was quite different.

Hahn and her colleagues found that Marilyn harbored an SIVcpz virus similar to the Gabonese strains. They then analyzed the DNA in the mitochondria of cells from the four animals to determine which particular subspecies of chimp they came from. They found that the Gabonese animals and Marilyn all belonged to *Pan troglodytes troglodytes*, while the Zairian animal belonged to the subspecies *P. t. schweinfurthii*.

Hahn believes that SIVcpz may have been in chimps for hundreds of thousands of years, and that viral strains have evolved to be specific to particular chimp subspecies, which are isolated geographically by rivers. *P. t. troglodytes*—whose natural range "coincides precisely" with the regions in Africa that have had HIV-1 infections in humans for the longest period—appears to be the source of the HIV-1 strains that now infect humans, Hahn concludes. She believes that three separate transmissions occurred, each of which gave rise to one of the three main groups of HIV-1. Although the exact route of transmission is unknown, Hahn speculates that butchering chimpanzees and other animals for so-called "bushmeat"—a practice she notes is common in parts of west equatorial Africa—may have provided the link.

Hahn concedes that the chimp-human link would be stronger if researchers could show directly that SIVcpz is widely prevalent in at least some wild chimp populations. She and other researchers now hope to do these analyses, but they face a potential problem: The chimps are being driven to extinction. Hahn says she hopes her findings will ultimately discourage people from eating chimps, and focus more attention on the question of why the virus that decimates human immune systems rarely harms our closest primate relative.

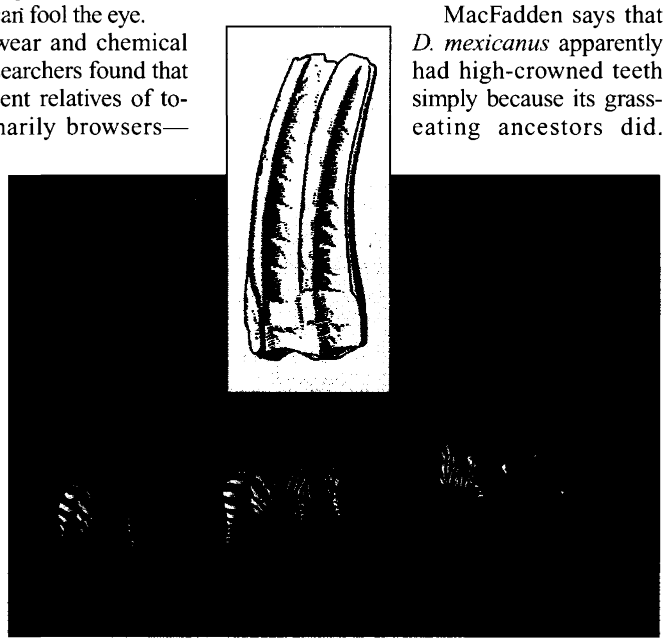
—JON COHEN

PALEONTOLOGY

Dietary Data Straight From the Horse's Mouth

Like the horse and carriage, horses and grasses have a long history together, or so paleontologists have thought. When modern grasses appeared some 20 million years ago, the thinking went, the teeth of ancient equines evolved to crop this new food, developing the high crowns seen in modern horses, and their owners changed from deerlike browsers of shrubs and trees to pure grazers. But on page 824 of this issue, Bruce MacFadden, a paleontologist at the University of Florida, Gainesville, and his colleagues show that in horses, at least, the tooth can fool the eye.

By analyzing tooth wear and chemical traces in the teeth, the researchers found that some of the closest ancient relatives of today's horses were primarily browsers—despite having teeth shaped like those of a grazer. "This is the best study to date on horse dietary behavior and change," says John Rensberger, a paleontologist at the University of Washington, Seattle. "They've taken a novel approach that challenges the traditional interpretations" of equine tooth shape, providing a model for analyzing the diets of other extinct mammals.



MacFadden's team teased apart the dietary preferences of six horse species that shared the grassy plains of Florida about 5 million years ago. The horses ranged from small, three-toed types to the heftier, one-toed *Dinohippus mexicanus*, one of the closest relatives of modern horses. All six species bore the dental hallmark of a grazer: high-crowned (or hypsodont) teeth with enameled ridges that can cut a stalk of grass as neatly as a lawnmower blade. But MacFadden puzzled over how all six could make a living cropping grass. "Ecological theory says that they'd have to partition the environment somehow; that some of them must have looked for another food," he says.

With his colleagues, MacFadden analyzed the carbon isotopes in the horses' teeth and their patterns of wear to show that that's what actually happened. Grazing horses typically eat grasses, which in many regions use the so-called C_4 photosynthetic pathway to turn carbon dioxide into sugars and starches. Such plants incorporate different amounts of the isotopes carbon-12 and carbon-13 than do C_3 plants, which are primarily trees and shrubs. Animals that eat different plants retain different amounts of isotopes in their teeth.

The team's analyses showed that some of the six horse species ate solely C_4 grasses, but others chewed a mix of C_4 grasses and C_3 shrubs and twigs, and a couple, including *D. mexicanus*, fed mostly on C_3 plants. Similarly, a microscopic analysis of tooth enamel showed that some species, again including *D. mexicanus*, did not have the characteristic abrasive marks incised by a purely grass diet but were pitted and scratched like the teeth of a browser in spite of their high crowns. "We used to interpret those high crowns as a sure sign of a grass diet," but that's not certain anymore, says Michael Woodburne, a paleontologist at the University of California, Riverside.

MacFadden says that *D. mexicanus* apparently had high-crowned teeth simply because its grass-eating ancestors did. When the species switched back to eating browse, its teeth did not change. He suggests that the high-crowned teeth represent an "irreversible" evolutionary change, but others are less sure. "It may be that horses invented a tooth that's simply good for eating anything—trees, shrubs, grass," says Paul Koch, a vertebrate paleontologist at the University of California, Santa Cruz.

All six horses eventually went extinct for some reason. Ironically, the future belonged to the big, one-toed browser, *D. mexicanus*, which gave rise to the oldest known species of modern horse—which was a grass-eater—some 4.5 million years ago. "That's the biggest surprise of all—I'd never have guessed that horse was a browser," says Koch. "It shows the power of these combined techniques." —VIRGINIA MORELL

CREDIT: M. MCRAE