of the sheet. But when they lie near the edge of the sheet, changing them has little effect on sheet stability.

Instead of relying on natural sheets to learn the rules of β sheet formation, the scaffold-builders position peptide strands side by side in an artificial scaffold, then see whether the strands hydrogen-bond into a sheet. And although Kelly admits that "peptide model systems are not absolute mimics of proteins," he and other model-builders maintain that the models make up for that drawback, because peptide strands can be chemically altered in ways that natural proteins cannot.

In 1994, for example, Kelly and his Texas A&M colleagues built scaffolds containing hydrophobic chemical groups—groups that flee from water's presence in the surrounding solution. The A&M researchers then used the scaffolds to anchor a pair of peptide strands, each of which also contained a hydrophobic group near the scaffold. The result, the researchers found, was that the hydrophobic groups clustered together, drawing the peptide strands close and encouraging them to form β sheets. Because this result echoes similar findings that hydrophobic interactions promote β sheet folding in natural proteins, "it suggests that hydrophobic interactions appear to be key for making β sheets," says Kelly.

Nowick and his colleagues have built larger scaffolds that can hold more peptide fragments side by side. At the ACS meeting, Nowick's graduate student Eric Smith told researchers that they had built a scaffold able to hold two peptide strands next to a so-called β strand mimic—a rigid, rodlike chemical group that forms hydrogen bonds with its flexible peptide neighbor to hold it in an elongated sheet formation. And because the second peptide strand formed similar hydrogen bonds with the first, all three strands ended up woven into a β sheet.

The group is now varying the amino acids in the peptide strands to tease out more secrets of β sheet formation. And to speed such comparative studies, the Nowick group has developed a technique for mass-producing variants of these β sheet mimics. Using standard "combinatorial chemistry" techniques, they attach their molecular scaffold and β strand mimic to each of thousands of polymer beads. They then split the beads into batches and vary the peptide strands that they add to each batch (*Science*, 31 May, p. 1266). "This allows us to juxtapose different amino acids next to one another to see how it affects the structure and stability" of the sheets, says Nowick.

Even before they have a complete book of rules for making β sheets, these chemists are thinking ahead, to how they might tailor their molecules to make them useful as everything from novel materials to drugs. In an article earlier this year in the journal *Macromolecules*, for example, Kelly and his colleagues reported that by changing pH, they could coax their two-strand β sheets to line up and link side to side. The result was long fibrils with a molecular architecture resembling that of portions of natural rubber or silk. These first fibrils had little of the strength or flexibility of the natural materials, but Kelly says that he and his colleagues are now trying to intersperse segments of their β sheet fibrils with regions of standard polymers in hopes of improving their properties.

Kelly and others are also thinking about how they might exploit the rules of β sheet formation in a possible treatment for Alzheimer's disease. Researchers suspect that runaway β sheet assembly could be what causes "β amyloid" proteins to agglomerate into dense plaques in the brains of patients with Alzheimer's disease. By engineering β sheet–forming compounds that could bind selectively to the amyloid proteins and block other amyloids from binding, Kelly, Nowick, and others hope to come up with a compound that might arrest plaque formation. If such efforts succeed, artificial β sheet–makers will have passed their language lesson with top marks.

–Robert F. Service

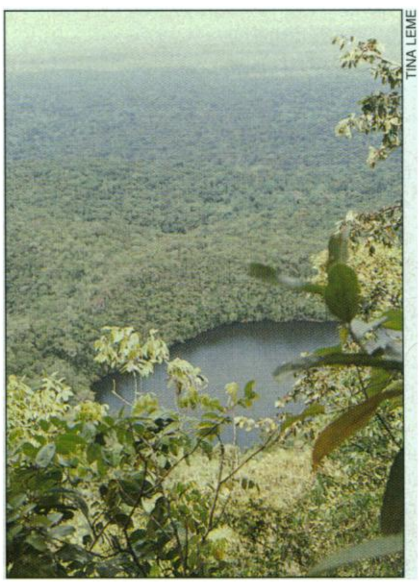
CLIMATE

Ice-Age Rain Forest Found Moist, Cooler

What happens to a hot, wet tropical forest when an ice age grips the world? In the case of the Amazon rain forest, the answer is crucial to two long-running scientific debates, one in climatology and one in evolution. Climate researchers have argued for years about whether the tropics cooled a little or a lot during the height of the last ice age 18,000 years ago (*Science*, 17 February 1995, p. 961). Their interest is more than academic curiosity, for the answer will offer clues to the sensitivity of Earth's climate system to the strengthening greenhouse effect.

On an entirely different front, evolutionary ecologists have squabbled for decades over how the Amazon flora and fauna became so stunningly diverse. One long-standing theory has suggested that glacial drying shrank the Amazonian rain forest to a few isolated patches surrounded by dry grasslands. New species arose in these refugia, then spread outward when the climate changed again and the rain forest expanded. But other biologists counter that there is precious little direct evidence of refugia—and plenty of alternative ways to generate high diversity.

Now, a single study of a couple of meters of lake mud from deep within the Amazon rain forest sheds new light on both of these controversies by pointing toward a cool but still wet ice-age Amazon. On page 85 of this issue, pollen specialist Paul Colinvaux of the Smithsonian Tropical Research Institute in Panama and his colleagues present fossil pollen evidence that tropical South America cooled a lot—5° to 6°C—during the last ice age, but remained relatively wet and as densely forested as ever. This undercuts the role of ice-age refugia in Amazonian speciation and implies a relatively sensitive climate system. Researchers debating glacial climates welcome this first long pollen record from deep within Amazonia, but urge caution in interpreting data from a single site. "It's provocative," says limnologist Kerry Kelts of the University of Minnesota—but a lone pollen core isn't likely to end either of these protracted disputes.



Window on the past. The pollen record buried in the mud of this lowland Amazonian lake reveals a cooler, moist ice-age climate in the tropics.

Even getting this much data was a struggle. Colinvaux has been working for more than 10 years to get ice-age temperature and ecological data from a single spot deep within the Amazon lowlands, which comprise an area nearly the size of the continental United States. The problem was finding a place where sediment was deposited continuously, such as a lake, that had been around since the height of the ice age. "It's a classic needle-in-the-haystack problem," says Colinvaux. "There's lots and lots of water, but which is an ancient lake?"

Colinvaux's eventual answer was Lake Pata, one of several lakes nestled on a low rise just north of the equator in northwestern Brazil. The site is remote—he and his colleagues carried coring equipment and rubber rafts on their backs for a day's march, in order to drill a core in the 7-meter-deep lake. According to radiocarbon dating done on the core, the top 1.6 meters of sediment accumulated during the past 42,000 years. So layer by layer, Colinvaux's team identified and counted pollen grains from the present back into the last ice age.

According to the refugium hypothesis, during glacial times the Amazonian climate dried out, favoring grasses and herbs over trees. Isolation is a classic means of speciation, so the idea was that many species arose in the resulting fragments of forest —"moist islands in a sea of aridity," as Colinvaux calls them. Most maps of presumed ice-age refugia, inferred from present-day biodiversity hot spots, call for dry savannah around Lake Pata. So the theory predicts that in the lake's bottom muds more than 15,000 years old, there should be less pollen from rain-forest trees and more from grasses.

Instead, throughout the Lake Pata record, 70% to 90% of the total pollen was from trees, with only a few percent from grass; all herb pollens remained below 10%. "The refuge hypothesis was a good one in that it was testable," says Colinvaux. "It said the Amazon was dry in the last glacial maximum. We drilled a lake core from the Amazon lowland in the last glacial maximum to see if it was dry. The hypothesis fails that test."


J. E. MORENO

Glacial visitor. Pollen grain from a montane tree species denotes a 5° cooling.

Some of Colinvaux's colleagues agree. The refugium theory was once "a very strongly held dogma," says Kelts, but it has been challenged in recent years, as researchers questioned the reality of the biodiversity hot spots and offered alternative speciation mechanisms (*Science*, 13 September, p. 1496). Says ecologist Edward Connor of the University of Virginia: "This puts an additional, if not the final, nail in the coffin." Others, however, worry about overinterpreting this single pollen record. "The problem is they just don't have that many samples to answer this question," says ornithologist Joel Cracraft of the American Museum of Natural History. Indeed, illustrating the difficulties of locating a sample site, in 1994 Thomas van der Hammen of the University of Amsterdam in the Netherlands suggested on meteorological considerations that in glacial times the Lake Pata site was actually within a rain-forest refugium, not savannah—in which case you'd expect to find rain-forest tree pollen throughout the core.

To address the dearth of sample sites, palynologist Simon Haberle, a former postdoc of Colinvaux's who is now at Cambridge University, surveyed the pollen in sand and mud dumped off the coast by the Amazon River. By carrying in pollen from as far away as the Andes, the river "gives a very broad picture of the basin's vegetation," says Haberle. The data, soon to be published in a report of the Ocean Drilling Program, resemble those at the Lake Pata site, showing low and stable abundances of grasses and savannah trees back into the last ice age. But even such a broadly based sample is open to criticism, notes limnologist Barbara Leyden of the University of South Florida, because gallery forests confined to the river edges might overwhelm any grass pollen that blew in from a distance.

However the evolutionary debate ends, the new data will heat up another dispute: the issue of tropical temperatures during glacial times. Many oceanographers have remained wedded to microfossil evidence taken from marine sediments around the world, which indicates just 2°C or less of tropical cooling during glacial times (*Science*, 14 January 1994, p. 173). But in the ice-age Lake Pata record, tree pollen typical of today's rain forest was joined by that of trees now found only at elevations 800 to 1000 meters higher. And Haberle also sees a changing pollen pattern in the Amazon river fan, suggesting "expansion of cold-adapted [Andean] vegetation types down into the lowlands of the Amazon."

The vegetation's altitude change at Lake Pata translates to a cooling of 5° to 6°C—the same amount implied by other recent studies in South and Central America, which focused on noble gases in ground water, changes in ice-age snow lines on peaks, and other pollen records. Analyses of Caribbean coral chemistry have shown the same cooling. All this data is beginning to make a dent, says climate modeler David Rind of NASA's Goddard Institute for Space Studies in New York City. "I'd say the [oceanographic] community is moving more in the direction that it's at least possible there was considerable cooling in the tropics."

But there's no consensus yet. "There are just enough questions about the methodology of these data on land," says paleoceanographer Thomas Crowley of Texas A&M University, that "I by no means am willing to throw in the towel and say the [marine temperatures] are wrong." With that kind of skepticism abounding, Haberle believes "it will not be until we get 100, 200, or 300 sites in the Amazon basin that we get a clear idea of how vegetation changed." But even one good sample is a lot better than none.

–**Richard A. Kerr**

ASTRONOMY

All-in-One Detectors for The Faintest Objects

Peter Jakobsen was skeptical, and perhaps a bit rude, a few years ago when Michael Perryman—his colleague in the Astrophysics Division of the European Space Agency (ESA) in Noordwijk, the Netherlands—first proposed equipping optical telescopes with a new kind of detector called a superconducting tunnel junction. STJs, which consist of an insulator sandwiched between two thin films of superconducting metal, had been studied for nearly a decade as possible x-ray detectors, but few believed that they could be sensitive enough to detect the far less energetic photons of visible light. "Come back to me when you have something that works," Jakobsen recalls saying.

Perryman did just that, and now Jakobsen is a self-described "STJ evangelist." Last spring, Tone Peacock, Perryman, and other scientists at ESTEC, an ESA research center, announced in *Nature* (9 May, p. 135) that they had built an STJ able to detect individual photons across a wavelength range spanning the near-ultraviolet to visible spectrum. And, unlike conventional detectors, the device simultaneously measures the photons' energy. That first demonstration has now touched off a flurry of activity by raising hopes that an array of these devices could serve as a detector more versatile and sensitive than today's instruments, collecting images and spectra at the same time from the very faintest astronomical objects.

In laboratories from ESTEC to Lawrence Livermore National Laboratory in California to Yale University, researchers are scrambling to improve STJs and fashion them into arrays. Astronomers, meanwhile, are thinking about how they would exploit such detectors. Jakobsen himself would like to see such a device fitted to the Hubble Space Telescope. And Shrivinas Kulkarni, an astrophysicist at the California Institute of Technology (Caltech) who is helping to develop STJ detectors, says, "If these devices work as promised, they will revolutionize the search for faint galaxies, planets around other stars, and pulsars."

In themselves, STJs are nothing new. The arrangement of slightly separated superconducting layers, cooled to near absolute zero, is essentially a "Josephson junction"—a device invented by the physicist