Positron emission tomography scans of rats that received radiolabeled Ampakines show that the drug is active at AMPA receptors for only 90 minutes. That means the animals "must have formed a stronger memory trace," says Lynch, which he chalks up to the drugs' ability to boost LTP.

Despite these results, some researchers doubt that Ampakines will affect memory and learning in people any more than does an extra cup of coffee. Charles Stevens, an LTP researcher at the Salk Institute in La Jolla, California, notes that Ampakines seem to be stimulating stronger synaptic currents as does caffeine, although by a different molecular route. And while caffeine and drugs with similar actions do boost learning, there are well-known limits to their effects. "Increasing synaptic strength is a simplistic way to increase memory," Stevens says. "There's no reason to think it will have a greater effect than that of caffeine."

"This possibility keeps us up nights," says Robert Schehr, a neurobiology consultant with Cortex, a biotechnology start-up hoping to commercialize the drugs. (Lynch was a founder and now owns Cortex stock.) Caffeine and other drugs that boost arousal, however, typically cause behavioral changes in the animals such as restlessness or jitters. "We don't see that with these drugs," says Schehr. But he adds that it's difficult to gauge the arousal level of animals, and a more definitive answer may come from the more sophisticated monitoring in human toxicology trials, slated to be conducted next month in Germany by Cortex and a German pharmacologic testing company. And in Staubli's upcoming *PNAS* paper, she reports that she implanted electrodes in the hippocampus of rats to induce LTP with an electrical pulse. In rats given Ampakines, LTP was easier to induce than in undrugged rats.

Stevens has other concerns as well. He's worried about the possibility of side effects, because Ampakines affect receptors prevalent throughout the brain. The drugs could, for instance, affect neurons in the brainstem, which could alter balance or the cardiovascular system. Lynch admits this may be so, but adds that "I worry about this less and less as time goes on because we're just not seeing" these side effects.

Others in the neurobiology community seem to have adopted a wait-and-see attitude towards Ampakines. Samuel Barondes, director of the Center for Neurobiology and Psychiatry at UC San Francisco, says the animal behavior is consistent with the notion that learning is being affected. But he's skeptical that any agent that works on one step in the complex, multistage process of memory making will prove clinically valuable. Whether Barondes and others are eventually swayed, and whether the clinical trials produce positive results, will determine whether Ampakines become a memorable drug—or just another blind alley, soon to be forgotten.

–Robert F. Service

PALEONTOLOGY

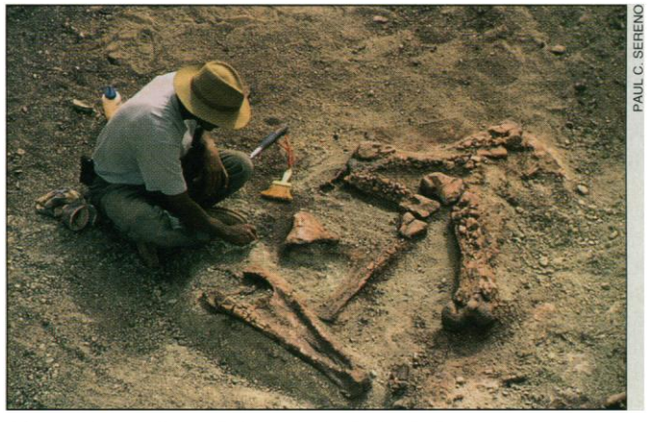
New African Dinosaurs Give An Old World a Novel Look

Last September, a caravan of six Land Rovers wound its way across 500 miles of Saharan desert, following sand-blown tracks from oasis to oasis in Algeria and Niger. The University of Chicago paleontologist leading the caravan, Paul Sereno, had traced this route before, on a 1990 survey with a British Museum expedition, and knew it would lead his team to a site dubbed "the dinosaurs' graveyard" 50 years ago by a French priest and paleontologist. But Sereno was after an even richer mortuary. Just 20 kilometers beyond the priest's site, Sereno had spotted a massive row of sauropod vertebrae poking above the sands and hinting at the wealth of bones that lay below. On last fall's foray, these hints were borne out. Almost every fossil Sereno and his team picked up was from a new, unknown species. "You can't find a dinosaur there that's been found before," he says.

On page 267 of this issue, Sereno and his colleagues report on two of those finds—previously unknown species of a carnivore and an herbivore—that lived about 130 million years ago. Paleontologists are hailing these discoveries as important new sources of information because, for creatures that supposedly dominated the entire planet, dinosaurs have been extremely difficult to find in Africa, particularly dinosaurs that lived during the Early Cretaceous, from 145 to 100 million years ago. "Africa at that time has been the most lost world of the dinosaurs," says Dale Russell, a dinosaur researcher at the Canadian Museum of Nature. "So Sereno's discoveries provide us with some badly needed diagnostic material." Adds Lou Jacobs, a paleontologist at Southern Methodist University in Dallas, Texas, who has discovered dinosaur fossils in Malawi: "These are good, fine skeletons from brand-new dinosaurs, and they suggest a diversity for that area [sub-Saharan Africa] that we didn't know about before. Finally, we've got some pieces of the puzzle coming in."

As researchers begin to assemble pieces of that puzzle, however, the image they see is rather unexpected. Sereno's finds are upsetting accepted notions about the relationships among dinosaurs at the end of the Jurassic, about 150 million years ago, when the supercontinent of Pangaea was beginning to break apart into the continents we know today. Some dinosaur experts had expected to find strong connections between African and South American species, suggesting that dinosaurs in the Early Cretaceous were divided into distinct northern and southern hemisphere populations. Sereno's finds, however, suggest a close connection between the African and North American dinosaurs, implying that Africa maintained a connection with the north far longer than previously believed. His hypothesis intrigues other paleontologists who are eagerly looking forward to putting it to the test.

The site that's triggering this excitement is called "In Abaka" in the language of the local Touareg inhabitants of the region. So Sereno and his colleagues have named the carnivore, which is the most complete of the specimens, *Afrovenator abakensis*, or "hunter from In Abaka, Africa." *Afrovenator*, with its sickle-clawed three-fingered hands and 2-inch-long, bladelike teeth, closely resembles the western North American *Allosaurus*, which thrived in the Late Jurassic, about 160 million years ago. The herbivore is a broad-toothed sauropod (a long-necked giant such as the brontosaurus); Sereno has not named this species, as the team did not find a complete skull. But the skeleton looks like *Cama-*



PAUL C. SERENO

African desert dinos. Paleontologist Didier B. Dutheil sits near a partially excavated dinosaur skeleton in Niger.

rasaurus, another dinosaur that flourished in Late Jurassic times in western North America.

These affinities upset the north-south dinosaur dichotomy suggested by some researchers during the 1970s. Throughout the Jurassic, dinosaur lineages were widely dispersed throughout the supercontinent of Pangaea. But in the Cretaceous that generalized distribution ended—as northern and southern dinosaur populations seemed to go their separate ways.

South America, for example, was dominated by the carnivorous abelisaurid theropods (large bipeds), such as *Carnataurus*, while to the north, East Asia and western North America were ruled by the meat-eating coelurosaurs such as *Tyrannosaurus rex*. Similarly, the most common herbivores in South America were titanosaurid sauropods, while hadrosaurs (duckbilled dinosaurs) and ceratopsians (horned dinosaurs) were the primary vegetation browsers in the north. Because Pangaea had begun to break apart into northern and southern components at the end of the Jurassic, it seemed logical to assume this geographic separation explained the differences among the dinosaurs.

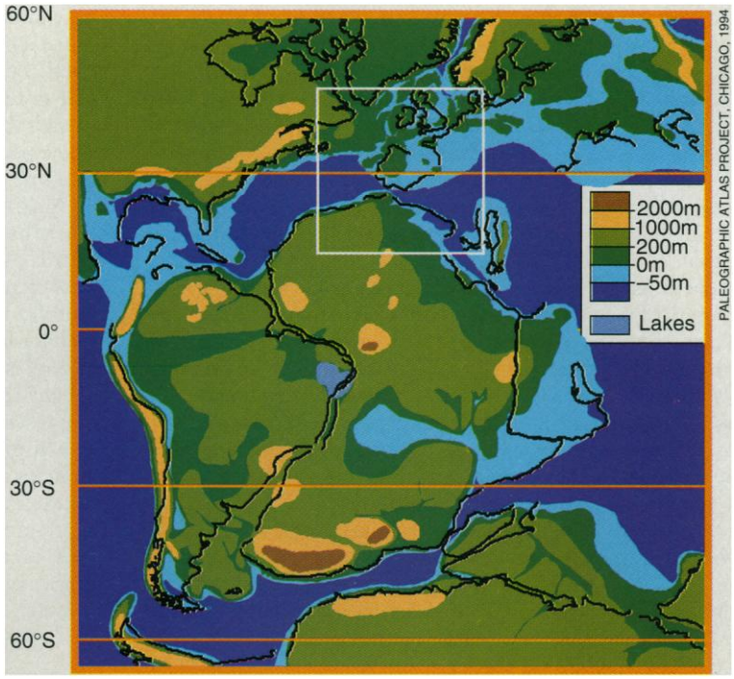
Therefore, although little was known about the Cretaceous dinosaurs of Africa, many scientists anticipated that they would fit the South American pattern. "People expected that the split-up of the continents would be matched by a similar north-south division among the fauna," explains Mike Benton, a vertebrate paleontologist at the University of Bristol.

The new dinosaurs, however, do not fit that particular bill. Rather than being related to the Cretaceous dinosaurs of South America, Sereno's African finds appear to be linked to dinosaurs that were widespread in North America and elsewhere in the Late Jurassic. Broad-toothed sauropods had vanished, in fact, from America by the Cretaceous, yet "you come to Niger and they are coming out of the woodwork," says Sereno. "They were clearly the dominant herbivore in the Cretaceous at this time." Indeed, Thomas R. Holtz Jr., a paleontologist with the U.S. Geological Survey, says that, if the geological context were removed, one would think these new dinosaurs were from the middle of the Jurassic, not the Early Cretaceous.

Sereno believes his unexpected dinosaurs are best explained by a geographic connection between Africa and Europe that lasted into the Early Cretaceous; this would have allowed the big beasts to migrate between these two land masses. And because Europe and North America were still connected at this point, the dinosaurs could have made it a tri-continent trek. "I think there was some kind of a tenuous land bridge [linking Africa and Europe] for several million years after" the initial breakup of Pangaea, Sereno says. "That bridge prevented the evolution, in isolation, of a unique southern dinosaur fauna."

Sereno's hypothetical passageway is "not untenable," says David Rowley, a paleogeographer at the University of Chicago. Although such prehistoric land bridges are not portrayed on paleogeographic maps, Rowley notes that a connection something like that which existed about 10,000 years ago through the Bering Strait could have linked Africa and Europe in the Late Jurassic. At times, he says, the sea may have been so shallow between the two regions that dinosaurs could have walked or waded across and continued on to North America. "That would be the most likely route for any exchange," says Rowley.

But even if Sereno's proposal of a land bridge between Africa and Europe might explain the similarities between his creatures and those from North America, it still doesn't explain why there are no resemblances between his new African dinosaurs and those from South America—a puzzle that is further complicated because there are strong similarities between other African and South American animals (such as crocodiles and coelacanths) from that time. "There was potentially a land connection between Africa and South America through the Early Cretaceous," says Sereno. So why don't his new finds resemble their counterparts from South America? "There must have been some geographic barrier," he speculates, "perhaps a desert or a large lake, that kept the dinosaur populations apart."



Ancient migrations? The similarity of African and North American dinosaurs implies a link *(boxed area)* between northern and southern land masses 150 million years ago.

Eventually at some point in the Early Cretaceous, Africa's tenuous land bridge to the north was severed, as well as its connection to South America, and it became an island continent. Only then, suggests Sereno, did the African dinosaurs begin to evolve in isolation from dinosaurs on other continents. The carnivore and herbivore from In Abaka show the beginning of that process. "I think these animals [the sauropod and *Afrovenator*] are the last trace of what was once a cosmopolitan group of animals," says Sereno.

Thus, the evolution of the dinosaurs in the Cretaceous, Sereno suggests, proceeded differently in different places, depending on when and how quickly the continents drifted apart and became isolated. "In some places, some of the lineages went extinct," he says. "In others, such as Niger, they survived and radiated into new species. But there's no clear-cut pattern about why that happened one way or the other. It shows us that evolution on a global scale is rather unpredictable."

Many paleontologists agree with this assessment. "Sereno's new evidence shows us that diversification was the new game for dinosaurs in the Cretaceous," says the Geological Survey's Holtz. "And that means that if you find the right [Cretaceous] locality, you'll have a lot of new taxa to describe."

Beyond that, the new dinosaurs demonstrate "how one or two specimens can radically change an earlier idea," says Jacques Gauthier, curator of reptiles at the California Academy of Sciences and a specialist on theropods. "So don't hold your breath about any of these ideas about the late evolution of the dinosaurs," he warns—one of those new creatures is likely to knock out the legs from under it. And as Holtz notes, more new species will probably be found, as Africa is now at the top of many dinosaur hunters' hit lists. "I think we'll find the final flowering of the dinosaurs there," says Canada's Russell, who's already gearing up for an expedition to Cretaceous deposits in North Africa. "Africa's going to provide us with a lot of entertainment in the years ahead."

–Virginia Morell