

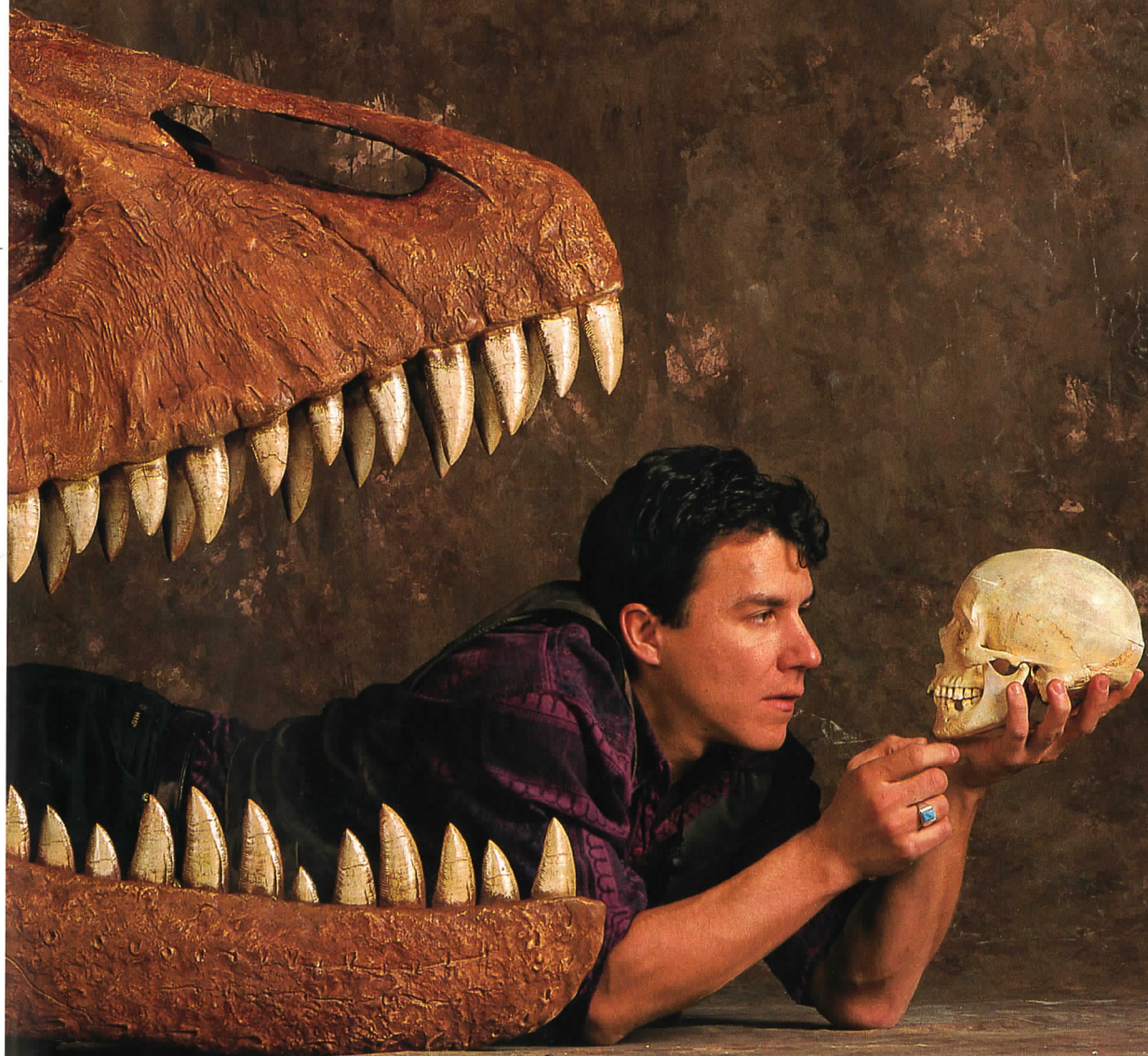
It could kill man-size prey in a single bite. *Carcharodontosaurus* —its 90-million-year-old skull reconstructed here—is the most remarkable of new finds excavated in the Sahara. Led by University of Chicago paleontologist Paul Sereno, below, a team has found compelling evidence that Africa's dinosaurs evolved along divergent paths from those elsewhere on earth.



AFRICA'S DINOSAUR CASTAWAYS

BY PAUL C. SERENO

PHOTOGRAPHS BY THE AUTHOR AND LOUIE PSIHOYOS



THE MORNING HEAT had soared to a hundred degrees, and the Atlas Mountains shimmered like a mirage in the distance.

A hundred miles of tilted plateau, more than 500 feet high, stretched to either side. No living thing made a sound in this barren valley of the Moroccan Sahara, but the rocks were waiting to tell of dinosaurs that had lived here some 90 million years ago.

Glancing across the jagged valley floor, I spotted a reddish patch of rock high on a cliff. Perhaps this sandstone held a clue to the world of Africa's dinosaurs. I began climbing. Near the top I stopped short before a scattering of yellowish bone fragments. I picked up the largest piece, about the size of a grapefruit, and examined it closely. Recognizing a knob that protruded from the bone, I knew I was holding the back of a huge predatory dinosaur skull.

The fragment looked freshly broken, as if it had fallen from the sandstone above, so I scaled the sheer face toward the top of the plateau. I found nothing, but as I made my way back down, I looked up and saw a bone jutting from the stone, camouflaged 20 feet above my original find. The edges matched those of the skull fragment. The carnivore's skull disappeared into the cliff side. Several of its teeth, which were about five inches long, were exposed. Wide-eyed in wonder, I ran my fingers across the saber-shaped teeth of

PAUL SERENO is an associate professor of paleontology and evolution at the University of Chicago. Photographs by LOUIE PSIHOFOS will illustrate a story on Mongolia's dinosaur fossils in next month's issue.

an animal I would later realize was perhaps the largest carnivore that ever walked the earth.

At five feet four inches long, the skull of this meat-eating theropod is a bit longer than the largest known skull of *Tyrannosaurus rex*, the massive 40-foot-long killer from North America. Such creatures would have most likely preyed on the long-necked plant-eating sauropods, which browsed on all fours and whose young made easy targets. The beast chased its prey by running on its powerful hind limbs, balanced by a muscular tail. It would have sliced into the thick skin of the plant-eaters with bladelike teeth. My colleagues and I identified this creature as *Carcharodontosaurus*, or "shark-toothed reptile." It is a well-deserved name.

A short distance from the skull,

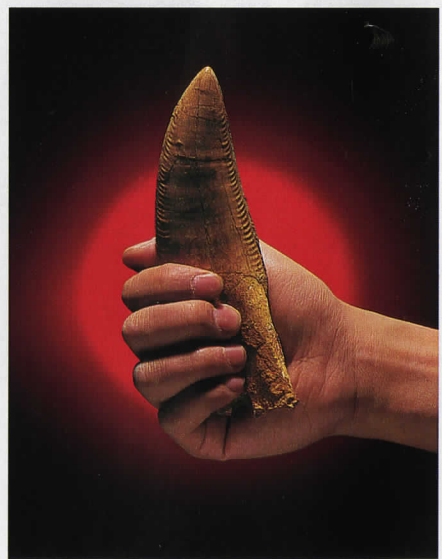
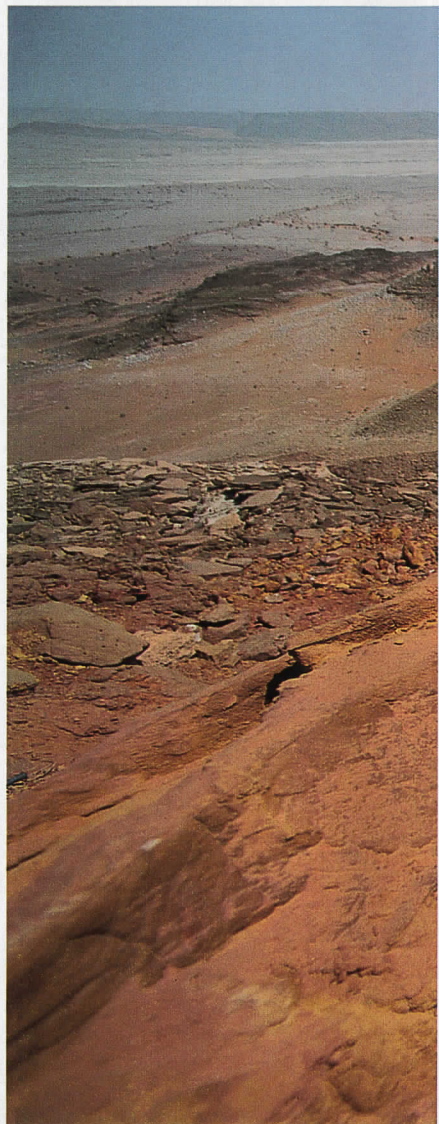
we discovered fossil crocodile teeth, turtle shells, and crayfish, and petrified wood—evidence that 90 million years ago today's scorched desert was a vast floodplain laced with rivers lined by coniferous trees. Crocodiles swam the rivers, and swift

predatory dinosaurs like *Carcharodontosaurus* ran through the mud, leaving dozens of three-toed tracks now fossilized in the sediment.

The discovery of the enormous *Carcharodontosaurus* skull was the most dramatic find of two expeditions I have led to the Sahara in Morocco and Niger. No one knew much about the dinosaurs that roamed northern Africa toward the end of their reign when our small band of paleontologists and students started out three years ago. Of the hundreds of dinosaur species that have been identified throughout the world, few have

DINOSAUR DISCOVERIES

Articles in this series reveal the latest insights into the world of dinosaurs. Much of the research was supported by your Society.





Braced on a sandstone cliff, the author uncovers teeth of *Carcharodontosaurus*. At five feet four inches, the skull measures a few inches longer than that of the largest *Tyrannosaurus rex*, putting *Carcharodontosaurus* in contention for the title of king of all land predators. Once it has been cleaned, a five-inch tooth (left) reveals a series of grooves —

their purpose unknown.

The team scaled crumbling slopes in 120°F heat on the 1995 expedition to the site in the Kem Kem region of Morocco. Fieldwork in Niger two years earlier covered flatter terrain. To get to the Niger dig, the crew drove from Algiers more than 1,500 miles into the Sahara (map) to prospect among some of the world's least explored rock formations.





Threats reverberate across a delta in what is now the Sahara as *Carcharodontosaurus* guards its kill against *Deltadromeus*. Unearthed from a slope in the Kem Kem, a skeleton of the smaller predator revealed a quick, two-legged creature measuring 25 feet long.



PAINTING BY MARK HALLETT

Nearby sediment gave up more evidence. Fossil remains of crocodiles, turtles, and crustaceans — as well as petrified wood — suggest the life and habitat that thrived in the region some 90 million years before humans walked the horizon.

"He seems to know every stone and bone in the desert," says Sereno of his turbaned Tuareg guide. During a 1990 exploratory expedition, the local chieftain led the author to the site of an ancient graveyard of plant-eating sauropods. Three years later the team found the spot again.



HANS LARSSON

been found in surroundings as remote or as hostile as the Sahara.

What little was known came from partial skeletons excavated years ago in Egypt, Morocco, and Niger. Those remains belonged to a strange two-legged predator called *Spinosaurus*, which had a large fin along its back, to a primitive duck-billed dinosaur, and to the huge, plant-eating sauropods.

WHEN dinosaurs emerged about 230 million years ago in the Triassic period, the world's continents were massed together into a supercontinent called Pangaea. Dinosaurs in every part of Pangaea looked remarkably alike. By the end of the Jurassic, 80 million years later, Pangaea had broken into two landmasses, a northern one, Laurasia, and a southern one known as Gondwana, which carried plants and animals with them. During the next great geologic period, the Cretaceous—

from 146 million to 65 million years ago—the continents drifted apart and began to assume their modern positions.

By the time of *Carcharodontosaurus's* appearance, some 90 million years ago, the world had become a patchwork of isolated island continents, each with unique dinosaur forms. Like all life-forms, dinosaur species slowly changed over generations. Predators like *Velociraptor*, a human-size killer with sickle-shaped claws, hunted in Mongolia. Rhino-like ceratopsians and herds of duck-billed dinosaurs browsed on ferns and flowering plants in North America.

But what about Africa's Cretaceous dinosaurs? What did they look like? And how did they fit in with those of the other continents? These were the questions that sent us to the Sahara.

For a long time scientists thought that dinosaurs evolved neatly into northern and southern subgroups after Laurasia and Gondwana split apart. This idea

was based in part on the discovery of strange dinosaurs in South America, such as *Carnotaurus*, a predator with bony horns above its eyes, that looked nothing like their northern counterparts. It was assumed that African dinosaurs, having begun to evolve in the isolation of the great southern landmass, would be similar to those in South America.

Our recent discoveries in Africa suggest that dinosaur evolution was much more involved than that. The dinosaur world may not have split neatly in two. *Carcharodontosaurus*, for example, seems to be most similar not to a South American carnivore but to *Acrocanthosaurus*, a huge allosauroid that thrived in North America during the early Cretaceous period.

Further evidence came last year, when our Morocco expedition was running out of time. Taouz, a town not far from the Algerian border, served as our base. From there we drove into the desert to a small oasis, where we slept and ate in the open beside a schoolhouse.

Fresh food was hard to come by and difficult to store, so we usually cooked the dehydrated food we'd brought with us. We hiked miles each day, climbing steep rubble-strewn inclines that tore up our shoes and wore out our knees. Soon we were patching the soles of our boots with strips of truck tires. The incessant heat took its toll too. Many of us lost more than 20 pounds in the first month.

Gabrielle Lyon, a writer and a former student at the University of Chicago, made the first major discovery, stumbling upon several beautifully preserved, six-inch-long dinosaur bones embedded in a rocky hillside. During the next two days we continued to dig bones from the hillside until the desks of the school were covered with them.

Late one night while the others



LATE JURASSIC EARTH

JURASSIC PERIOD
Begins 208 million years ago

KEY TO DINOSAURS

- Allosauroid lineage
- Coelurosaur lineage
- Ceratosaur lineage

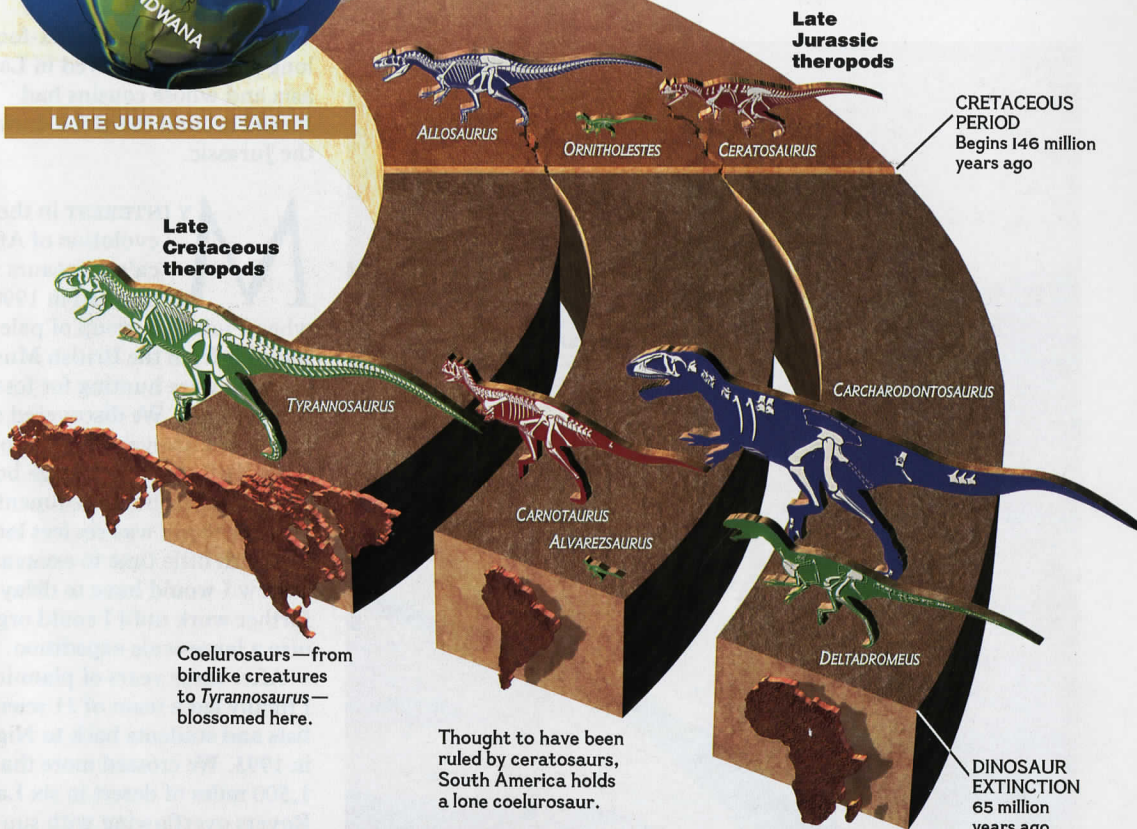
SKELETONS SHOW ALL KNOWN FOSSIL BONES.

ART BY CHUCK CARTER. MAPS PROVIDED BY PALEO-GEOGRAPHIC ATLAS PROJECT, UNIVERSITY OF CHICAGO. DINOSAURS BY CAROL A. ABRACZINSKAS AND PAUL C. SERENO

Late Jurassic theropods

CRETACEOUS PERIOD
Begins 146 million years ago

Late Cretaceous theropods



Coelurosaurs—from birdlike creatures to *Tyrannosaurus*—blossomed here.

Thought to have been ruled by ceratosaurs, South America holds a lone coelurosaur.

DINOSAUR EXTINCTION
65 million years ago

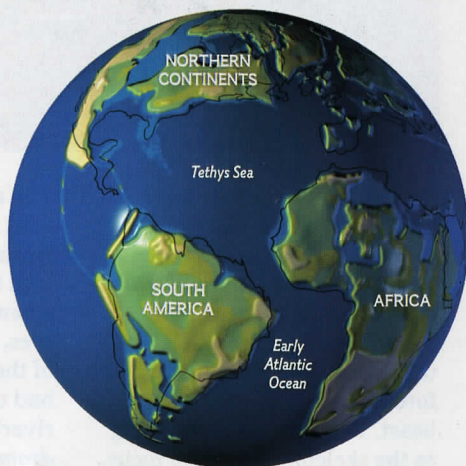
Allosauroids flourished in Africa. *Deltadromeus* is one of the few known coelurosaurs.

Dinosaurs adrift

Dispersed by earth's drifting continents, dinosaurs evolved into a spectacular array of species during their 165-million-year reign. When they first arose, most dry land was consolidated in a supercontinent called Pangaea, and animals migrated freely. By the end of the Jurassic period Pangaea had broken into a northern landmass—Laurasia—and a southern one—Gondwana

(top globe). The author's study suggests that intermittent land bridges and shallow seas allowed common passage long after the breakup—in fact long after South America and Africa began to separate.

By the late Cretaceous, the continents had become isolated, each with unique dinosaur forms. Some lineages died out, while others flourished.



LATE CRETACEOUS EARTH

Oasis-hopping for fuel and water, the caravan nears the Algerian town of Taghit at the edge of a 400-mile-long sand sea. Later near In Gall, in Niger, the team found a sand-scoured fossil jutting from the ground, the forelimb (opposite, foreground) of a 60-foot-long, four-legged sauropod.



PAUL C. SERENO (ABOVE AND OPPOSITE)

slept, I tried to solve what looked like an enormous jigsaw puzzle. I picked up a piece we had thought was a tailbone of *Spinosaurus* and fit it onto another piece. I soon realized that I had the delicate shoulder blade and forelimb of a different sort of beast. My heart was pounding as the skeleton came into focus.

The animal's spine was long and stiff, and its limbs were slender. It wasn't like any dinosaur I had seen before. I suspected we had a new species. With tears in my eyes, I woke Gabrielle to tell her of the 25-foot-long carnivore we had unearthed from an ancient riverbank. We named it *Delta-dromeus*, the "delta runner."

This animal was much smaller than *Carcharodontosaurus* but probably no less aggressive. While we never found its skull, we can guess that it chased down its prey or scavenged the kills of other predators. *Deltadromeus*, most important, has skeletal similarities to coelurosaurs like *Ornitholestes*, an agile six-foot-long predator that lived in Laurasia and whose cousins had spread around the globe during the Jurassic.

MY INTEREST in the evolution of Africa's dinosaurs was sparked in 1990 when I joined a group of paleontologists from the British Museum who were hunting for fossil fish in Niger. We discovered a dinosaur graveyard the size of a basketball court with huge bones protruding from the sediment—one thighbone was six feet long. But with little time to excavate, I knew I would have to delay further work until I could organize a large-scale expedition.

After three years of planning I finally led a team of 21 scientists and students back to Niger in 1993. We crossed more than 1,500 miles of desert in six Land Rovers overflowing with supplies to spend two months searching for dinosaurs that lived some 130 million years ago, during the early Cretaceous.

But political turmoil stopped us. The site of the dinosaur graveyard, some 400 miles northeast of the capital of Niamey, was located within a military zone. Days turned into weeks as I tried to gain permission to explore the area. Meanwhile, my expedition crew languished in the oasis of Agadez, not far from the site. Isolation, fear, and illness eroded their confidence, and many decided to return home. With half our field season gone, I arrived in Agadez to call the expedition off.



But just as we prepared to leave, permission was finally granted. Many of the students decided to stay, and I and my streamlined crew of nine headed west and settled into a mud-brick compound in the oasis of In Gall. Relying on faded Polaroids, a rough topographic map, and a local guide, we soon relocated the graveyard.

As we brushed back the sediment, well-preserved white bones appeared. The skeletons, still arranged as they had been in life, looked as if they had been resting peacefully for millions of years. We guessed that the creatures had been buried in minutes, perhaps by a flash flood of an ancient river.

We began to dig around a forelimb of one of the plant-eaters. As the pit expanded, we slowly unearthed a hind limb, backbone, and tail of a 60-foot-long skeleton. It had much in common with a sauropod from North America, the 60-foot-long *Camarasaurus* that lived during

the Jurassic. A jaw fragment had similar broad, spoon-shaped teeth and suggested the same rounded skull.

The next day several team members and I came upon a muddy plain strewn with weathered bone fragments. As we fanned out for the search, the curved edge and socket of a large bone caught my eye. I tiptoed closer, trying not to disturb the bones underfoot, and realized I was looking at the hipbone of a predatory dinosaur.

Then Jeff Wilson and Hans Larsson, graduate students from the University of Chicago, pulled a claw from the sediment. More bones of the beast lay just beneath the surface.

We named it *Afrovenator*, or "African hunter." It had jaws studded with two-inch, blade-shaped teeth, and powerful forelimbs armed with three curved claws. This 30-foot-long hunter closely resembled *Allosaurus*, a Jurassic predator from North America, and other predators of

Pieces of a puzzle

slowly surface as Sereno and his team uncover bones of a predator, just five miles from the sauropod site near In Gall. They named the swift 30-foot-long carnivore *Afrovenator*, or "African hunter."

Driven by hunger 130 million years ago, two hunters emerge from the underbrush (right, at right) and strike quickly at a young sauropod. The scene is based partly on excavation of a herd of sauropods that died together, probably from a flash flood. Sediment found beneath the herbivores shows that a river system once flowed through the region.



PAUL C. SERENO; PAINTING BY MARK HALLETT





Poised to attack

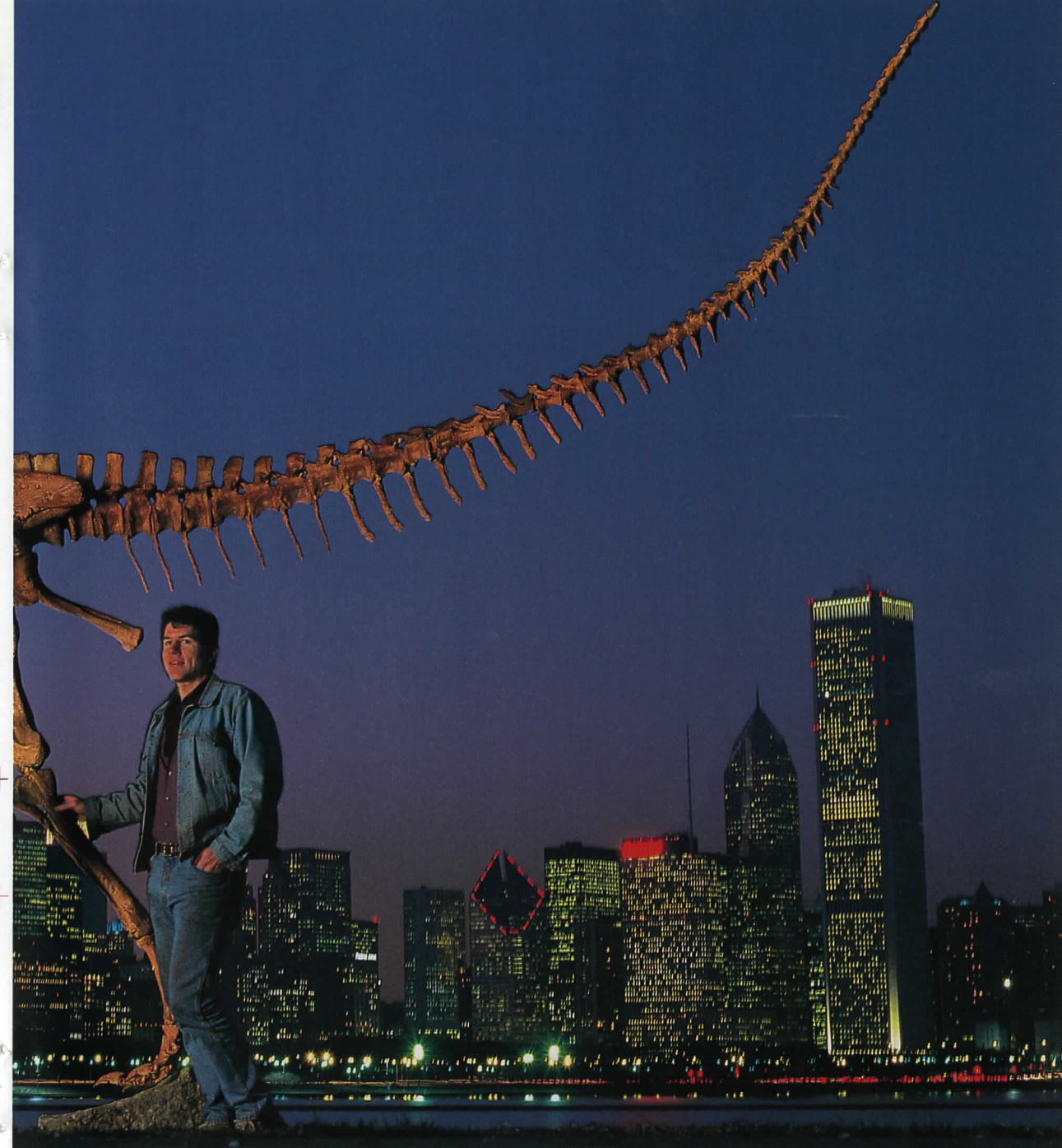
Chicago, a long-silenced *Afrovenator* was reconstructed from a largely complete skeleton. Says Sereno: "We're just scratching the surface of a dinosaur world that's waiting to be unearthed."

similar age on both northern and southern continents.

What could explain these similarities between Africa's early Cretaceous dinosaurs and dinosaurs from northern continents? Perhaps land bridges or shallow seas remained between Laurasia and Gondwana after they had split apart. This would have allowed migrating dinosaurs—

and evolutionary changes—to spread throughout both landmasses, keeping dinosaur forms more or less similar worldwide.

We do know that by 90 million years ago a broad waterway separated Africa and the northern continents, and a narrow Atlantic Ocean split Africa and South America. On each now isolated continent some dinosaurs



became extinct while others thrived. In North America, for instance, allosaurs died off, and tyrannosaurs emerged to take over the role of dominant large predator. Plant-eaters such as the once prolific sauropods were overtaken by armored, horned, and duck-billed ornithischians, a major group of dinosaurs that roamed the continent's western

plains in huge herds like buffalo.

In Africa predatory dinosaurs evolved along other paths, with *Carcharodontosaurus* representing a triumph of the allosauroid lineage unseen elsewhere.

Our discoveries suggest that continental movements did affect the evolution of dinosaurs toward the end of their reign. Evolving in partial and—much

later—complete isolation, dinosaurs in Africa adapted uniquely to their habitats, aided over the millennia by chance and invention, the results of which we are only now beginning to appreciate. In the next few years I hope to return to the Sahara and continue the search for clues. The story of Africa's dinosaurs has just begun. □