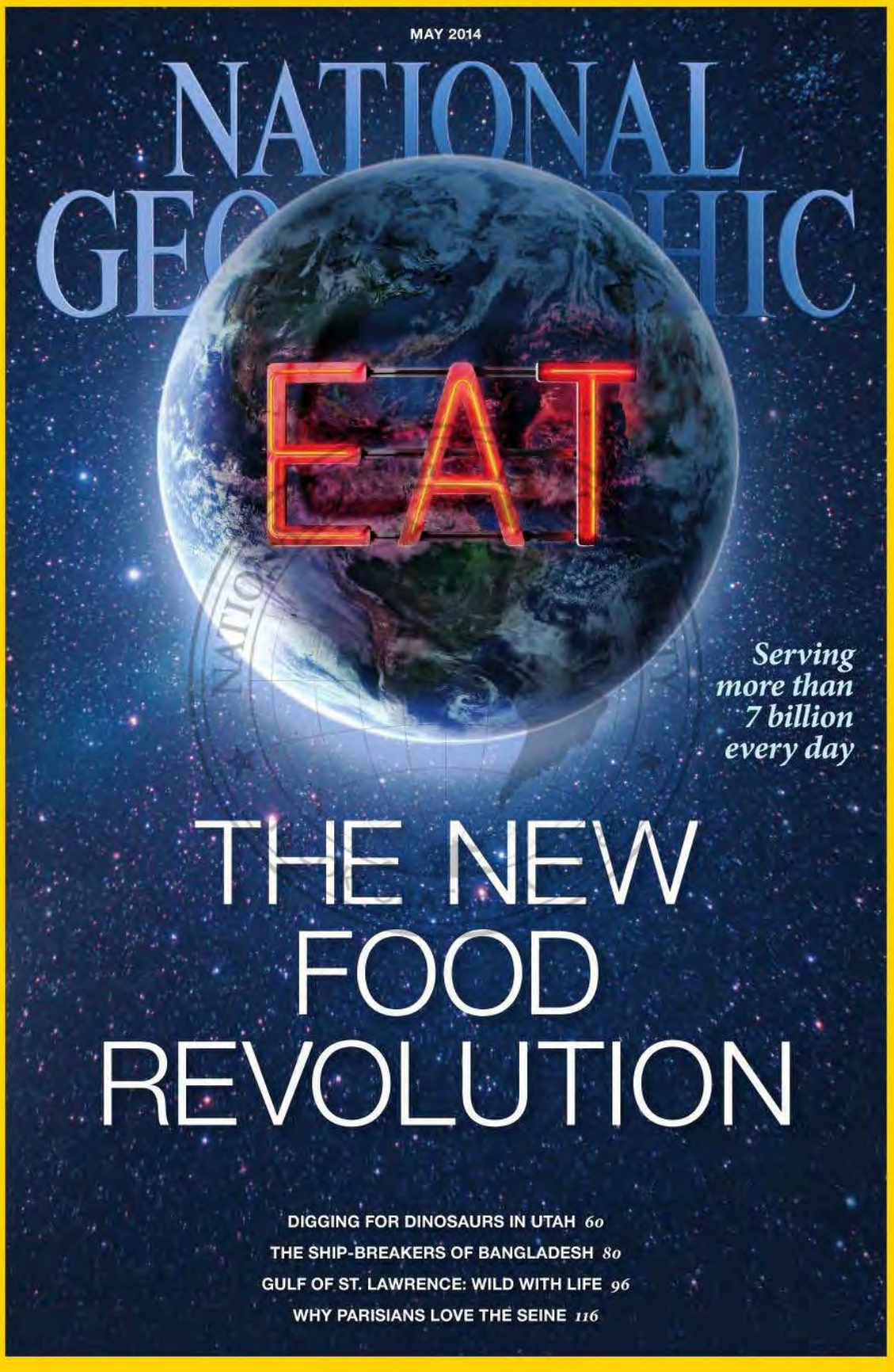
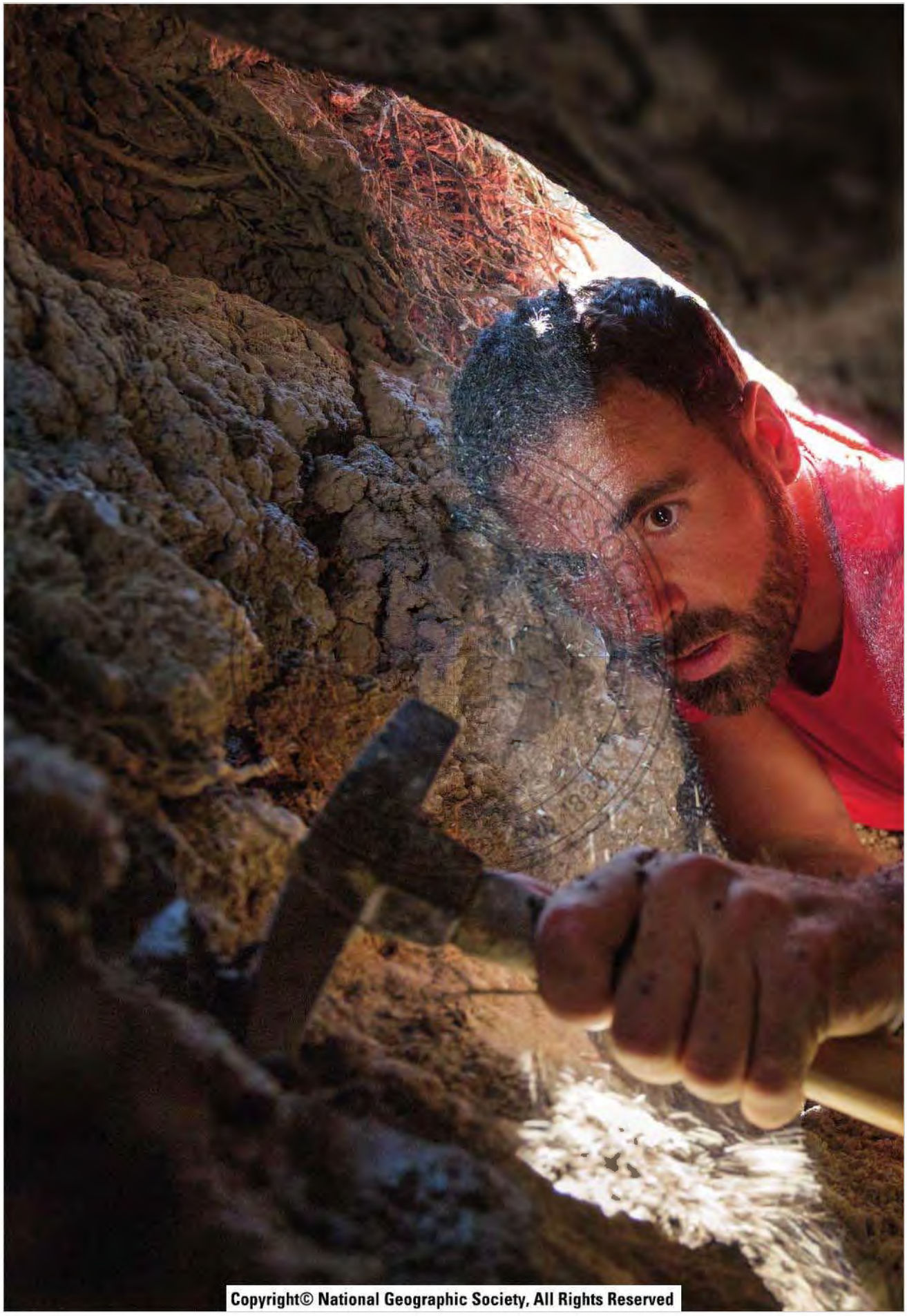
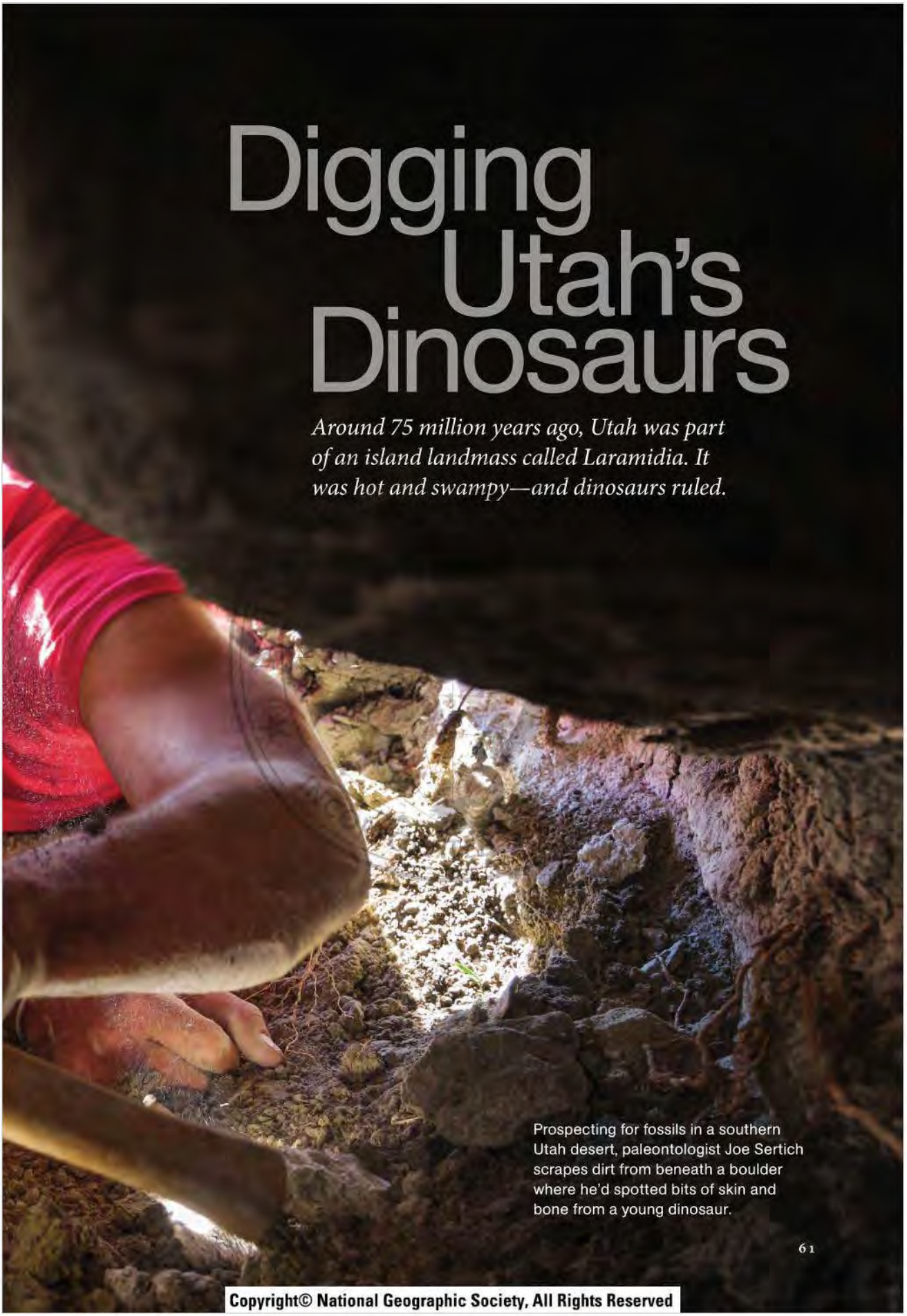




Digging Utah's Dinosaurs

Around 75 million years ago, Utah was part of an island landmass called Laramidia. It was hot and swampy—and dinosaurs ruled.



Prospecting for fossils in a southern Utah desert, paleontologist Joe Sertich scrapes dirt from beneath a boulder where he'd spotted bits of skin and bone from a young dinosaur.

On a cold May evening Sertich and volunteer Billy Doran walk a ridgeline—often the only way to get from here to there in the fossil-rich badlands of southern Utah.

Kosmoceratops richardsoni, a rhino-size plant-eater that lived on Laramidia, had five horns around its face and ten on the rear of the fanlike frill. Potential mates may have been impressed.

NATURAL HISTORY MUSEUM OF UTAH

By Peter Miller

Photographs by Cory Richards

The Miller brothers looked more like prospectors than paleobotanists. Their beards were caked with dirt; goggles kept their eyes from being sandblasted by the desert winds. Both were big men, more than six feet three, and on a knife-edged ridge in southern Utah they moved with the quiet confidence of outdoorsmen. As Ian swung a pickax into the mudstone, Dane attempted to roll a cigarette between gusts. Loose tobacco flew from the paper. "Doggone it," he said, and tried again.

Along with Scott Sampson, chief curator at the Denver Museum of Nature & Science, and Joe Sertich, the museum's dinosaur paleontologist, the brothers were prospecting for fossils last spring in the Grand Staircase–Escalante National Monument. Within that largely roadless wilderness they were exploring a particularly remote area, a maze of steep bluffs and gullies north of Horse Mountain. While the rest of their team was a few miles away, working fossil quarries discovered in previous years, Sampson, Sertich, and the Millers were looking for new ones. After months of office duty at the museum Sampson could barely contain his joy at being "where no paleontologist has ever been before"—with the prospect of discovering new treasure from the "lost continent" of Laramidia.

The layer of mudstone the Millers were hacking into had been deposited on the east coast of that slender landmass, which once stretched 4,000 miles from the Arctic Ocean to the Gulf of Mexico. Laramidia was created 90 million years ago, during the late Cretaceous period, when rising seas flooded the middle of North America and split it in two. Today Laramidia is buried under the western states; it can be accessed only in eroded badlands like these, where wind and rain have brought its fossil-rich deposits within reach of picks and shovels.

Since 2000 Sampson had helped lead expeditions into the wilds of Laramidia. The researchers and the impetus came from the Natural History Museum of Utah and the U.S. Bureau of Land Management as well as the Denver Museum. Working mainly in the Kaiparowits formation, a 2,600-foot-thick deposit dating from 77 million to 75 million years ago, they'd unearthed fossils of thousands of plants and animals,

Peter Miller is a contributing writer. Cory Richards has shot several adventure stories for the magazine, but this is his first foray into paleontology.

Hot, swampy, and teeming with dinosaurs

Horned and duck-billed herbivores meet at a river 77 million years ago in what is now southern Utah desert. A carnivore called *Talos*, a birdlike theropod, watches from a tree. The landscape that supported such a dense concentration of species on Laramidia may have resembled the subtropical wetlands of northern Louisiana.

Parasaurolophus

Utahceratops

Talos

Kosmoceratops

ART: RAÚL MARTÍN
SOURCE: SCOTT SAMPSON, DENVER MUSEUM OF NATURE & SCIENCE

An adult and a juvenile *Ieratophoneus* get a dusting from Geoffrey Leonard at the Natural History Museum of Utah. Like *Tyrannosaurus rex*, their larger relative, they likely were fierce predators.

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from conifer cones to crocodiles, turtles, and dinosaurs—especially dinosaurs. During the 20 million years or so that it existed, Laramidia seems to have been a runaway dinosaur factory, cranking out large and small dinosaurs in a surprising diversity of species. Figuring out how and why that happened, the researchers said, could tell us something fundamental about the interplay between ecology and evolution.

"This place is littered with bones," Sampson said, as his boots crunched up a slope not far from where the Miller brothers were working. "I've got pieces of a turtle going up this hill, but I have no idea where the rest of this thing is." He picked up a small beige object and licked it to see if it was porous bone or boring rock. "If it's bone, it will stick to your tongue," he said. "If it's rock, it won't." This one stuck.

FOSSIL HUNTING has always been stubbornly low-tech. When it comes to fieldwork, not much has changed since the great "bone rush" of the 19th century, when discoveries in the Wild West sparked a furious campaign to get fossils out of the ground and into the great halls of East Coast museums. While the U.S. Army was chasing Sitting Bull across the northern plains, teams of scholars, wranglers, and ruffians were pulling giant leg bones from the badlands, wielding the same picks, shovels, and plaster employed by paleontologists today.

"We use the same techniques because they work," said Ian Miller, who heads the department of earth sciences at the Denver Museum. His preferred tool: a six-pound pickax with a hickory handle. "A good one is hard to get these days," he said. "But they don't break."

One of the first big discoveries in the Kaiparowits came in 2002, when a field volunteer named Duncan Everhart spotted a jawbone in the ground. As researchers later found out, it was attached to the hefty upside-down skull of a 30-foot-long hadrosaur, or duck-billed dinosaur. Its jaws were packed with as many as 800 teeth, making it the "Cuisinart of the Cretaceous," according to Sampson. The snout had a pronounced crest that placed the animal in the genus *Gryposaurus* (hooked-nose lizard), first described a century ago from specimens at what is now Dinosaur Provincial Park in Alberta. This Utah giant, though, was clearly different from its Canadian cousins. It looked "pumped up," Sampson said, switching metaphors, "like the Arnold Schwarzenegger of duck-billed dinosaurs." He and Terry Gates, then a University of Utah graduate student, named the new species *G. monumentensis*, after the site where it had been found.

That same year Mike Getty, now the chief preparator at the Denver Museum, discovered another novel creature here, a seven-foot-tall dinosaur. This meat-eating, two-footed, and possibly feathered beast became *Hagryphus giganteus*, or giant birdlike god of the western desert.

More species followed: dome-headed dinosaurs, armored dinosaurs, a cousin of *Tyrannosaurus rex*, sickle-clawed relatives of *Velociraptor* (the speedy predator made famous by the movie *Jurassic Park*), and several new horned dinosaurs, each more extravagant looking than the last. Consider the brute that Sampson and colleagues named *Kosmoceratops richardsoni* in 2010: A rhino-size relative of *Triceratops*, it had a record-breaking 15 horns on its head.

Specimens related to most of these animals had been found at late Cretaceous sites in Alberta, Montana, and Wyoming, places that at that time had also been along Laramidia's east coast. But the Utah dinosaurs were different.

"Almost every animal was a new species," Sampson said. And it wasn't just the dinosaurs,

FORGOTTEN WORLD

A shallow sea divided North America about 77 million years ago, during the late Cretaceous period, when Earth was much warmer than it is today. Recently discovered fossils from Laramidia, as the western landmass is called, suggest that evolution was in high gear there: New species of dinosaurs and other animals were emerging in the south that were distinct from those up north.

Exposed by wind and rain, a two-foot-long segment of a duck-billed dinosaur tail (above) remains embedded in sandstone in the Kaiparowits formation. Duckbills, or hadrosaurs, are so common in this deposit that "we didn't even collect this one," Joe Sertich said. Another hadrosaur tail (below) remains in the plaster jacket used to transport it to the museum in Salt Lake City. A fossil branch (right) came from an extinct species of conifer, similar to living sequoia trees, that once may have towered above Laramidian forests.

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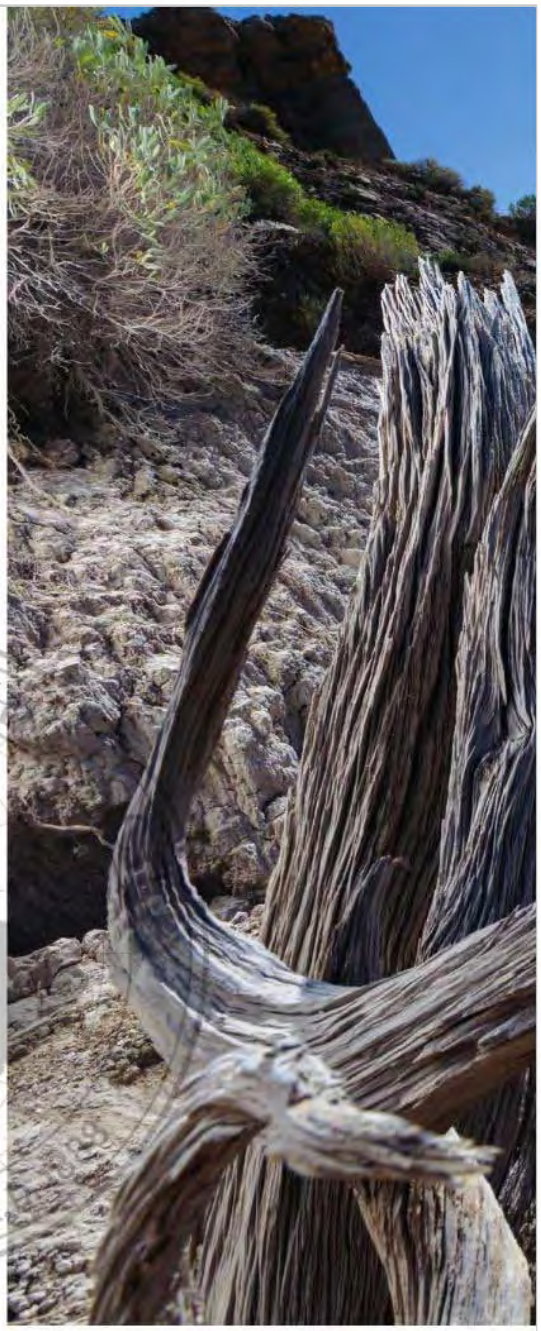
but also the mammals, fishes, lizards, turtles, and crocodiles. "The whole fauna, it seemed, was new to science."

Something had isolated the dinosaurs of southern Laramidia from their relatives up north, the researchers figured. Left to itself, each community of animals had evolved differently, just as Darwin's famous finches had done in the Galápagos, where they'd become new species after populating different islands. But Sampson and his colleagues were skeptical of the idea that a physical barrier, such as a mountain range or a large river, had kept the animals apart. Mountains may block the path of some animals, he said, but others are known to walk right over them: "They do it all the time." As for rivers, "it's hard to imagine that a river could last for tens of thousands or hundreds of thousands of years," Sampson said. "Sooner or later there will be periods of drought when rivers dry up."

THAT NIGHT, sitting beside our campfire near a dry creek bed, Sampson laid out an alternative explanation for the "provinciality" of Laramidian dinosaurs. As he talked, Ian Miller's dog, Wilson, which was curled up next to him, cocked his ears at a sound in the darkness. Earlier we'd seen mountain lion tracks. But the Australian shepherd wasn't concerned enough to get up.

The theory Sampson favored took off from work done in the 1980s by Thomas Lehman, a paleontologist at Texas Tech University. What if variations in environmental conditions had segregated the animals on Laramidia, Lehman wondered? That made sense to Sampson: Once a dinosaur species had spread over a large enough range, the populations at opposite ends of it would find themselves adapting through natural selection to different climate zones and vegetation. Over time members of the two populations might evolve so disparately that even if they were to meet, they would no longer recognize each other as potential mates—and at that point the two populations would have become two species.

What's more, Sampson and his colleagues



At the Grand Staircase–Escalante National Monument, Carol Lucking of the Denver Museum of Nature & Science cuts through a slab of sandstone with a diamond-bladed rock saw. Her object: bones from a young duckbill.

reasoned, the divergence might have been encouraged not only by natural selection but also by another evolutionary force: sexual selection. The bizarre-looking traits that differentiated these southern animals from those up north, especially among the herbivorous dinosaurs, looked like prime examples of sexual selection. Whereas natural selection acts preferentially on features that are essential to the struggle for survival, such as limbs and teeth, sexual selection is concerned with features key to the competition for mates, such as peacock tails or moose antlers. The elaborate horns, spikes, and frills of the Utah herbivores wouldn't have been much use against predators. The horns of ceratopsians, for example, were better suited for contests against other animals of the same species to establish dominance. And their frills, which were too thin to withstand combat, were probably used to impress the opposite sex, Sampson said. "They were more about showing off."

But what about the jumbo size of these dinosaurs? How could so many different giants—more

A carnivore from the dromaeosaurid family shares the freight elevator at the Natural History Museum of Utah with exhibit designer Tim Lee. A cousin of *Velociraptor*, it may have had feathers—and it definitely had slashing talons.

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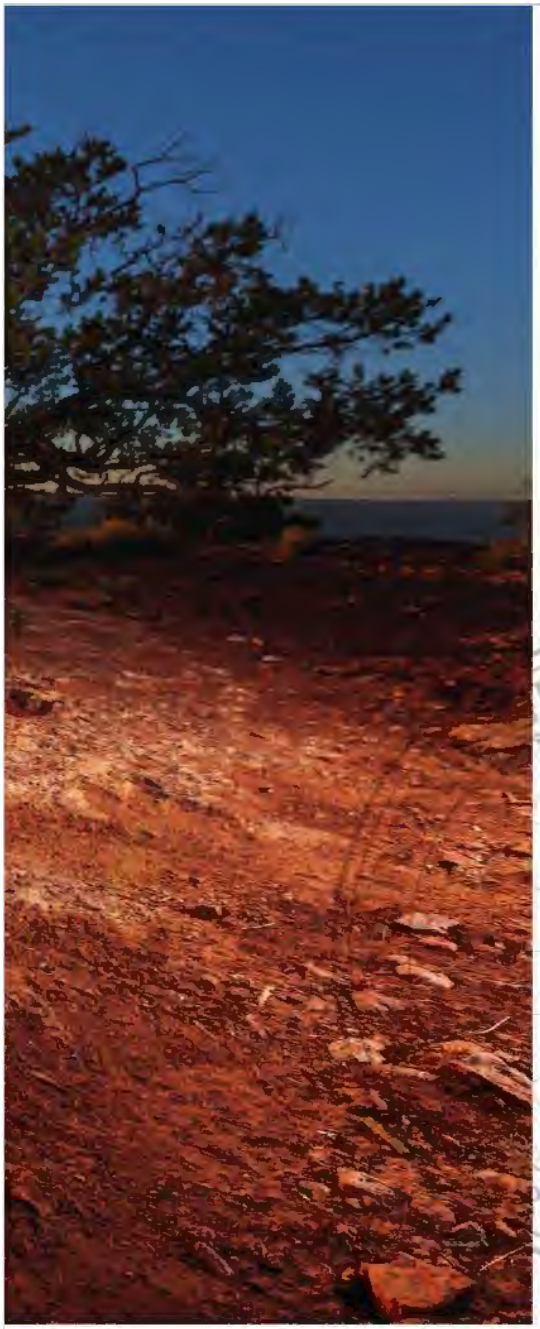
than there have ever been on the African savanna—have survived in Laramidia? Wouldn't they have needed room to spread out? Making the thousand-mile journey between Utah and Alberta shouldn't have been a challenge for, say, 30-foot-long dinosaurs. Shouldn't there have been more mingling going on?

THAT'S WHERE THE PLANTS came in, said Ian Miller the next morning at the new leaf quarry he'd found on the ridge. Sitting on a ledge, looking out over an arid, jagged, and mostly unvegetated landscape, Miller tapped a cantaloupe-size rock with his hammer, splitting it neatly in two. On either side of the interior were mirror-image impressions of a leaf—intact, with all the detail of a specimen that had fallen into a pond the day before.

"This wasn't a desert 75 million years ago," Miller said. "We've found more vines in this formation than in any other I've ever seen. The forest here was more like a jungle, with vines



These theropod tracks, up to 17 inches long, cross Flag Point near Kanab. They're relics of an era 100 million years before Laramidia became an island—and evidence that, in the American West, dinosaurs ruled for a very long time.

twining up the trees. We've also found lily pads and water lettuce, so we know there were ponds here with floating vegetation. And big rivers. Think of the Amazon, where you have the main channel of the river but also side channels and lakes that are so filled with tannin they turn black. That's probably what the little pond looked like that this leaf fell into."

The vegetation could have been so thick and lush in this part of Laramidia that there was no need for animals to wander very far, Miller speculated. Perhaps even the largest duck-billed dinosaur was able to get its fill within a relatively small range. That's what you see today in tropical rain forests, he said: many species sharing the same small spaces. The whole continent could have been organized as a series of ecological zones at different latitudes, each defined by varying amounts of precipitation or sunlight and each supporting its own set of dinosaurs. You wouldn't need a physical barrier to explain the explosion of new species.

"We haven't done enough work yet," Miller said. "In many respects it's still a hunch. But if we're right, and there were these small provincial populations that weren't moving around, not interacting with other populations, you could have sexual selection happening very rapidly."

The lush landscape that would have made this possible was more like the swamplands of Louisiana than what you see here today, Sampson said. But any such comparison is necessarily flawed, he added, because the Earth was so different 75 million years ago. "We're still really in the dark when it comes to understanding the ecological dynamics."

That's why he and his team return season after season to the Utah badlands, where every trek into the desert sheds new light on Laramidia's story. "Every rock you crack open, you're saying, Oh my God, I've never seen that before," Miller said. "It's brand-new. Unknown to science." ▯

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