Margot Sanger-Katz ’02

When Nick Longrich was a graduate student in paleontology, he knew he wanted to study the early evolution of birds, starting with the Archaeopteryx. For 150 years, the famous fossil had been considered the "first" bird. Every grade school student has seen a picture of the sprawling skeleton with its arched back and outstretched wings—almost perfectly preserved, right down to the feather impressions that first showed scientists that this animal, whose skeleton looked like a dinosaur's, had probably taken flight.

Longrich too had seen pictures, but he wanted to see the fossil itself. When he made his pilgrimage to the Humboldt University natural history museum in Berlin, he asked to see not just the well-known slab of stone that had been studied, photographed, and displayed all these years, but also the "counterslab"—the impression the bones had made in the mud 150 million years earlier, which had been sitting untouched in a safe.

What he found completely changed his understanding of the animal. Along the bird's hind legs, Longrich found distinct impressions of the type of long, asymmetrical feathers birds use for flight. It turned out that the people who had prepared the main slab all those years ago thought those feathers weren't important and had chipped them off.

Wondering why the animal would need flight feathers on its shins and thighs, Longrich studied aerodynamics. He bought textbooks on airplanes and modern bird flight. For his dissertation, he argued that the Archaeopteryx's hind limb anatomy suggests it used both front and hind limbs for flight. It's a proposal that could upend the consensus view about the evolution of bird flight.

Longrich, 35, now a postdoctoral fellow at Yale with a long list of surprising and even flamboyant discoveries, is making his name by finding epiphanies among fossils that other scientists have already examined and put into storage. Instead of digging new creatures from the ground, he's managed to solve several paleontological puzzles—and name a half-dozen new dinosaur species—by hunting for overlooked treasure among the scraps of fossil in old collections. He's made significant new discoveries among decades-old specimens at Yale's Peabody Museum, the American Museum of Natural History, the Smithsonian, the Museum of the Rockies in Montana, and others. Since coming to Yale in 2009, Longrich has published 18 papers in academic journals; only two were based on material he excavated from the field.

"He collects in museum collections," says Jacques Gauthier, the Yale professor who is supervising Longrich's fellowship. Gauthier recommended Longrich for the position after seeing the then-graduate student identify a string of Yale's fossils on sight during a short visit. "It's kind of like prospecting in someone else's digs."

On a recent trip, Longrich was touring dinosaur country, visiting small museums in Wyoming and Colorado near the sites where the great nineteenth-century bone hunter, Yale paleontologist O. C. Marsh, dug up much of the Peabody's collection. But unlike Marsh, Longrich was travelling without a shovel or crew, limiting his search to the basements and back storage rooms of the natural history and geological museums and his luggage to jeans, polo shirts, and a digital camera.

Nick Longrich has found a half-dozen new species by looking at fossils other scientists had forgotten.

Laramie was the first stop. Historically, the University of Wyoming's paleontologists had focused on mammals, not dinosaurs—which is why few of the non-mammal fragments in the collection were catalogued correctly or in much detail. As Longrich opened locked metal cabinets to peer into drawers full of specimens, he found jars and jewelry boxes of tiny, broken fossils labeled simply: Dinosaur Teeth, Lizard Jaws, Birds. Except, often, they weren't. The box of stoppered jars of bird fossils contained no bird bones. The container of "crocodile" teeth contained Tyrannosaurus rex teeth. The jar of "lizard" teeth was full of amphibians.

"It's not even close," Longrich said as he peered at a tiny salamander tooth from the lizard jar.

When archaeologists collect new fossils, they mostly find scraps. Much more common than the complete skeletons on display at natural history museums are single teeth, toe bones, or jaws. For smaller animals, whose bones are more vulnerable to damage before they fossilize, tiny fragments may be the only fossils ever found. As a result, much of paleontology consists of piecing together information from minute differences between fragments.

With a knack for anatomy and a willingness to spend hours looking at tiny fragments, Nick Longrich, a paleontology postdoc at Yale, has discovered new species of dinosaurs, birds, and lizards using fossils collected long ago. At left are some of the **fossils that helped him identify new animals**.

NICK LONGRICH

MARGOT SANGER-KATZ '02

When Nick Longrich visits a museum collection, he wants to see everything. At the University of Wyoming this spring, he pored over every **drawerful of Cretaceous material**, hunting for new species.

Most carnivore teeth are triangular in shape, but the teeth of the plant-eating Thescelosaurus are acorn-shaped in cross section. T. rex teeth have a distinct pattern of serration. Bird species are frequently identified by a shoulder bone alone.

Many scientists know one area of the fauna well; they can distinguish between similar dinosaurs, say, but not lizards. Longrich has an unusual knack for shapes and patterns. He can frequently identify a species based on one of its least distinctive bones, or fit broken pieces of fossil together to form a frill or horn. He can whip up a sketch of an animal from a few fragments. He has discovered new birds and lizards as well as dinosaurs. Other scientists who have crossed paths with him say he has an unusual talent for spotting species.

"I've had a lot of experience, and I think I'm good at it, but he impressed me," Gauthier says. "You can't send Nick down to New York without him coming back with 'Look at this, I found a new one, a new lizard. Look.' And you look at it and say, 'Yes, we've never seen anything like this.'"

One of Longrich's biggest early discoveries, a new species of small dinosaur in Canada, was based on a single pelvis bone that fit in the palm of his hand. Relatives of the animal, a feathered carnivore that was an early ancestor of modern birds, had been found in China, but not in North America. After spotting the pelvis, he examined material that had been collected nearby and found more bones.

"I'm kicking myself for missing these things," says Philip Currie, a professor of dinosaur paleobiology at the University of Alberta and the president of the Society of Vertebrate Paleontology. He curated the collection where Longrich had found the bone. "It had been sitting here in our collection in Edmonton for 30 years, misidentified as a lizard."

Longrich also has a talent for visualizing how the living animals used their anatomy. Another small Canadian dinosaur he found interested him because it didn't look like most carnivores: it had unusually short arms, each with a single claw. Longrich proposed that it ate insects, using its distinctive claws to scrape termites from rotten wood. In the case of

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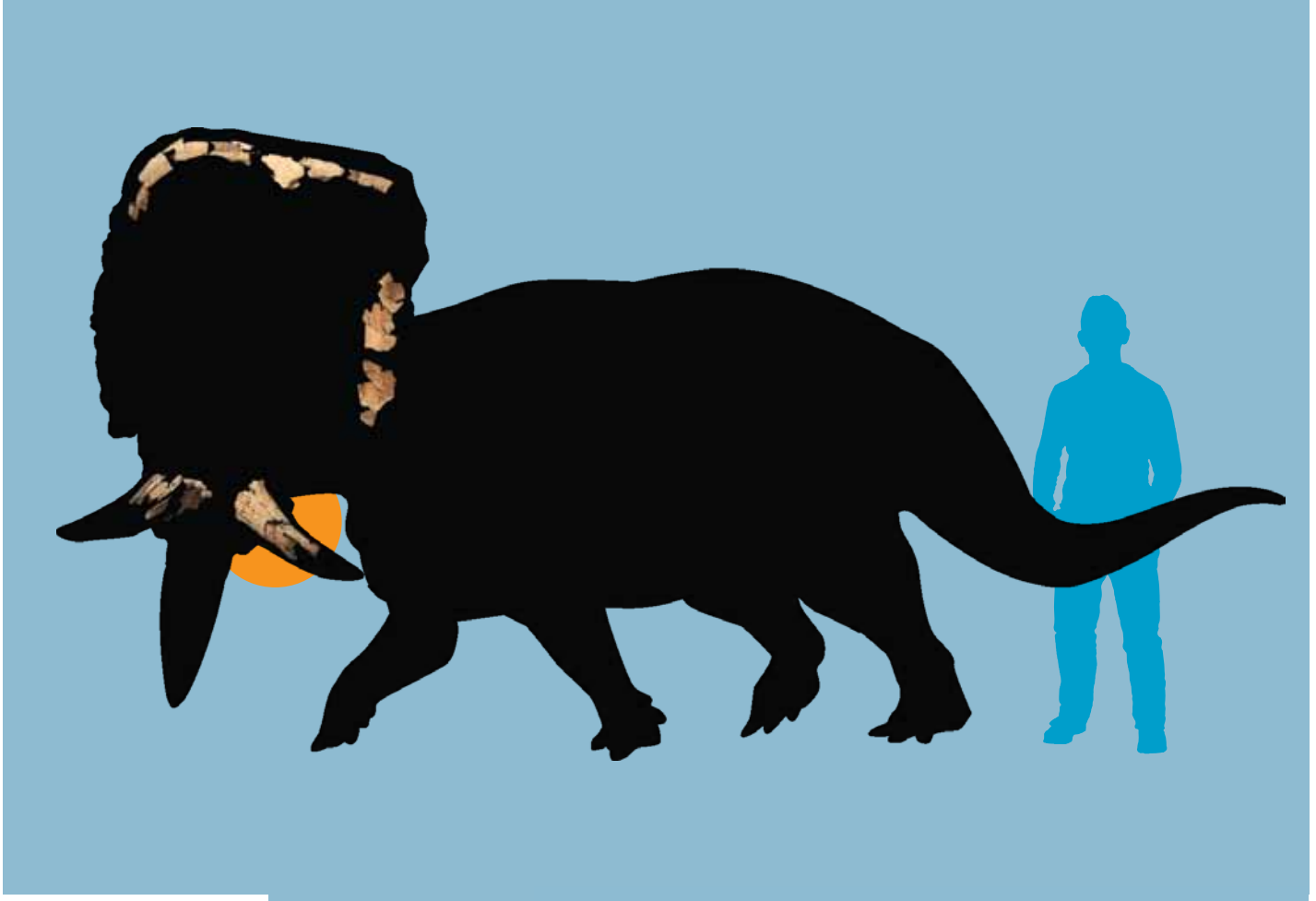


PHOTO ILLUSTRATION: MARK ZUROLO '01MFA. DINOSAUR IMAGE: NICK LONGRICH.

NAME
This 78-million-year-old herbivore species is still unnamed. Longrich is proposing a name based on that of the river basin where it was collected.

HEADGEAR
The smooth, rectangular contour of its five-foot-tall frill makes it distinctive.

BASEMENT
Longrich found the fossils at the Peabody. They were collected in the 1970s.

a sheep-sized Cretaceous herbivore called Protoceratops, he noticed that some of its eye socket bones were large, like those of certain modern species, and suggested it might have been nocturnal.

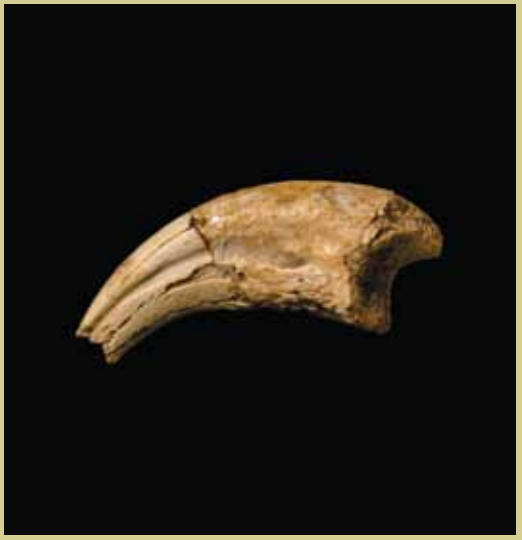
In recent years, Longrich has made a series of discoveries that landed him in major newspapers and magazines, along with the elite science journals that matter to his peers. He found a "ninja bird" that wielded its club-shaped wings "like nunchucks." And named the Mojoceratops, a hippo-sized dinosaur with a heart-shaped scalloped frill. He found evidence that Tyrannosaurus rex was sometimes a cannibal. And named a dome-skulled Texas dinosaur that competed for mates by butting heads with its rivals. The PR team at Yale has suggested Longrich for *Popular Science*'s annual "Brilliant 10" list.

Matthew Lamanna, an assistant curator at the Carnegie Museum of Natural History, hasn't collaborated with Longrich, but says he's been consistently impressed by his creative work. "He'll give you a controversial idea, and my first reaction is 'Holy crap, what the hell is this?' But then you read his paper or listen to his presentation about it and find yourself nodding your head. He's an out-of-the-box thinker, but in the best way. He backs up his at-first-glance-wild ideas with really rigorous research."

Longrich grew up in a family of fishermen on Kodiak Island, Alaska, where he and his brothers watched wildlife and hunted for Indian artifacts. He studied biology at Princeton before settling on paleontology—attracted to the field less by its outlandish fossilized creatures than

The **fragments** above had been sitting in the Peabody basement for years, labeled Ceratops. The bone scraps were "broken to hell," says Longrich, but to him they never looked like Ceratops. After laying out the pieces this spring, he decided they didn't look like anything else he knew either. It was a new species.

PHOTO ILLUSTRATION: MARK ZUROLO '01MFA. DINOSAUR IMAGE: NICK LONGRICH.



NAME
Albertonykus is named for the region of Canada where paleontologists found its fossils. It means "Alberta claw."

SIZE
At 2.5 feet long, this 70-million-year-old dinosaur is one of the smallest ever found in North America.

DIET
The animal's short arms and signature long claws were used for digging termites from rotten wood.

Philip Currie, one of Longrich's mentors, dug up this **fossilized claw**. But Longrich figured out its significance afterwards, speculating that the species was an insect eater.

by its ability to answer big questions. "I was interested in evolutionary problems," he says. "How did birds evolve flight? That's not something you can answer by looking at modern birds."

He began graduate study at the University of Chicago, but didn't like the atmosphere and left after earning his master's. Then, a few years later, he went to work at the University of Alberta as a volunteer, and started finding new species in the collection. He did his PhD work at the University of Calgary, focusing on birds. His dissertation was on the "four-winged" Archaeopteryx.

The paper was "heretical," Longrich says. The prevailing theory was and still is that, because the bird is most closely related to therapod dinosaurs like Tyrannosaurus rex, it was a ground-running animal and launched into flight from land, like a chicken. Longrich thinks it was a tree-climber. Its wings and hind limbs, he says, weren't built for the kind of powerful lift needed for taking off from the ground. Instead it leaped from tree limbs, and, with its feathered legs spread out behind for loft, the Archaeopteryx glided into flight.

It was also in graduate school that Longrich started traveling around the country to pore over existing collections. It's very expensive to launch new digs. But this, he thought, was a way to tackle big ideas and publish big papers on a shoestring. (And it also suits him. In his spare time, he looks at dinosaur fossils on eBay. He thinks he may have identified a new therapod species in one auction, but it was hard to tell just from the photographs.)

These travels helped him form relationships at several important institutions, but he's also ruffled some academic feathers along the way. "He sometimes had trouble dealing with people because he is so enthusiastic," says Currie, who has been a mentor. "It was just part of that awkward stage in life when he was focusing on one thing and didn't realize he was failing in another."

When Longrich visits a collection, he wants to see everything. As his experience in Alberta taught him, sometimes the most interesting dinosaur speci-

men is hiding in a lizard drawer. But many institutions will share only parts of their collections with outside researchers, reserving much of the material for their own scientists to explore—and publish on. Restrictions like these are hard on Longrich, with his freewheeling research approach. He sees scientists who keep material off-limits to other scholars as "territorial."

Jack Horner, a paleontologist at the Museum of the Rockies, ended up coauthoring the paper on T. rex cannibalism with Longrich, who he says has the potential to be a gifted researcher. But he was angry at first, because Longrich had looked at the recently collected fossils without asking. Horner says he had already been planning to publish on the cannibalism when Longrich proposed a paper. "We didn't collect for everybody else to come in and just poke around in it," he adds. (Longrich says he didn't have the impression the material was restricted or that Horner was planning a cannibalism paper. But he knew Horner was "working on" the bones.)

Horner is eminent in his field and celebrated in the media for his numerous big dinosaur digs. He dismisses Longrich's tours through the storage drawers, saying it's an approach unlikely to earn him research funding or a tenure-track job: "You can't go out and get an NSF [National Science Foundation] grant to rummage."

But in some ways, Longrich's strategy isn't so different from the traditional approach of searching rock beds for fossils. Both rely on luck—to pick the right place, to spot the right fossil—and on having the skill to interpret significant specimens. Longrich sees himself as filling an important role by correcting errors in the published record and making the most of the work of paleontologists who came before him. And the sheer toil of reviewing hundreds of original specimens has its value. "It's kind of important to know the basics, but a lot of guys don't even do this type of thing any more," he says.

Longrich was just a graduate student when he wrote his Archaeopteryx paper, and his theory was unconventional, so it was published in a specialized journal and didn't attract much notice. But he is revisiting the species: he's planning a series of papers looking in detail at Archaeopteryx anatomy and aerodynamics. He hopes they will be accepted by a high-impact journal, where they can make more of a splash and start to affect the scientific debate.

Lately, the prominent bird discoveries have been coming out of the abundant bone beds in China. In July, a team of researchers published on newly discovered birdlike animals even earlier than Archaeopteryx, whose iconic status as the first known bird is now under challenge. The new work appears to support Longrich's views about bird flight. But he's not part of the action; the finds don't make it any easier for him to earn a reputation as an expert on bird evolution or to find a permanent job.

Sometimes the most interesting dinosaur fossil is hiding in a lizard drawer.

Longrich knows he may be running out of low-hanging fruit in the old collections. He's been to nearly every major natural history museum in the country, as well as a few small ones. In Wyoming, he stopped at a one-room museum staffed by a teenager and a team of elderly volunteers who call themselves the "bone biddies." (The museum had some fine specimens. "You have a freakin' Torosaurus," Longrich exclaimed giddily over one dinosaur skull.)

After four museums in four days, Longrich's last stop in the West was an actual fossil bed—the Lance formation, near Lusk, Wyoming, where O. C. Marsh collected many of his most famous specimens. Paleontologists at the Tate Geological Museum in Casper had arranged permission for him to drive on private land to see the massive ridge, with the understanding that he'd leave behind anything he found there.

It was late in the day when Longrich jumped out of the car. He climbed over a hill before bending down to scrape sand off the ground, and within a minute, he came up with a handful of rocks. "Bone scrap, bone scrap, bone scrap, here's a gar scale. Here's a turtle fragment," he said, triumphantly, holding up a pebble-sized fossil that looked a lot like a pebble. "Oh! I found a lizard jaw. Nice." But Lance is well sampled, and unlikely to yield any more game-changing fossils. The future, Longrich says, will be in China, Argentina, the Arctic, and other rock beds that are less explored. He hopes he can get the funding to be a part of those discoveries.

As the sun was setting, Longrich wandered up and down the hills of the formation, picking up fossils, putting them down, and taking in the big orange sky that he'd missed for all those days in the basements. Y