Student Reading

Unearthing Pterosaurs

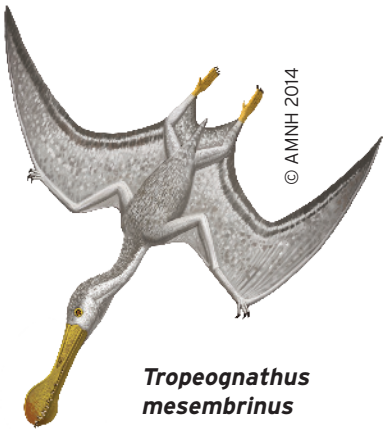
There is a place called the Araripe Basin in a remote, sparsely populated region of northeastern Brazil. Arid but beautiful, it can be a difficult place for farmers to grow crops. But the earth provides another bounty: fossils. And among the bevy of bones are some rare finds — including 23 species of extinct flying reptiles called pterosaurs.

More than three decades ago, a local there found some large pterosaur bones. He delivered them to the Museu Nacional in Rio de Janeiro, where they were tucked away in a drawer. As it happens, many natural history museums have a trove of unexamined fossils awaiting study in their collections — there are just too many to go through. But a few years ago, paleontologist Alexander Kellner, a research associate at the American Museum of Natural History who as a doctoral student trained with Curators John Maisey and Malcolm McKenna, found the time to examine the 30-plus-year-old fossil finds at the Rio museum, where he is now a curator.

One especially rich layer, the Romualdo Formation, produced distinctive round nodules. Here, calcium collected around dead plants and animals that sank into the soupy mud. Sometimes, a hard shell, or calcareous nodule, formed around them. These rocky coverings preserved fish, plants, even entire pterosaurs, in three dimensions.

Before studying the bones, Kellner had to dissolve the calcereous "nodules" of rock in which the bones were entombed by sinking the fossils into buckets of formic acid. Using a pneumatic hammer, specialists at the museum gradually freed a partial skeleton of the animal from its stony home.

It included part of the animal's skull, complete with a bony crest at the tip of its nose, vertebrae, pelvis — and, perhaps most dramatically, arm and wing-bones. The wingspan of this pterosaur was, the research team concluded, nearly 27 feet — the largest pterosaur discovered so far in the Southern Hemisphere. A model of this recently described giant specimen, from the species *Tropeognathus mesembrinus*, flies overhead at the entrance to the special exhibition *Pterosaurs: Flight in the Age of Dinosaurs*, overseen by Curator Mark Norell with Kellner as co-curator.



Tropeognathus mesembrinus

Not a Bird, Not a Dinosaur

© AMNH/C.Chesek

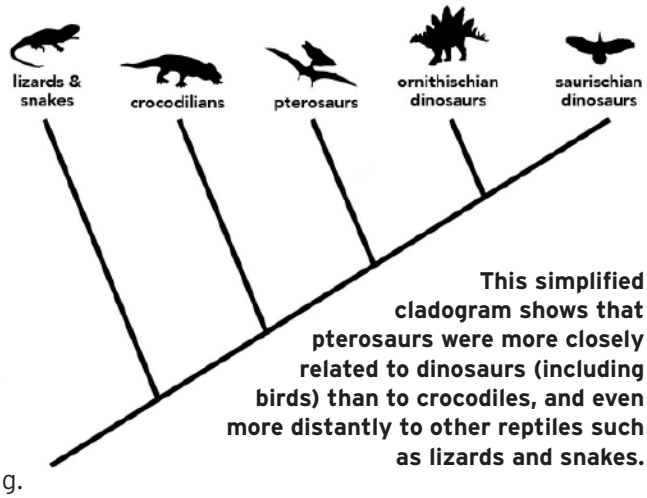
This fossil animal's long forelimbs perplexed early naturalists. In 1809, it was finally identified as a flying reptile and named *ptéro-dactyle*, meaning "wing finger."

What is a pterosaur? It sounds like such a simple question. But the answer was by no means obvious when the first pterosaur skeleton was discovered in the mid-1700s, in the Solnhofen limestone quarry in Germany. Perhaps, early observers theorized, that specimen's long skinny arm-and-finger bones were for swimming? Or was it some kind of toothed, clawed, winged bird? Or even a mammal? Debates raged, even after 1801, when the great French anatomist Georges Cuvier analyzed drawings of the skeleton and determined the animal to be something new to science: a flying reptile that Cuvier later named ptero-dactyle (wing finger in Greek), whose wings were composed of a shortened upper arm bone, along with a dramatically elongated fourth finger that likely supported a wing membrane.

Since Cuvier's time, the fossil record has revealed much more about these extinct reptiles, which lived from about 220 million years ago to the end of the late Cretaceous period 66 million years ago, disappearing at the same time as large dinosaurs in a mass extinction event.

Still, although pterosaurs may often be grouped with dinosaurs in children's picture books, they are not dinosaurs.

"Dinosaurs are characterized by a set of anatomical features pterosaurs don't have," explains Norell, including a hole in the hip socket. Today's scientific consensus is that pterosaurs are nonetheless more closely related to dinosaurs, whose living descendants are birds, than to any other group, including the next-closest, crocodiles.



This simplified cladogram shows that pterosaurs were more closely related to dinosaurs (including birds) than to crocodiles, and even more distantly to other reptiles such as lizards and snakes.

What is also clear is that pterosaurs were the first vertebrates to fly — an amazing feat. Tiny, invertebrate insects had long since taken to the air, but nothing as large as a four-legged vertebrate had attempted such a thing.

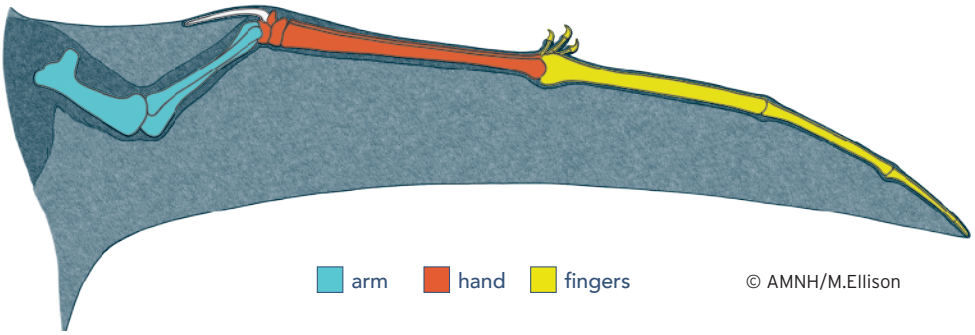
"They are the most fabulous creatures that ever existed! I am not exaggerating," says Kellner. "They made the first attempts among vertebrates to conquer the air — they were the first to develop powered flight," that is, the type of sustained flight that evolved, later and independently, in birds and bats.

Still, many mysteries remain. What type of material covered their skin? Was it hair, or feathers, or something in between? What did they eat, and how did they hunt? Many pterosaurs had flesh-and-bone crests atop their skulls — dramatic anatomical characteristics whose purpose is still debated by paleontologists.

Unlike dinosaurs, whose living descendants are modern birds, pterosaurs left no heirs when they disappeared from Earth. That means paleontologists have no living analogs to draw from as they make inferences about pterosaur behavior. Nonetheless, in the past decade or two, there has been a resurgence of pterosaur research and synthesis, as new methods of examining fossils, such as computed tomography (CT) scanning and UV lighting to discern heretofore invisible details, have become commonplace; as researchers share data digitally; and as researchers begin to find new fossils in previously unexplored locales, including China and Brazil.

Fossils Reveal Diversity

Pterosaur bones have been found on every continent including Antarctica. Although all pterosaurs share the wing anatomy in which the upper-arm bone (humerus) and elongated fourth digit form the truss of the wing membrane, the wing shapes are quite diverse: from long, thin soaring wings like those of an albatross to short, stubby wings that might have allowed for more frequent flapping flight, like that of a cardinal. Some early pterosaurs had peg-like teeth seen in living reptiles, while many others were toothless. Early pterosaurs often had long tails that they might have used as airborne rudders, while later species have a short tail or no tail at all.



A number of adaptations made flight possible: a greatly elongated fourth finger of the hand that evolved to support a wing; flexible, hollow bones; and membranes between different parts of the body.

The above text is excerpted from the article "Unearthing Pterosaurs," which appeared in the Spring 2014 issue of Rotunda, *the American Museum of Natural History's member magazine.*

Crazy Crests

The incredible diversity of pterosaurs is perhaps best expressed in one of the prehistoric flying reptile's most intriguing and mysterious features: the head crest.

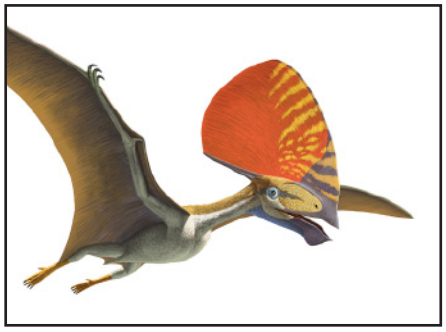
Akin to a rooster's comb, peacock's crown, or the frill on some lizards' necks, pterosaur crests were prominent anatomical features found across many species. But rather than flesh or feathers, these reptiles' crests were made at least in part of bone — a boon to paleontologists, as hard bone tends to be preserved as a fossil. Recent research also indicates that other horn-like material comprised part or even most of some pterosaur crests, with the thin, underlying bony structure supporting sometimes expansive membranes. Pterosaurs crests are thought to have been fairly ubiquitous, appearing in many groups of pterosaurs from the Triassic (252–201 million years ago) through the Jurassic (201–145 million years ago) and Cretaceous (145–66 million years ago) periods. In terms of size and dramatic effect, crests peaked in the Late Cretaceous, when the biggest pterosaurs also evolved.

Among pterosaur species known to have had crests, there is an amazing range of shapes and sizes. *Pteranodon sternbergi*, for example, had a high upright crest on its skull; *Pteranodon longiceps*, dagger-shaped blades at the back of its head; and *Nyctosaurus*, a fan-like structure at the rear of its head. *Dsungaripterus weii* had two: a long, low crest on its snout and a short crest rising above the back of the head. The *Anhanguera* species had rounded disk shapes on both upper and lower jaws, while *Gnathosaurus* pterosaurs had long, low ridges running down the middle of their heads. *Tupandactylus* imperator had huge sail-like extensions that dwarfed the rest of its head.

Dsungaripterus weii

Nyctosaurus gracilis

Tupandactylus imperator



Could something so flashy be all form and no function? The heavier crests cost the reptiles a lot in energy to grow and carry around. Reason suggests if they weren't useful, they would have disappeared over millions of years of evolution. But just what that use was is a question that puzzles pterosaurologists to this day.

There are competing theories, chief among them that crests serve as a form of species identification. Other possibilities include a role in sexual selection, heat regulation, as a rudder in flight, or as a keel in the water, stabilizing the reptile as it dove or skimmed for food. The discovery in Brazil of wildly different crests among closely related species lends credibility to the theory of species identification: like a Mesozoic mohawk, a distinct crest would allow ready recognition of one's own kind and, equally important, rule out others.

Were the crests as brightly colored as shown in artists' renderings? While scientists cannot know for certain, light and dark bands of color on the rare preserved tissue of a *Pterorhynchus wellnhoferi* crest found in China led to speculation that crests might indeed have been highly colored, especially if they served to communicate identity or attract mates.

Still, without living descendants for comparison and the relative scarcity of fossils, definitive proof has been elusive — so far.

The above text is excerpted from the article "Flying Colors," which appeared in the Spring 2014 issue of Rotunda, *the American Museum of Natural History's member magazine.*