DENVER, COLORADO—Almost 1000 paleontologists and enthusiasts met here from 3 to 6 November for the 64th annual meeting of the Society of Vertebrate Paleontology.

Head Games Show Whether Dinos Went on Two Legs or Four

Your mother was right: Posture matters. For dinosaurs, it's one of the most basic features that paleontologists—and exhibit designers—want to know. In Denver, a trio of paleontologists presented a broad survey of dinosaurs and showed that the shape of the inner ear canals can reveal whether a dinosaur stood upright or walked on all fours. The approach is great, says Donald Henderson, who studies dinosaur biomechanics at the University of Calgary in Alberta, Canada. "It's a completely independent, objective source of evidence."

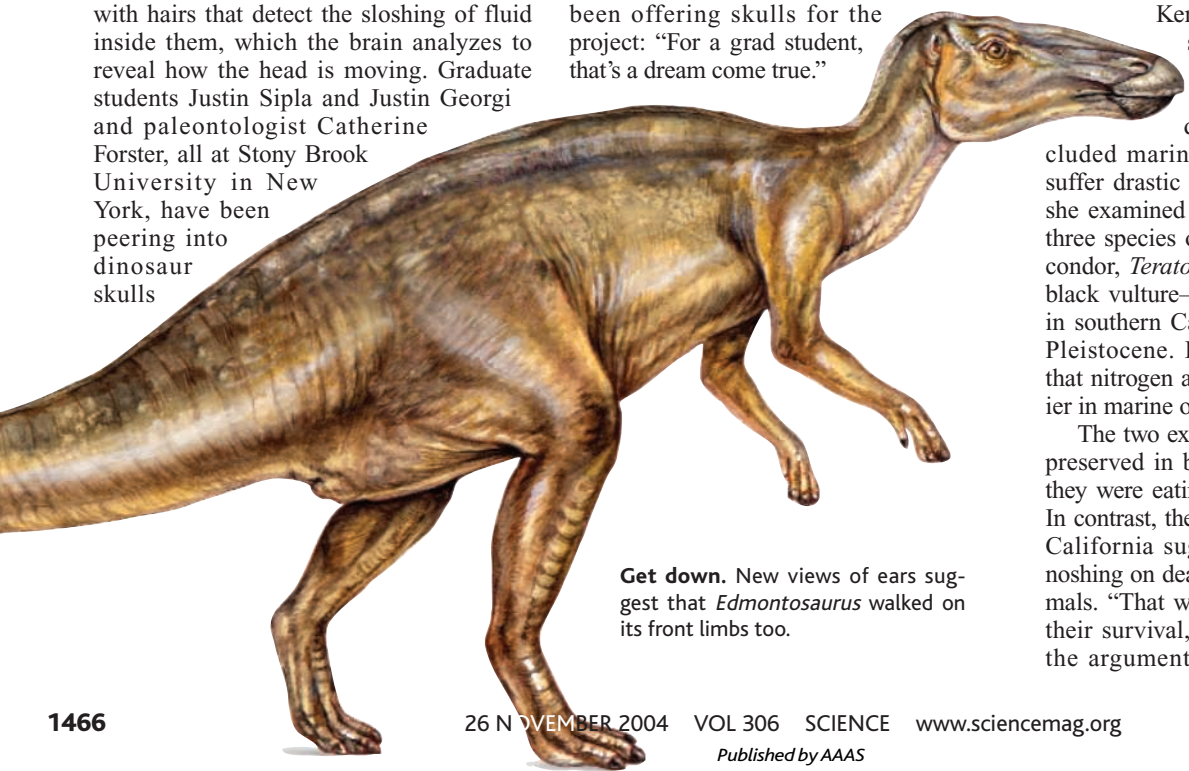
There's no doubt, of course, that the massive, thick-legged sauropods kept four feet on the ground. Or that *Tyrannosaurus rex*, with its shrimpy arms, walked upright. But for other creatures, the picture has not always been so clear. The duck-billed dinosaurs, such as *Edmontosaurus* for example, had strong legs and were sometimes reconstructed as being bipedal, sometimes quadrupedal. To make their various cases, paleontologists have traditionally looked at limb proportions and other aspects of anatomy, such as joint articulation.

The inner ear offers another way to examine posture and locomotion (*Science*, 31 October 2003, p. 770). With three semicircular canals oriented at right angles to each other, the inner ear helps keep the head oriented. The canals are lined with hairs that detect the sloshing of fluid inside them, which the brain analyzes to reveal how the head is moving. Graduate students Justin Sipla and Justin Georgi and paleontologist Catherine Forster, all at Stony Brook University in New York, have been peering into dinosaur skulls with computed-tomography scanning to reconstruct ancient postures.

After examining 19 taxa from all the major groups of dinosaurs, they identified a distinct difference between bipeds and quadrupeds. In those that walked upright, such as the birdlike *Dromaeosaurus*, the anterior semicircular canal—which detects dipping of the head—was enlarged vertically relative to the posterior canal. That was not the case in four-footed dinosaurs, such as *Chasmosaurus*, a relative of *Triceratops*. "The correlation between the size of the anterior semicircular canal and posture was really nice," Henderson says. The researchers speculate that the reason for expanding the canal—which makes it more sensitive—is that the head of a biped experiences greater downward accelerations while moving and must coordinate with the neck muscles to remain stable.

Next, the team analyzed taxa for which posture had been debated. As for *Edmontosaurus*, its ear resembled those of known quadrupeds—backing up recent inferences. And a scan of *Anchisaurus* confirmed that the closest relatives to sauropods, the prosauropods, were bipedal. The team plans to investigate when and how transitional forms in these groups began to evolve quadrupedality. Sipla says that since the talk, other paleontologists have been offering skulls for the project: "For a grad student, that's a dream come true."

Reconstructing posture can be a slippery business, cautions Robert Reisz of the University of Toronto in Ontario, Canada. "But as long as we can get hard data, like the shape of the semicircular canals, then we're more confident about our interpretations," he says. That prospect alone will make paleontologists sit up straight.



Get down. New views of ears suggest that *Edmontosaurus* walked on its front limbs too.

Antiextinction Tip: Eat to Live

A cosmopolitan diet may have helped the California condor avoid the fate of many other large scavenging birds 12,000 years ago, a paleontologist reported at the meeting.

The late Pleistocene was a difficult time for large animals in North America. Climate was changing, and human hunters had marched into the continent. Although the ultimate cause of the extinction of the mammoths and other large herbivores is still debated, it's clear that their demise had drastic effects that cascaded through food webs. Saber-toothed cats and other predators went extinct as well, as did many kinds of vultures, including *Teratornis merriami*—the largest flighted bird ever, with a wingspan of 3 meters or more. Yet the California condor pulled through.

Kena Fox-Dobbs of the University of California, Santa Cruz, hypothesized that the reason might be that condors had broader diets that included marine mammals, which did not suffer drastic extinctions. To test the idea, she examined the isotopes in the bones of three species of fossil birds: the California condor, *Teratornis*, and the extinct western black vulture—all of which were common in southern California until the end of the Pleistocene. Ecologists have established that nitrogen and carbon isotopes are heavier in marine organisms.

The two extinct scavengers had isotopes, preserved in bone collagen, that indicated they were eating carcasses of land animals. In contrast, the condor bones from southern California suggested that they were also noshing on dead seals and other marine animals. "That wide dietary niche was key to their survival," Fox-Dobbs says. Boosting the argument, condor fossils from New

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