PALEONTOLOGY

T. rex Was Fierce, Yes, But Feathered, Too

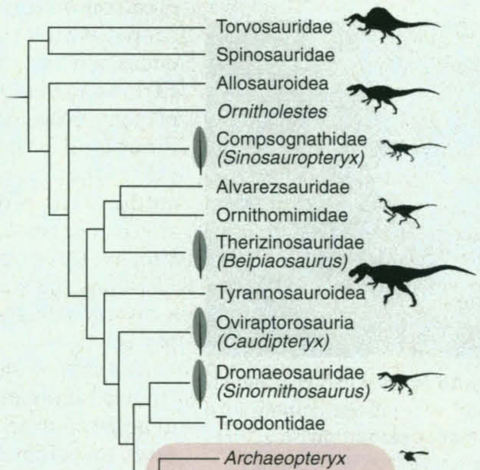
A new "feathered" fossil, this one a close relative of *Velociraptor*, adds to evidence that many predatory dinosaurs had some kind of plumage

Dinosaurs live on as sedate green lizards on the Sinclair gas station signs, but for the real beasts, that look was passé long ago. As anyone familiar with *Jurassic Park* can tell you, dinosaurs were brightly colored and awesomely athletic. Now, paleontologists say it's time for yet another makeover, at least for some of *Jurassic Park*'s most menacing characters.

Picture this: Adult *Velociraptors*, savage man-sized hunters with slashing claws, may have been covered in downy feathers, like newly hatched chicks. The same goes for the young of *Tyrannosaurus rex*, and even the full-grown monster may have had a tuft or two.

That's the implication of the stunningly well-preserved fossils unearthed over the last several years from spectacular fossil beds in China: a total of five small dinosaurs apparently clad in some kind of feathers, ranging from fibrous down to true feathers as unmistakable as a pigeon's. The most recent find, which a Chinese team reported last week in *Nature*, is a small, birdlike animal called a dromaeosaur. The 125-million-year-old fossil is an undersized ancestor of *Velociraptor*, which makes it almost certain that the later, larger creatures had similar plumage, says dinosaur paleontologist Mark Norell of the American Museum of Natural History (AMNH) in New York City. "We have as much evidence that *Velociraptors* had feathers as we do that Neandertals had hair," he says.

Almost a bird? A 125-million-year-old dromaeosaur had long, mobile forelimbs and what appears to be downy plumage.



Feathered nests. The distribution of feathers or "protofeathers" on this family tree, which includes many meat-eating dinosaurs as well as birds (pink), suggests that forms including tyrannosaurids may have had feathers, too.

From the widely scattered perches of this and the other feathered fossils on the dinosaur family tree (see diagram), paleontologists are realizing that many other dinosaurs on intermediate branches probably also had some kind of feathers, which may have served as insulation. "Feathers are marching their way down" the tree, says Paul Sereno of the University of Chicago—and settling on such unlikely creatures as *T. rex* and its relatives. It's a proliferation that, to some, dramatically underscores the proposed evolutionary link between dinosaurs and birds. But even for ardent proponents of that link, it takes some strenuous mental adjustment to picture such a wide range of dinosaurs in their new clothes.

And a small, energetic band of dissenters is not at all ready to make this kind of adjustment. The halos of fibers found around several of the crucial fossils, including the latest one, are far more likely to be some kind of internal connective-tissue fibers left behind when the flesh decayed than anything related to feathers, according to John Ruben of Oregon State University in Corvallis. "We think these are just collagen," he says.

This controversy first erupted when a "feathered dinosaur," *Sinosauropteryx*, emerged 3 years ago from the fossil deposits in China's Liaoning province, where volcanic eruptions some 125 million years ago in the early Cretaceous period entombed a menagerie of ancient animals (*Science*, 1 November 1996, p. 720, and 13 March 1998, p. 1626). The fine-grained sediments had preserved a fibrous mane along the creature's neck and back—"protofeathers" to many paleontologists, internal fibers to some others.

No one could deny the reality of the feathers on two fossils found later in the same deposit, creatures called *Caudipteryx* and *Protoarchaeopteryx* (*Nature*, 25 June 1998, p. 753, and *Science*, 26 June 1998, p. 2051). *Caudipteryx*, the better preserved of the two, had unmistakable feathers on its forelimbs and tail, although it was evidently flightless. But that did not win over the doubters, who think birds originated from reptiles that lived well before the dinosaurs. They agreed that the feathers were real enough but said that based on other features, both creatures were not dinosaurs at all but unusual flightless birds. *Caudipteryx*, says Ruben, is "a Cretaceous turkey, so to speak."

Many paleontologists had a very different view, considering *Caudipteryx* and *Protoarchaeopteryx* as feathered dinosaurs all right, but ones that were somewhat removed from the main line of descent to birds. A better candidate for close cousins of the first birds seemed to be the dromaeosaurs, a group of small predators with a massive claw on each hindlimb and shoulder joints that gave the forelimbs a wide range of motion, a prerequisite for the evolution of flight. But paleontologists had few good fossils of these animals, let alone a view of one with feathers.

Now, Xiao-Chun Wu and his colleagues at the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing have filled that gap with yet another fossil from the Liaoning deposits. The fossil they describe in *Nature*, a 40-centimeter-tall, downy dromaeosaur called *Sinornithosaurus*, "has more bird fea-

CREDITS (TOP TO BOTTOM): XU ET AL.; P. SERENO AND C. ABRACZINSKAS tures than any of the other feathered dinosaurs," says James Clark of George Washington University.

"Everything about the fossil is skewed toward similarity to birds," adds Wu, citing the mobility of the shoulders, the shape of the breastbone, and the proportions of its limbs. Unlike other meat-eating dinosaurs, it has forelimbs nearly as long as its hindlimbs, which may have originally served in "a form of predation associated with grabbing and clutching," says Thomas Holtz of the University of Maryland, College Park, and could easily have evolved into wings. And the downy fringe that appears to cover much of the new dromaeosaur is "a nice confirmation of the existence of feathers—or whatever we want to call them—on dromaeosaurs," notes Holtz.

What *Sinornithosaurus* lacks are complex feathers like those of *Caudipteryx*, which troubles advocates of the bird-dino connection. If *Caudipteryx*—which they view as less birdlike—had true feathers, so should this missing link. This conundrum leads Wu to suggest that the dromaeosaur did have true feathers that somehow weren't preserved, perhaps because the wind blew them away, leaving only the down, before the animal was buried and fossilized. To doubters such as Larry Martin of the University of Kansas, Lawrence, however, the absence of true feathers is telling. "Flight feathers are bigger and have more structure than these fibers," so they should have been preserved along with any down, he argues.

Ruben adds that if this dromaeosaur—supposedly so close to birds—didn't have true feathers, the "down" is probably a chimera as well. He thinks the same is true for *Sinosauropteryx*, the first "feathered" dinosaur, as well as another downy creature, a so-called therizinosaur, reported in the 27 May issue of *Nature*. As Ruben puts it, "All of these things are in all likelihood something like collagen connective fibers."

But if Ruben and his fellow skeptics are wrong about the nature of these fibers, the images of many familiar dinosaurs should be softened with a coating of down. In the family tree of small, meat-eating dinosaurs, *Sinosauropteryx* lies well away from the dromaeosaurs and the putative ancestors of birds. "It's an ordinary ground-running dinosaur," in Holtz's view. So creatures that perch in between could well have been downy too. Says the AMNH's Norell, "If you're willing to consider the fluffy stuff that's covering the body of *Sinosauropteryx* as feathers, you've got to contemplate *T. rex*, ornithomimids [a group of long-legged, ostrich-sized dinosaurs], and many others as having this kind of plumage at one time in their lives."

Don't start describing *T. rex* to your 4-year-old as a toothy version of Big Bird, though. "Whether an adult *T. rex* had full plumage—well, there's no direct evidence for it, and it might not have been great to have a lot of insulation when you weighed 5 or 6 tons and lived in an environment like Louisiana," says Holtz. "I wouldn't be at all surprised if adult *T. rex* had lost its plumage, although it may have had feathers here and there." **–TIM APPENZELLER**

MEETING AMERICAN CHEMICAL SOCIETY

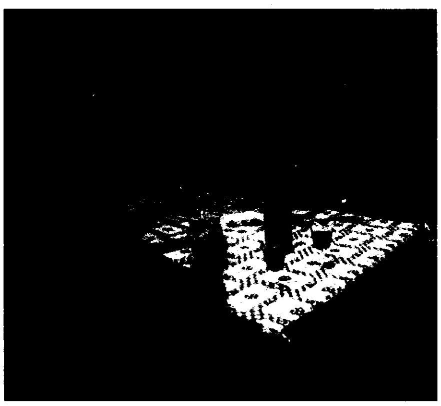
Raising a Glass to Health And Nanotubes

NEW ORLEANS, LOUISIANA—For the 12,000 researchers who sweated out the dog days of summer at the American Chemical Society (ACS) meeting here from 22 to 26 August, the hot papers included a novel explanation for the healthy effects of moderate alcohol consumption, and both triumph and trials on the road to electronic devices based on carbon nanotubes.

Fathoming the French Paradox

The French seem to have it all. They eat an exquisite diet full of high-fat foods such as cheese and meats washed down with fine wines, and yet they suffer from only one-third as much heart disease as do inhabitants of the United States. One explanation for what health experts have dubbed the "French paradox" is that antioxidant compounds in red wine prevent fats from being oxidized into forms that tend to build up in coronary arteries, among other places. Yet simply eating grapes that harbor the same compounds as wine doesn't seem to confer the same benefits. "So something else must be going on," says Yousef Al-Abed, an organic chemist at the Picower Institute for Medical Research in Manhasset, New York. At the meeting, Al-Abed reported that rat studies suggest a new possibility: that an alcohol metabolite prevents the formation of harmful compounds called advanced glycation end products (AGEs), which are thought to initiate the potentially deadly plaque buildup in coronary arteries.

"I feel quite excited about it," says Helen Vlassara, an AGE expert at the Mount Sinai School of Medicine in New York City. Although the notion that alcohol suppresses AGEs has been around for a while, "this was the first time it was solidified [experimentally]," she says. In addition to helping explain the French paradox, the new work may also lead to the development of novel drugs that combat heart disease by targeting AGEs—work that biochemist Richard Bucala, the senior scientist on the Picower team, says is already under way.



Cup of good health? Does an alcohol metabolite protect drinkers from heart disease?

AGEs begin to take form when common proteins circulating in the blood pick up a sugar group or two in their wanderings, which bind to the proteins to create key AGE intermediates called Amadori products (APs). The sugar groups on APs can adopt either a looped structure that behaves like a molecular Dr. Jekyll or a Hyde-like linear form. The linear form is harmful because the glucose remains reactive and can act as a molecular coupler, linking proteins together to form AGEs. The AGEs in turn can aggregate to form a thick, cross-linked web of proteins, which is thought to play a role in everything from atherosclerotic plaques to the loss of tissue flexibility with age. AGEs also bind low-density lipoprotein, the so-called bad cholesterol, and slow the rate at which it is cleared from the blood, thus increasing a person's cholesterol level and overall risk for heart trouble.

Amadori products with looped sugars are less reactive, but the rings can still open up into the Hyde-like chains—except on certain APs containing a pair of rings that seem frozen in their safe, unreactive form. Researchers weren't sure what causes the freezing, but Al-Abed thought some ring-forming compounds called aldehydes could be responsible. So he decided to test one called acetaldehyde, a byproduct of alco-

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