Warm-Blooded Dino Debate Blows Hot and Cold

A group of researchers has recently taken the temperature of a 67-million-year-old corpse —and, remarkably, found it warm. Since the body in question was that of a *Tyrannosaurus rex*, their claim has reignited one of the hottest debates in paleontology: whether dinosaurs were warm-blooded, like mammals and birds, or cold-blooded, like reptiles.

On page 222 of this issue, paleontologist Reese E. Barrick and geochemist William J. Showers from North Carolina State University report on their analysis of the proportions of several oxygen isotopes in the bones of a *T. rex*. The balance of those isotopes is affected by body temperature, and Barrick and Showers conclude the beast's temperature was stable and uniform throughout.

"*Tyrannosaurus rex* was maintaining a body temperature in its core and extremities that varied by 4 degrees centrigrade or less, which means it was homeothermic," says Barrick. And homeothermy, the researchers argue, is a sign of a warm-blooded animal; the temperature of a cold-blooded reptile varies between core and limbs. "The ability to maintain that constant high temperature removes *T. rex* from the strictly reptilian class," Barrick says.

This statement, however, has received a lukewarm reception from many other scientists, who say the issue is not that clear-cut. Isotopes are a relatively new line of evidence in an argument that erupted 25 years ago when Yale paleontologist John Ostrom suggested dinosaurs' anatomy implied they were active, upright, and constantly feeding, behavior that in turn suggests the high metabolic rates of warm-blooded animals. But many paleontologists still consider dinosaurs to be reptiles. And even those who favor warm-blooded behemoths admit the isotopes are far from unequivocal.

Ostrom, for instance, says that "their conclusions are reasonable, but I'm afraid it's still indirect evidence." Paleontologist David Varricchio of Montana State University (MSU) says "it's a great avenue to pursue, simply because it's so different from other approaches to this problem," but he notes there are still questions about both the technique and the analysis. Those in the reptile camp put those questions bluntly. "The dinosaurs were warm and homeothermic because they were big, not because they had a high metabolism," growls Frank V. Paladino, a physiologist at Indiana-Purdue University. "They were reptiles and nothing more," Other scientists quarrel with the assay, doubting that the isotopic signal has survived the ravages of time unaltered.

That assay is one that has been around for some time, commonly used for finding the temperature of ancient oceans. The ratio of two oxygen isotopes within bony tissues, oxygen-16 and oxygen-18, changes according to temperature; there is relatively more oxygen-18 when it's colder. These isotopes are incorporated into a creature's bones from its surrounding body fluids. Since the resulting ratio of heavy-to-light isotopes is controlled by the temperature at which bone forms, Barrick and Showers reasoned that the isotopic differences between bones in different parts of the dino's body could serve as a marker for the temperature of particular body parts.

Barrick and Showers tested their technique on bones from a cow and from a Komodo dragon, a large lizard (*Science*, 24 July 1992, p. 487), to find out whether the isotopes could distinguish between warm- and cold-blooded animals. That study revealed little disparity between the temperature of the cow's leg and rib bones. The tail bones of the Komodo dragon, however, were 2 to 9 degrees centrigrade cooler than its ribs.

Hot discovery? Isotopes taken from the bones of this *T. rex* may indicate that the creature was warm-blooded, but some scientists doubt the evidence.

When it came time to apply the technique to fossils, however, even the researcher who pioneered these isotopic studies had doubts. "The problem with this method, which I love dearly, is it's hard to tell if the bone actually holds the original signal from the beast," says geochemist Yehoshua Kolodny of the Hebrew University of Jerusalem. Kolodny says the signal can be altered during the mineralization that changes bone into fossil, or from burial and ground-water. And, as these caveats might suggest, Barrick and Showers' first attempts to read the signal from some dinosaur bones weren't convincing.

But not all ancient bones become mineralized, and last year the researchers turned their attention to the bones of an astonishingly well-preserved *T. rex* recently discovered in Montana. "This *T. rex* shows little or no fossilization within the internal bones," explains John Horner of MSU, who headed its excavation. "So it's pretty hard to argue that the signal has been altered during the fossilization process." Barrick and Showers drilled samples from several of the giant's bones, including ribs and vertebrae along with leg, toe, and tail bones. The analysis produced a hot finding: little disparity among the isotope ratio from bones in the extremities and the midsection, as well as consistent ratios in different samples of the same bone.

This would seem to be strong evidence, but it doesn't seem to be changing a lot of minds. Kolodny, for one, still questions the validity of the isotopic signal, pointing out that most fossils have been recrystallized (evidenced by high concentrations of foreign elements such as strontium)—a process that would likely change the bones' original isotopic ratio. And even if the ratios do turn out to be genuine, physiologists doubt that one can deduce much from them about the metabolic rate of the dinosaurs. "To assume that a homeotherm is an endotherm is a weak argument at best," says John Ruben, a zoophysiologist at Oregon State University at Corvallis. "The dinosaurs may well have been homeotherms—their bulk alone would have generated enough heat to create a stable body temperature. But every physiologist knows that homeothermy tells us nothing about an animal's metabolic rate."

Barrick and Showers are undaunted by the criticism. In fact, they plan further tests using the same methodology. They intend to sample reptile bones from deposits similar to the one that entombed the *T. rex*. If their signals show the pattern found in modern cold-blooded animals, Barrick says their critics will have to concede that the method works. Varricchio and Horner point out that the present work is in line with some of their own research on dinosaur bone growth, which indicates the tissue had a lot of blood vessels—a warm-blooded hallmark.

But the researcher who has been in the middle of this argument the longest doesn't think even that work will end the argument. Says Ostrom: "I've puzzled over the question for years; I've seen the evidence come and go, and I'm still no closer to the truth, whatever that might be."

–Virginia Morell