EVOLUTION

Did an Asteroid Leave Its Mark in Montana Bones?

Now that geologists have found a huge crater on the Yucatan Peninsula that appears to have been formed when a massive asteroid smashed into Earth 65 million years ago, the debate over what killed off the dinosaurs—and with them more than half of the other species known to exist then—has finally been settled, right? Well, not quite. Although most geologists are convinced that they have found a murder weapon in the asteroid impact, paleontologists are sharply divided over just what, if anything, it wiped out.

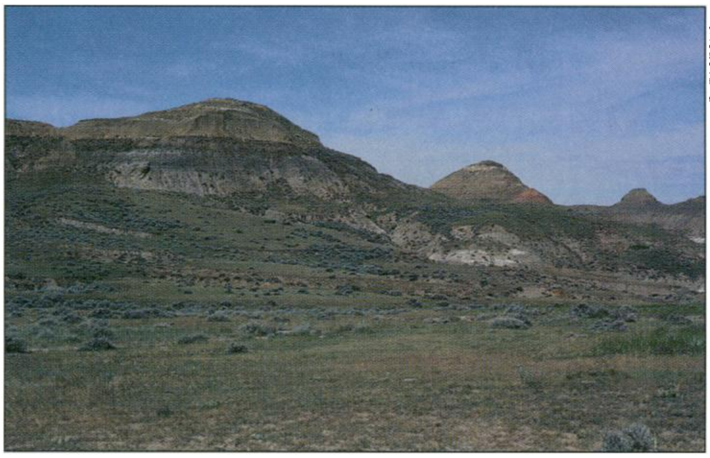
The debate in the paleontology community, which has been simmering for several years, is likely to be brought to a boil by the publication in the June issue of *Geology* of a reinterpretation of a collection of 150,000 vertebrate fossils from eastern Montana—the best vertebrate fossil record paleontologists have of the period in question. According to the original analysis, published 2 years ago, the eastern Montana collection shows little sign of a single catastrophic event. Rather, an array of earthly forces, such as the retreat of an inland sea, produced a complex pattern of extinction and survival among the dinosaurs, mammals, amphibians, reptiles, and fish that lived there 65 million years ago. As dinosaur paleontologist Peter Dodson of the University of Pennsylvania puts it, the impact advocates "may have a smoking gun, but some victims died of stab wounds."

But paleontologists Peter Sheehan of the Milwaukee Public Museum and David Fastovsky of the University of Rhode Island have now taken another look at the very same fossil record and, in their *Geology* paper, say they see a much simpler pattern of extinctions—one consistent with an asteroid impact. This new view of the Montana fossils is intriguing some skeptics. Says dinosaur paleontologist John Horner of Montana State University: "I've always had a horrible time with this asteroid thing, but I think there's a great deal of sense in both" interpretations. In fact, the argument for an impact-induced extinction "is almost enough to make me a believer," he says.

Both camps agree that roughly half the species represented in the Montana fossils were wiped out 65 million years ago. And both acknowledge that land-dwelling animals fared worst. But they disagree sharply on just about everything else.

Representing one camp is David Archibald of San Diego State University, who with Laurie Bryant, now teaching at Boise State University, presented the original version of events in a meeting proceedings published in 1990. Both are former graduate students of paleontologist William Clemens of the University of California at Berkeley, under whose supervision the Montana fossils were collected over the past 20 years.

Archibald and Bryant compared species found in the Hell Creek formation—sediments laid down during the 2 million years or so immediately before the mass extinction—with those represented by the Tullock formation, which was formed after it. They found that sharks and their saltwater relatives disappeared, while freshwater fish, amphibians, and turtles largely escaped extinction. This disparity, they suggested, can be explained by the retreat of a great inland sea that receded southward, taking the sharks' preferred brackish water with it.



D. FASTOVSKY

A catastrophe? Eastern Montana holds the best record of vertebrate life before *(below the dark band)* and after *(above)* a mass extinction.

As for land-dwelling animals such as dinosaurs and lizards, they suffered heavily or went totally extinct. Indeed, Archibald, in a recent unpublished reanalysis of the data, found that 78% of land animals disappeared, compared with 28% of freshwater species. The reason that the land animals were so severely affected, Archibald and Bryant argue, is that their favored seasonally dry habitat turned swampy and coastal lowlands became fragmented and shrank in size as the sea retreated south. While the researchers didn't rule out some role for an impact, "there wasn't one, single cause" for the extinctions, Archibald concludes.

Now come Sheehan and Fastovsky, whose analysis of the fossil record produced a far simpler pattern of which species survived and which succumbed. They put their emphasis on the striking difference in survival between land-dwelling species such as dinosaurs and mammals and those that lived in fresh water and along stream banks. They calculate that land animals suffered a bruising 88% extinction while only 10% of freshwater species disappeared—a much sharper disparity than that now found by Archibald.

Sheehan and Fastovsky see the impact at work. The classic impact scenario includes months of near-total darkness imposed by a veil of impact-generated dust that would temporarily cut off photosynthesis. With the production of plant food halted, they reason, species in and near fresh water, where feeding on detritus is a typical way of life, should have fared better than land animals, which were more likely to be feeding directly on plants wiped out by the impact.

But Archibald is not buying the argument. "They have zero evidence of the kind of scenario they're trying to argue for," he says, adding that the evidence for the regression of the inland sea is incontestable and fits the extinction pattern much better. Sheehan and Fastovsky are "rather grasping at straws to say an impact fits the pattern when you have right in front of you the geologic evidence."

Fastovsky counters that he and Sheehan see their stark pattern because they focused solely on fossils from Montana. That was the point of Archibald and Bryant's study, they thought—to infer what happened in Montana using the world's finest collection of vertebrate fossils. But Archibald and Bryant blurred the picture, Fastovsky says, by going outside the collection to find survivors of species too rare in Montana to be included otherwise. "That doesn't strike me as statistically rigorous," he maintains. Archibald responds that those added species were common outside the study area, so he sees no reason to exclude relevant data from the analysis, wherever it can be found.

Fastovsky also has problems with the special treatment that mammals get in Archibald's analysis. Some species are classified as survivors because they appear to have descendants in the Tullock formation. Aside from the difficulties of identifying descendants, says Fastovsky, "if you're going to integrate the mammals into the rest of the database, you have to treat them like other taxa in the database." If you don't use the available data on mammals, Archibald replies, you would find yourself in the uncomfortable position of having the mammals become totally extinct.

Both sides concede a certain predisposition in their views of the extinctions recorded in Montana. How the raw data from the field should be handled must be worked out, everyone agrees, but even given the same numbers, interpretations are going to vary. "It's really flavored by what you think about what happened" 65 million years ago, Sheehan says, and on that at least, Archibald agrees.

Historically, overwhelming evidence is needed to resolve such philosophically entrenched conflicts. If 150,000 specimens aren't overwhelming, what would be? Some paleontologists want to see another study area like eastern Montana for comparison, but they won't find it in North America. The betting money is on China.

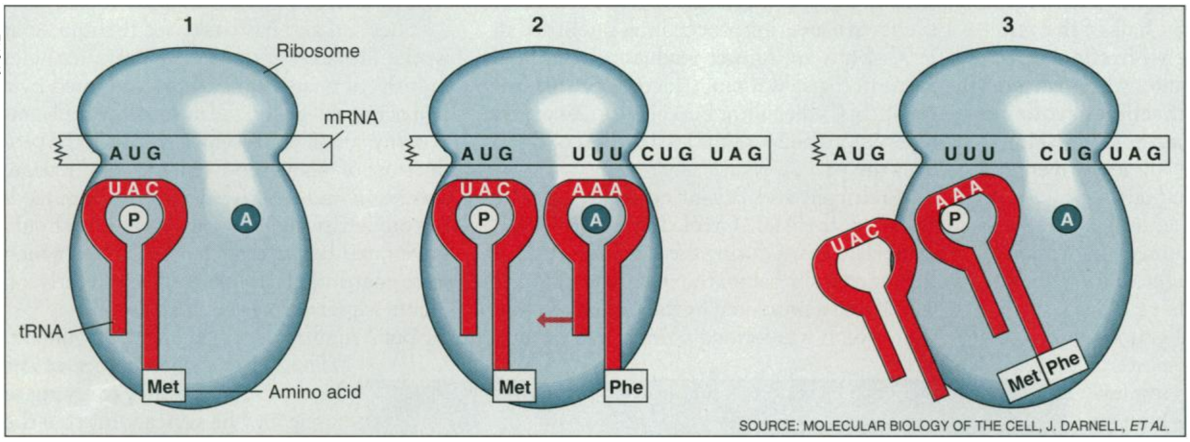
–Richard A. Kerr

ADDITIONAL READING

■ J.D. Archibald and L.J. Bryant, "Differential Cretaceous/Tertiary Extinctions of Non-Marine Vertebrates; Evidence From Northeastern Montana," in *Global Catastrophes in Earth History*, V.L. Sharpton and P.D. Ward, Eds. (Geological Society of America, Denver, 1990).

■ P.M. Sheehan and D.E. Fastovsky, "Major Extinctions of Land-Dwelling Vertebrates at the Cretaceous-Tertiary Boundary, Eastern Montana," *Geology* **20**, 556 (1992).

MOLECULAR BIOLOGY



Meet your maker. The joining of amino acids (here Met and Phe) is the key step in creating a protein chain. An article in this issue of *Science* offers strong evidence that the joining reaction is carried out by the RNA component of the ribosome and not by the ribosome's protein components, as was once thought. This finding supports the notion that RNA was the first genetic material.

Finding RNA Makes Proteins Gives 'RNA World' a Big Boost

Not so long ago, cell biologists believed that the functional activities in living tissues were carried out entirely by proteins, acting as enzymes. It was only in the early 1980s that this tidy picture began to be thrown into disarray, when it was established that RNA, once thought to be largely a passive carrier of genetic information, can sometimes function as an enzyme as well—a finding for which Thomas Cech of the University of Colorado in Boulder and Sidney Altman of Yale University shared the Nobel Prize in Chemistry in 1989. Their results revived a long-standing speculation that the earth was once an "RNA world": a pre-DNA realm populated by organisms that stored genetic information in RNA, catalyzed chemical reactions with RNA, and carried out all the other necessities of life with RNA—and RNA alone. And now our knowledge of RNA's capabilities has been been widened still further, giving the RNA world idea another boost into the bargain.

On page 1416 of this week's *Science*, molecular biologist Harry Noller and his coworkers at the University of California, Santa Cruz, present nearly conclusive evidence that a fundamental step in protein creation—the formation of a peptide bond linking one amino acid to the next—can be catalyzed solely by RNA in the cell's protein factories, the ribosomes. Meanwhile, a companion paper from Cech's laboratory (see page 1420) reports the discovery of a closely related activity in the original RNA catalysts, the "ribozymes." Once thought to be capable only of cutting, joining, and moving around pieces of other RNA molecules, the ribozymes also turn out to have a small but significant ability to make and break the bonds that join amino acids to transfer RNA, the molecule that carries them to the ribosomes for protein synthesis. As Norman Pace of Indiana University points out in his Perspective article on page 1402, these two findings have greatly expanded the known repertoire of RNA chemistry.

The Noller paper, in particular, has left other molecular biologists feeling a combination of shock, astonishment, and delight. "People are viewing this as an absolutely stunning result," says Christine Guthrie of the University of California, San Francisco. "The implications are profound." Specifically, the Noller paper points the way toward a complete reassessment of RNA's role in the ribosome—and by implication, in many other parts of the cell. "It's the discovery of the year, agrees Gerald Joyce of the Scripps Clinic in La Jolla. "It's just gorgeous."

Noller himself seems a little abashed by all the enthusiasm. "I'm amazed how excited people have gotten over this," he says. Obviously, he adds, the finding has come as a big surprise to many biologists. But within the small community of ribosome researchers, it was considered almost inevitable. "There's been a growing suspicion that ribosomal RNA was fundamentally involved in the mechanism of protein formation, starting as early as 1970," he says.

Back in the 1960s, he explains, when the broad outlines of protein synthesis were first being worked out, the main roles assigned to RNA were informational and structural, not enzymatic. In the first step of protein synthesis, researchers discovered, the genetic information encoded in a stretch of DNA in the nucleus of the cell is transcribed into a linear molecule known as messenger RNA (mRNA), a kind of molecular data tape that encodes the instructions for a new protein molecule. Then the mRNA migrates from the nucleus into the cytoplasm and attaches itself to a ribosome, which is a dense ball of proteins tightly wound together with several lengths of ribosomal RNAs. The ribosome moves along the mRNA data tape like the head of a tape recorder, translating the genetic code into a precise sequence of interlinked amino acids—which are brought in one by one by a third type of RNA molecule, the transfer RNA. When completed, this chain of amino acids forms a brand-new protein.

At the time this picture was being developed, says Noller, the RNA component of the ribosome was thought to be little more than a scaffolding to hold the protein com-