

the Real Jurassic Park

by Mary Schweitzer and Tracy Staedter

A thin slice of *T. rex* bone glowed amber beneath the lens of my microscope. Blood vessel channels snaked through a bone matrix, and tiny chambers known as lacunae, which house bone-forming cells, appeared as small ovals.

One by one my co-workers, paleontology students at Montana State University, took turns peering through the eyepiece. The lab filled with murmurs of amazement, for I had focused on something inside the vessels that none of us had ever noticed before: tiny round objects, translucent red with a dark center.

Then a colleague took one look at them and shouted, "You've got red blood cells. You've got red blood cells!"

Red blood cells? The shape and location suggested them, but blood cells are mostly water and couldn't possibly have stayed preserved in the 65-million-year-old tyrannosaur. Perhaps the mysterious structures were, at best, derived from blood, modified over the millennia by geological processes.

Finding remnants of dinosaur blood cells would have astounding implications. Tiny bits of proteins and DNA possibly locked away inside the structures could contain the coded messages of life just waiting for scientists to decipher them. Recently, the notion of finding preserved dino DNA has produced a lot of headlines, not to mention blockbuster movies. Most scientists don't put much stock in the idea because it's unlikely that DNA could last for millions of years. But some of us think that proteins might prove to be the genuine article.

Bigger and heartier than DNA, some proteins may have a better chance at surviving for eons and could provide clues about an extinct animal's life not as easily extracted from DNA. For example, by matching certain aspects of ancient protein molecules with modern ones, we could

determine just how closely related dinosaurs really are to birds, which most people think are their descendants. Granted, we can never bring dinosaurs back to life as Steven Spielberg did in his movie. But we could bring the essence of their lives into the present and come as close as science might ever get to a *real* Jurassic Park.

So I showed these microscopic bone slices to my boss, paleontologist Jack Horner, renowned for his work on dinosaur nesting sites. He took a long look and then asked, "So you think these are red blood cells?" I said, "No." He said, "Well, prove that they're not."

So far, we haven't been able to.

The bone sample that had us so excited came from a beautiful, nearly complete specimen of *Tyrannosaurus rex* unearthed in 1990 by a team from Montana State University's Museum of the Rockies in Bozeman. When the team brought the dinosaur into the lab, we noticed that some parts deep inside the long bone of the leg had not completely fossilized. Normally a bone becomes fossilized with the help of groundwater, which permeates it, washes away its organic components and replaces them with minerals. But water also interacts with DNA and protein molecules, breaking apart the bonds that hold them together. One possible explanation was that not much water had gotten into this *T. rex*. If that was true, then some biomolecules could remain. It was a long shot but clearly worth checking out.

To find DNA is to find the molecule of life. DNA contains building blocks, called bases, that record information used to determine an animal's characteristics. The sequence of the bases also tells the genetic story of the animal's lineage. Scientists can compare sequences from two animals, for example, and draw conclusions about their family tree. The more similar the two sequences, the more recently in the past the animals shared an ancestor. So if scientists could obtain DNA from a dinosaur and compare it to DNA from living creatures, the world would gain a much better picture of the evolutionary history of these "terrible lizards."

But finding DNA has its challenges. It's not clear that the molecules can remain recognizable over tens of millions of years. And even if the simple ravages of water and time do not destroy

them, proving which organism owns the DNA adds another complicated dimension.

The problem is that DNA is everywhere. In the case of our *T. rex*, the skeleton lay buried in soil where bacteria lived and died, leaving behind their DNA. When the crew from the museum recovered the bones, they touched them and probably transferred some of their DNA, too.

This creates major headaches in the lab, for the technique we use to make enough copies of DNA for analysis isn't very picky about what it copies. It will duplicate any DNA — DNA belonging not only to the dinosaur but also to bacteria or people.

Indeed, running the *T. rex* bone through a battery of tests, we discovered DNA — but it was the DNA of fungi, bacteria and insects, clearly not of dinosaurs. We also had DNA sequences that we couldn't identify at all. It's possible that these mystery molecules could belong to the dinosaur or they might just be scrambled bits of DNA from otherwise familiar organisms. We hope to find longer strands that could give us more information.



The more we understand about extinct animals, the more we will learn about the varying fortunes of the creatures who inhabit this planet, including us.

But DNA isn't the only show in town. Other biomolecules such as proteins could remain in the fossil tissue. And as the foot soldiers carrying out the instructions from the DNA generals, proteins contain much of the same information as DNA — sometimes even more. For example, the sequence of the protein collagen in warm-blooded animals may be slightly different than that in cold-blooded animals. Information gleaned from collagen could help us settle the long-debated issue about dinosaur metabolism. Proteins also make up pigments, which color skin and may exist in some fossilized skin imprints. If we could identify these, we might come closer to learning something about how dinosaurs looked.

We first came upon the possibility that proteins might exist in the the *T. rex* quite by accident. In the fall of 1991, I was trying to find a way to prevent the *T. rex* bone sections from slipping off glass slides. Looking for some help, I took the samples to the university's vet histologist, Gayle Callis, who specializes in examinations of modern bone. Then I promptly forgot about them. Three months later she called. Apparently she had taken the samples to a confer-

ence, and someone asked her about the oldest bone she had ever worked with. She said, "I just happen to have this dinosaur sample. . . ." and put it under a microscope. A pathologist took a look at it and said, "Do you know you have blood cells in this bone?" Gayle brought the slides back and showed me. And that's when all the excitement in the lab began.

If the unknown structures in the well-preserved tyrannosaur's bone were indeed derived from red blood cells, then we might be able to find fragments of the protein hemoglobin. A large, complex protein found in enormous quantities inside each red blood cell, hemoglobin ferries life-giving oxygen around the body. And because blood cells are born deep inside the kind of bones our tissue samples came from, we knew the protein was once plentiful there.

Hemoglobin contains iron, which gives blood its reddish color. When an organism dies, the blood cells fall apart, and hemoglobin, no longer hemmed in by the cell walls, bursts through and stains the surrounding tissues red. The tissue samples from our *T. rex* appeared reddish brown, as did liquid extracted from the tissue.

We also thought hemoglobin could be in the

tissue because at its core are structures that have a reputation for durability. Called heme units, these chemically stable structures consist of a ringlike organic compound called porphyrin bound to an iron atom. Porphyrins are an important part of many biological molecules, including chlorophyll, which plants need for photosynthesis. Porphyrins derived from chlorophyll have been found in sediments dating back to the Carboniferous, when vast forests blanketed the planet many millions of years before the dinosaurs existed. So we did not think it too far-fetched that heme units from hemoglobin might still exist in our *T. rex*.

To find out, we enlisted the help of chemists Scott Bohle, Keith Carron and Ernst Arnold from the University of Wyoming, as well as Scott Busse, Joe Sears and Craig Johnson from Montana State University. We began probing the *T. rex* tissue for chemical signatures that are specific for heme units. The bonds of the heme actually vibrate in a unique pattern when stimulated with certain wavelengths of laser light. Our extracted tissue vibrated in the same way as modern heme compounds. Heme also reacts to a magnetic field differently than other proteins because of its association with iron. Our samples reacted differently, too. And heme tends to absorb light at a specific wavelength.

Our samples absorbed light strongly in this wavelength, using two different tests.

By now, we felt fairly comfortable claiming that these dinosaur tissues contained heme. But heme doesn't quite equal hemoglobin. Some other proteins that contain absolutely no hemoglobin do contain a heme unit. For example, cytochromes, proteins found in all living organisms, including tiny soil-dwelling microbes, have heme. So it became crucial to determine whether we had hemoglobin not found in microbial interlopers.

I sent some of the *T. rex* extract to Mark Marshall, an oncologist at Indiana University. Familiar with blood work and immunizing techniques, Marshall knew that if heme remained attached to small protein fragments, he could home in on it with the help of the immune system of some lab rats. Rats, like humans, are capable of producing antibodies in response to foreign proteins. Once manufactured, the antibodies will respond in lab tests by binding to proteins similar to the one that stimulated the antibody production in the first place.

Marshall collected blood from the rats so that we had a "before" sample. Then, over the course of several weeks, he injected some of the dinosaur tissue extract into the rats. If the dino tissue contained proteins, the rats' immune systems would react to them by producing specific antibodies against them. After giving the rats time to mount a strong response to any dinosaur protein, he collected their blood and filtered out the cells and other solid particles to leave only the antibodies against the dinosaur tissues. The result is called an antiserum.

Now for the real test. Marshall mixed the dinosaur antiserum with hemoglobin proteins from various modern animals, including birds, crocodiles and humans. If the dinosaur antiserum recognized the modern hemoglobin proteins, it would react by bonding to regions on the modern hemoglobins. The more specific the bonding (a reflection of the number of characteristics shared between the antiserum and the modern proteins), the more tightly they bond together and will stay bonded, despite repeated washings. It's then possible to attach chemical labels that change color when this bonding occurs. When Marshall mixed the dinosaur antiserum with the modern proteins, the label

changed color: The antibodies to the dinosaur extracts recognized the modern ones.

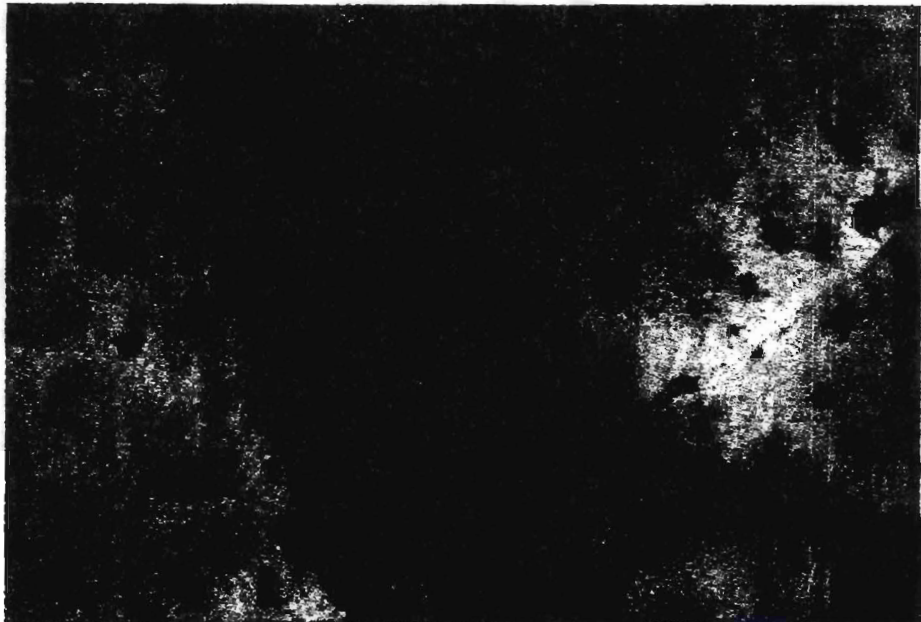
As a control, he mixed the "before" sample of rat serum with the same proteins. There was no reaction. Antibodies normally present in the rats' blood did not recognize the hemoglobin proteins from other modern animals.

So far, we think that all of this evidence supports the notion that our slices of *T. rex* could contain preserved heme and hemoglobin fragments. But more work needs to be done before we are confident enough to come right out and say, "Yes, this *T. rex* has blood compounds left in its tissues."

We hope to repeat the study with similarly preserved dinosaur bones. Paleontologists at other institutions have discovered dinosaur specimens with a good possibility of containing protein. For example, an *Oviraptor* specimen, found in a nesting position, appears to have bits of a claw sheath on one of its feet. The sheath is made of protein, so such a sample may contain protein remnants. We hope to someday look at such dinosaur specimens to expand our search, not just to understand more about the dinosaurs but to gain useful information about how proteins might remain preserved over such long time spans.

The future holds an infinite number of questions about ancient life. And scientists could answer some of them with the life-building codes locked away in fossil molecules. The more we understand about extinct animals, the more we will learn about the varying fortunes of the creatures who inhabit this planet, including us. ☉

Blood from rock. Looking suspiciously like red blood cells, these mysterious spheres tucked into the blood vessel chambers of a 65-million-year-old *Tyrannosaurus rex* fossil could contain fragments of DNA and proteins.



Bruce Seligman/Museum of the Rockies