Paleontology

Hot under the collar over dinosaurs

Two researchers have added a hot new twist to the simmering debate over dinosaur physiology. By analyzing oxygen stored within the bones of a *Tyrannosaurus rex* skeleton, they have found evidence suggesting that the king of all carnivores had a warm-blooded metabolism more like that of mammals than that of reptiles.

Their study, however, has received a cool reception from researchers who question the validity of applying this innovative technique to fossil samples.

Reese E. Barrick and William J. Showers of North Carolina State University in Raleigh studied an exceptionally well preserved *T. rex* skeleton from the late Cretaceous, a period that ended 65 million years ago. To gauge the body temperature of the animal during its life, they measured the ratio of two oxygen isotopes in bones from several different parts of the body. A high ratio of oxygen-18 to oxygen-16 indicates that the bones developed at relatively cool temperatures.

Barrick and Showers contend that isotopic tests can tell warm-blooded from cold-blooded metabolisms. Because of their high metabolisms, mammals and other endotherms show little temperature variation throughout the year, the researchers suggest. They also surmise that endotherms keep their extremities at almost the same temperature as their body core.

Given that supposed pattern, the isotopic signature of *T. rex* bones suggests that the animal was endothermic. The dinosaur's limbs and tail averaged only 2°C cooler than its core, and its overall body temperature varied less than 4°C for different times in its life, they report in the July 8 SCIENCE.

But physiologist John Ruben of Oregon State University in Corvallis argues that Barrick and Showers have jumped to conclusions without studying enough about modern endotherms. Mammals, says Ruben, sometimes keep their limbs much cooler than their bodies.

Other investigators also question the study. Among the skeptics is Yehoshua Kolodny of the Hebrew University of Jerusalem, who applied the oxygen isotope technique to the study of fossils. At an international meeting last year in Oxford, England, Kolodny reported that his experiments with fossil dinosaurs, fish, mammals, and aquatic reptiles revealed that the fossilization process altered the oxygen isotope ratios, wiping out the original information.

Anusuya Chinsamy of the University of Pennsylvania in Philadelphia contends that Barrick and Showers should have tested whether the isotopic technique can discern a difference between fossil mammals and reptiles before reporting the *T. rex* data. "They haven't done the basic research yet," she says.

Chinsamy has other reasons to doubt the findings. In her own preliminary studies of *T. rex* bone, she has found growth rings, a characteristic of ectothermic animals (SN: 5/14/94, p.312). "The growth rings indicate that these animals were not endothermic," she says.

T. rex discovered in Canada

Three years after a local principal brought them pieces of a *Tyrannosaurus rex*, paleontologists with the Royal Saskatchewan Museum in Regina finally found time to check out the lead. What they uncovered ranks among the rarest of all fossil discoveries: a well-preserved *T. rex* skeleton.

"This would be only the 12th decent *T. rex* skeleton," says curator John Storer, who is working with assistant curator Tim Tokaryk to unearth the fossil. So far, they have found major parts of the skull, the lower jaw, parts of the hip, various vertebrae, the femur, and elements of the front leg. "I'm quite confident that what we have is a nearly complete *T. rex*," says Storer.

Technology

Richard Lipkin reports from Cambridge, Mass., at the Artificial Life IV conference

Simulated creatures evolve and learn

In nature, most biologists concur, competition, natural selection, and sexual reproduction constitute the driving forces of evolution. Consequently, evolution proceeds undirected, as organisms mate and adapt to a changing environment.

To explore this process of survival of the fittest, computer scientist Karl Sims of Thinking Machines in Cambridge, Mass., has devised a simulated evolutionary system in which virtual creatures compete for resources in a three-dimensional arena.

The creatures, resembling toy-block robots, enter one-on-one contests in which they vie for control of a desired object—an extra cube. Winners—deemed more fit— reproduce, while losers bear no offspring. Sims endows the virtual environment with physical parameters, such as gravity and friction, and restricts behaviors to plausible physical actions.

When the creatures mate, their offsprings' nervous systems and body types reflect a genetic recombination, thus permitting evolution to determine their attributes. Over hundreds of generations, the creatures compete, reproduce, and evolve, learning complex strategies for controlling resources. Through trial and error, they figure out which strategies work, discarding poor techniques and enhancing effective ones.

Some species found successful strategies in the first 10 or 20 generations, Sims says, while others took much longer. Some creatures threw their arms around the cube or leaped on it. Others crawled or somersaulted to it. A few formed leg-like appendages and learned to walk. They also devised strategies for countering opponents—for example, by covering up the cube, pushing it out of reach, or shoving contenders away.

This evolutionary method may enhance artificial intelligence research by giving rise to autonomous computer programs more complex than scientists can currently design. "It may be easier to evolve virtual entities with intelligent behavior than to design and build them" from scratch, says Sims.

An immune system for computer viruses

Trying to mimic the human body's ability to fight off infection, computer scientists are developing immunologically inspired systems to ward off computer viruses.

Jeffrey O. Kephart of the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., reports designing an immune system for computers that "takes much of its inspiration from nature." As in vertebrates, the new system develops and stores "antibodies," enabling a computer to stop computer virus attacks more quickly.

"We are also careful to minimize the risk of an autoimmune response," he says, "in which the immune system mistakenly identifies legitimate software as being undesirable."

The new immunity program detects known viruses by their computer-code sequences and unknown viruses by their unusual behavior within the computer. Decoy programs then seek out and trap the viruses. Then the computer extracts the malevolent coding, turns on a repair program to fix damaged software, and "immunizes" itself against similar viruses.

To forestall an epidemic—a virus spreading through a group of linked computers—infected machines send out "kill signals" to warn other computers of the rampant invader. The signals tell how to kill the new virus as well as similar ones.

The rate at which new viruses are created and the cost to businesses of virus damage have grown, Kephart says. More than 2,000 known viruses exist, and, on average, two or three new ones emerge each day. Of more than 100 million personal computer users worldwide, roughly 1 million, he estimates, have had their work affected by viruses. "This technology will gradually be incorporated into IBM's commercial antivirus product during the next year or two," Kephart says.