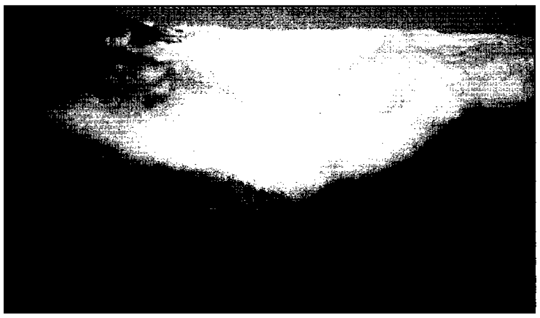
colleagues agree that more records from other areas are needed to confirm that there were no strong El Niño cycles 5000 to 12,000 years ago. One new record in coral—from the other end of the El Niño system in Papua New Guinea—does suggest a much subdued El Niño 8000 years ago, according to work presented last month at the meeting of the American Geophysical Union in San Francisco by paleoclimatologist Sandy Tudhope of Edinburgh University in the U.K.



Cloud-spotting. El Niño–driven clouds often bring heavy rains to this Ecuadorian site.

El Niño's temporary absence also fits into an archaeological scenario for the emergence of complex cultures on the west coast of South America. Using evidence such as the species composition of mollusk shells, which reflects ocean temperature, archaeologist Daniel Sandweiss of the University of Maine, Orono, has long argued that El Niño was shut down between 5000 and at least 8000 years ago. The onset of crop-nourishing El Niño rains by 5000 years ago sparked population increases, temple construction, and more complex societies on the Pacific Coast, he suggests (see his Perspective on p. 499). Critics such as geologist Lisa Wells of Vanderbilt University in Nashville, Tennessee, disputed some of his evidence, but Wells now agrees that the lake core backs his claim about El Niño.

But if El Niño did switch off, no one is sure why—so no one is sure of El Niño's future. From 5000 to 8000 years ago, the world was warmer than today, during the so-called Altithermal regime. If warmth alone had suppressed or eliminated El Niño, then it might again fade with the greenhouse warming of the next century. But if something else was the trigger—such as the changing strength of the seasonal cycle, which was greater at that time thanks to changes in Earth's tilt and orbit—the analogy between the Altithermal and the greenhouse might not hold. "It makes a lot of sense to look back at a previous warm period," says paleoclimate modeler John Kutzbach of the University of Wisconsin, Madison, who has started to model paleo–El Niño, "but it's incredibly tricky." Humans may have been familiar with El Niño for thousands of years, but that doesn't mean we understand it yet.

–RICHARD A. KERR

PALEONTOLOGY

Stunning Fossil Shows Breath of a Dinosaur

Hoping to see the innards of a 100-million-year-old dinosaur, respiratory physiologist John Ruben hauled an 80-watt ultraviolet (UV) lamp from Oregon to an archaeology office in Salerno, Italy. His trouble paid off: The UV light, which can coax out patterns invisible in ordinary light, conjured up the outlines of the juvenile dinosaur's intestines, liver, trachea, and muscles. Now Ruben and colleagues are using the arrangement of internal organs to bolster their idea that dinosaur lungs were structurally simple, most resembling those of living crocodiles. Their analysis, presented on page 514, would imply that these animals were basically cold-blooded.

That's an argument Ruben has made before (*Science*, 14 November 1997, p. 1267), but now he adds a new twist. He thinks these simple lungs were also able to power periods of high metabolism and intense activity. If so, the old question of whether dinosaurs were cold- or warm-blooded would have a hybrid answer. "This is almost better than warm-blooded," he says.

Not everyone is convinced, but many researchers are intrigued. "If they're right, this could represent landmark work suggesting a whole new way to view dinosaur physiology—it could in some sense be bimodal," says anatomist Lawrence Witmer at the Ohio University College of Osteopathic Medicine in Athens. Researchers have suspected dinosaurs of having some sort of hybrid metabolism, adds paleontologist James Farlow at Indiana University–Purdue University in Fort Wayne. The skeletons of theropod dinosaurs—meat eaters like *Tyrannosaurus rex*—suggest that they were highly active like warm-blooded mammals, but their bones lack the signatures of warm-bloodedness. Coupling an economical resting metabolism with a capacity for bursts of activity may have been the best of all possible metabolic worlds. "It's not surprising that they ruled Earth for over 100 million years," Farlow says.

Ruben, of Oregon State University in Corvallis, says the specimen of *Scipionyx samniticus*, a raptor or small meat eater, offers even more dramatic support for his anatomical argument than did a specimen he examined before, a 120-million-year-old Chinese fossil. Under the UV lamp, his team could see *Scipionyx*'s liver, which extended from the top to the bottom of the abdominal cavity, just behind the lung-heart cavity, as well as a muscle next to the pubis bone. In modern crocodiles this muscle runs from the pubis to the liver and helps move the liver back and forth like a piston, causing the lungs to expand and contract. An airtight layer of tissue, the diaphragm, separates liver and lungs.

Finding this arrangement, called a hepatic-piston diaphragm, in theropod dinosaurs rules out the possibility that they breathed with a sophisticated birdlike lung, the kind that supports birds' high metabolism, says Ruben. But because raptors like *Scipionyx* were among the most dynamic dinosaurs, Ruben began to question the assumption that a bird or mammal lung is needed for high metabolism. And recent work by other scientists (*Science,* 3 July 1998, p. 45) showed that a well-ventilated reptilian lung might be capable of unexpectedly high rates of gas exchange. Because most reptiles lack the power of a hepatic-piston diaphragm, relying only on the action of their ribs to ventilate their lungs, Ruben reconsidered the advantages of the diaphragm.

The problem with this logic, says Witmer, is that the only living animals with a hepatic-piston diaphragm are the sedentary crocodiles. But Ruben argues that crocs' sluggish, aquatic lifestyle is a secondary development. He suggests that ancestral crocodilians were dynamic, bipedal land-dwellers who used a hepatic-piston system for vigorous activity—as did dinosaurs.

Ruben further argues that the lack of a bird-type lung in dinosaurs casts doubt on the idea that they gave rise to birds. Some paleontologists disagree, because birds could have evolved their lung later. Indeed, questions remain about the reliability of the fossil itself. "You can't take a squashed specimen and interpret the position and shape of any soft organ inside," says paleontologist Phil Currie of the Royal Tyrrell Museum in Drumheller, Alberta, Canada. Ruben counters that although the fossil is two-dimensional, "nothing is displaced. … All [organs] are preserved in relation to each other."

Shining through. UV light revealed this young raptor's anatomy.

In any case, there's no doubt that the idea of metabolically hybrid dinosaurs is an appealing middle ground. Says Witmer: "In some ways everyone could be right."

–BERNICE WUETHRICH

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