Brushing the Dust Off Ancient DNA

Genetic relics reveal hidden details of prehistoric life

By KATHRYN HOPPE

The oldest reported DNA comes from some bugs that stepped in the wrong place about 30 million years ago.

This dramatic evidence of DNA's durability emerged last month in two papers announcing the successful extraction of DNA from fossil insects. Descriptions of DNA extracted from a fossil bee by California researchers appeared in the September MEDICAL SCIENTIFIC RESEARCH. A similar report by researchers at the American Museum of Natural History in New York City – focusing on an extinct termite – followed in the Sept. 25 SCIENCE.

In each case, scientists managed to amplify small fragments of DNA with a molecular copying process known as polymerase chain reaction (SN: 4/23/88, p.262). And both teams examined insects preserved in pieces of amber from the Dominican Republic, one of the world's most significant sources of this gem.

Amber-encased fossils, long valued for their excellent three-dimensional detail, are particularly suited for molecular studies. Some "specimens are so well preserved that you can identify cellular structures" under the microscope, says Raul J. Cano, a microbiologist at California Polytechnic State University in San Luis Obispo, who took part in the bee study.

American Museum of Natural History

Polished amber preserves an extinct termite.

People have long recognized that amber, a form of fossilized tree resin, preserves organic tissue extremely well. The ancient Egyptians used crushed amber to preserve mummies, notes Ward Wheeler, who coauthored the termite report.

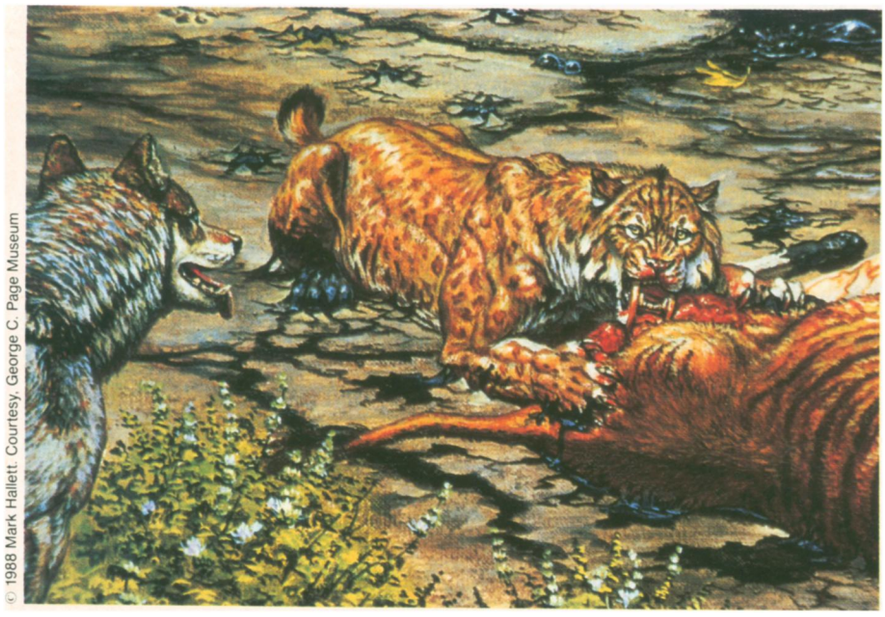
Normally, organic tissue – and the DNA it contains – degrades rapidly after an animal dies. When sealed in amber, however, tissues remain isolated from the decay-promoting effects of external air and water. Amber not only acts as a natural antibiotic that prevents the growth of microbes, but it also dries out the creatures it entombs to form natural mummies. An animal trapped in a glob of sap "is there for good," Wheeler says.

Such prisoners include "pretty much anything you can imagine that would be on the side of a tree – small frogs, small lizards, bird feathers, land snails, and a tremendous variety of insects," he says. The animals thus trapped are typically small, since the largest pieces of amber reach only about 6 inches across.

Wheeler's group studied an extinct termite called *Mastotermes electrodominicus*. Considered by some "a missing link between cockroaches and termites," this particular bug had the potential to solve "an interesting evolutionary question," explains entomologist David Grimaldi, who participated in the investigation. In the past, researchers had debated whether termites evolved from cockroaches or in parallel with them. Using sequenced fragments of DNA from *M. electrodominicus*, the New York scientists determined that their ancient bug was more termite than roach, suggesting separate origins for the two groups.

The California researchers extracted DNA from an extinct species of stingless bee known as *Proplebeia dominicana*. They hope their sample will reveal details about the evolution of this bee's modern relatives and provide a reference point for measuring evolutionary changes over time, says Cano.

Such investigations can provide detailed information that may not be avail-



© 1988 Mark Hallett. Courtesy, George C. Page Museum

Saber-toothed cats roamed southern California until their extinction approximately 10,000 years ago.

able from studies of modern groups or from the anatomical details of fossils. In the future, "amber is going to be looked at for a wealth of information" about ancient lineages, predicts study coauthor George O. Poinar Jr., a paleontologist at the University of California, Berkeley.

Amber fossils represent only a small fraction of the many potential sources of prehistoric DNA.

Other researchers have examined a wide range of preserved bones for information about animals much larger than those trapped in amber. As with the amber-entombed insects, however, only tissues protected from weathering and microbial decay yield remnants of their original DNA.

These remains must be naturally mummified — as in the case of 3,300-year-old bird bones discovered in a dry cave (SN: 9/19/92, p.183) — or preserved in rare deposits such as the tar pits of Rancho La Brea in Los Angeles.

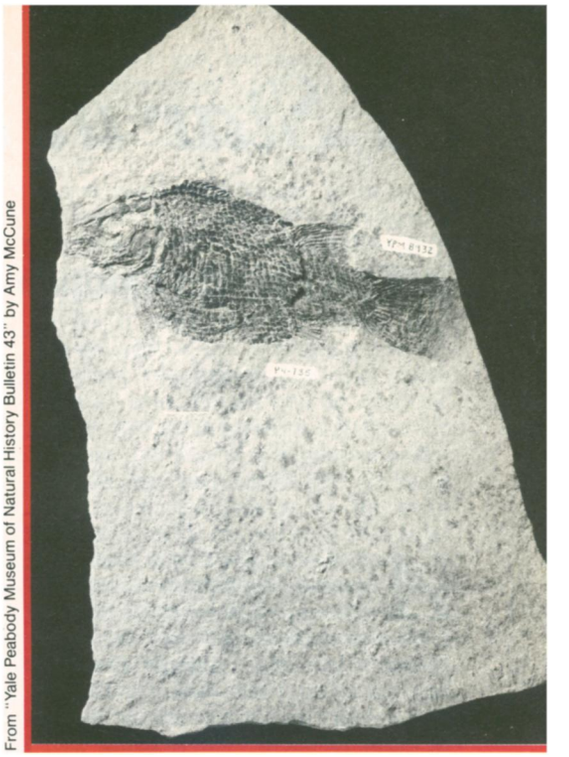
Although not nearly as ancient as some of the amber reserves, the La Brea tar pits represent one of the world's richest fossil deposits. They have yielded approximately 2 million specimens representing more than 460 animal species, some of which date back almost 40,000 years.

The first report of sequenced DNA from bones preserved in these tar pits appeared in the Oct. 15 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES. The study focused on the 14,000-year-old bones of an extinct saber-toothed cat, known as *Smilodon fatalis*, in the collection of the George C. Page Museum of La Brea Discoveries in Los Angeles.

These animals, which brandished long, knife-like canine teeth, have been placed in several different groups of carnivores over the years. The DNA sequencing results now indicate that they belonged to the same family as modern cats and were closely related to the great cats, such as lions, leopards, and tigers, according to a research group led by Stephen J. O'Brien of the National Cancer Institute's Laboratory of Viral Carcinogenesis in Frederick, Md.

Additional studies of fossil DNA may clarify the evolutionary histories of other extinct animals from the La Brea deposits, among them mammoths, mastodons, giant ground sloths, and dire wolves. But such investigations may also have "implications beyond paleontology," asserts O'Brien.

DNA studies "offer the prospect of relating evolutionary adaptations to gene sequences and open the door for the search for ancient pathogens that may have contributed to species extinction," he says. For example, if a virus drove these animals to extinction, then traces of viral DNA might appear in their remains. O'Brien hopes such pathogenic studies will also allow researchers to test hypotheses about the relationship between modern epidemics and modern species.



From "Yale Peabody Museum of Natural History Bulletin 43" by Amy McCune

Bony scales encase a fossil fish that became buried in the mud at the bottom of a lake approximately 200 million years ago.

Regardless of the exact information DNA sequencing may provide in the future, it seems certain that the current chronological record holders will not reign for long. Specimens in amber date back approximately 100 million years, providing the potential for DNA studies of animals that lived during the time of the dinosaurs.

Moreover, researchers have achieved "positive results" in their preliminary attempts to obtain DNA from the scales of fossil fish preserved in lake sediments approximately 200 million years old, says Amy R. McCune, a paleontologist at Cornell University. McCune hopes that DNA from these ancient species will not only show their connections to modern species, but also clarify their relationships to one another.

On the other hand, the new excitement over ancient DNA won't put conventional paleontologists out of work, predicts Wheeler. DNA extraction "is a different tool, but not necessarily one that will supersede morphologic or anatomical analyses," he says. Not only are the majority of fossils preserved in conditions that do not protect DNA, but anatomical comparisons will continue to provide overall details that an isolated fragment of DNA may not reveal.

Scientists might not go through the elaborate effort needed to sequence ancient DNA when their questions can be answered through more traditional comparisons. But in some cases the new tool may provide answers to formerly unanswerable questions.

Although "there are a lot of problems and difficulties associated with working with fossil material," says O'Brien, "the prospect of being able to look at the DNA sequences of species that are no longer alive makes this kind of exercise worth it." □

What about dinosaur DNA?

As researchers sequence ever-older genetic fragments, public attention focuses on the potential for finding dinosaur DNA.

Science-fiction writer Michael Crichton capitalized on such interest with his thriller *Jurassic Park*, which he based partially on early work by paleontologist George O. Poinar Jr.

In Crichton's novel, scientists clone a living dinosaur using DNA extracted from samples of blood found in the stomachs of biting insects preserved in amber.

Poinar does not foresee "any direct likelihood of that happening in the near future. . . . The dinosaur DNA would be degraded and . . . there are too many things that we still don't know how to do yet." But he does believe that scientists may extract a fragment of DNA that could shed light on dinosaur lineage, revealing whether these beasts were most akin to modern reptiles, birds, or mammals.

While admitting that such a find "is a long shot," microbiologist Raul J. Cano says he feels that "given the right piece of amber with the right insect . . . the chances [of success] are fairly good."

Many scientists still consider this idea farfetched, but Poinar points out that not long ago few people believed *any* ancient DNA could be sequenced. "When we started, we were told that we were crazy," he says.

And even if amber fossils were to prove useless for dinosaur studies, scientists might extract their answers from the remains of dinosaur bones. Just this month, researchers reported evidence that some of these bones still retain their original proteins, which could potentially reveal some of the same general taxonomic features as DNA (SN: 10/3/92, p.213). — *K. Hoppe*