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Mastodont Hair Gives Clues to Habitat

Kimberly J. Sawtelle, *University of Maine*

MAMMOTH TRUMPET

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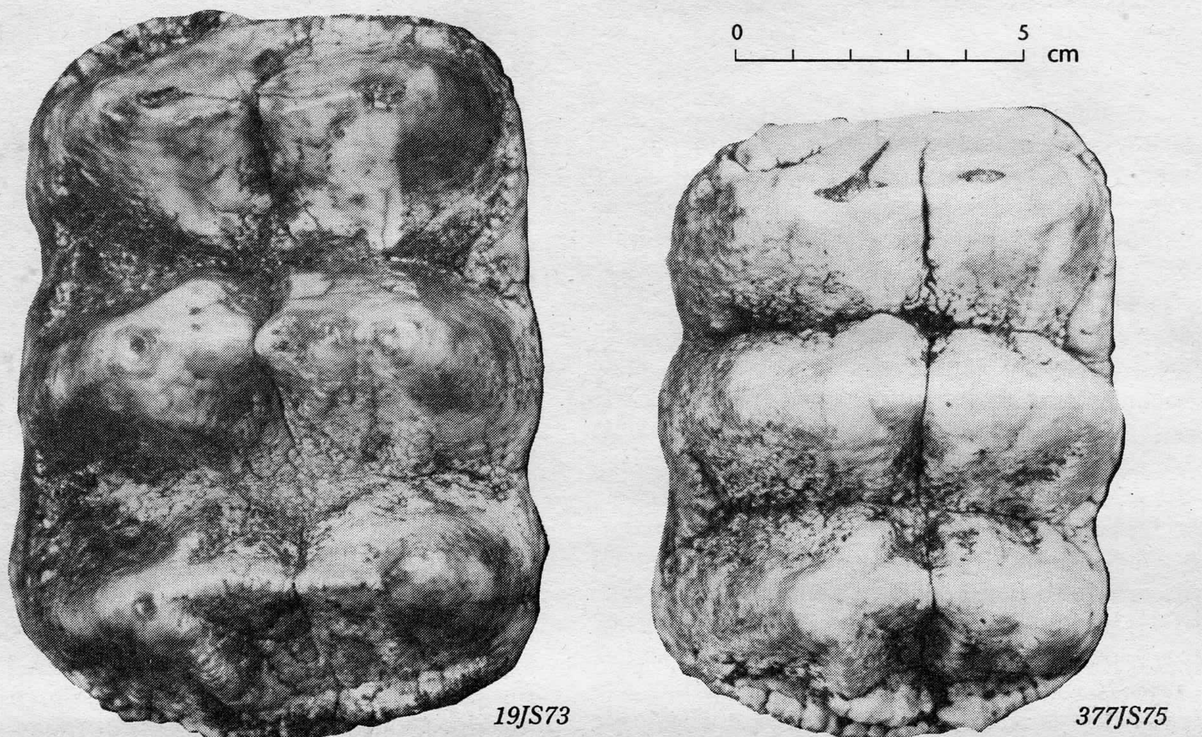

Crown views of the left M2/'s of *Mammut americanum* from Jones Spring faunal assemblages (Hickory County, Missouri) illustrating examples of the rugged (right) and smooth (left) varieties of cheek teeth in this species. Both teeth are in full eruption and early wear, and both are from young adult individuals between 26 and 28 years of age at death based on comparison with tooth eruption and wear patterns in living African elephants.

The rugged variety is smaller and is from a faunal assemblage associated with high-pine-pollen abundance. It exhibits greater development of the cingula, seen especially at the posterior (bottom) border of the tooth and at the ends of the transverse valleys. In addition, the ridges descending from the cusps are stronger, bulging into and obstructing the valleys at their bases. *(From Saunders, J. J., and P. Tassy 1989 Le Mastodonte Americain.* La Recherche *20:452-461; Photo courtesy of J. J. Saunders).*

MASTODONT MICROEVOLUTION LINKED TO CLIMATIC CHANGE

"We seem to go through cycles in paleontology, and mastodonts are certainly on an upswing. They continue to be interesting animals—they're still very enigmatic, and they're just too damn big to be ignored," Dr. Jeffrey Saunders of Illinois State Museum joked during a recent informal interview. His enthusiasm may seem surprising: one could easily assume that after over 200 years of widespread discoveries of mastodont remains in sites throughout Europe, Asia, and North America, the scientific community would have formed a fairly complete picture of these megamammals.

Yet Saunders and numerous colleagues are working on a much more comprehensive scale. Using a wide range of techniques, they are arriving at new understandings of how mastodonts adapted to changing environments. Their data indicate that the species changed physically over time, fueling the debate on why mastodonts became extinct 11,000 years ago along with so many other mammals.

Scientists such as Saunders pay attention not only to the mastodont bones recovered from a site, but also to the types of other animals found with them, any evidence of the presence of humans, and the geology and formational history of the site—clues to the ecology of the time. Pollen and fossil wood can be used to verify what plants were present in the area where an animal lived, or even, when plant matter is found in mastodont intestinal remains, what the animal ate.

Saunders and his colleague Dr. James King have focused on a series of sites in the western Missouri Ozarks that are providing geological and biological data on mastodont habitats over a 60,000-year time span. Four sites contain mastodont remains and associated biota, thus constituting a remarkably long fossil record of ecological changes in one area and accompanying mastodont response. King and

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INSIDE

EVIDENCE OF MASTODONT'S LAST MEAL:

Bacteria still working after 11,000 years

People say that elephants never forget. In the case of what they last ate, this may be true, at least for one mastodont. Although the animal has since passed on, the meal has yet to. And some very dedicated digestive-tract bacteria are still hard at work on one poor pachyderm's last repast.

Researchers recently announced that living intestinal bacteria have been found in the stomach contents of an 11,500-year-old mastodont. Biologists working on the project have hypothesized that the bacteria may be either the original inhabitants of the living animal's digestive tract or their slowly reproducing descendants. "We've resurrected," notes archaeologist Dr. Bradley Lepper, "part of that mastodont, part of that biological system."

The surprising discovery of what may prove to be the world's oldest living organisms was made following the excavation of a nearly complete mastodont skeleton from the Burning Tree Mastodont site near Newark, Ohio, in December, 1989 (see ***Mammoth Trumpet*** 6:2 "The Burning Tree Mastodon: A Nearly Complete Skeleton from Licking County, Ohio"). Headed by Lepper, Curator of the Ohio Historical Society's Newark Earthworks State Memorials, and Paul Hooge, Director of the Licking County Archaeology and Landmarks Society, the

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CLUES TO PALEOINDIAN SURVIVAL:

Underwater caches may have supplied meat in winter

"This is very different from the classic western U.S. Clovis sites that we know and love." Dr. Daniel C. Fisher is describing the Heisler site, a Pleistocene pond bed located in south-central Michigan, which contains the disarticulated remains of a single mastodont.

In his search to understand how humans interacted with late Ice-Age megafauna, Fisher, of the

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Mastodont's Last Meal

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team excavated both the skeleton and the animal's 11,000- to-12,000-year-old intestinal contents.

In addition to the bacteria, the mastodont intestinal contents are providing tantalizing (and unexpected) clues concerning the dietary habits of this long-extinct species. In contrast to previous finds, the vegetal matter suggests that the animal's last meal consisted of wetland-associated, rather than spruce-associated, plants.

The Burning Tree mastodont is also important because of what it may tell us concerning human interaction with these animals. No projectile points or other artifacts were found with the skeleton, and there is no indication of a killing blow or the entry of a projectile. However, the evidence strongly suggests that the animal died elsewhere, was disarticulated, and then brought to the site and cached.

The mastodont skeleton is remarkably complete, missing only its right rear leg, tail, and toes. The animal was apparently disarticulated into chunks and cached in three distinct piles: the cervical vertebrae, still articulated, were discovered upside down in association with the forelimbs; the pelvis, skull, scapula, and left rear leg were found together in another area of the site; and most of the ribs and thoracic vertebrae were recovered from yet a third locality.

So far, three dates have been obtained on the mastodont. Accelerator dating of twigs from the mastodont intestinal contents produced an age of 11,660 ± 120 yr B.P. (BETA 38241/ETH6758); a second sample from the gut contents yielded a radiocarbon date of 11,450 ± 70 (PITT 0832); and a bone collagen sample produced a date of 10,860 ± 70 yr B.P. (PITT 0830). Lepper believes that the bone collagen date is somewhat too recent, and that 11,500 yr B.P. will turn out to be the correct age for the site.

The Burning Tree Mastodont site has produced the only substantiated mastodont gut contents discovered thus far. These materials were found underneath the animal's ribs and thoracic vertebrae. Explains Lepper, "I identified an elongate mass of vegetable material, matted vegetation, that was distinct in color. It was a dark red-brown, as opposed to the dark brown or black peat that it was in, and it smelled really bad. It smelled like partially digested material—fecal material, actually. . . ."

From the outset, Lepper believed the unearthed vegetal matter to be intestinal contents, but had no way to prove it. He describes how the material came to be analyzed: "I was describing the excavation of the specimen [to a group of visiting students and faculty], when Jerry Goldstein, a microbiologist, said, 'Has anybody looked at it for bacteria?' And I said, 'Well, no, it's probably 12,000 years old, so nothing will have survived.'" Goldstein—Dr. Gerald Goldstein, of the Department of Botany and Microbiology at Ohio Wesleyan—asked for samples of the vegetable material. Provided with a frozen specimen, Goldstein found a wealth of living intestinal bacteria. In contrast, control samples taken from the peat adjacent to the mastodont carcass contained no intestinal bacteria. Although bacteria were found in the samples, these were all species typical of freshwater lakes and normal for the context of the site.

The bacteria identified by Goldstein were enteric bacteria, also called coliform bacteria. These bacteria primarily live and thrive in intestinal contents. Lepper points out that one of the species identified, *Enterobacter cloacae,* is so typical of intestinal contents that it is used in England as a diagnostic to demonstrate fecal contamination of water supplies. Although *Enterobacter cloacae* can be found occasionally in other contexts, it lives primarily in intestines.

Lepper explains that intestinal bacteria were a normal part of the mastodont's biological processes. "Mastodonts had bugs in their intestines to help them digest [their food]. The bugs lived in symbiotic relationship with the mastodonts. . . . [The enteric bacteria are] in essence, part of the biological system of the mastodont." It is far from impossible for bacteria to remain dormant for 11,000 years, he notes. The bacteria are living and reproducing. Says

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Mastodonts Are People, Too

As we at the ***Mammoth Trumpet*** know, everybody loves a mammoth. This issue, we turn our attention to a different kind of proboscidean—*Mammut americanum*—the American mastodont.

Though certainly as large as mammoths and a prominent part of late Pleistocene American faunal assemblages, mastodonts have received relatively little public attention—perhaps because of their presumed absence from the Paleoindian record. Increasingly, however, there is a growing body of evidence that points to human exploitation of mastodonts, if in a different way than their better-known proboscidean cousins. This issue of the ***Mammoth Trumpet*** explores this idea and other areas of recent research relating to these pachyderms of the past. *–Editor*

We're MOVING!

Effective September 1, 1991, the Center for the Study of the First Americans is moving from one coast to the other. Our new home will be Oregon State University. Please address all correspondence to Center for the Study of the First Americans, Department of Anthropology, Oregon State University, Corvallis, OR 97331.

UPCOMING CONFERENCES

September 1–7, 1991 International Union of Prehistoric and Protohistoric Sciences, 12th Congress, Bratislava, Czechoslovakia.
Contact: Archeologicky stav Slovenskij Akadmid Vied, Sekretarit XII Kongresu UISSP, 949 21 Nitra-hrad, Czechoslovakia.

September 6–11, 1991 Paleoecology, 2nd International Congress, Nanjing, China.
Contact: Ma Yu-Ying, Nanjing Institute of Geology and Palaeontology, Academia Sinica, Chi-Ming-Ssu, Nanjing 210008, People's Republic of China.

October 6–11, 1991 8th International Congress on Human Genetics, Washington, D.C.
Contact: John J. Mulvihill, M.D., Secretary-General ICHG, 9650 Rockville Pike, Bethesda, MD 20814.

October 21–24, 1991 Geological Society of America Annual Meeting, San Diego, California.
Contact: GSA, 3300 Penrose Place, Boulder, CO 80301; (303)447-2020.

October 27–November 1, 1991 Soil Science Society of America Annual Meeting, Denver, Colorado.
Contact: SSA, 677 S. Segoe Road, Madison, WI 53711; (608)273-8080.

November 13–16, 1991 49th Annual Plains Anthropological Conference, Lawrence, Kansas.
Contact: Museum of Anthropology, University of Kansas, Lawrence, KA 66045; (913)864-4245.

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SUGGESTED READINGS

ON Evidence of Mastodont's Last Meal

Fisher, D. C., B. T. Lepper, and P. E. Hooge 1991 Taphonomic Analysis of the Burning Tree Mastodont. *Current Research in the Pleistocene.* In press.

Lepper, B. T. 1990 The Burning Tree Mastodon: A Nearly Complete Skeleton from Licking County, Ohio. *Mammoth Trumpet* 6(1):7.

Lepper, B. T., T. A. Frolking, D. C. Fisher, G. Goldstein, J. E. Sanger, D. A. Wymer, J. G. Ogden III, and P. E. Hooge 1991 Intestinal Contents of a Late Pleistocene Mastodont from Midcontinental North America. *Quaternary Research* 36:120-125.

Pienkny Zakin, L. 1990 A Mastodon in Search of a Home. *Columbus Monthly Magazine* June:81-89.

ON Mastodont Microevolution Linked to Climatic Change

King, J. E., and J. J. Saunders 1984 Environmental Insularity and the Extinction of the American Mastodont. In *Quaternary Extinctions: A Prehistoric Revolution,* edited by P. S. Martin and R. G. Klein, pp. 315-339. University of Arizona Press, Tucson.

Saunders, J. J. 1977 *Late Pleistocene Vertebrates of the Western Ozark Highland, Missouri.* Illinois State Museum Reports of Investigations No. 33. Springfield.

ON Clues to Paleoindian Survival

Fisher, D. C. 1984 Taphonomic Analysis of Late Pleistocene Mastodon Occurrences: Evidence of Butchery by North American Paleo-Indians. *Paleobiology* 10:338-357.

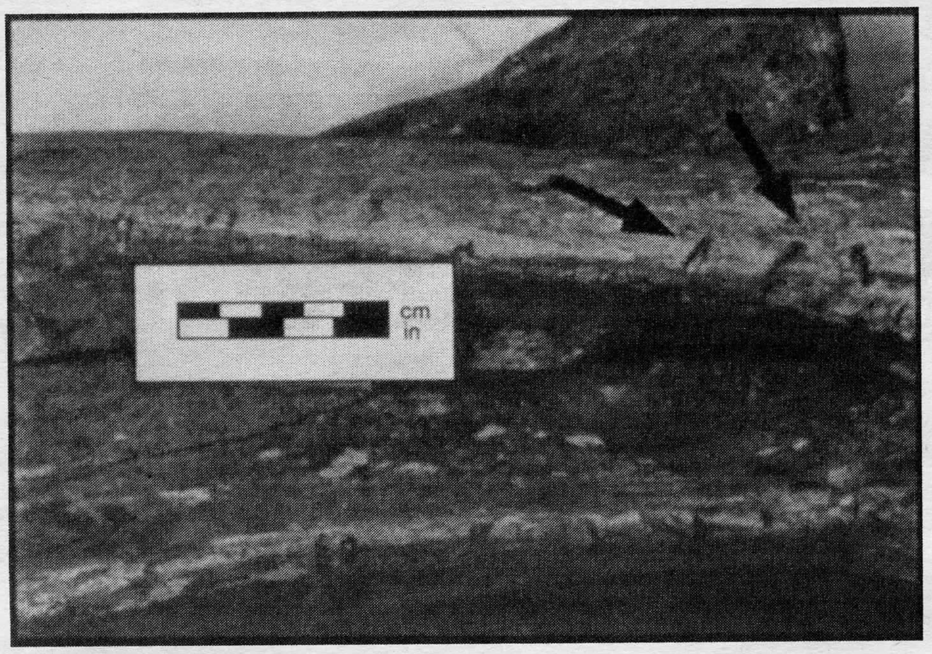
Fisher, D. C. 1987 Mastodont Procurement By Paleoindians of the Great Lakes Region: Hunting or Scavenging? In *The Evolution of Human Hunting,* edited by M. H. Nitecki and D. V. Nitecki, pp. 309-421. Plenum Press, New York.

ON What Do Mammoths, Mastodonts, and Gomphotheres Have in Common?

Kurten, B., and E. Anderson 1980 *Pleistocene Mammals of North America.* Columbia University Press, New York.

ACCIDENTAL DISCOVERY OFFERS EVIDENCE OF MASTODONT BUTCHERING

A day of routine museum paperwork produced an exciting and unexpected discovery for Dan Joyce and Dave Wasion of Kenosha, Wisconsin. Joyce, curator of Exhibits and Collections at the Kenosha Public Museum, and Wasion, an avocational archaeologist, were doing archival research on archaeological sites at the Kenosha County Historical Museum. As Wasion walked by a cabinet full of extinct proboscidean bones, he stopped to examine them and quickly noticed that they bore many cut marks.



The Mud Lake mammoth radius and ulna shown here in their articulated position. Arrows point to cut/hack marks along both ridges of the bones. *(Photo courtesy of D. Joyce.)*

In the ensuing days, Joyce and Wasion examined both museums' collections of paleontological specimens and ultimately discovered three well-documented bone assemblages that showed evidence of extensive butchering. The bones were mammoth and mastodont remains that had been accidentally recovered from three different sites in Kenosha County, at different times during this century.

"At first it was a bit difficult to believe," Joyce recalls, "because [the marks] were so obvious." Often, he notes, people look for butchering marks under a scanning electron microscope, but "these marks were obvious, by comparison, to the naked eye." All the remains were found during construction projects, identified as mammoth or mastodont, and curated at the local museums. "Basically what we have here," explains Joyce, "are specimens that were found during construction or laying of field drainage tiles. These were accidental finds. . . . Nobody ever bothered to look at them [the bones] closely."

In the months since Wasion's and Joyce's discovery, the bones have been studied by Joyce, an archaeologist with extensive experience with Paleoindian sites; Kurt Hallin, a paleontologist at the Milwaukee Public Museum; David Overstreet of the Great Lakes Archaeological Research Center in Milwaukee; and Jeff Saunders of the Illinois State Museum.

The proboscidean remains came from three Wisconsin localities. The first is the Fenske site, about 7 km northwest of Kenosha. At this locality in the early 1920s, railroad construction workers found a mastodont femur and partial humerus, both belonging to an adult animal. The Fenske site was adjacent to a huge marsh, which would have been a large lake during the Pleistocene period.

The femur is in excellent condition. "Judging from eyewitness accounts, it came from bog deposits," Joyce says, adding that the bone's preservation seems to corroborate this. Butchering marks are located on the distal and proximal ends of the femur.

"We assume these bones were part of the same animal. Eyewitness accounts say there were many more bones that were left in place," Joyce notes. He believes the rest of the animal is still in situ.

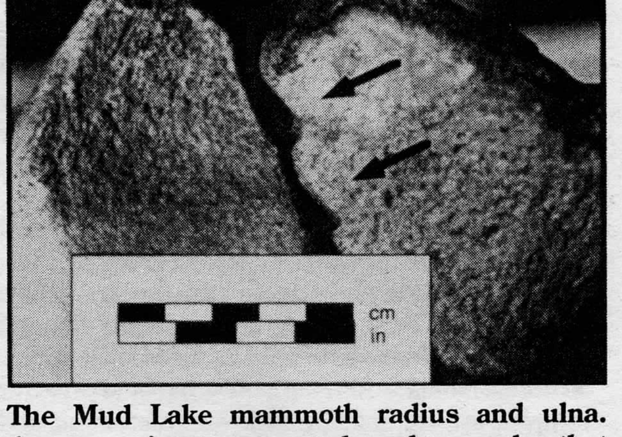
The second site is the Schaefer site, 15 km northwest of Kenosha. Proboscidean bones were found at this location in 1964, when the landowner was laying field drainage tile. Skeletal remains from the site include the distal end of a femur and several tusk fragments. Unfortunately, the surfaces that would identify the bones as either mastodont or mammoth were not preserved, so precise identification is not possible.

The femur shows several kinds of butchering marks, including "a huge cut mark, where the surface of the bone is removed and cancellous material is exposed," Joyce says. "All around the cut you can see extensive bone bruising, which would indicate that it was done while the bone was fresh." In addition, the femur exhibits spiral fractures, as well as marks on the normally polished articular surfaces. Finally, the end of the femur was broken open and scoop marks can be seen on the inside, where people likely removed bone marrow.

The third site, Mud Lake, is located 19 km west of Kenosha. There, mammoth bones were discovered during a road construction project in the 1930s. Eyewitness accounts say that the bones were found buried below 1.25 m of peat. Preservation was excellent. Joyce notes that, according to records from an 1836 government land survey of Kenosha County, the Mud Lake site was located on the eastern edge of a lake at that date. The area is now a marsh. Such damp, boggy sites are ideal for bone preservation, unlike the drier sites of the western United States.

So far, environmental data from these particular sites are sketchy, although Pleistocene/Holocene paleoenvironmental data are available from two nearby sites. The evidence from Mud Lake suggests that the mammoth inhabited a wet locality. This is in contrast to the commonly held theory that mammoths lived in upland, grassy areas where they browsed for food. "We don't know what the environment at the edge of this proposed lake was like," Joyce notes. "Did they go to the lake just for water and then go back to the uplands, or were there grasses at the edge of the lake?"

The Mud Lake bones are the only confirmed mammoth remains from the three sites. Bone elements include a butchered radius, an ulna, and manus (foot) bones. Joyce is confident that these remains come from the same animal, becaŝe the bones articulate and butchering marks travel from one element to another. "Mud Lake is the most convincing evidence of butchery that we have," Joyce says. Over 100 cut marks of various types have been found on the mammoth remains.



The Mud Lake mammoth radius and ulna. Arrows point to repeated wedge marks that occurred when Paleoindians separated the two bones. *(Photo courtesy of D. Joyce.)*

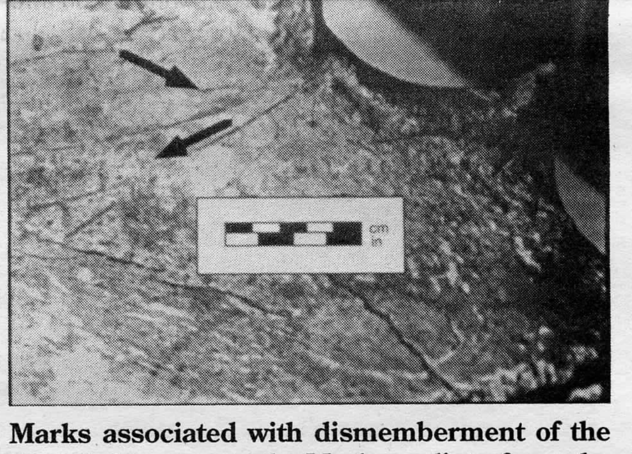
The Mud Lake bones exhibit hack marks: short, deep, V-shaped marks cut into the bone surface, perpendicular to the axis of the bone. Impact marks can be seen as well; slight depressions on the bone surfaces that show evidence of bone bruising. Slightly circular or oval in shape, these impact marks were likely made by the tip of a wedge during a prying episode.

The Mud Lake mammoth is the first butchered mammoth found east of the Mississippi.

The wedging marks are particularly distinct, Joyce says. "You can see marks where they wedged the lower from the upper leg to disarticulate it. You can also see where they were wedging the radius from the ulna. The marks are so distinct that tool diameters can be measured from them."

As with the bones from the Fenske and Schaeffer sites, the ends of the Mud Lake bones had been broken and bone marrow removed. The same scooping marks are also present: distinct, parallel U-shaped grooves.

The Fenske and Schaeffer bones have fewer marks than the Mud Lake bones, but they do show similarities. Bones from all three sites have scoop marks, cut and hack marks, and some evidence of microgrooves caused by flake tool use.



Marks associated with dismemberment of the Mud Lake mammoth. Marks radiate from the lateral border across the ulnar-humeral articular surface of the ulna. *(Photo courtesy of D. Joyce.)*

Curious to see if such types of butchery have been found at western mammoth sites and to confirm the evidence of butchery in the samples, Joyce took the bones to Saunders, who has extensive experience working with large mammal bones from such sites. Saunders compared the Mud Lake bones with similar bones found at the Blackwater Draw site in New Mexico, the Naco and Lehner sites in Arizona, and the Domebo site in Oklahoma. "The hack and cut marks," says Joyce, "are amazingly consistent in form, location, and orientation. The Wisconsin specimens are better preserved, so even minute marks can be seen."

Joyce also took bone samples to Russ Graham and Jim Oliver of the Illinois State Museum. Oliver's specialty is distinguishing marks on bones made by human activity from marks made by rodents and other natural processes. Oliver confirmed that the marks on the Wisconsin bones are butchering marks. The Mud Lake mammoth is the first butchered mammoth found east of the Mississippi, Joyce notes.

The Kenosha County finds are also remarkable because they locate mammoth and mastodont within

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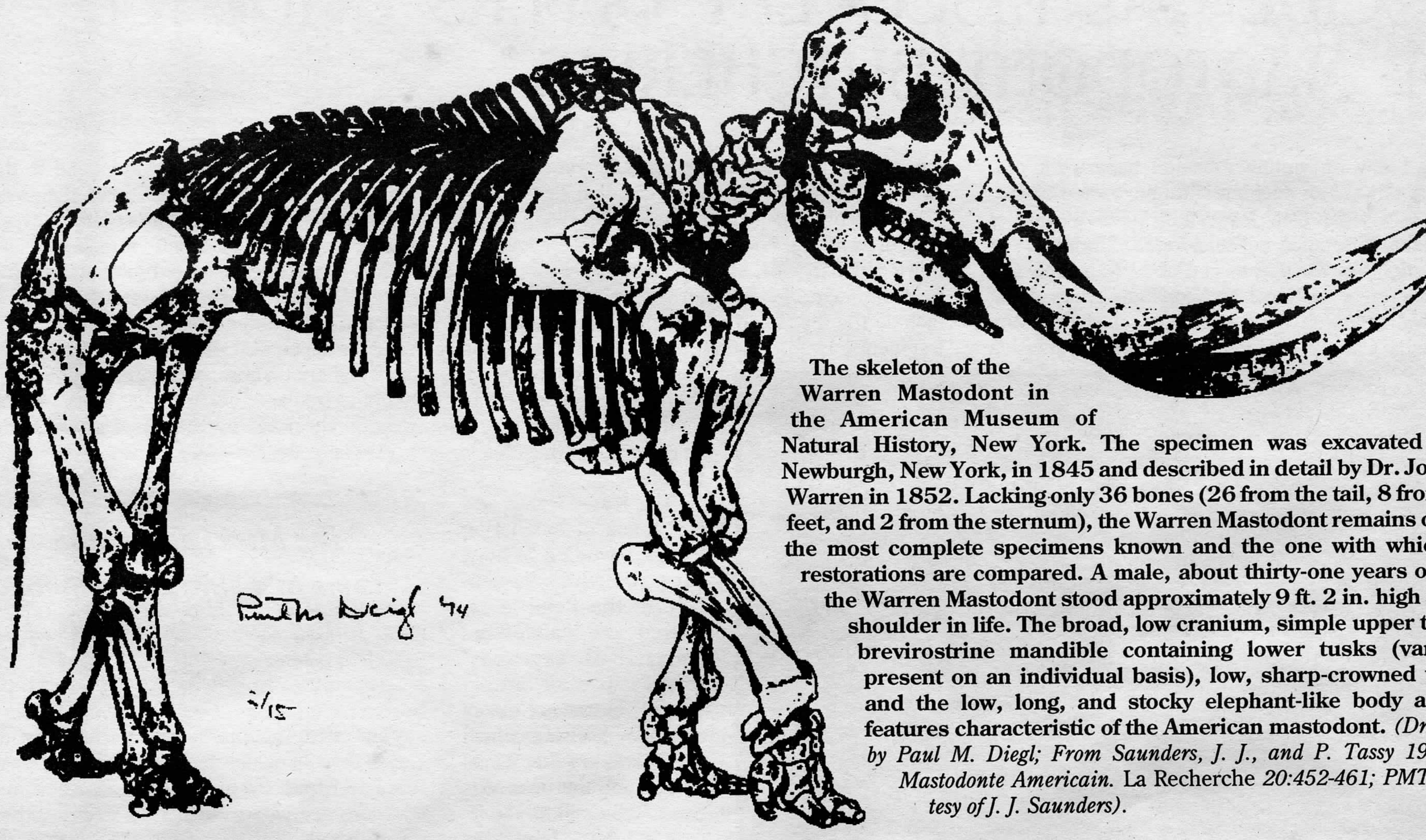

The skeleton of the Warren Mastodont in the American Museum of Natural History, New York. The specimen was excavated near Newburgh, New York, in 1845 and described in detail by Dr. John C. Warren in 1852. Lacking only 36 bones (26 from the tail, 8 from the feet, and 2 from the sternum), the Warren Mastodont remains one of the most complete specimens known and the one with which all restorations are compared. A male, about thirty-one years of age, the Warren Mastodont stood approximately 9 ft. 2 in. high at the shoulder in life. The broad, low cranium, simple upper tusks, brevirostrine mandible containing lower tusks (variably present on an individual basis), low, sharp-crowned teeth, and the low, long, and stocky elephant-like body are all features characteristic of the American mastodont. *(Drawing by Paul M. Diegl; From Saunders, J. J., and P. Tassy 1989 Le Mastodonte Americain.* La Recherche *20:452-461; PMT courtesy of J. J. Saunders).*

Mastodont Microevolution

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Saunders have found evidence of a "microevolution" in the mastodont populations that lived in this area that seems linked to climatic change.

At the Missouri sites, King and Saunders tracked pollen percentages through sedimentary sequences dating from the mid-Wisconsinan interstadial through the full-glacial and late full-glacial periods. Pollen counts have long been used as evidence of climate change. Correlating evidence from faunal remains with the pollen record in such areas makes it possible to associate climate change with its effect on animals.

The earliest of the Missouri sites is Jones Spring, where the second of three fossil horizons has been dated to the early mid-Wisconsinan interstadial interval. At Jones Spring, King and Saunders observed vegetation shifts from deciduous to pine pollen by 40,000 years ago, indicating a change from a warmer, dryer climate to a moister, cooler environment.

The late phase of the mid-Wisconsinan interval is represented by the third and final horizon in Jones Spring and by the second of two accumulations in the nearby Trolinger Spring site. Early Trolinger Spring fossils indicate the area was inhabited by savanna-dwelling fauna: bear, mammoth, horse, deer, and bison. Later at Trolinger Spring, faunal remains demonstrate the presence of browsing animals, such as mastodont, stilt-legged deer, and woodland musk ox, with associated pollen of an open pine-parkland.

The first appearance of spruce in abundance occurs at Boney Spring, in a full-glacial horizon dated at about 23,000 years ago. Just a few vertical centimeters "later" in the sediment, the percentage of spruce pollen here and at Trolinger Spring jumps to 60–90 percent. This dramatic shift correlates with the increasingly colder climate of the full-glacial period.

In later levels at Boney Spring, pollen found in mastodont tusk pulp cavities shows the percentage of spruce decreasing to 26–36 percent, with an increasing proportion of deciduous tree pollen. This period appears to have occurred approximately 13,500 years ago "during a stressful period of drought," based on taphonomic analysis. At this time, in the view of King and Saunders, the full-glacial vegetation was collapsing, with spruce eventually disappearing from Missouri as it "retreated" north and east.

With these markers of climatic change at the Missouri mastodont sites as a control, Saunders was able to examine mastodont remains, specifically teeth, for evidence of adaptations that might be associated with vegetation shifts. He found that mastodont cheek teeth occur as the two tooth types first postulated by Joseph Leidy in 1869: smooth and rugged; and hypothesized that mastodonts developed these different types as an adaptation to diet.

According to Saunders, mastodont cheek teeth

When the last of these 'islands' left the landscape, presumably mastodont extinction resulted.

from the mid-Wisconsinan spring sites are on average rugged—the enamel is corrugated and the "valleys" in the chewing surface of the tooth are obstructed by crests. Much later, at Boney Spring when spruce became dominant, mastodont teeth are smooth, with smooth enamel and unobstructed valleys.

Saunders suggests that rugged mastodont teeth occurred as an "enamel-enhancing response to what they were eating in those interstadial, pine-dominated environments. Similarly, the mastodont teeth from later Pleistocene sites . . . such as at Boney Spring, were presumably smooth—which is to say enamel-deficient—because they were most efficiently capable of being utilized in a spruce-dominated environment."

Mid-Wisconsinan mastodont teeth also show more wear compared with late full-glacial mastodonts at Boney Spring. This suggested to King and Saunders that pine-parkland was a less favorable environment for mastodonts; although clearly the species was able to survive in this type of environment, evolution may have selected for rugged teeth less susceptible to wear.

The size of the cheek teeth also appears to have changed over time, raising the possibility that animal size may have decreased as a response to less favorable habitats. Although the number of Missouri samples is very small, cheek teeth from the mid-Wisconsinan, pine-parkland associated sites were smaller than those from Boney Spring. Though Saunders cautions that small teeth do not necessarily indicate a small animal, he interprets the larger teeth and demonstrably big animals at Boney Spring as suggesting that, at least in midcontinent, "there was something dynamic going on with both the dentition and size in response to environment." Moreover, two very late mastodont finds at Kimmswick, Missouri, that are associated with Clovis points also have very small teeth.

One possible interpretation might be that mastodonts were a constant size during the mid-Wisconsinan interstadial, perhaps then increasing in size during the full-glacial and decreasing rapidly in size during the late-glacial. If more data were found in evidence of this, it would support the theory that mastodonts were most suited to the spruce-dominated habitat of the full-glacial period, responding with increased size and smooth cheek teeth. Linking their data to an extinction hypothesis, King and Saunders suggested that as this habitat disappeared, mastodonts became smaller and then (when it did not reappear) extinct.

Further clues as to how mastodonts were faring in Missouri 13,500 years ago are provided by examining individuals for signs of their physical condition at death. Again comparing mastodont remains from different time periods, King and Saunders looked at percentages of suckling individuals, immature individuals, and adults (both prime and aged) entering the fossil record. Relative ages were determined by the eruption of cheek teeth and the degree of their wear, a method first developed by Richard Laws for African elephants. Their data suggest that greater numbers of prime adults were entering the fossil record during the late Pleistocene as the coniferous habitat collapsed, and that mastodonts were attempting to adjust by producing fewer stress-susceptible young. King and Saunders suggest that the rate at which the climate was changing further reduced the mastodont's chances of adapting.

The Laurentide ice sheet retreated north rapidly, followed by spruce woodland, between 12,000 and 10,000 yr B.P. Mastodont distribution appears to have followed this retreat, becoming centered in the Northeast. As the climate continued to warm, the glaciers north of the Great Lakes melted into lakes and the spruce forests below them were replaced by pine and deciduous species. Spruce occupied a wet and, from point of view of megamammals, inhospitable landscape. By the time the lakes drained, spruce had returned but the mastodont had become extinct.

King and Saunders have constructed a model that

What Do Mastodonts, Mammoths, and Gomphotheres Have In Common?

Mastodonts seem to have problems maintaining a separate identity from their distant proboscidean relatives. Frequently confused with mammoths (which get far more press), they are also often lumped together with the South American gomphotheres, which are actually more closely related to mammoths.

Although mastodonts are often referred to in archaeological literature as occurring at both North and South American sites, "South American mastodons [gomphotheres]," emphasizes Dr. Jeffrey Saunders, "are quite different animals than the North American mastodonts." Not only do the two occur in separate genera, they are members of different families as well. The North American species is *Mammut americanum*, the American mastodont, of Family Mammutidae. South American mastodons are members of Family Gomphotheriidae, the same family from which mammoths and today's living elephants evolved.

"There have been 35 million years of evolution since they [mastodonts and gomphotheres] had a common ancestor," Saunders points out. *Mammut americanum* did at times and places in the past coexist with gomphotheres, but never in South America; both lived in North America, arriving here from Eurasia about 15 million years ago.

The early North American distribution of *Mammut americanum* appears to have centered in the Pacific Northwest during the Blancan Land Mammal Age, with some occurrence in Florida. By the Irvington Land Mammal Age (1.9 million years ago), mastodonts had spread to Nebraska and to the east coast. During the Rancholabrean Land Mammal Age (300,000–10,000 years ago), mastodonts ranged from Alaska to Florida, becoming increasingly numerous in the eastern forests around the Great Lakes and along the Atlantic Coast as time went on.

Gomphotheres reached North America at about the same time as mastodonts. Whereas mastodonts, however, were browsers, gomphotheres, with more complicated teeth, were grazers. "Then, at about 1.9 million years ago," explains Saunders, "true mammoths [Genus *Mammuthus]* were introduced to the American West, South, and Central Plains. With the appearance of mammoths [which, like the gomphotheres, were grazing animals], we see the disappearance of gomphotheres in North America."

"If mammoths, through competition, excluded the gomphothere from North America, then that set the stage for the gomphothere to continue on and succeed in South America. The gomphothere record is well established in South America, with at least three forms developing. . . . But neither mammoths nor mastodonts penetrated to South America."

Mastodonts do not seem to have competed with either gomphotheres or mammoths. "*Mammut americanum* had a very fine-tuned browsing adaptation. Although some recent work does show it eating more grass than was previously supposed, I still think of *Mammut americanum* . . . as a woodland inhabitant and a very highly evolved browser."

Mastodonts, says Saunders, are "going to occupy habitats that are not going to be very inviting for grazers, certainly not for mammoths." Similarly, "gomphotheres, by their first appearance in North America, also had a pretty well-designed grazing adaptation." Saunders explains that differences between grazing and browsing adaptations led to "quite different animals—behaviorally, anatomically, and ecologically. If you're interested in exploring behaviors of mastodonts, you must consider the other very basic distinctions. This [the North American mastodont] would have presented Paleoindians with different opportunities and challenges than the [South American] grazing form." *–Susan Simpson*

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accommodates both data on the changing climate and on the disappearance of the mastodont. "If you show this [late Pleistocene dynamic] graphically on a map," says Saunders, "with dated mastodont findspots and the distribution of late Pleistocene flora, you find that mastodonts disappeared rapidly when the Great Lakes become occupied primarily by warm temperate flora." They envision, he says, "islands of habitat in an environment that was rapidly going modern, with the mastodonts seeking and occupying these island-like refugia. When the last of these 'islands' left the landscape, then presumably mastodont extinction resulted." Saunders notes that at the very late mastodont site of Kimmswick, Missouri, the associated fauna contain modern elements and have been interpreted to indicate a temperate deciduous environment. "This," he says, "is exactly the environment in which the last mastodont died out, based on our model."

The extinction of mastodonts is complicated by a much larger mystery: evidence points to the demise of mammoth, horse, camelids, giant beaver, and numerous other North American mammals and birds at roughly the same time. Some scientists have suggested that rather than changing environmental conditions, or perhaps in addition to them, people may have been responsible for the mass extinctions. Hunting might explain why so many species became extinct in the Americas and Australia, with relatively fewer losses in Asia and Africa. It has even been suggested that vegetation change could have been the result of the loss of megaherbivores rather than the cause of it. Research to better understand how extinct animals reacted to changing habitats may be crucial to resolving this debate.

Certainly humans were present during this time of great change. Humans are known to have lived in North America by 11,000 years ago, and their Clovis points have been found in association with mammoths, mastodonts, and other extinct fauna. King and Saunders' model does not disallow the possibility of a triggering device such as human culture, and Saunders notes that there is increasing evidence of this.

Despite a perplexing lack of lithic artifacts associated with mastodonts, some studies are suggesting a range of intriguing indirect evidence of human involvement. Sites in Michigan, Wisconsin, and Ohio are offering promising signs that people hunted, or at least scavenged, mastodonts far more frequently than previously believed and cached their remains in interesting ways (see related stories, this issue).

Saunders stresses that these questions are open issues and should not be ignored for want of associated evidence. "As researchers we have a greater challenge in making such evidence acceptable . . . but I'm encouraged by the suggestion of what sorts of things now constitute evidence."

Do archaeological finds tell us anything about mastodont behavior? Two subjects currently under debate are their diet and whether they were solitary or herd animals.

It has been generally thought that mastodonts preferred a habitat of open spruce woodlands and forest, browsing on twigs, needles, and cones. However, scientists have been able to analyze undigested plant material found in mastodont rib cages to determine that mastodonts also ate coarse grasses, swamp plants, and moss. This would explain their ability to live in lowlands and swamps, where they have been found in the Great Plains, Florida, and Texas.

Other research seems to support the claim that at least some mastodonts ate more grass than has been generally thought. Although Saunders regards this as entirely plausible, he cautions that grass eating may have been primarily the result of the environment in which an individual lived. "In an understory that is associated with a late Pleistocene bog, you would expect that there would be a lot of sedges, and undoubtedly the mastodont would be exploring and selecting some of those materials in his diet as well. They would then be metabolized and incorporated into the animal's framework. So through analytic procedures, mastodonts would be recorded as grass eaters."

> *It's likely mastodonts could not accumulate in great numbers in a closed environment—there would be too much havoc.*

It is clear to Saunders from looking at the structure of the cheek teeth, however, that mastodonts "were not grazers by any means. They possessed low-crowned, heavily rooted cheek teeth equipped for a diet of browse, for chewing woody plants and stems, and perhaps leaves." Without disputing that mastodonts may have incorporated grass into their diet, perhaps as a result of exploratory feeding, Saunders maintains that "nature had not equipped them to be more than occasional grass eaters. Their teeth would have been annihilated by a steady grass diet, and furthermore, the design of their teeth prohibits it."

Were mastodonts herd animals similar to modern elephants? Saunders examines this issue by questioning whether herding would have satisfied any possible need. "I don't view mastodonts as being gregarious in the sense that elephants are today," he comments. "Gregarious behavior is a defense mechanism for animals that are exposed in open areas, such as on grasslands. We infer the mastodont habitat to have been either parkland or woodland, and it is not usual for animals who occur in a closed environment to come together in great numbers. In a closed area the mastodont would not have the need to defend itself through large numbers. Furthermore, although mastodonts were no taller than elephants today, they were very much heavier. This gives me the impression . . . that it's likely mastodonts could not accumulate in great numbers in a closed environment—there would be too much havoc." Saunders suggests instead that mastodonts might have been organized socially in small units of a mother and a calf, with the unit becoming larger only when males joined for breeding purposes.

Unfortunately, our knowledge of mastodonts may be biased by the locations in which their bones have been preserved. For example, the records of most mastodonts come from wet, boggy, lowland areas. This may be, Saunders cautions, "simply because animals who occupy upland areas do not find their way into the fossil record as readily as animals in lower areas. As water seeks lower areas, it disperses and destroys the remains of animals that died in the uplands."

This raises the question of whether mastodonts actually inhabited bogs. "Did they seek out these swampy areas," asks Saunders, "because they were adapted to them—or do we find them there because that's where we find lots of fossils? All proboscideans need a lot of water to render their fodder."

"We have some intriguing ways now of pursuing our questions," Saunders concludes. "The important thing is to keep the mud from settling—to keep things stirred up." The debates generated by these new types of evidence promise to do just that.

–Susan Simpson

Clues to Paleoindian Survival

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University of Michigan's Museum of Paleontology and Department of Geological Sciences, has found intriguing new information at the Heisler and other sites concerning Paleoindian food-caching behavior. Through the coordinated investigation of several lines of evidence, e.g., sedimentary context, plant remains, and the association, distribution, and modification patterns of mastodont skeletal remains, Fisher has come to propose a radical new hypothesis. He suggests Paleoindian peoples stored meat from proboscideans by anchoring it under water in ponds—a caching concept that may have been critical to human survival during cold Northern winters.

Excavations at the Heisler site, which have been ongoing since 1986, revealed the remains of a single mastodont buried in Pleistocene pond sediments. In total the bones occurred in at least five clusters on the former pond bottom.

One unusual feature of the site is that some of these bones were closely associated with oval-shaped concentrations of sand and gravel that were about the size of a football and were surrounded by a layer of finely ground plant material. Both the coarse clastic concentrations, which contained some fist-sized cobbles, and the encircling fine-grained vegetable material contrasted sharply with the adjacent pond sediments.

Palynological study (with R. O. Kapp and G. G. Snyder) of the vegetable remains to search for microscopic fossil pollen has produced fascinating results. The pollen content of this plant material is low in comparison with that of the surrounding sediment, but even more interesting, much of the pollen that is present came from plants that produce pollen in late summer or early autumn, with low representation of pollen produced at other times of the year. "The pollen profiles from the surrounding sediment are what normally accumulates year-round, year-in and year-out," explains Fisher. "In contrast, what we seem to be seeing in the plant material surrounding the sand and gravel concentrations is a sort of snap-shot predominantly reflecting a single season's pollen production." A seasonality study conducted on the mastodont's tusks has confirmed early fall as the season in which this individual died. From these lines of evidence, Fisher infers that the likely origin of the plant material surrounding the podlike features was the intestinal tract of the Heisler mastodont. This interpretation has subsequently been confirmed by comparisons with intestinal contents from the Burning Tree mastodont from Licking County, Ohio (see related story, this issue).

Vertically oriented wooden post, intrusive into marly clay pond sediments, in association with bones of the Heisler mastodont. The only preserved part of the post is what penetrated pond bottom sediments at the time carcass parts were introduced into the pond. The post may have originally extended up through the water and into the air, as a meat cache marker. *(Photo courtesy of D. C. Fisher.)*

The cobbles and coarse clastic material that were apparently contained in the mastodont's intestines are less easily accounted for. Fisher explains that while modern elephants occasionally ingest sediment, they do not consume it in large amounts nor

Mastodont's Last Meal

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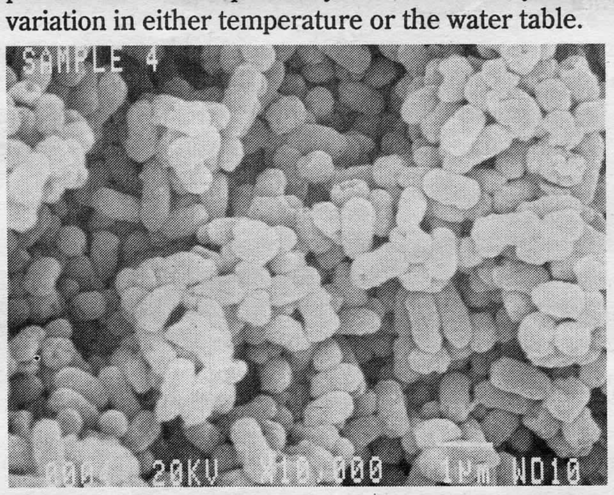
Lepper, "Jerry Goldstein likens their discovery to 'parking your Volkswagen, shutting it off, coming back 11,000 years later, jumping in, putting the key in, and starting it up again.'"

Goldstein believes that, without a fluctuating temperature or water table, bacteria can be preserved virtually indefinitely. Since the Burning Tree mastodont was deeply buried in a wetland, Lepper explains that there probably has been very little variation in either temperature or the water table.



Enterobacter cloacae. *(Photo courtesy of B.T. Lepper.)*

There is some possibility that the bacteria are not the original intestinal organisms, but are instead descended from the initial colony. Even so, it is likely that the bacteria would have reproduced so slowly, and in such isolation from other enteric bacterial forms, that they are probably very close to the original bacteria.

Whether the bacteria are actually 11,000 years old or are the descendants of the original colony, "either way we should expect to see some marked difference in the DNA of those bugs compared to recent representatives of the same species. We are doing some sequencing of the DNA and RNA now and hope to have some results soon." Study of the bacteria may provide ground-breaking information about genetic evolution.

Although some have speculated that the bacteria may have been introduced from the ground above, because the organisms were not found in the peat immediately adjacent to or above the skeleton, it seems unlikely they filtered in. "The fact that we do not find any of this coliform bacteria in the associated peat," observes Lepper, "is an excellent argument for this being the bacteria that were originally a part of the intestinal remains." Lepper and Hooge's team is currently studying additional peat samples from the surrounding bog to confirm that the bacteria are restricted to the vegetal mass.

The discovery of living bacteria in mastodont intestinal remains has no precedent. "No one's dreamed of looking for enteric bacteria in intestinal remains before," Lepper says. "No one's pursued analogies in the modern animal world." Lepper hopes that other archaeologists will examine probable mastodont intestinal remains from other sites for bacteria. "The site could be a unique situation, but since nobody's looked anywhere else, maybe it's not."

He adds, "I think the business of looking for enteric bacteria samples as a means of corroborating gut contents will be a valuable tool. . . . We can get more reliable and more definitive identifications of intestinal remains to work with."

The intestinal remains have produced a second set of surprising data: the types of vegetation found in the intestines are quite unexpected. Probable mastodont stomach contents found at other sites have always been reported to contain chunks of spruce.

The mastodont at Burning Tree seems to have eaten a lot of things for its last meal—but no spruce. Instead, scientists have found wetland-associated plant remains such as swamp grass, as well as leaves, moss, and non-coniferous twigs. Seeds contained in the stomach contents came from a wide variety of plants: clover, sedges, naiads, pond weed, water lily, and pigweed. Pollen samples taken by J. Gordon Ogden of Dalhousie University, Nova Scotia, from cracks and crevices in the mastodont's teeth correlate with the gut contents.

Most of the botanical remains were identified by Dr. Dee Anne Wymer, a paleoethnobotanist at Bloomsburg University. Other analyses were conducted by Howard Crumm and Anthony Resnicheck of the University of Michigan, David Johnson of Ohio Wesleyan, and Jan Janssens of the University of Minnesota.

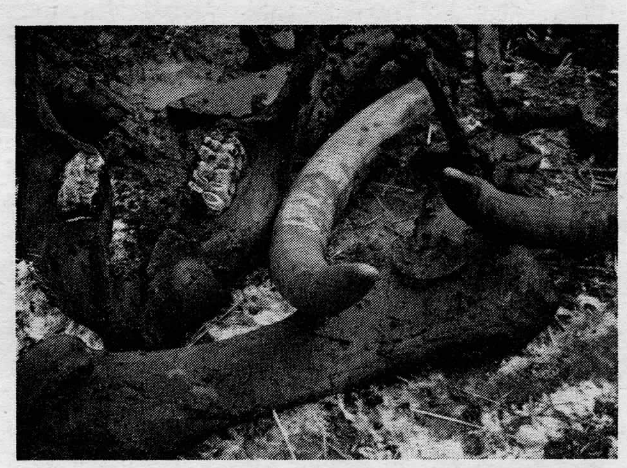
"In this site," Lepper says, "where the intestinal source of the remains is corroborated independently, the mastodont seems to have been avoiding spruce that was abundant in the environment and eating a lot of low, herbacious vegetation. . . . The mastodont may have been eating very much like a moose, wading in the water and nipping off buds and florets of tender plants, foraging on clover and mosses."

The third and final area of research at Burning Tree is that of the disarticulation pattern of the carcass and marks on the bones. Dr. Daniel Fisher of the Museum of Paleontology at the University of Michigan has examined the bones and reports the presence of cut, butchering, and drag marks.

The drag marks are fine parallel striations across partial areas of elements that were probably exposed during butchering. The scratches may have been made when the bones were dragged across a gravely or sandy substrate. There are also some sand grains embedded in bone cavities. Since there is no sand in the bog deposit, it is clear that the sand came from somewhere else and entered the animal's bones after its death. Says Lepper, "We have evidence of parallel, symmetrical butchering marks on sets of bones on both sides of the body, and piles of bones involving an entire carcass."

The Burning Tree Mastodont site provides yet another piece of evidence that suggests Pleistocene peoples interacted with these animals. Because Paleoindians hunted mammoth on the Plains, researchers have suggested that people probably also hunted elephant-like animals in the East. "But there was no evidence to prove this hypothesis. Now we're finding that Paleoindians in the East were generalists, eating whatever they could find on the landscape. Mastodonts were one part of that."

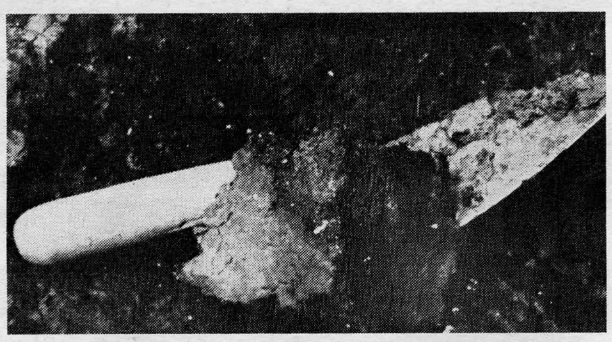
Because the Burning Tree Mastodont site was a salvage operation, archaeologists cannot go back to it in the future. Knowing that the site would be unavailable for further excavation, Lepper and Hooge's team collected a large number of botanical and soil samples for future analyses. Lepper and Hooge are very interested in hearing researchers' proposals for further study of these materials and encourage anyone interested to get in contact with them. A research committee will decide what studies will be done on this material, some of which will be preserved in perpetuity. *–Nancy Allison*



Discovered and excavated in December, 1989, near Newark, Ohio, the Burning Tree mastodont is one of the most complete and best preserved mastodont specimens in the world. It is the only mastodont from which corroborated intestinal contents have been recovered.

do they eat cobbles. An investigation of the lower stratigraphic levels of the pond deposit indicated that, although clastic sediments occur, they are significantly different from the features associated with the mastodont bones. This finding rules out the possibility of "squeeze out" phenomena, in which lower sedimentary deposits rise through upper-level sediments, creating isolated pockets of clastic material.

"We just don't have . . . any explanation for these masses," says Fisher, "except that they represent some artificial introduction into a piece of mastodont intestine. That raises the question of why humans . . . would have loaded a piece of mastodont intestine with sand and gravel."



Corner section removed from near the base of a "clastic anchor" associated with bones of the Heisler mastodont. The uppermost corner of this material consists of the sand and gravel filling of the anchor. This is surrounded by a ca. 1-cm-thick zone of plant material (preserved intestinal contents), beyond which is the sharp contact with the marly clay pond sediment. *(Photo courtesy of D. C. Fisher.)*

Fisher's explanation for this anomoly is that these masses represent, "quick, makeshift anchors . . . found in immediate association with clusters of bones out in the pond." The purpose of these anchors, Fisher suggests, was to weigh down sections of the mastodont carcass for winter food storage in the pond.

During late Ice Age times, the shallow pond had a maximum depth of slightly greater than 3 m and was about 75 m across. Bones found at the site were originally submerged some distance from the pond margin in 1 to 2 m of water.

In addition to the "intestine anchors," the excavation also uncovered two vertical posts in the pond sediment, each several inches in diameter and sunk three to five feet into pond sediment. Fisher believes these posts are part of a marker system used to facilitate recovery of the meat during winter when the pond was frozen. This natural refrigeration system of cold-meat storage would have delayed bacterial decomposition and served as deterrent to marauding carnivores.

The pond deposits contain between 40 and 50 percent of the mastodont carcass spread throughout at least five cache-like concentrations. Three of the bone clusters appeared to be relatively undisturbed and are interpreted by Fisher as unrecovered meat caches.

At least two other areas of the pond are characterized by a diffuse scattering of bones and pieces of partially burned wood. Fisher suggests that the correlation between the mastodont bones and burned wood may mean that prehistoric peoples were building winter fires on the pond's frozen surface in association with retrieval of their meat caches. After recovery and consumption, bone remains may have been discarded on the ice, sinking to the pond bottom during the spring thaw.

The intestinal contents and wood associated with the bones suggest an age of around 11,200 yr B.P. A single bone date of 10,800 yr B.P. has been obtained, which, Fisher says, "may be a little young."

Although the radiocarbon ages of the Heisler mastodont overlap in time with that of Clovis sites, at present no diagnostic artifacts have been found that indicate a Clovis association. An Early Archaic-style habitation site located on a knoll has been found immediately north of the pond sediments, but no evidence has yet turned up that would place this site in temporal association with the mastodont remains.

Though direct evidence of lithic artifacts associated with the bones is sparse, a single rough chopper found with one of the diffuse bone clusters lends credence to Fisher's argument. This, in conjunction with cut and gouge marks on some of the bones and the seemingly non-random pattern of bone distribution, supports Fisher's theory that the Heisler site was a mastodont meat cache.

"The reason we're not finding more lithic material," Fisher says thoughtfully, "is probably because lithic material that was discarded or lost during carcass processing would occur at the butcher site. Little or none of it would be expected at a site where you bring carcass parts for caching. Even the recovery of the caches would be, to a large extent, feasible without much lithic evidence."

How viable is the meat-caching hypothesis? Fisher has attempted to test his theory by experiment, recreating scaled-down meat caches in ponds similar in size and setting to the one that occurred at Heisler. Although mastodont-sized animals have not been readily available, Fisher has used smaller masses of meat from deer and lamb. These field experiments indicate cold-water refrigeration is a thoroughly feasible and practical way to store meat with a modest investment of time and energy.

The evidence unearthed at Heisler and other sites in the eastern United States represents a "different behavior pattern from what we're used to seeing—something that is feasible within a different climatic setting than what we're used to dealing with. . . . Some of the most interesting tests of this idea will involve excavations at new sites, but there are also important contributions to be made by studies of previously excavated sites." Fisher's discoveries and experiments may have a profound impact on how we eventually interpret hundreds of proboscidean sites located in the eastern United States.

–Kimberly Sawtelle

Evidence of Mastodont Butchering

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10 km of each other. Joyce explains that current theory says these two animals exploited two different, zoned environments. However, the evidence from these three sites suggests that "possibly it was not a zonal but a mosaic environment, where you get patches of different environments relatively close to each other. This is assuming contemporaneity of the specimens. Other non-cultural mammoth/mastodont sites in Wisconsin have very close dates."

In addition, the Kenosha finds call another theory into question. Because there has been a lack of definitive butchered mastodont remains east of the Mississippi, some archaeologists have hypothesized that Paleoindian peoples did not exploit mastodonts, but caribou instead. "This material initially tempers

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MASTODONT HAIR GIVES CLUES TO HABITAT

Two unusual samples of preserved mastodont hair and possible soft tissue remains were discovered at the Milwaukee Mastodont site. These data, recovered by a research team from the Milwaukee Public Museum, could shed new light on the paleoecology of *Mammut americanum* and how this animal related to its natural habitat.

"Hair is a very good indicator, in many species of mammals, of adaptation to environment," explains Kurt Hallin of the Milwaukee Public Museum, who found the two postage stamp-sized specimens. "If you look at the type of underfur and [compare] its similarity to that of mammals adapted to aquatic environments it suggests . . . a new dimension to the paleoecology of mastodonts."

The samples were discovered after workers from the Wisconsin Electric Power Company came across two large molars while conducting underground utility-line maintenance. The molars were later brought to the museum for identification, where researchers determined the teeth were those of a mastodont. A paleontological excavation was subsequently initiated that led to the recovery of the fragmentary remains of a mastodont cranium. No post-cranial remains were located, likely owing to extensive construction that had previously taken place on the site.

Though extensive research has not been conducted to establish the site's environment at the time the mastodont was deposited, indicators suggest a Pleistocene lake was present. The current matrix that contained the fossil remains is a peat bog.

Although in "quite damaged" condition, several cranial fragments were identified, including parts of the zygomatic and both occipital condyles. A large quantity of bones containing sinuses was also identified, one of which was in direct contact with the hair and soft tissue specimens. These samples, Hallin explains, were positioned on the bone's underside, directly above a small cavity in the peat deposit.

The positioning of the find is important in two respects, says Hallin. "First of all since the specimens weren't in direct contact with matrix, we were able to recognize hair. Had it been in contact with mud or other peat matrix, that material [the hair] probably would not have been recognized."

"Secondly," he observes, "it's uncertain at this time, but it's possible that being in an open cavity . . . may also have had some role in the preservation of soft tissue."

Examination of the external surface of the hair sample by a scanning electron microscope provided positive identification of diagnostic cuticle (the outside layer of a single hair strand). Two variations of hair were discovered: the first being a coarse overhair (guard hairs); the second being "bundles" of finer-textured underfur.

Since discovery of the samples, Hallin's team has been evaluating the environmental implications of the find. Hallin explains that the mastodont hair has been compared with a number of fur-bearing mammal pelts. Results show greatest similarity to the underfur of mammals adapted to aquatic environments, including such species as beaver, otter, and muskrat. Hallin has also compared the hair samples to hair of modern proboscideans and a Woolly Mammoth and found significant differences in composition and texture from that of other proboscideans. "Elephants today," explains Hallin, "have a very coarse type of hair. This [the mastodont hair] is very fine . . . even finer than the mammoth guard hair." Another interesting difference, says Hallin, is the continuous or hollow medula of the mastodont hair, a feature shared by caribou and polar bear.

According to Hallin, the hair sample is anchored to a material which "appears to be of tissue origin." Testing has included histo-specific staining that identified collagen fibers associated with the material. The origin of these fibers is most probably the subdermis.

Unfortunately, further excavation of the Milwaukee Mastodont site appears unlikely because of the status of development at this location. Details of the find and analyses results will be published in the near future.

The Milwaukee Public Museum is grateful to the Wisconsin Electric Power Company, both for donating the find to the museum's collection and for assistance in searching for additional materials in that area. Hallin also expressed appreciation to Dr. Jeffrey J. Saunders for his support and advice on the project. *–Kimberly Sawtelle*

Evidence of Mastodont Butchering

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that conclusion," Joyce says. "We hope that this evidence will help solve questions about mastodont exploitation east of the Mississippi."

Another question relates to the Paleoindian peoples that lived in the Kenosha County area. Since butchered mammoth remains are commonly associated with Clovis peoples, one might expect to find Clovis-like artifacts in the area. However, Clovis tools are actually quite rare in Kenosha County.

Instead, a unique localized Paleoindian tradition existed in this part of Wisconsin. Studied by David Overstreet of the Great Lakes Archaeological Research Center in Milwaukee, the Chesrow site (and 10 others) south of Kenosha produced unusual fluted points made of a poor-quality local material derived from glacial gravels. This material was used exclusively in this area during the early Paleoindian period.

Paleoindians usually imported beautiful lithic material for flint knapping, and classic Paleoindian points with remarkable workmanship made from imported chert can be found only 20 miles from Chesrow. At the Chesrow site, the flint knappers had good lithic techniques, but because of the poor quality of their lithic materials, the points they produced were clumsy and thick in cross-section.

"Were the Chesrow people Clovis equivalents? Or were they a later culture?" Joyce asks. So far, no one knows. Additional study will also be necessary to determine whether it was the Chesrow people who hunted and butchered the mammoth and mastodont found in Kenosha County.

In the future, Joyce hopes to return to the sites for additional excavation of bones and sediments, as well as any associated tools. Because exact locations exist for all three sites, it should be possible, he says, to further prove that they contain proboscideans that were butchered. When fresh bones and sediments are obtained, samples for radiocarbon dating will also be available. Questions about exact depositional contexts and whether the animals were hunted and scavenged could also be addressed. Joyce says, "We are proceeding very carefully with these sites, and hope to be able to retrieve extensive information on mammoth/mastodont exploitation east of the Mississippi." *–Nancy Allison*