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STUDYING ANCIENT AMERICAN DNA

It is now becoming possible to study the question of the peopling of the New World on the molecular level. In the past, tracing the ancient migration routes of the first cultures to spread across North America or establishing a correlation between modern-day Indians and their ancestors was done by observing stylistic differences in pottery, dwellings, and other cultural remains. Now, using a new microbiology technique called PCR (polymerase chain reaction), researchers can actually begin to study the genetic makeup of prehistoric cultures by extracting, copying, and sequencing segments of DNA from ancient human bodies. The samples used for this are currently limited to soft tissue.

For archaeology, PCR may turn out to be the tool that allows a family lineage to be built for the early inhabitants of North America. This technique promises to provide new insights into human population movement, genetics, and evolution, as well as people's response to viruses introduced by invading cultures.

Dr. Svante Pääbo, a post-doctoral researcher working at Berkeley, is on the forefront of the effort to use PCR to isolate DNA from ancient human samples in the New World. "The goal of the research," Pääbo says, "is to try to get genetic information at the molecular level from archaeological remains. The hope is that we're going to get a time perspective on genetic change in North America. We'll be able to look at population movements that have occurred since people entered North America, how much they have diverged, and how many differences have accumulated between different groups since the colonization of North America by Native Americans." The research may also answer questions about present-day American Indians, including which prehistoric cultures were the ancestors of certain tribes, how much European, African, and other non-Native American genetic information has been mixed into the American Indian gene pool over the last 500 years, and the effect on the genetics of different Indian populations caused by devastating introduced viruses like smallpox.

So far, Pääbo's research has focused on a type of DNA called mitochondrial DNA. Inside a human cell, the nucleus which contains most of our genetic information consists of DNA that we inherit from both our mother and father. Outside of the nucleus, however, there are many small, circular organelles called mitochondria which contain DNA that is only passed down from the mother's side. The mitochondrial DNA in your body came from your mother, your grandmother, and your great-grandmother. If you are a female, you will pass your mitochondrial DNA down to your children, unaffected by the mitochondria in your husband.

Mitochondria, whose general purpose is to produce energy for the cell, exist in thousands of copies per cell. Due to these sheer numbers, mitochondrial DNA is easier to extract from ancient samples than is nuclear DNA, and so researchers like Pääbo are currently concentrating on this particular genetic material.

Before beginning to look for ancient mitochondrial DNA, Pääbo participated in research led by Dr. Allan Wilson at Berkeley, which observed the current world population. "There are some striking things that come up when you study mitochondrial DNA variations between all different human groups in the world," says Pääbo, who obtained a PhD in medicine in Sweden. "First, there is very little difference between us all." It turns out that the genetic differences on the molecular level between all living races of humans today are only about .6%. As would be expected, there is a larger genetic divergence between humans and chimpanzees, an even greater difference between humans and cows, and a much larger variation between humans and marsupial animals like wombats. The more divergence there is, the greater is the difference on the genetic level. The .6% genetic difference between present day humans is an indication of how far back in time our different racial branches diverged.

"The data we have," Pääbo explains, "indicates there is a steady rate of accumulation of change in mitochondrial DNA. By studying the current differences between species, it appears that quite recently we had a common human ancestor for all the mitochondria that we see today. From what we know of the behavior of DNA, this means around 200,000 years." The extrapolation backwards to a female ancestor who produced mitochondrial DNA that is common to all present-day humans is known as the "Mother Eve" theory.

"It's natural," Pääbo observes, "that our mitochondrial DNA point to one common ancestral mother, due to the fact that mitochondrial DNA is passed down only from the mother's side." Many women throughout history had no daughters, in which case their mitochondria died out. "It's a statistical phenomenon that as we go back further in time we should eventually find one common mother."

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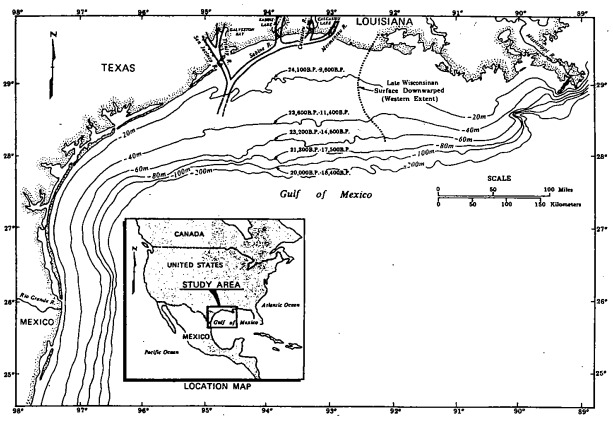
SEARCHING FOR SITES IN THE GULF OF MEXICO

Archaeological sites beneath the Gulf of Mexico? Are they there? And if they exist, how can their existence be detected, let alone verified?

These are some of the questions that are being addressed by the Minerals Management Service, an agency of the United States Department of the Interior. Researchers at the Minerals Management Service not only suspecedt that there may be old hunting camps or other prehistoric sites under the silt and sediment of the Gulf, but funded a study to try to detect where these sites may be, contracting with Coastal Environments, Inc., a research firm in Baton Rouge. Although further analyses must be completed, some of the material that has been pulled up from beneath the ocean floor shows interesting traces of having been associated with past human settlements.

How could there be remains of ancient cultures underneath the Gulf of Mexico? The answer is relatively straightforward: during two periods in the recent geologic past, between 6,000 and 25,000 years ago and 40,000 and 80,000 years ago, the sea level was much lower than it is today, since much of the planet's water at that time was locked up in glaciers. It is probable that many Paleoindian or pre-Paleoindian peoples established hunting and fishing camps on land that is currently covered by water, taking advantage of areas where fresh water, shelter, and abundant food from the oceans were all readily available.

In the case of the Gulf of Mexico, the shoreline at that time extended up to 250 miles further out than it does today. As the glaciers continued to melt, the level of the oceans gradually rose, inundating any sites that may have been established in this area by early peoples. Given certain cir-



Central and western Gulf of Mexico continental shelf showing approximate position of Late Wisconsinan shoreline and major Late Wisconsinan river systems. (From figure 3 of Stright, M. 1986 Human Occupations of the Continental Shelf During the Late Pleistocene/Early Holocene: Methods for Site Location. *Geoarchaeology* 1 (4):347-364).

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Bonnichsen, R., and C. W. Bolen 1985 A Hair, Faunal, and Flaked Stone Assemblage: A Holocene and Late Pleistocene Record from False Cougar Cave, Montana. In *Woman, Poet, Scientist: Essays in New World Anthropology Honoring Dr. Emma Louise Davis*, edited by T. C. Blackburn, pp. 5-15. Ballena Press/Great Basin Foundation, Los Altos, CA.

Bonnichsen, R., and C. W. Bolen 1985 On the Importance of Hair for Pleistocene Studies. *Current Research in the Pleistocene* 2:63-64.

Bonnichsen, R., R. W. Graham, T. Geppert, J. S. Oliver, D. Schnurrenberger, R. Stuckenrath, A. Tratebas, and D. E Young 1986 False Cougar and Shield Trap Caves, Pryor Mountains, Montana. *National Geographic Research* 2:276-290.

ON SEARCHING FOR SITES IN THE GULF OF MEXICO

Coastal Environments, Inc. 1982 *Sedimentary Studies of Prehistoric Archaeological Sites*. Prepared for Division of State Plans and Grants, National Park Service, United States Department of the Interior.

Coastal Environments, Inc. 1986 *Prehistoric Site Evaluation on the Northern Gulf of Mexico Outer Continental Shelf: Ground Truth Testing of the Predictive Model*. Prepared for Minerals Management Service, United States Department of the Interior.

Stright, M. J. 1986 Human Occupation of the Continental Shelf During the Late Pleistocene/Early Holocene: Methods for Site Location. *Geoarchaeology* 2:347-364.

Stright, M. J. 1986 Evaluation of Archaeological Site Potential on the Gulf of Mexico Continental Shelf Using High-Resolution Seismic Data. *Geophysics* 51:605-622.

ON STUDYING ANCIENT AMERICAN DNA

Pääbo, S., and Wilson, A. C. 1988 Polymerase Chain Reaction Reveals Cloning Artefacts. *Nature* 334:387-388.

Pääbo, S., Gifford, J. A., and Wilson, A. C. 1988 Mitochondrial DNA Sequences from a 7000-year Old Brain. *Nucleic Acids Research* 16:9775-9787.

Pääbo, S. 1989 Ancient DNA: Extraction, Characterization, Molecular Cloning, and Enzymatic Amplification. *Proceedings of the National Academy of Sciences* 86:1939-1943.

Pääbo, S., Higuchi R. G., and A. C. Wilson 1989 Ancient DNA and the Polymerase Chain Reaction. *Journal of Biological Chemistry* 264:9709-9712.

ON COASTAL ENTRY MIGRATION

Fladmark, K. R. 1978 The Feasibility of the Northwest Coast as a Migration Route for Early Man. In *Early Man in America from a Circum-Pacific Perspective*, edited by A. L. Bryan, pp. 119-128. University of Alberta, Edmonton.

Fladmark, K. R. 1979 Routes: Alternate Migration Corridors for Early Man in North America. *American Antiquity* 44(1):55-69.

Gruhn, R. 1988 Linguistic Evidence in Support of the Coastal Route of Earliest Entry into the New World. *Man* 23(1):77-100.

Rogers, R. A. 1985 Glacial Geography and Native North American Languages. *Quaternary Research* 23 (1):130-137.

Rogers, R. A. 1985 Wisconsinan Glaciation and the Dispersal of Native Ethnic Groups in North America. In *Woman, Poet, Scientist: Essays in New World Anthropology Honoring Dr. Emma Lou Davis*, edited by T. C. Blackburn, pp. 105-113. Ballena Press/ Great Basin Foundation, Los Altos, CA.

HAIR FROM ARCHAEOLOGICAL SITES

If Charles Bolen is going to visit your site, he's likely to show up just as the dig is winding down. As the team packs up the artifacts and pulls down the mess tent, Bolen heads off to the excavations, alone.

It's not that he doesn't enjoy the company of other people; he does. But other people, by their simple presence, are likely to contaminate Bolen's samples. This is because Bolen studies hair, all kinds of hair, from archaeological and paleontological sites. Since human beings, like all mammals, shed hair, Bolen waits until everyone has left the site before he begins collecting soil samples that will later be float-tested for hair.

Although in its infancy, the use of hair as a paleoecological tool promises to complement traditional vertebrate studies. Whereas an animal must die for its bones to enter the fossil record, hair has no such restriction. Hair is reasonably durable and may be deposited in feces or in regurgitated stomach contents, as well as by simple shedding.

"What you have to remember," Bolen explains, "is that mammals shed hair continually. Some of us shed a little faster than others," he adds with a smile. "As hair grows longer and breaks off, it blows down to the soil. It's there to be found."

Bolen, who received a bachelor's degree in anthropology from the University of Maine after retiring from a career in the military, became interested in hair studies while working in the UM archaeology laboratory for Dr. Robson Bonnichsen. Bolen and Bonnichsen observed that sediment samples from False Cougar Cave in the Montana Pryor Mountains contained hair. Bolen says, "I asked Rob 'Why don't we identify the hair?' And we did. That started me analyzing hair."

Bolen describes the painstaking process by which he collects and studies this unusual clue to the past. Before taking any samples from an excavation unit, Bolen scrapes down the entire pit wall, removing about an inch of sediment. This ensures that no hair shed by the team members, or modern animals like horses or cattle living in the area, will contaminate the sample.

Bolen then collects a 25 cm^2 vertical column from the pit wall, which he removes either in stratigraphic sequence or in arbitrary 10-cm levels. He double-bags and seals the samples in plastic bags.

Next, the samples are removed to the lab, where they are float-tested for hair. Bolen uses water softener or detergent to help break down the clays in the sediments. "One clay granule will keep a small rodent hair from floating," he explains. After agitating the sample in warm water, Bolen uses a fine-mesh strainer to collect the organics which rise to the surface. He puts the skimmed materials in aluminum foil, folds it up, and places the foil in a plastic bag. Once Bolen has float-tested all his samples, he takes them out one by one and picks through them, pulling out all the hair, or possible hair, that he finds.

Bolen acknowledges that this laboratory process is labor-intensive. He emphasizes that "All the organics come to the surface when you do a float: roots, stems, bird nests, whatever. Every fragment must be examined carefully." At the Mammoth Meadow site in southwestern Montana, for example, "There was a ball of roots the size of a football at the 20-30 cm level. Picking through it took about 3 days, with a dissecting needle and a pair of tweezers." Interestingly, once finished, Bolen found no hair at all in this level.

Bolen continues, "I then take the hair and put it in xylene, which is a solvent, for 24-48 hours to clean it." Some hair samples, like those from False Cougar Cave, have fungus on them when they arrive at the lab. The fungus must be removed, Bolen explains, because when he puts the hair on a slide for study under the microscope, "Any dirt or fungus can cloud the image." In addition, "If you don't kill it and clean it off, eventually it will eat your sample."

After taking the sample from the xylene, Bolen runs it through a bath of 200 proof laboratory alcohol. This removes water from the hair, and serves as an additional cleansing agent. All moisture must be removed; if there is any left, the slide containing the hair turns white.

Once the hair is clean and dry, Bolen may take other steps. If the hair is so dark that it is hard to see the internal structure, Bolen bleaches it with hydrogen peroxide. On the other hand, if a hair has split open and lost its pigmentation, Bolen may stain it to make its structure more visible.

Once samples are finally ready, Bolen makes slides of them and examines the hair through a microscope. It is not always obvious what is a hair and what isn't. "I have made many slides of roots," Bolen notes humorously. If a sample is questionable, he makes a temporary slide of it and examines it. "If it's a root, it goes back in the pile."

To identify the species represented in the slide, Bolen looks at the external and internal structure of each hair, comparing the sample with hair in his reference collection. Most hair, Bolen explains, consists of three layers: the exterior, or cuticle; the cortex, which contains the pigmentation; and the medula, which is the center.

Charles Bolen. *(Photo courtesy of C. W. Bolen).*

When Bolen examines a hair, he first looks at the cuticle, which has a pattern that is somewhat similar to a fingerprint. However, this scale pattern differs by species, rather than individual animals. For example, although all water shrews have the same exterior scale pattern on their hair, this pattern is different from that found on the hair of other shrew species.

Scale patterns are a "shaky" source of information, Bolen says, because they can easily be destroyed. When a piece of hair falls to the ground in a region with a cold climate, the hair undergoes cycles of freezing and thawing, and these temperature extremes destroy the scale pattern. Also, acidity can etch it off. "It's just like when women go to the beauty parlor and have their hair bleached, dyed, or curled: the scale pattern is destroyed." Bolen notes that he has never found a complete scale pattern on hair from a woolly mammoth, probably because "The cold and rain erased the scale pattern on their hair."

Bolen also looks at the internal structure of the hair. Like the scale pattern, this structure is different for each species. By studying the internal structure of a human hair, an investigator can estimate a human being's age to within about five

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MAMMOTH TRUMPET

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UPCOMING CONFERENCES

April—

April 18-22, 1990 Society for American Archaeology, 55th Annual Meeting, Las Vegas, NV
Contact: SAA, 808 17th St. NW, Suite 200, Washington, D.C. 20006 Tel. (202) 223-9774

April 19-22, 1990 American Association of Geographers Annual Meeting, Toronto, Ontario, Canada
Contact: AAG, 1710 16th St. NW, Washington, D.C. 20009 Tel. (202) 234-1450

May—

May 16-18, 1990 Geological Association of Canada, Annual Meeting, Vancouver, BC, Canada
Contact: GAC-MAC '90, 801-750 Jervis St., Vancouver, BC, Canada V6E2A9

May 20-25, 1990 Society for Imaging and Technology (SPSE), 43rd Annual Conference, Rochester, NY
Sessions will include: Computer imaging and digital graphics; Advances in image processing techniques; electro-optical imaging systems.
Contact: Prof. Rodney Shaw, Rochester Institute of Technology, Centeer for Imaging Science, One Lomb Memorial Drive, Rochester, NY 14623

May 21-25, 1990 International Council for Archaeozoology, 6th International Conference, Smithsonian Institution, Washington, D.C.
Special session: Approaches to Faunal Analysis: Past, Present, and Future; also regular sessions; one- and two-day workshops.
Contact: ICAZ, Dept. of Anthropology, MMNH, Smithsonian Institution, Washington, D.C. 20560

May 28-June 1, 1990 Sixth International Conference on Hunting and Gathering Societies, Fairbanks, AK
Sessions include: Past and present health and nutrition patterns; ethnoarchaeology.
Contact: Linda Ellanna, CHAGS 6, Anthropology Department, University of Alaska, Fairbanks, AK 99775

June—

June 4-6, 1990 First Joint Meeting CANQUA/AMQUA, Waterloo, Ontario, Canada
Theme: Rapid change in the Quaternary record. Field trips and short courses before and after meeting.
Contact: Alan V. Morgan, General Chairman, Waterloo 1990, Quaternary Sciences Institute, Department of Earth Sciences, University of Waterloo, Waterloo, Ontario Canada N21 3G1 Tel. (519) 885-1211 (X-3231)

June 4-8, Four Decades of Radiocarbon Studies: An Interdisciplinary Perspective, University of California Conference Center, Lake Arrowhead, CA
Session topics include: the natural carbon cycle, instrumentation and sample preparation, hydrology, paleoanthropology and archaeology, earth sciences, and environmental sciences.
Contact: R.E. Taylor, Conference Secretariat, Raiocarbon Laboratory, University of California, Riverside, CA 92521 Tel. (714) 787-5521

June 13-15, Hydrologic Aspects of Global Climatic Change, Lake Chelan, Washington
Contact: Meetings, AGU, 2000 Florida Avee NW, Washington, D.C. 20009 Tel. (202) 462-6900

June 21-22, International Symposium on Mapping and Geographic Information Systems, San Francisco, CA
Contact: Dorothy Savivi, ASTM 1916 Race Street, Philadelphia, PA 19103 Tel. (215) 299-5413

June 24-29, Fourth International Conference on Geoscience Information, Ottawa, Ontario, Canada
Themes include: Geographic and expert systems; Constructing and managing data-bases; Managing collections and archives.
Contact: David Reade, GeoInfo Secretary-Treasurer, GEOSCAN Centre, 601 Booth St., Ottawa, Ontario, Canada K1A 0E8 Tel. (613) 992-9550

July—November

July 1-7, 1990 Society for the Study of Evolution Annual Meeting, St. Louis, MO
Contact: Dr. Barbara A. Schaal, SSE Executive Vice-President, Department of Biology, Washington University, St. Louis, MO 63130 Tel. (314) 889-6822

August 6-9, Annual Joint Statistical Meetings, Washington, D.C.
Contact: ASA, 1429 Duke St., Alexandria, VA 22314-3402 (703) 684-1221

September 4-8, Second World Archaeological Congress, Cartagena, Columbia
Contact: Dr. Paul Reilly, IBM UK Scientific Centre, St. Clement St., Winchester SO23 9DR, United Kingdom

September 20-24, 1990 Fifth Nordic Conference on the Application of Scientific Methods in Archaeology, Stockholm, Sweden
Contact: Arkeologiska Forskningslaboratoriet, Greens Villa, Stockholms Universitet, 106 91 Stockholm, Sweden

October 8-12, 1990 Fifth Australasian Remote Sensing Conference, Perth, Australia
Contact: Golden West Conventions, PO Box 411, West Perth, Western Australia 6005

October 14-21, Lubbock Lake 50th Anniversary Celebration, Lubbock, TX
Dedication of new facilities; Public lecture series; and Symposium focusing on the integration of the geological and biological sciences in archaeology as a driving force behind the current era of Quaternary research.
Contact: 50th Anniversary Celebration, Lubbock Lake Landmark, Museum of Texas Tech University, Lubbock, TX 79409-3191 Tel. (806) 742-2479

October 21-26, 1990 Soil Science Society of America Annual Meeting, San Antonio, TX
Contact: SSA 677 S. Segoe Road, Madison, Wisconsin, 53711 Tel. (608) 273-8080

October 29-November 1, 1990 Geological Society of America Annual Meeting, Dallas, TX
Contact: GSA Meeting Department, PO Box 9140, Boulder, Colorado, 80301 Tel. (303) 447-2020

November 14-18, 1990 American Anthropological Association Annual Meeting, New Orleans, LA
Contact: AAA 1703 New Hampshire Ave. NW, Washington, DC, 20009 Tel. (202) 232-8800

November 25-Dec. 1, 1990 International Symposium on Loess, Mar del Plata, Argentina
Symposium will consist of paper sessions and local field excursions in the surrounding area of Mar del Plata.
Contact: International Symposium on Loess - Marcelo Zárate, Centre de Geología de Costas y del Cuaternario - UNMDP, Casilla 722, Correo Central, 7600 Mar del Plata, Argentina

•STUDYING ANCIENT AMERICAN DNA

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The other striking result from studies of present-day mitochondrial DNA is the appearance of an African origin for all humankind. This is inferred from the way current mitochondrial DNA of different populations compare, and that the closest relatives of all modern populations—European, Asian, et al.—all point to an origin in Africa. "There are many paleontologists that agree that the origin of modern man could be in Africa," Pääbo says. "There are also those who disagree and say that we have multiple origins in Asia, for example. However, if one accepts the view of the African origin, there are other interesting things." Archaeological evidence indicates that in the past, other types of humans lived alongside modern humans, e.g. *Homo erectus* and Neanderthals. Yet, "We don't see that in the mitochondrial DNA; we don't see any deep lineages going far far back, 600,000 or a million years ago, to a common ancestor of Neanderthals and modern humans. It seems from the mitochondria studies that modern humans replaced Neanderthals without interbreeding."

"By studying the current differences between species, it appears that quite recently we had a common human ancestor for all the mitochondria that we see today."

Pääbo is presently looking at ancient North American mitochondrial DNA to reconstruct Native American New World lineages. The tool that has allowed him to do this research is PCR (polymerase chain reaction), a technique which is only two or three years old. PCR allows a researcher to reproduce, or amplify, DNA from a very small sample.

The polymerase chain reaction is just beginning to contribute to several different fields. In addition to archaeology and population studies, it's being applied to virology, forensic medicine, and genetics. In fact, in 1988, the Institute of Scientific Information in Philadelphia rated the PCR technique second only to superconductor research as the most promising area of current scientific research.

The PCR technique is one that enables researchers to make millions of copies of a very small sample of DNA so that the DNA can be easily studied and sequenced. It involves adding a substance called DNA polymerase, an enzyme, which mimics the action that takes place when a DNA molecule replicates naturally.

A small sample of DNA is heated until the double strands of DNA separate from each other. Knowing beforehand which portion of the DNA is of interest, the researchers add two short synthesized segments, or primers, of DNA which attach to the strands; the part of the strands they want to duplicate lies between the primers. When the DNA polymerase is added, the ensuing chain reaction causes the area between the primers to be duplicated. Every cycle that this is performed results in a doubling of the amount of DNA segments of interest. Before long, the scientist has millions or even billions of copies of the original DNA segment with which to work.

The DNA polymerase that is used must be stable at the high temperatures at which the DNA strands separate. The polymerase is manufactured by making use of a bacterium called Thermus aquaticus (Taq) which lives in hot springs.

Ancient DNA, as may be expected, is not an easy thing to find. DNA begins to degrade quickly after the death of an organism. The DNA molecule is delicate and only under unique conditions can parts of it remain intact over thousands of years. "It turns out that it's quite destroyed compared to modern DNA," says Pääbo. Living organisms have mechanisms which protect DNA and which can repair damage, but these processes cease upon the organism's death. Thus, various types of damage accumulate in the DNA, for example, strand breaks and modifications introduced by oxygen in the atmosphere.

Pääbo's first work with ancient North American mitochondrial DNA involved looking at that obtained from prehistoric brains retrieved from Florida peat bogs. At Windover, an early North American site in Florida, people buried their dead along a sink-hole about 7000 to 8000 years ago. The conditions in the water today are low in oxygen and are Ph neutral, allowing some soft tissue of the bodies to survive with usable DNA; in particular, skulls which still contain parts of the brain. "There are over 60 such brains that have recently been excavated in Florida. We may be able to study frequencies of genes for the population," observes Pääbo.

The researchers have already been successful in obtaining some results. For instance, in one specimen, they observed a DNA segment that is rare in modern Asian, Native American, or New Guinean populations (the latter two populations are also considered to be of Asiatic origin). Another amplified DNA segment was one that is present in about 95% of Orientals, but is not present in about 40% of Native Americans. The combination of DNA sequences carried by this ancient individual shows that it represents a mitochondrial type that so far hasn't been seen in modern Native American populations.

Part of the problem inherent in these studies is that, due to the degradation of the DNA, the researchers can generally study only short segments. "We have to do many short pieces and puzzle them together if we want to do a longer stretch," Pääbo explains. "Whereas from modern DNA we can do a long stretch immediately. This is the biggest problem, I think. It gets very laborious and time-consuming." The neutrality of the soil in the Florida peat bog was an important factor in the survival of the DNA, and may also be why the Florida specimens are better for study than are remains found in the more acidic European bogs.

By studying the tissue from American "mummies", Pääbo hopes to be able to correlate present cultures with past. "There are questions, for example, in the southwestern United States concerning the Pueblo Indians, the present-day Hopi. If we go back in time in the same area, we have the Anasazi Indians. So the question is: are they the direct ancestors of present-day Hopi?" With a good number of North and South American human remains available and the PCR technique, Pääbo believes it may be posssible to trace past human migration routes over a wide area and solve other lineage questions.

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COASTAL ENTRY MIGRATION

The traditional model of human entry into the New World generates the popular image of a gaggle of spear-wielding hunters pursuing a Woolly Mammoth through an ice-free corridor. An increasing number of researchers, however, are looking seriously at an alternative route of entry along the North American Pacific Coast. One such individual is Dr. Ruth Gruhn, Professor of Anthropology at the University of Alberta. Gruhn hypothesizes that the first American colonists may have paddled, rather than walked, from Alaska to points south.

In its broadest sense, the coastal entry model argues that the First Americans entered the New World via the Pacific Coast; establishing settlements as they continued southwards and very likely using small vessels. Although the concept of a coastal entry route, explains Gruhn, has been around for some time, little note was taken of the idea until the 1970s. At that time, Knut Fladmark, now of Simon Fraser University, did a dissertation involving study of North Pacific paleoenvironments. "He came to the conclusion," says Gruhn, "that it would have been very feasible for people to have passed along the North Pacific Coast."

Gruhn has found that current paleoenvironmental reconstructions indicate that climate and vegetation in the North Pacific area were much as now during the Middle Wisconsinan interstadial, between about 50,000 and 25,000 years ago. An ethnographic analogy with the historic Yahgan Indians of the southern coast of Tierra del Fuego suggests that a littoral-adapted population could survive in a high latitude maritime environment with a minimum material culture.

"Fladmark pointed out," Gruhn continues, "that actually there would have been certain advantages for people to come along the coast, as opposed to the interior. One is that there is a very rich and productive biomass there—you would have fish, shellfish, sea mammals, and seabirds—whereas the interior route would involve long stretches of relatively unproductive tundra."

A major concern connected with the coastal entry theory is the lack of hard evidence; the earliest sites in the northern Pacific area are about 10,000 years old. Rising sea levels at the end of the last Ice Age radically altered the continental coastline. Any sites that were occupied at the time of the earliest migrations are now likely to be under water. Although Fladmark published several papers on the subject of coastal entry, they were "more-or-less shelved," largely because of the apparent absence of early sites along the North Pacific Coast.

There the idea remained until the early 1980s, when "some very early sites were discovered in South America. The lithic industries associated with these sites," explains Gruhn, "were quite unspecialized, with such things as pebble tools, utilized flakes, or minimally retouched flakes. Of course, the question raised was 'how could people with such unspecialized lithic industries make it through Beringia and go all the way down to South America without leaving any obvious traces in North America?' It occurred to me that perhaps we had better look again at the coastal entry idea."

Gruhn believes that human populations passing along the coast may have moved relatively rapidly. "They would be expanding along a very narrow front. It may be that people actually moved along the west coast of North America and into South America long before they began to go up the rivers and into the continental interior of North America."

While reexamining the coastal entry model, Gruhn also explored historical linguistic evidence relevant to the early peopling question. This evidence, which was first proposed by Richard Rogers, appears to support the idea of an early coastal entry route. Rogers noted that the comparative density of different Native American languages south of the ice sheets suggested that humans were already established there at the time of the last glacial advance. Rogers also observed that Native American languages were most diversified along the Pacific Coast. "The implication of the language distributions," Gruhn explains, "is a much greater time depth of populations on the West Coast than in the interior of the continent."

Taken together, the various lines of enquiry strengthen the coastal entry hypothesis. "A coastal entry route," says Gruhn, "is a viable alternative to the conventional model of entry through the interior of Alaska and into the northern plains."

At the very least, the idea of an early North American coastal entry calls for a provocative reexamination of our perceptions of the First Americans. Indeed, observes Gruhn, the day may come when images of "fur-clad folk trudging through the tundra" are replaced by the idea of "a woman paddling the family canoe down the coast of beautiful British Columbia."

- Paul Doty

•SEARCHING FOR SITES IN THE GULF OF MEXICO

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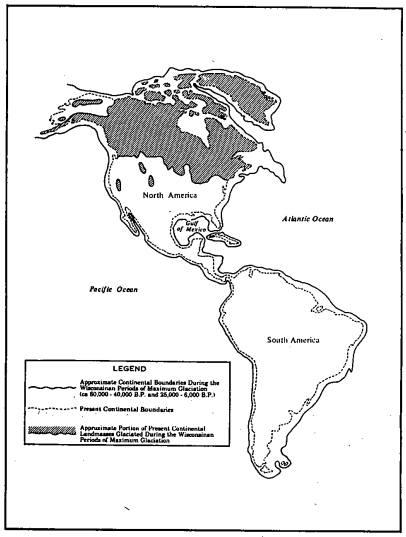
cumstances, such as a site that is first covered by sediments under low-energy conditions before being inundated by the encroaching sea, the archaeological remains may be preserved even better than a site found on land today. Researchers at the Minerals Management Service and Coastal Environments, Inc., are working to predict and detect where these sites may be.

One of the roles of the Minerals Management Service is to protect our nation's archaeological sites from being destroyed as a result of federal undertakings. Melanie Stright, a scientist with the MMS, explains that if an area in which an oil or gas company is going to work is determined through remote sensing surveys to have a high probability of containing an archaeological site, the company must either avoid the area or conduct further testing to determine whether any sites actually exist. Unfortunately for research, Stright observes, "Mainly they choose to avoid the areas." In the case of an oil well, there is usually little difficulty in shifting a drilling operation 500 feet to the side, away from an area of high site potential. With an underwater pipeline, the pipe will only be buried in the sediment to a depth of three feet or so. Since most sites would be deeper in the silt than this, it is rare that a company must perform further testing to see if any archaeological remains intersect their pipeline. "In order to test the basic validity of our approach, MMS funded a study to go out and test one of the areas where we thought there was a high potential for archaeological sites."



Approximation of continental landmass during the Wisconsinan periods of maximum glaciation. (From Figure 1 of Stright, M. 1986 Human Occupation of the Continental Shelf During the Late Pleistocene/ Early Holocene: Methods for Site Location. *Geoarchaeology* 1(4):347-364).

Stright believes that these efforts did uncover some plausible evidence of archaeological remains under the Gulf of Mexico seafloor. "Based on the results of the coring and sediment analyses," Stright says, "Coastal Environments, Inc., came up with two possible archaeological sites."

The methods used in the Gulf of Mexico study involve several steps: 1) conducting seismic analysis to locate the most promising landforms; 2) taking a series of core samples; and 3) analyzing the sediments in the core samples to see if they display evidence of having been associated with past cultural activity.

It is possible that archaeological sites may be found on just about any part of the continental shelf that was exposed during the last period of glaciation. It can be expected, however, that there were places which had a higher probability of attracting early peoples. Rivers, lakes, ponds, and other sources of fresh water were all good candidates for providing basic resources needed by early settlers.

The general region the Minerals Management Service selected for study was the old Sabine River Valley system. The present-day Sabine is a slow, marshy river that forms much of the border between Texas and Louisiana before it empties into the Gulf of Mexico. The seafloor of the Gulf is fairly smooth; there's not much indication of a buried valley. "But just below the seafloor you find this huge river valley," Stright explains. The old Sabine Valley under the Gulf of Mexico extends out under the seafloor for many miles from the present-day coast, and it has been mapped extensively by other researchers and by oil and gas development firms. "You can see it in great detail on the seismic data," Stright says, "the old tributaries, confluences, and terraces that would be good locations for sites."

Having identified the ancient Sabine River Valley as a likely region for containing inundated archaeological sites, Coastal Environments, Inc., narrowed down the search to specific areas that were favorable for site preservation. After reviewing the existing maps, they selected several areas that displayed the types of landforms in which they were interested, such as points where tributaries converged with the main Sabine Valley.

The primary tool used to find such landforms is the "subbottom profiler," a seismic device mounted on the hull of a boat that is piloted over the area to be profiled. Looking at the results of a subbottom profile on paper is like looking at a drawing of the side of a canyon, where the curves and closeness of the various layers indicate the original nature of the geographical features that have been buried there. A good subbottom profile can give an indication of the amount of erosion that has occurred since burial. By looking at the profiles, the researchers were able to identify places like river terraces that not only would have been desirable habitats for past cultures, but which also were buried by enough sediment prior to marine transgression to survive the subsequent erosion. "The seismic data produced excellent examples of fluvial terraces, preserved natural levees, point bars, and tributaries at their convergence with the major river valley," Stright says.

After identifying several promising landforms, CEI collected 77 vibracores. With this technique, a core barrel mounted on a jack-up rig was vibrated down through sediment to retrieve core samples. The vibracorer is just one method of obtaining samples; it was chosen for this work because a vibracore can be driven down through the sediment without overly compacting the cored material, and because it achieves greater penetration then other coring devices.

The cores did not contain projectile points or pieces of pottery conveniently grouped together. Nobody expected that they would; instead it was hoped that the presence of early humans could be deduced from the components of the soil and its physical and chemical characteristics.

These criteria, established by earlier research also conducted by Coastal Environments, Inc., for the National Park Service, can be used to determine the probability of cored material having come from an archaeological site. In the initial study, sediment samples were collected from 15 known archaeological sites located on various landforms near the present Gulf of Mexico coastline. These samples were compared with off-site samples taken from the same landforms to develop physical and geochemical criteria distinguishing cultural from natural deposits.

Stright explains the process, "Coastal Environments, Inc., took borings through an archaeological site along the Gulf Coast, and then went off-site and took another boring. They did this for several different kinds of sites on different kinds of landforms. The researchers then analyzed the differences between the sediments from the archaeological sites and those from the same landform off-site, for example, a natural levy. They compared the differences and categorized what were significant parameters that characterized the archaeological site. They also performed statistical tests to determine what was and what was not significant as far as a characteristic.

"All on-site and off-site samples were subjected to macro-sedimentary, point-count, and grain-size analyses. Sedimentary analysis is a particularly valuable tool when dealing with core samples from a potential archaeological site because of

(Continued on page 5)

"Based on the results of the coring and sediment analyses, Coastal Environments, Inc., came up with two possible archaeological sites."

the small size of the sample. Additionally, geochemical analysis was conducted on selected samples."

_ Macro-sedimentary analysis—One of the main indicators of cultural activity is the overall composition of a deposit. The National Park Service study indicated, for example, that an archaeological shell midden is likely to contain fewer broken, abraded, and encrusted shells than would occur in a natural deposit, as well as fewer numbers of species.

_ Point-count analysis—Another form of evidence of an archaeological site under the seafloor is actual material within the core sample that can be identified and directly ascribed to origin. "Literally you take a small sample, separate out each soil grain under a microscope, and classify it as to whether it's clastic, shell, bone, vegetable material, whatever," Stright explains. "Each individual grain of sediment is classified." After sieving out a group of particles of the 2 millimeter size, for instance, the analyst determines how many particles are from bone, how many from seed, etc. Statistical tests are then used to determine the significance of various components as cultural indicators.

_ Grain size—Another possible indicator of an archaeological site is a large overall size of the individual particles. Generally, "but not always," Stright points out, "an archaeological site is going to have a larger size of sediment grain than the soils from the same kind of topographic feature that is not an archaeological site." When humans grind stone, make pottery, or otherwise work the natural materials around them, they may leave behind particles that are generally larger than the fine-grained, wind or water-borne sediments that usually make up a topographic feature.

_ Geochemical analysis—One thing that can also be looked at is the abundance of heavy metals, such as manganese and zinc. Analyses suggest that coastal archaeological sites contain higher concentrations of these materials than natural coastal deposits. The concentration of heavy metals in cultural deposits is likely a function of shellfish ingestion. Since shellfish tend to have a high concentration of heavy metals because they live on the seafloor where these materials collect, a population that eats shellfish may leave behind a significant percentage of these trace metals.

Another material whose abundance may indicate the presence of an archaeological site is phosphate. Phosphate is a component of human bone and waste. A larger-than-normal abundance of phosphate in the soil of an area that has already been determined as a good candidate for an archaeological site is additional evidence that the locale was used intensively by humans.

Although the reliability of these tests is not yet fully determined, it is believed that the co-occurrence of several criteria may corroborate the presence of an archaeological site. The Minerals Management Service study showed that two of the 77 cores collected exhibited characteristics consistent with archaeological deposits.

At one location, sixteen whole "rangia" shells, radiocarbon dated to approximately 8000 yrs B.P., were discovered in the core samples. Two traits of the shells led the researchers at CEI to believe that the deposit from which they were taken may be of archaeological origin. One is that the shells showed minimal wear, a characteristic interpreted as implying a cultural association, as shells that remain in a natural environment are thought to be exposed to more erosive natural forces. Another factor was the presence of pollen among the shells, pollen which did not appear to have been affected by water movement as would be expected if it had been deposited by water. "Both of these factors," Stright explains, "suggest that the deposit may be an archaeological, rather than a natural, shell deposit."

Another possible archaeological site discovered by CEI consisted of a deposit containing several organic lenses. High concentrations of burned and unburned fish, amphibian, and mammalian bone, and carbonized seeds and vegetal matter within the lenses strongly imply an archaeological origin. The lowest level of the deposit produced a radiocarbon date of 13,120 ± 150 yrs B.P. Overlying lenses may represent either reworking of the lowest level or subsequent depositional episodes. Palynological analysis suggests that the upper two organic lenses were formed adjacent to a brackish marsh.

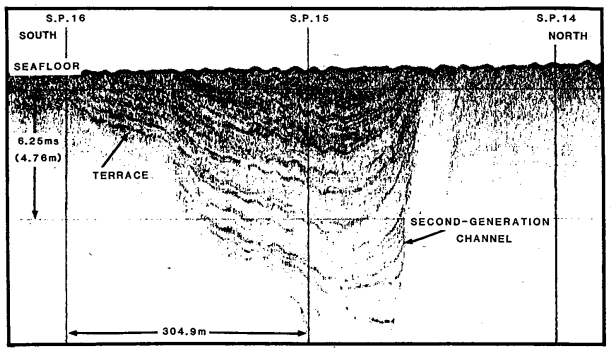
"Any other explanation for burned fish bone is pretty far-fetched," Stright points out, "I mean you have to really think to come up with an explanation for finding burnt fish bone and scales." An alternative hypothesis proposed for the burnt fish parts is that the fish may have been caught in a natural marsh fire. "But there was no burning north or south of this area," Stright emphasizes, "and if it had been a marsh fire it would not have been so concentrated."

One of the most important things is setting up criteria that are pertinent. "The trick of using sediment analysis to find archaeological sites is that you have to establish criteria for an area very similar to the one where you're going to be working. You can't apply what is significant as far as geochemistry or grain size in the Gulf of Mexico to what might be significant somewhere in Europe or even on the Atlantic Coast. This can't be overemphasized. You can't take the criteria established by Coastal Environments, Inc., for the Gulf and apply it just anywhere; even another coastal area. It may not be valid."

Stright hopes to eventually compile an array of substantial evidence demonstrating the existence of underwater sites on other portions of the continental shelf outside the Gulf of Mexico. "The Gulf of Mexico was chosen as a proving-ground because it is such a good environment (i.e. generally low-energy environment, gently sloping shelf, and sufficient sediment to bury and protect sites). However, there are several areas on the Atlantic, Pacific, and Alaskan shelves of the United States where sites are just as likely to be preserved. The Minerals Management Service is looking at these areas as well."

"The most significant thing that could be learned right now is that the sites are there and to convince people that they're there. Most people, even if you can get them to admit there may have been sites on the exposed continental shelf during the Ice Age, are not willing to admit that they've been preserved. They assume everything's been destroyed. We have a lot of evidence that shows that's not true."

—Jim Bonnichsen



Subbottom profiles reveal landforms buried beneath the ocean floor. [From Figure 12 of Stright, M. 1986 Evaluation of Archaeological Site Potential on the Gulf of Mexico Continental Shelf Using High Resolution Seismic Data. *Geophysics* 51(3):605-622. *(Courtesy of Shell Offshore, Inc.)*].

MAMMOTH BRIEFS

UPDATE ON THE THUNDERBIRD SITE: RESCUE UNDERWAY

In Mammoth Trumpet Issue 4-3, we related the potential destruction of the Thunderbird Paleoindian archaeological site, which was threatened by a construction project. Thanks to corporate, government, and public support (including that from Mammoth Trumpet readers), key portions of the Warren County, Virginia, site are now protected from destruction.

The Thunderbird site (44WR11) exhibits a continuous stratigraphic record ranging from the Paleoindian period to the end of the Early Archaic, preserved in a series of largely undisturbed, superimposed living floors. Additionally, the site contains documented evidence of one of the earliest human structures in the Western Hemisphere.

The discovery of an entire complex of functionally different sites at the Thunderbird locale which fit into a total settlement pattern — jasper quarry site, lithic reduction stations, processing area, and the habitation site — has changed traditional thinking about eastern Paleoindian settlement patterns. Previously, prevailing opinion among those who worked in eastern Paleoindian studies has been that these early populations were highly migratory, inhabiting no permanent settlement sites.

Although the site was recognized nationally and internationally as one of the most important archaeological localities in the eastern United States, Thunderbird remained virtually unprotected until recently. In mid-March, 1988, a five-acre lot on the site was cleared of timber and partially bulldozed in preparation for building on the property. Clearing and grading across a 300' section hit the core of an ongoing research excavation.

It immediately became clear that the only long-term answer for the preservation of Thunderbird was outright purchase of the property. Through two $50,000 grants from the Commonwealth of Virginia and donations from concerned individuals throughout the country, title to two lots has now been transferred to the non-profit Thunderbird Research Corporation (TRC). In return, TRC has granted an archaeological easement in perpetuity to the Commonwealth of Virginia. A major land development company has assisted with an interest-free loan of $35,000 for purchase of a third lot, which TRC predicts will be repaid in early April of this year. The TRC is currently working to raise funds for the purchase of the two remaining lots containing the site. The long-range plan at Thunderbird is to continue excavation on a limited basis, keeping the site available and intact for future generations.

Those interested in additional information on the site may write to: Thunderbird Research Corporation, 126 East High Street, Woodstock, VA 22664.

•STUDYING ANCIENT AMERICAN DNA

(Continued from page 3)

There have been successful analyses of individual specimens, but it's still too early to tell what wide-scale mitochondrial types there may be in the ancient New World. "The only thing we see so far is that there is actually a lot of divergence. There are many different mitochondrial types present. This indicates that there were quite a few people involved in the colonization of the Americas. But this is quite preliminary." It cannot be determined, for instance, whether there is support for such theories as the 3-wave hypothesis of North American colonization. Whether or not the DNA of the earliest North American cultures can be traced all the way up to Alaska and back across the land bridge to Siberia is also yet to be seen.

A potential problem with the PCR technique in general is that it is so sensitive that the researchers must take extreme care that the process actually amplifies the DNA in the intended sample, and not extraneous DNA that has contaminated the sample from an external source, such as the handlers themselves. Some of the laboratory methods that help avoid this problem include performing the tests in different parts of the lab and, when possible, using several samples from a specimen.

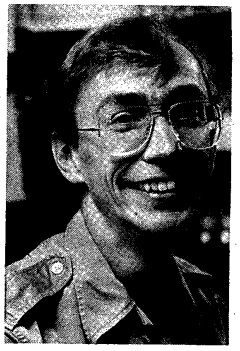
Despite these problems, PCR is much more powerful than the previous technique of studying DNA. Referred to as bacterial cloning, this technique involved using a certain bacteria which would interact with and duplicate a DNA segment. Dr. Russell Higuchi, a scientist at Cetus Corporation in Emeryville, California (a biotechnology firm credited with developing and refining the PCR technique) explains that the bacterial method could give misleading results. "Bacteria may balk at replicating the DNA, but it also may try to repair it. It can mis-repair it and make mistakes." With PCR, however, DNA will either be amplified or it won't; the DNA polymerase will not try to alter the DNA. And since the PCR technique involves a repetitive doubling of the DNA strands, any random error or damage in particular strands of DNA will be lost in the averaging. "You're looking at the aggregate of the DNA," Higuchi explains, "it's sort of like a TV picture that fuzzes out, rather that a complete change."

For general applications of PCR involving modern DNA, such as using it to determine the DNA type present in a single hair left at a crime scene (which could not be done using previous cloning techniques), a major advantage of the process is the speed with which results may be obtained. "Some of what PCR does could have been done previously using the recombinant DNA cloning technique," explains Higuchi, who worked under the guidance of Dr. Allan Wilson while a post-doctoral fellow at Berkeley. "But the process altogether would have used at least a couple of weeks, if not longer. Now it can be done in an afternoon, and one can even do multiple samples." To help facilitate PCR research by such groups as police crime labs and hospitals, there is even a move to develop PCR diagnostic kits which may be available in a year or two. The kit, which could be used by police crime laboratories, is a collaboration between Cetus and the Eastman Kodak Company.

The small size of the sample is, in fact, one of the main benefits of PCR when applied to archaeological questions. Museums and other protectors of archaeological remains are understandably wary of research methods that utilize large amounts of the original specimen. The amount of sample needed for PCR analysis is on the order of half of a gram or so of tissue, about the same amount used in a hospital for a biopsy. The small sample that is required for PCR analysis also makes it much easier when researchers are studying DNA in living persons, as all that's required is a hair or two, or a small amount of blood.

In addition to the contributions of PCR to Pääbo's field of molecular archaeology, this technique is expected to bring great benefits to many other areas of science. It may, for instance, allow progress to be made in the study of viruses, as PCR can potentially amplify the DNA of the virus itself for sequencing and study. "It's even possible that it may be particularly useful in the diagnosis of HIV, the AIDS virus," Russell Higuchi notes. "The AIDS virus affects a relatively small percentage of white blood cells. The virus by itself is very difficult to detect." The current method of diagnosis depends on the development of antibodies. "The data suggest we could detect the virus itself before the patient develops the antibodies."

For researchers like Pääbo, who is using the PCR technique to address the question of the peopling of the New World, there are several areas in which further advances in PCR analysis would be useful. So far, extracting DNA from ancient samples can only be done on soft tissue, such as that obtained from the Florida remains or the flesh of well-preserved mummies found in arid deserts. "So far, it hasn't worked with bones, which would really be the thing," Pääbo says. It is hoped that someday it may be possible to extract DNA from bone, allowing DNA amplifications and sequencing to be performed on the extensive number of skeletons that have been unearthed and collected throughout North and South America.



Dr Pääbo Svante. *(Photo courtesy of P. Svante).*

Pääbo is optimistic about further refinements in microbiology techniques. Mitochondrial research gives a female perspective on history. "The important thing now, I think, is to study other genes; genes in the nucleus that have been inherited from both the mother and father, as well as genes that have been inherited only from the father. To be able to see if all these three genetic systems give the same date. Because if they do, then there's a really strong case that there was an origin for modern humans 200,000 years ago. Or, it may be that there are some special phenomena that we see; that modern humans came out of Africa, did interbreed with the Neanderthals, but didn't acquire the mitochondria for some reason."

In any case, it is expected that further advances and refinements in the application of PCR techniques to questions in the world of molecular archaeology will help confirm or disprove such issues, bringing interesting new developments to light in the future.

—*Jim Bonnichsen*

THE BURNING TREE MASTODON: A NEARLY COMPLETE SKELETON FROM LICKING COUNTY, OHIO

On 12 December, 1989, construction workers excavating a pond at the Burning Tree Golf Course, south of Newark, Ohio, encountered the remains of an extremely well-preserved mastodon skeleton. Over the next two days, salvage excavations were co-directed by Paul Hooge, Director of the Licking County Archaeology and Landmarks Society, and Bradley Lepper, Curator of the Ohio Historical Society's Newark Earthworks State Memorials. Temperatures dropped to the low twenties with a wind-chill factor approaching zero, but excavations continued with the enthusiastic support of Sherman Byers, owner of the Burning Tree Golf Course, Philip Flowers and his construction crew, and volunteers from the Licking County Archaeology and Landmarks Society and the Licking County Joint Vocational School.

The Burning Tree Mastodon site currently is being studied by a multi-disciplinary team including, in addition to Hooge and Lepper: Dan Fisher, Museum of Paleontology, University of Michigan; Tod Frolking, Department of Geology, Denison University; Jon Sanger, Department of Botany-Microbiology, Ohio Wesleyan University; and Dee Anne Wymer, Department of Anthropology, Bloomsburg University.

The mastodon skeleton is nearly complete. Only the right rear leg, the tail, and the toes are missing. The skeleton was largely disarticulated, but many anatomical sets of bones remained together: including the cervical vertebrae, the thoracic vertebrae and some ribs, and the forelimbs. Scratches and grooves present across several ribs are being studied to determine whether they represent evidence of Paleoindian butchery and/or carnivore gnawing.

The mastodon was a young, but mature, male. Healed fractures of a vertebra and a rib are evidence for rough treatment at some point in the animal's life. The cause of death is, so far, undetermined.

In addition to the mastodon remains, the humerus of a muskrat was also recovered from the Pleistocene deposits. Due to the salvage nature of the excavations, it was not possible to screen the sediments. Undoubtedly, therefore, other small mammal remains were present but have not been recovered.

Spruce branches in association with the remains have been dated to 11,720 ± 110 (Beta-35045) and 12,620 ± 90 (Beta-35046). Other paleobotanical data indicate the surrounding environment was a small shallow pond or open marsh fringed with brushy vegetation, including some deciduous woody brushes or trees along with spruce trees.

A more complete summary of research to-date will be presented at the Ohio Academy of Science Annual Meeting at Wright State University, 28 April, 1990.

—Bradley T. Lepper
Newark Earthworks State Memorials Ohio Historical Society

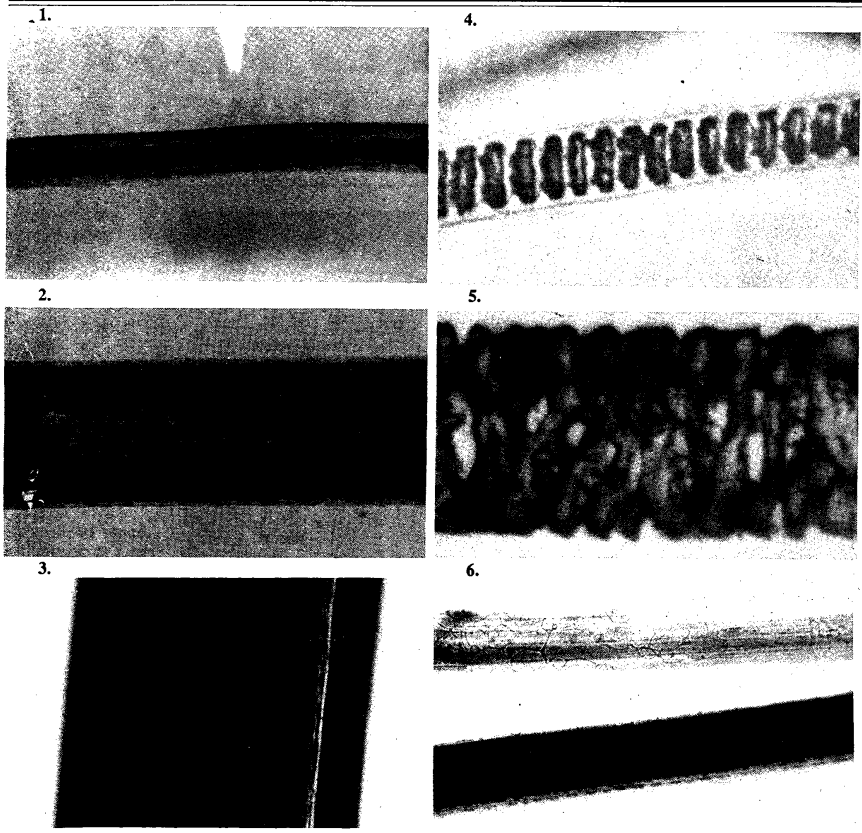
Left,* Bradley Lepper, co-director of the excavation, unearths the ribs of a well-preserved mastodon skeleton found at the Burning Tree Golf Course in Ohio last December. *(Photo courtesy of LCALS).

Right,* A volunteer views the partially excavated mastodon skelton. From foreground, the bones are: several articulated foot bones; a humerus; and articulated cervical vertebrae. Despite the subfreezing temperatures, volunteers turned out in force to assist in the two-day emergency excavation. *(Photo courtesy of LCALS).

Right, Aerial view of the Burning Tree Mastodon site. The mastodon skeleton was recovered from the darker stained area on the left side of the pond, behind the backhoe. ***(Photo courtesy of LCALS).***

MAMMOTH TRUMPET

...Upcoming Conferences
...New References and Resources
...Suggested Readings
...and more



•HAIR FROM ARCHAEOLOGICAL SITES

(Continued from page 2)

years. The older a human gets, the bigger the medula becomes. At the same time, the cortex gets smaller. Since the cortex contains the hair's coloration, the hair eventually turns white. "Judging by the diameter of the medula, you can estimate the age of an individual," Bolen explains.

Usually, when he studies the internal structure of a hair, Bolen looks at the medula. However, in artiodactyls, such as elk, bighorn sheep, moose, or caribou, there is no medula. "The hair internally is made up of small air pockets," Bolen explains. "It looks like a solid string of grapes. You can tell if it's a mule deer, whitetail deer, caribou, or moose by the total number of air pockets across the hair."

"What you have to remember is that mammals shed hair continuously. Some of us shed a little faster than others."

Bolen compares mammoth hair and the hair of its living relative, the Indian elephant. "Elephant hair is almost a bristle or whisker. It's so thick... you have to bleach the heck out of it to get the internal structure, and it's the lack of internal structure that is the identifying factor." Although mammoth hair also lacks an internal structure, here the similarity ends. Unlike Indian elephant hair, mammoth hair is not bristly, but is much closer to ordinary hair in texture. Mammoth hair, Bolen adds, comes in all colors: blond, reddish-brown, and black, just the way human hair does.

Clearly, structural analysis has its limits. "I have some hair samples that match nothing living. I have no idea what they are. They look like sloth of some type, similar to Shasta [ground sloth], but instead of a double medula, they have a quadruple medula." Researchers have suggested that the hair may come from a giant armadillo.

In addition to studying specimens under the microscope, Bolen observes that hair samples can be chemically tested for mineral traces. "When hair erupts through the skin, it becomes dead, like your fingernails. It records what your blood chemistry is at that time. Hair grows between six and seven inches per year; if you get a hair that is a foot long, you have at least several years' recordings of diet and blood chemistry."

For example, by analyzing human hair from the nape of the neck, scientists can detect the onset of leukemia before a doctor can find it in the patient's blood system. And a ratio between phosphates and calcium indicates how much meat and vegetable matter a human has in his or her diet.

Since he began collecting and studying hair samples in 1980, Bolen has worked at a number of digs, among them False Cougar Cave and Mammoth Meadow. "False Cougar Cave was one of the best tests for hair analysis," Bolen says. Bolen recovered a total of 850 hairs from 22 taxa, including horse, bison, shrew, and pika. Although generally comparable to the taxa list developed through bone analysis, the hair study revealed the presence of four species not represented by bone: elk, wolverine, black bear, and human.

Six human hair fragments were recovered from two levels in the cave; four of them directly below charcoal radiocarbon dated at 10,530 ± 140 yrs B.P. and lateral to a date of 14,590 ± 300 yrs B.P. Although excavator contamination is an inherent danger in prehistoric hair studies, tests conducted on the False Cougar Cave human hairs suggest they are Mongoloid in origin. Since none of the crew members were of Asiatic ancestry, it is unlikely the hairs are the product of excavator contamination.

"At False Cougar Cave," says Bolen, "we have no human bones, we have no projectile points. We have some charcoal, which, it could be argued, is the product of a forest or brush fire. We have some small flakes, which could be caused by natural spalling. But we have human hair. This, to me, is very significant."

Bolen explains the discrepancy between the False Cougar bone and hair record, "With bones, you have to have a carcass, or an animal has to die there to leave his bones. But anything that has to visit the cave, spend the night, go to sleep, or go in there and scratch a flea or rub on a rock is going to leave behind hair samples."

Mammoth Meadow, the most recent site Bolen has worked at, also promises to yield a rich hair record. Although he has float-tested only three of the fifteen sample bags he collected, Bolen reports hair from horse, bison, bighorn sheep, least chipmunk, and shrew.

When asked what kinds of research he would like to do in the future, Bolen easily lists several possibilities. "I'd like to find out what environments preserve hair: analyzing soil for pH and other trace minerals," as well as the deposition and moisture content. "Do peat bogs contain hair? Do shell middens? Middens along the coast get a lot of small animal bones. Is hair there also?"

In general, he says, "Hair and bone seem to go together. Conditions that preserve one preserve the other also. Permafrost preserves [hair] beautifully. False Cougar Cave was wet but real cold and had good hair preservation. Also dry caves, and there are some [containing faunal material in western North America] going back 30-40,000 years."

Because hair analysis is so rarely done, it is important to realize that "Just because hair has not been reported from a site, you can't assume there is no hair.

"All the skeptics say, 'There are all these excavations going on all over the world, and nobody's reported hair,'" Bolen says. "But my question is, 'Has anybody looked?'"

"How many early sites are there that are supposedly questionable, that just have flakes and don't have a Clovis point? If you float-tested [samples from these sites], would you find human hair? Would you find extinct species hair? The bones may not be there. But you might find hair. If you don't look," Bolen emphasizes, "you won't find it."

—Nancy Allison

NEW REFERENCES AND RESOURCES

Agenbroad, L. D., J. I. Mead, E. D. Mead, and D. Elder 1989 Archaeology, Alluvium, and Cave Stratigraphy: The Record from Bechan Cave, Utah. *Kiva* 54:335-351.

Bateman, R., I. Goddard, R. O'Grady, V. A. Funk, R. Moooi, W. J. Kress, and P. Cannell 1990 Speaking of Forked Tongues: The Feasibility of Reconciling Human Phylogeny and the History of Language. *Current Anthropology* 31:1-24.

Berry, S. H., and D. B. Bamforth 1989 Microwear Analysis of Prehistoric Stone Tools. *MRS Bulletin* 14(3):45-48.

Budiansky, S. 1989 The Ancient Contract. *U.S. News and World Report* March 20, pp. 75-79.

Cole, K. L. 1990 Reconstruction of Past Desert Vegetation Along the Colorado River Using Packrat Middens. *Palaeogeography, Palaeoclimatology,* Palaeoecology 76:349-366.

Davis, O. K. 1990 Caves as Sources of Biotic Remains in Western North America. *Palaeogeography, Palaeoclimatology, Palaeoecology* 76:331-348.

Madsen, D. B., and D. Rhode 1990 Early Holocene Pinyon (*Pinus monophylla*) in the Northeastern Great Basin. *Quaternary Research* 33:94-101.

Piperno, D. R., M. B. Bush, and P. A. Colinvaux 1990 Paleoenvironments and Human Occupation in Late-Glacial Panama. *Quaternary Research* 33:108-116.

Wright, K. 1990 The Road to the Global Village. *Scientific American* 262(3):83-96.

Directory of photos (above):

1) **Horse (*Equus* sp.) hair from False Cougar Cave, Montana. The hair was recovered from deposits dating 10,000 - 14,000 yrs B.P.** *(Photo courtesy of C. W. Bolen).*

2) ***Nothrotheriops shastensis* (Shasta ground sloth) hair from Utah. Note the distinctive double medula.** *(Photo courtesy of C. W. Bolen).*

3) ***Glossotherium* (mylodont sloth) hair from Mylodon Cave, Chile. Although differing internally from *Nothrotheriops* (shown above), the outer cortex of the two genera exhibit similar scale patterns.** *(Photo courtesy of C. W. Bolen).*

4) **Shrew (*sorex* sp.) hair from False Cougar Cave, Montana.** *(Photo courtesy of C. W. Bolen).*

5) **Least chipmunk (*Eutamias minimus*) hair recovered from recent Mammoth Meadow, Montana, excavations.** *(Photo courtesy of C. W. Bolen).*

6) **Mammoth (*Mammuthus*) hair collected from a dry cave in Utah (upper sample) and from permafrost in Siberia (lower sample).** *(Photo courtesy of C. W. Bolen).*