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## BONES REVEAL PALEOINDIANS' WAY OF LIFE

### New Interior Alaska Site Rich in Faunal Remains

On a height overlooking a great plain of braided glacial outwash channels that dominated their Eastern Beringian surroundings 11,500 years ago, people butchered and cooked a wide variety of mammals and birds.

Their camp lay in what now is popularly considered an immigrant route from Eurasia into the Americas, yet the people surely didn't consider themselves immigrants. Their bluff-top camp was a convenient place to prepare food in spite of the dust storms. Perhaps the site offered the people a vantage point for spotting game, as well as predators that might have caught wind of their food. Bison and elk constituted a major part of the people's diet, although during waterfowl migration, birds supplemented the large mammals as food. Among the possessions of the hunters were pieces of mammoth tusk.

The Richardson Highway, leading from nearby Delta Junction to Fairbanks, now passes below their camping area, which has become known as the Broken Mammoth site. There on the bluff 70 feet above the Tanana River at the confluence of Shaw Creek, investigators from University of Alaska Anchorage and the Alaska State Department of Natural Resources have spent two summers excavating the site, which has proven to have been used from about 3,000 years ago back to 7,500, 10,000 and 11,500 years ago.

The river continues to drain the Ice Age environment of the Alaska Range to the south and some of the broad Yukon-Tanana Upland that extends northward and eastward. Wind continues to carry silt across the site from the river's many gravel bars. Because of a combination of favorable characteristics, Broken Mammoth has revealed some of the first solid evidence of the way of life led by those early Americans.

Dr. David R. Yesner, a specialist in faunal analysis and human ecology at UAA and co-director of the Broken Mammoth Archaeological Project, is studying a revealing assemblage of bones from the site.



The 1991 excavation at the Broken Mammoth site opened the side of the south-facing bluff.

"Although a few other sites of about the same age have been found in the interior of Alaska," Yesner said, "none has ever produced more than a few scraps of bone."

Dr. Charles E. Holmes, an archaeologist with the Office of History and Archaeology, Alaska Department of Natural Resources, and project co-director, discovered the site in 1989. His finds, which included fragments of mammoth tusk exposed on the edge of the bluff, earned the site its name. One of the tusk fragments contained a small stone chip embedded in channels that had been scratched into its ivory. No mammoth bones have been found, however, leading investigators to suggest that tusks may have been scavenged from the shrubby tundra not far away. Mammoth ivory fragments have been found at the base of the Broken Mammoth and nearby sites. Holmes is analyzing artifacts, which include at least one small dowel-shaped ivory frag-

*continued on page 3*

## PRE-CLOVIS HUMAN PRINTS FOUND IN CLAY

### Dates of N. Mexico Find Fixed about 28,000 B.P.

Pendejo Cave, near Orogrande, NM, has produced startling new evidence of pre-Clovis culture in North America: a human fingerprint and palm print found in a clay layer dated at about 28,000 years B.P.

Dr. Richard S. MacNeish, principal investigator of Pendejo Cave, describes how the prints were found: "We were digging up a number of chunks of clay in zone I, underneath a fire pit in H, and one of the people noticed a peanut-sized piece of burned clay that had some little round parallel rings on it. We began to look at other pieces of clay, including some still *in situ*, and there were lots of other little rings on it, so they brought them back to the lab."

After examining the clay, MacNeish says, he and his colleagues concluded: "These look like palm prints. Let's send them to an expert."

Two experts examined the prints, J. F. Hines, a fingerprint expert and manager of the Ontario Provincial Police Forensic Identification Services, and Dr. Jamshed Mavalwala, a University of Toronto physical anthropologist who has published extensively on dermatoglyphics. Both concluded that the prints had been made by a human hand.

"The fingerprint and the palm print could be from two different individuals," MacNeish says. He explains that the loops on the fingerprint are much smaller than the loops on the palm print. The fingerprint may be from the little finger of the same hand that produced the palm print, or it may be the fingerprint of a second person, possibly a child. Since the prints are on two separate pieces of clay, it is impossible to conclude whether they are from the same individual.

*continued on page 6*

## MAMMOTH BONES RECOVERED FROM UNDERWATER SITE

### Associated Stones Suggest Meat Anchors

Last summer a scuba diver noticed an oddly shaped object at the bottom of a lake in northwestern Pennsylvania. He examined it and then phoned Dr. M. Jude Kirkpatrick, archaeologist in the anthropology department at Gannon University, Erie, PA, to describe his find. He couldn't say for sure if it was wood or bone, but he knew it was about two feet long and it had three points.

"I said, well, maybe we ought to look at that," Kirkpatrick said in a recent telephone interview. Kirkpatrick instantly recognized it as a scapula—the scapula of a mammoth. He asked scuba divers to

search the area, under about 20 feet of water, where it was found. "They came up with a couple more [bones] and told me there was more down there."

Kirkpatrick, who also is a research associate with the Carnegie Museum of Natural History in Pittsburgh, quickly organized an underwater archaeology project utilizing the expertise of volunteer scuba divers. "This was a first for me." Work necessarily had to be conducted discretely so as not to get the attention of anyone who might vandalize the site. "It's a good-sized lake, used for boating and every-

*continued on page 6*

## INSIDE

OSU Welcomes CSFA .....	2
Clovis Book Forthcoming .....	2
Paleoindians and DNA .....	4
Upcoming Conferences .....	5
A Mammoth Data Base .....	5
Education on the Alaska Coast .....	7
Suggested Readings .....	7

# OREGON STATE UNIVERSITY EXTENDS WARM WELCOME TO CSFA

New opportunities for developing the Center for the Study of the First Americans and its programs have been made possible by a generous offer from Oregon State University to serve as the Center's new home. The Center's director, advisory board, Bingham Trust for Charity, University of Maine officials, and Oregon State University officials worked through the spring and early summer to establish the Center at OSU. Director Robson Bonnicksen has an appointment in the Department of Anthropology and will work closely with anthropology faculty as well as specialists in allied disciplines to establish a program in First American Studies on the OSU campus.

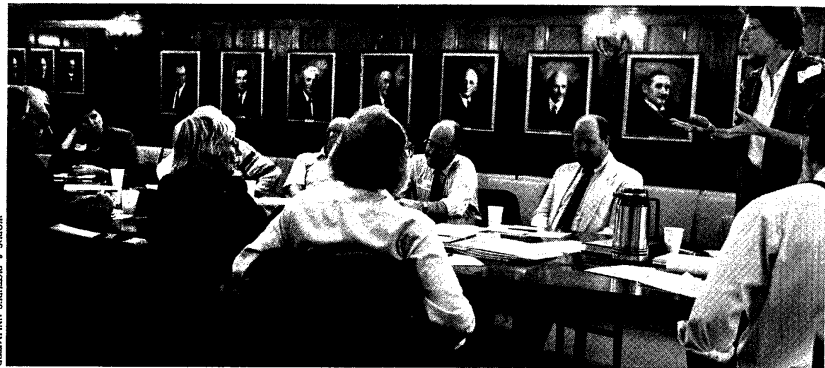
While there remains much to reorganize, the office, lab and programs already are in full operation in Corvallis, OR. The Center's advisory board met at OSU Nov. 9-10 and set in motion an ambitious program that will build upon the Center's decade of experience advancing research in all aspects of the peopling of the Western Hemisphere. The Center's three-pronged program of research, education and development is perfectly compatible with OSU's own goals and organization.

"OSU has set up an environment so right for us," said Jo Ann Harris, co-chair of the Center's board, as she convened the meeting. "This is the place for us and here we are."

Harris, a New York City attorney, and co-chair Christopher Pratt, a Vermont computer-company executive, are drafting details of plans that will govern the Center's broad international focus on the peopling of the Americas. The board will meet in April to finalize a formal governing structure that the Center lacked during its tenure at the University of Maine. Elected to serve with Pratt and Harris on the CSFA board's executive committee was Carolyn Maresh, director of administration at OSU's College of Liberal Arts. OSU is fully committed to the success of the Center as an independent entity under the overall auspices of the university.

Director Bonnicksen expressed enthusiasm about the welcome OSU has accorded the Center and the Center's staff. "This is a wonderful university to do things in," he told board members. Bonnicksen said the university is very strong in physical sciences and encourages interdisciplinary approaches. "We came here to be an interdisciplinary program." He has been meeting specialists from various scientific disciplines at OSU who may know how to find answers to the many complex questions posed by studies of the peopling of the Americas. He told the board that the Department of Anthropology has an array of strengths for supporting the Center, and he noted the department's Asian Studies Program has close ties with China and other Pacific-rim countries. Further, the department has a linguist and two physical anthropologists. David Brauner, acting chair of the Anthropology Department, was elected to the Center's board of advisors.

As part of the Center's educational role, Bonnicksen will be teaching a cluster of courses in First American Studies. Education and public outreach are evident in the Center's ambitious publication



Co-chair Jo Ann Harris, standing, speaks to board members at the November meeting of the Center's board at Oregon State University in Corvallis, Oregon.

program, which the director described to the board. Bonnicksen announced that David J. Meltzer of Southern Methodist University has been named assistant editor of the Center's Journal, *Current Research in the Pleistocene*.

Bonnicksen outlined the Center's recent research and laboratory activities and described the new video digital imagery system, state-of-the-art technology that converts photographic images of artifacts to a computerized format that allows quantitative analysis and comparison. The Center is beginning a data bank of artifact images that will be available to scholars.

"We came here to be  
an interdisciplinary program."

Harris presented the board a draft mission statement for the Center based on three goals: outreach, research and education. Her draft:

The mission of the Center for the Study of the First Americans is the promotion of interdisciplinary undergraduate and graduate teaching and research, and the stimulation of public interest on the subject of the peopling of the Americas. Toward these goals, the center provides leadership and coordination to scholars worldwide; creates and implements programs of study and research involving the physical, biological and cultural sciences; and disseminates the product of this synergism through public education programs reaching a broad range of groups, from local school children to international scholars.

The board's draft of its working committee structure included specific focus on development, outreach, education and research. It should be noted that those titles create the acronym DOER, an apt description of members of the Center's advisory board.

Of highest priority to the board is the completion of an endowment fund for Bonnicksen's chair at OSU. Additional development activities will involve providing money for specific research projects and an array of other activities that may range from sponsoring visiting scholars to creating and sponsoring traveling museum exhibits.

John Evey, director of the OSU Development Office, and Harold Hunter, director of development for OSU's College of Liberal Arts, described in detail the University's financial development programs. Both emphasized the compatibility of the CSFA with OSU, and board members expressed their admiration for OSU's development staff. "They have an incredible fund-raising machine here at this university," said Harris.

While much of the board's discussion was related to the move from Maine to Oregon, the focus was on the future. Board members presented ideas for

broadening the dissemination of information and for widening the base of disciplines and geographical expertise on the Center's scientific council. The board learned that a volunteer program organized in Corvallis already has attracted about 50 persons. Board member Paul Kifer, professor emeritus in the Department of Food Science and Technology at OSU, was chosen to coordinate the Center's volunteer activities.

Charles Bolen has volunteered to serve as the Center's laboratory manager. "Charlie" will be responsible for overseeing student and volunteer workers who are engaged in first Americans archaeological research. Bolen is now responsible for unpacking the countless artifacts that were moved across the continent. Also in Corvallis now is Bolen's precious reference collection of hair that includes samples from many extinct species and many samples in excess of 9,000 years old. "I don't know anybody but the Center that keeps hair," Bolen said.

Although we are located in temporary quarters, Bolen notes that planning is in full swing to establish state-of-the-art lithic, bone and computer laboratories on the OSU campus.



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## CLOVIS BOOK FORTHCOMING

The book, *Clovis: Origins and Adaptations*, is scheduled to be in print early in January. Unforeseen editorial delays have slowed publication. Persons who have made pre-publication orders should be getting the book in a few weeks. *Clovis*, the latest book from the Center for the Study of the First Americans, was edited by Robson Bonnicksen and Karen Turnmire. The 350-page volume contains 20 papers focusing on Clovis origins and adaptations.

## Broken Mammoth

continued from page 1

ment that appears to have been shaped by humans, from those sites.

Broken Mammoth lies in an area known to local biologists as a relict Beringian flora. The south-facing slope is warm and well drained and the vegetation includes grasses, sedges, and *Artemisia* (sagebrush), as well as some birch and alder trees. During the time of the earliest occupation of the site (the so-called "Birch Interval" from around 14,000 to 9,000 years ago) the local environment was changing from a tundra-like grassland to an open forest of scrub birch and willow.

There is no permafrost in the vicinity of the Broken Mammoth site that might confuse the stratigraphy with heaving, solifluction, or gelifluction. Above the weathered bedrock about two meters of soil and sand form uniform layers that extend more than 100 meters along the bluff face. "We don't have reversals of radiocarbon dates and some of the problems that have plagued sites like Onion Portage, Dry Creek and other early Alaskan sites," said Yesner. The soil itself, rich in calcium carbonate, may have provided the most favorable aspect for the site since it has resulted in remarkable preservation of bone. The sedimentary matrix of the site is loess, carried by the winds from glacial outwash, that may well have caused relatively sudden burial of bones and artifacts. Dr. Kristine Crossen, a UAA geologist, is analyzing sediments from the site. "There's a tremendous source of loess coming from the Tanana River," said Crossen. "It's also one of the windiest areas in the interior of Alaska."

Field workers can still experience rapid deposition of soil. "You can be working at the site when a big wind comes along and you can get three centimeters of loess deposit on some of the bones you were just excavating," said Yesner.

In 1990 Holmes, Yesner, and their crew excavated several two-meter-square units on a checkerboard grid extending 10 meters back from the bluff. In 1991, field workers followed a different tactic, excavating along the face of the bluff where most materials had been recovered the previous year.

From the upper layer of loess that contains cultural remains dating to 2,800 years ago, the excavation proceeded down through sterile loess overlaying a uniform five-centimeter band of sand. The excavation then descended through three distinct paleosol complexes, the middle and lowest of which contain organic lenses of bones and artifacts.

The 1991 excavation concentrated on the oldest strata. "We did get a lot more preserved bones that really are in good shape," Yesner said. "It's quite clear now that the big animals that predominated in the lowest levels were bison and elk."

"Bison and elk make it sound like a Yellowstone kind of place rather than an Alaskan kind of place you think of today," he said, "and of course it was a lot warmer at that time than it was subsequently." He noted that understanding the environment is prerequisite to understanding the kind of strategies human hunters would have used.

Yesner considers Broken Mammoth and three related sites nearby as seasonal, short-term hunting encampments. "We do have hearths, and they're fairly large hearths, but there's no evidence yet of dwellings or structures of any sort." Buried by silts

deposited during the extremely windy periods late in the Pleistocene, the hearths were preserved. Yesner compared the hearths, especially a large one in the middle paleosol dated at 10,300 years B.P., to classic Old World upper Paleolithic living-floor surfaces with their scatters of bone fragments and flakes. "The big stuff was all pretty clearly food remains. It was hauled up on top of the bluff. Most of it is pretty smashed up, but then we do get some big sections of pelvis as well as mandibles with intact teeth."

While bison and elk were the predominant large mammals, small mammals and birds constituted fully 60 percent of the number of identifiable specimens from the lower paleosol complexes. Birds,

Mammoth remains at Broken Mammoth present the team with unanswered questions. So far, only tusk material has been found. At Broken Mammoth itself, only tusk fragments have been recovered, but the team excavated an intact tusk at a closely related site a short distance away. "It was not in the world's best condition," Yesner conceded. "It did exfoliate quite a bit when we were removing it, but it was, at the time we exposed it, an intact tusk." No mammoth bones have yet been found, suggesting that there may have been no mammoths still alive in central Alaska by 11,500 years ago. Holmes notes that if the site should ultimately produce conclusive evidence that humans and mammoths coexisted, it would be a

first for Alaska. Previous studies have suggested that Alaskan mammoths became extinct perhaps two thousand years earlier, around 13,500 years ago. If mammoths were hunted by Broken Mammoth people, they must have been killed away from the campsite and the bones not brought back. Or else the bones remain to be discovered.

As he analyzes the wealth of faunal material, Yesner has more to consider than ecology and adaptation. "Right now one of the big problems for me is going to be the whole question of bison taxonomy," he said. Bison remains are associated with the earliest components of the site. "We're starting out, we assume, with *Bison priscus*, the big Pleistocene bison. The bones are very similar to those found in the Fairbanks muck deposits of the late Pleistocene. But by 2,800 years ago we end up with something like *Bison bison*." Yesner notes that at sites in the lower 48 states, bison discoveries often start with *Bison antiquus* or *Bison occidentalis*.

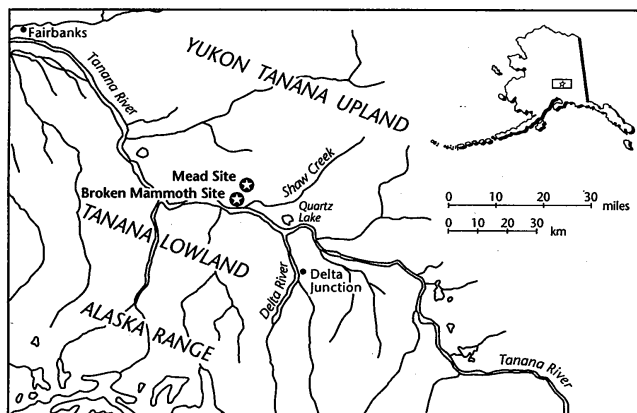
At Broken Mammoth, Yesner is facing what seems a long record of continuous bison evolution. "What do you do in terms of taxonomy, and where do you break this thing down and say you have one species or another? Or do we throw up our hands as Mike Wilson [archaeologist and faunal authority at the University of Lethbridge] has suggested and just talk about our intergrading species of bison?" Wilson has proposed combining *Bison antiquus* and

*Bison bison* into one species, but Jerry N. McDonald, in his 1981 book *North American Bison, Their Classification and Evolution*, rejected the idea by contending that both taxa were adapted to "different selection regimes at different times." McDonald wrote that *Bison priscus* originated in Eurasia and dispersed into North America. His book indicates that of 54 North American specimens of *priscus*, 35 were from central Alaska and 12 from sites nearby in Yukon Territory. The biogeographer McDonald likely would agree that Yesner is facing a fascinating challenge with Broken Mammoth's assemblage of bison remains.

The sheer variety of creatures recovered at Broken Mammoth also is a continuing fascination. "We have two or three pieces of what look like large predatory birds," Yesner said. He recently examined and photographed specimens at the Los Angeles County Museum for comparison, but he is not yet ready to speculate on whether he might have evidence of giant condors at the site.

The site has revealed only the slightest hint that Alaskans might have eaten fish 11,500 years ago. Two scales identifiable as being from a salmonid fish were found in the lowest component. Yesner suggested that the scales could be from grayling, a salmonid species now common in Shaw Creek which enters the Tanana River near the site, but he cautioned that a predatory bird or something else other

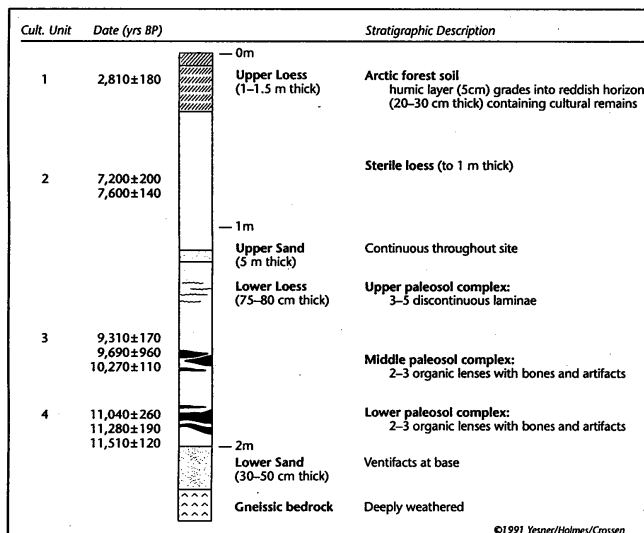
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Location of the Broken Mammoth site in the middle Tanana Valley, Alaska.

mostly waterfowl and cranes, made up 40 percent of the total and small mammals 20 percent. Mammal remains include moose, caribou, beaver, hare, ground squirrel and small rodents. Small mammals were predominately ground squirrels and hares. Yesner said that some of the small mammal bones might not have been at the site as the result of human agency, but he suggests that human occupation may have been timed to take advantage of local wildfowl migrations; it probably means that the modern migratory bird flyways had been established by 11,500 years ago.

"It may well be that those people timed their



Generalized stratigraphy of the Broken Mammoth site.

occupation, specifically, at least in part, to get some of the birds as they came up in the late summer and early fall during their migration period." Yesner noted that cranes, swans, and other waterfowl continue to congregate in large numbers along the Tanana River in September. Those early Americans, Yesner notes, were trying to maximize their food supply by taking small animals and birds as well as big game.

Two conflicting recent reports on the genetic histories of American Indians raise the question of whether these molecular studies are a gold mine or a mine field to those seeking details about the peopling of the Americas.

Theodore Schurr and his coauthors, centered at Emory University in Atlanta, concluded that American Indian mitochondrial DNAs (mtDNAs) derived from perhaps four founding females in the colonizing population(s). Richard Ward and his coauthors, working out of the University of Utah in Salt Lake City, concluded that American Indians derive from many more than four founders, thus suggesting that several migrations may have been responsible for peopling the Western Hemisphere.

Since neither study is comprehensive, further work will be needed to achieve a clear outline of the peopling of the Americas. Still, the two studies can give us an overview of the frontier where genetics, molecular biology, and anthropology intersect. The two studies agree on a basic point. Both the Atlanta and the Salt Lake City groups present findings that New World colonizers came from Asia, confirming previous genetic evidence.

Both research groups analyzed the hereditary but non-chromosomal molecules of DNA found in the mitochondria of cells (*Mammoth Trumpet* 6:3 "Living Cells Unlock Ancient Mysteries," and 6:1 "Studying Ancient American DNA"). Each cell has mitochondria numbering in the hundreds or thousands in the cytoplasm outside of its nuclear horde of chromosomal genes. Mitochondria uniquely produce chemical energy for cell functions; life would be impossible without them.

The minute mtDNA molecule is circular and over 16,000 subunits in circumference, and each subunit is known as a base pair, or bp. A decade ago the sequence of base pairs was identified for the entire mtDNA molecule from one individual source. This sequence is used as the standard for measuring mtDNA differences in other individuals. Since mtDNA changes, or evolves, quite rapidly in its base-pair sequence, individuals chosen at random are usually quite different in their mtDNA sequence "signature." Curiously, mtDNA is inherited intact through the female line (see box on Page 5), which simplifies study of its evolutionary history.

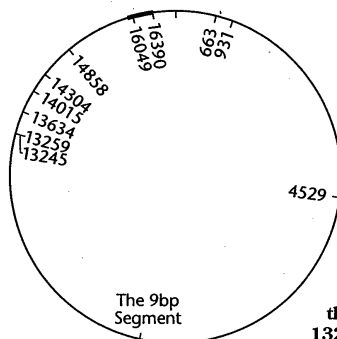
Both the Schurr and Ward groups isolated mtDNA from cells of American Indians and, in certain cases, broke the molecular circles into precisely sized segments using various enzymes that cut DNA. Each enzyme cuts at a specific but different kind of site. These cutting enzymes, called restriction endonucleases, are a vital part of the tool kit of molecular genetics. If an individual's mtDNA has a critical base-pair change—a mutation—at a restricted cutting site, the enzyme will not cut there. Such variant DNAs are genetic clues to the past.

Another part of the tool kit of importance to the study of human origins is the polymerase chain reaction (known as PCR). Using this technique, any chosen segment of the mtDNA circle can be copied many-fold to provide an abundant supply of identical sequences for analysis of base-pair variation. This amplification of a DNA segment requires having on hand so-called primers, short runs of DNA that can bind specifically to the two ends of the desired segment. By a simplified analogy, one could uniquely locate this particular paragraph in this issue of the *Mammoth Trumpet* by knowing that the first three words in it were "Another part of" (the front-end primer), and that the last three words were "quickly and conveniently" (the back-end primer). The paragraph could then be copied in either direction in its entirety, as many times as one wished. Before the PCR technique was developed several years ago, ferreting out information on a particular sequence from human DNA, isolated from unique individuals, was arduous because the sequence was not a readily renewable resource. With PCR, an individual's DNA can be restudied in many ways quickly and conveniently.

The laboratory techniques, then, of the Atlanta and Salt Lake City groups were quite similar. So

# Paleoindians and DNA: A Review

By Dee Baer



On this mtDNA diagram is a small, darkened arc just past 11 o'clock that represents the 360-bp sequence from numbers 16024 through 16383 studied by Ward and his coworkers using the PCR technique. Twenty-six variable sites were found within this arc by the Ward group. The variable sites numbered 16049 and 13259 were studied by both the Ward and Schurr groups, as was the 9-bp segment located near the bottom of the circle. The other variable sites listed on the circle, nine in all, were studied only by the Schurr group. These nine, plus the 16049 and 13259 sites, are detectable using restriction enzymes.

what might account for the difference in their conclusions about the number of Asian colonizers of the Americas?

The main reason for the difference seems to be that Ward et al. scanned 26 variable sites in the mtDNA molecule while Schurr et al. scanned only 11. In addition, both groups tested for the deletion of a certain nine-base-pair segment of the molecule, one that was previously known to occur in low frequency in some Asian and Pacific peoples.

Since the two groups studied largely different mtDNA sites (as shown in the accompanying chart), the totality of their findings cannot be compared directly. Yet it is possible to compare the two labs directly on three mtDNA sites, all of which are known to occur in Asia (and also in the Pacific) in low frequencies. For these three sites, four different genetic types (often called haplotypes) can be distinguished overall (see accompanying table). The Nuu-Chah-Nulth, or Nootka, of Vancouver Island and the Olympic Peninsula, were studied by the Ward group. The Pima of Arizona, the Maya of Yucatan, and the Ticuna of the Amazon Basin were studied by the Schurr group. The Nuu-Chah-Nulth have three of these four haplotypes, while the Pima, Maya and Ticuna taken together have all four. In contrast, when we look at the complete data set given in each report, we find that the Nuu-Chah-Nulth have 28 different haplotypes while the Pima, Maya and Ticuna considered together have only 14. Clearly the higher the number of variable sites studied in human mtDNA, the greater the genetic variability that is discovered. As every reader knows, the thicker the book, the larger the number of typographical errors that slip (oops!) slip in.

In any event, based on present information none of the four American Indian groups studied can be derived genetically from a single female founder—a mother of the tribe, so to speak. All the groups are genetically heterogeneous: the Nuu-Chah-Nulth haplotypes, for instance, differ by up to 13 mutational changes. That is, chance differences (mutations) have become embedded in various

lines of descent in 13 base pairs scattered throughout the 360-base-pair mtDNA segment that they studied. Indeed, as Ward and his coauthors point out, the Nuu-Chah-Nulth population is at least 80 percent as diverse as the much more numerous Japanese population, studied previously in the same manner.

While the Nuu-Chah-Nulth have 28 different haplotypes, this finding cannot be attributed to a large number of individuals being sampled. Only 63 were. The Schurr group studied 99 individuals among three widely separated tribes—31 Pimas, 37 Mayas and 31 Ticunas—and found only 14 types. Nor can the greater genetic diversity in the Nuu-Chah-Nulth compared with the other three tribes be attributed to a higher percentage of outside genes. According to these reports, while the Pima have only one percent admixture with Europeans and the Nuu-Chah-Nulth up to five percent, the Maya have 10 percent. The Ticuna have two percent admixture with non-native populations. Taking the numbers studied and the genetic admixture into consideration, it seems that the level of mtDNA variability studied per individual is more important than either sample size or a modest level of admixture in producing the dissimilar results of the Schurr and Ward research groups.

The meaning of the mtDNA variability found in the Nuu-Chah-Nulth is somewhat problematical until it is confirmed for other Amerindian groups. But such intra-group diversity has already been established for nuclear genes in South American tribes by a team led by James V. Neel of the University of Michigan. That team studied variation in traits such as enzymes and immunological proteins, all the products of chromosomal DNA.

The magnitude of genetic diversity observed in small American Indian groups suggests to Ward and his coauthors that the Beringia crossing event was not a genetic bottleneck, contrary to the opinion of the Schurr group. Likewise, neither was the passage of Paleoindians through the Panamanian isthmus a bottleneck. Preliminary results from a research team at Yale University (J. R. Kidd and K. K. Kidd) on nuclear, rather than mitochondrial, DNA also argue against bottlenecks. Geographical constrictions need not be genetic ones.

Dee Baer is a human geneticist with special interest in indigenous populations of Southeast Asia.

Observed mtDNA Haplotypes			Tribal Frequencies (percent occurrence)			
Has 16049 restriction site	Has 13259 restriction site	Has 9-bp segment deleted	Nootka	Pima	Maya	Ticuna
yes	yes	yes	3.2	45.2	21.6	0
yes	yes	no	77.8	3.2	67.6	64.5
yes	no	no	19.0	51.6	10.8	3.2
no	no	no	0	0	0	32.3



## Tracing Human Evolution: Was it Really Ariadne's Thread?

**M**itochondria have an unusual inheritance pattern, being transmitted entirely, or almost entirely, through the egg rather than both the egg and the sperm. Thus mtDNA is passed on maternally, from mother to daughter, down through the generations. Sons do not pass it on.

This pattern of inheritance permits evolutionary biologists to follow, as best they can, the Ariadne thread through the labyrinth of American Indian genetic history, as revealed by breeding females. But now comes the catch. Does the thread they follow really belong to the famous daughter of Minos who showed Theseus the way out of the labyrinth?

The person who developed the field of female-line human evolution through mtDNA studies was the late Allan C. Wilson of the University of California at Berkeley. Wilson, an inspired and indefatigable researcher, was able to show, with the aid of various coworkers, that all human mitochondrial DNA could be traced back to African females living about 200,000 years ago. Or so it seemed.

Wilson, however, was not one to leave a stone unturned. Before he died of leukemia in July, 1991, he and several colleagues published a paper in the journal *Nature* on the inheritance pattern of mtDNA in mice. The investigators found paternal mitochondrial genes can leak, or sneak, into the fertilized egg. Since an unfertilized egg has about 100,000 mtDNA molecules while a sperm cell has only 50, it is technically difficult to detect a mtDNA contribution from the sperm to the next generation. In fact, no such trace of paternal mtDNA has so far been detected in humans; although it may exist.

Wilson's studies on mice show why paternal mtDNA leakage in humans is suspected to exist. Dan Wharton, a research worker at the Bronx Zoo, had developed a mouse strain that is descended from a hybrid between two mouse species. Hybrid females were back-crossed to the father's species. Daughters were again back-crossed in the same fashion for 26 generations.

The process maximizes the input of paternal mtDNA, should such exist. The strain that Wharton produced has most of its heredity identical to that of the patriarchal mouse species. The only matriarchal genetic contribution, according to standard theory, is the mtDNA from the original hybrid female's egg.

Wilson realized that this newly created mouse strain was a suitable test animal for his purposes. He and his colleagues analyzed the mtDNA of the two original species, noted the differences (which are greater between species than between populations within a species), and searched for male-contributed mtDNA traits in Wharton's back-crossed strain. They discovered that only about one mitochondrion per thousand came from the patriarch's species.

If such leakage occurs in humans, one effect would be paternal mtDNA taking over a maternal mtDNA line of descent on rare occasions, causing a few twigs or branches of the human evolutionary tree to be misplaced grafts. Secondly, since this paternal inheritance expands the calculated size of the ancestral population somewhat, the effect is to make our ancestral genetic diversity appear to be greater than it actually was. The time periods previously estimated by molecular evolutionists for such events as the emergence of modern humans or the colonization of the Americas are then overestimated, with errors accumulating as time goes on. It is thus possible, for instance, that modern humans arose in Africa not 200,000 years ago but more recently, maybe even 75,000 to 100,000 years ago. Or so Allan Wilson speculated before his untimely death. It is also possible that the time of divergence of various ancestral Nu-Chah-Nulth haplotypes proposed by Richard Ward's group, based on the same Wilson-esque calibration of the mtDNA evolutionary clock, is too great. Instead of these ancestral haplotypes separating from 41,000 to 78,000 years ago in Asia, they may have separated more recently. But whether they did so in Asia or in the New World remains a conundrum. —Dee Baer

for people on the move. Small bands may be an amalgam of ancestral genes from widely dispersed homelands.

The wealth of genetic diversity in small groups reflects, according to the Ward report, the propensity of small human groups to be part of large interacting social networks. Genetic diversity is the biological spin-off from cultural interactions. If genetic diversity characterizes tribes, can the notion of three or any other number of discrete colonization waves across Beringia be supported?

Since work over a number of years on nuclear genes has shown that northern peoples often referred to as Aleuts and Eskimo are closer to northeast Asians than to American Indians, these people can easily be counted as one wave. Confirmation of this view by future mtDNA studies can be expected with some confidence. For the rest, no mtDNA studies have yet been published on speakers of Athapaskan languages; so whether these tribes represent a separate wave has not been substantiated genetically. To sort out the evolutionary relationships among the rest of the American Indians, however, will clearly require more mtDNA information than we are likely to have soon. Not only will a great variety of American tribes need to be studied, but also various Siberian peoples, as the Schurr report points out. So far, much more is known genetically about more southerly Asians, such as the Japanese and Han Chinese, than is known about Siberians.

Beyond quantifying the number of Asian waves or trickles across Beringia, their timing is an intriguing question. Molecular-genetic reports so

far provide no firm answer to the timing question, although there is already some progress in that direction.

Since mtDNA changes, or mutates, over time it acts as a ticking clock in a matriarchal line of descent. If two strangers share a great-grandmother in common through their mothers and maternal grandmothers, they are likely to have identical mtDNA base sequences. Or, just possibly, they may differ from each other at one of the more than 16 thousand sites in the mtDNA sequence, caused by a mutation subsequent to the great-grandmother's time. Briefly, comparing human mtDNA overall with mtDNA from a species such as the common chimpanzee provides a base line for estimating the time of divergence between different types of human mtDNA found today. The mtDNA clock can be calibrated in years by the divergence interval between human and chimp lines of descent as estimated by paleontological evidence. Based on human-chimp divergence estimates ranging from four million to nine million years ago, Ward and his coworkers have tentatively estimated that certain of the 28 Nu-Chah-Nulth haplotypes they discovered started to diverge 41,000 to 78,000 years ago. This calculation appears to rule out a close maternal relationship among the early American ancestors of the Nu-Chah-Nulth. If this is so, the Nu-Chah-Nulth are an amalgam, but whether the amalgamation took place 10,000 or 50,000 years ago, or occurred by accretion over many millennia, is a mystery. If it took place between 15,000 and 33,000 years ago, it just might represent different "waves." But all this is conjecture.

## UPCOMING CONFERENCES

Feb. 6-11 American Association for the Advancement of Science Annual Meeting, Hyatt Regency Chicago, Chicago, IL.

Sessions Sunday, Feb. 9 will include "The Newest World: Original Peopling of North America," with papers by Enoke Szathmari on genetic evidence for Asiatic origins, Richard Morlan on Beringian paleobiology, Russell Graham on dynamic fluctuations of late Pleistocene biota, Jack L. Hoffman on Western founding populations, David Anderson on Eastern founding populations, and other specialists. Richard MacNeish will lecture on "The Earliest North Americans." A session on South American Paleoindians will include papers by John Rick on Andean Paleoindians, Anna Roosevelt on early foragers in the Amazon, Wesley Hurts on the earliest Indians of East Brazil, Ruth Gruhn on Paleoindian sites in interior Brazil, Alan Lyle Bryan on early occupations of northwestern South America, and other specialists.

April 1 Human Biology Council, Hotel Riviera, Las Vegas, NV.  
Contact: Dr. Sheila Brooks, University of Nevada, Las Vegas.

April 1-4 American Association of Physical Anthropologists, Hotel Riviera Las Vegas, NV.  
Contact: Dr. Sheila Brooks, University of Nevada, Las Vegas.

April 8-12 57th Annual Meeting of the Society for American Archaeology, The Pittsburgh Hilton & Towers, Pittsburgh, PA.

April 16-18 45th Annual Northwest Anthropological Conference, Simon Fraser University, Burnaby, British Columbia.

Plenary sessions April 17 will feature speakers from the academy of Science, Yakutsk, Siberia, Yuri A. Mochanov on "Early Paleolithic in Northeast Asia" and Svetlana Fedoseeva on "Neolithic Cultures of Yakutia." Papers will include all aspects of anthropology. There will be a special exhibit on contemporary native art in British Columbia.

Contact: NWAC Steering Committee, Department of Archaeology, Simon Fraser University, Burnaby, B.C., Canada V5A 1S6 (604) 291-3135.

May 6-10 25th Annual Meetings of the Canadian Archaeological Association, London Centre Radisson Hotel, London, Ontario.

Contact: Neal Ferris, 55 Centre St., London, Ontario N6J 1T4 (519) 433-8401 FAX (515) 439-1696.

The mtDNA data on the Nu-Chah-Nulth do tell us, however, that this tribe did not arise from a one-time-only fusion of two genetically homogeneous groups. The mtDNA diversity in the Nu-Chah-Nulth goes far beyond that possibility. Nevertheless, multiple fusion, and perhaps also fission, events cannot be ruled out.

The data presented in the papers by the Atlanta and Salt Lake City groups are like potsherds. We may fit together such fragments as we have and envision a whole as best we can.

## A MAMMOTH DATA BASE

Dr. William Gregory, dean of the College of Science and Engineering at Gannon University, Erie, PA., is working with Gannon archaeologist M. Jude Kirkpatrick to plan a national data base of information on mammoth discoveries. Kirkpatrick said that Gregory is developing a system that will make use of a new computer center now under construction at Gannon. The two researchers are working with a major corporation in exploring the use of computer techniques that will give three-dimensional designs of mammoth bones. Kirkpatrick said the system will automatically measure and store dimensions of each bone.

## Pendejo Cave

*continued from page 1*

(A third, smaller piece of clay also appears to contain a print, but because the piece is so small, it is not clear whether the print is human or not.)

The finger or palm prints have been dated by samples taken from locations immediately above and adjacent to the prints' original location. The sample from zone H, immediately above and adjacent to the prints, produced two dates, 27,860 and 30,300 years B.P., and the sample taken from an adjacent square of zone I—the zone that produced the prints—produced a date of 27,960 years B.P. "So it looks like we have a pretty good fix on the date, and it looks like we have pretty good evidence of human beings," MacNeish says with evident satisfaction. Arrangements are also being made to date the clay itself by thermal luminescence, but this date will not be as good as the C-14 one, he added.

It is possible that even more prints will be found. "Crazily enough, we have a large clay sample from that square—which is in our soil sample to be analyzed—which we haven't literally ever looked at. And we also have a piece of that same piece of clay still sticking in the wall. So we may have a number of fingerprints before we're finished. All we need is the finger!"

Pendejo Cave is 30 miles north of El Paso, Texas. (see *Mammoth Trumpet* 6:2 "Pre-Clovis Barrier Broken in New Mexico?") Situated on the edge of Otero Mesa, the cave is halfway between the lower valley basin and the Sacramento Mountains. The location made it ideal for hunters, MacNeish says. "Every year, when winter came on, animals migrated from the mountains into the valley bottom. People could sit in this cave and knock off the migrating animals with great ease, then drag the animals up to be butchered and eaten in the cave." As a result, the tools found in the cave have been butchering tools; few other kinds of stone tools have been found there. The cave measures five meters wide and 12 meters deep, with a maximum ceiling height of three meters.

MacNeish began work at Pendejo Cave in 1990. During that first season, his team dug a three-meter by five-meter trench that revealed 24 stratigraphic zones and at least 28 occupation levels. These occupation levels produced a wide range of stone tools used for butchering. Soon after the end of the first season, a sample taken from zone K produced a radiocarbon date of 24,450 ± 620 years B.P. (UCR-2499a).

During the 1991 season, MacNeish's team ex-

tended the excavations both inside and immediately outside the cave, and sent out many charcoal samples for radiocarbon dating. Twenty-eight dates have been produced thus far with zone L showing the cave's oldest date of more than 38,000 years B.P.

The range of pre-Clovis dates from the cave is extensive: all but one of the dates reported thus far are more than 11,000 years old. According to the Clovis theory of the peopling of the Americas, no human beings lived in North and South America before 11,000 years ago. However, the dates from Pendejo Cave, from charcoal taken from human occupation levels, begin at 1,150 years B.P. and extend to 38,000 years B.P.

The dating process involved two difficulties: anomalous dates and the limitations of dating equipment. The anomalous dates (see table) may be explained by the fact that the inhabitants of the cave had repeatedly dug pits, including hearths, storage pits, and a pit house, throughout the cave's history. "If you dig a pit from one level down to the next, you're liable to dig up a piece of wood that's 10 thousand years older than the floor you're living on, and you deposit it on your floor and this can make, and has made, for some very confusing carbon-14 dates," MacNeish says.

Of all the eight dates that are improbable, he notes, "Almost every one of those is older than it should be. In other words, these people, in digging up their pits, keep digging up earlier wood which screws up our dating of that floor." Despite this difficulty, the site has now produced 13 dates MacNeish considers "quite probable, in good sequential order," and seven which he terms "not bad." Twenty out of 28 carbon-14 dates is a pretty good average, he adds.

The second dating difficulty is the fact that the inhabited layers extend back before the time period

Stratum	Date B.P.	Possible/Improbable Date
A Grass, soil, rodent and owl droppings and vegetal material	no date	
B Charcoal and vegetal material; dark brown soil	1,150 ± 100	16,410 ± 260
C Charcoal		
C2-D Charcoal with some vegetal matter	12,970 ± 170	
D Charcoal	16,440 ± 650 17,380 ± 150	
E Cemented sediments	19,180 ± 290	>28,430
F Charcoal	19,930 ± 230	
F1	21,350 ± 350	
G Charcoal underlain by pale deposits	27,090 ± 190	>31,600
H Charcoal	27,860 ± 260	30,350 possible and 33,830, 32,800
I Charcoal over pale silty sediment	27,960 ± 970	35,960 ± 740
J Charcoal over pale soils	>28,500	>37,000
K Charcoal	29,650 ± 900	>36,920 possible and 25,420 ± 620
L Charcoal	32,500	>38,100 possible
M Charcoal and burned clay		>35,560 possible and >29,200
N Orange-brown mature soil		30,210 ± 840 and >36,290 possible
O Loess-like sediments	no date	

### Pendejo stratigraphy and dates.

that the average radiocarbon machine can accurately date. The typical machine can date carbon back to about 35,000 years ago. However, a newer, enriched-carbon dating technique gives off more radioactivity and is easier to read; these machines can detect the clicks of the carbon-14 isotope and measure back to 40,000 or 50,000 years ago. MacNeish hopes to use one of these newer machines to date the cave's older levels.

No bones have yet been used for dating. "It takes much more bone than carbon to get a good date," MacNeish explains, adding that he wants to identify every bone before using any bones for dating purposes. Eventually, with enough funding, he will use some bones for dating.

The excavations have produced stone tools from every level except the lowest part of level O. These tools include chips, flakes, cores, choppers, unifaces, scrapers, flake-pointed wedges, burins, anvils

*continued on page 8*

## Underwater Mammoth

*continued from page 1*

thing else," he explained. The waters are under the jurisdiction of the commonwealth of Pennsylvania and a state permit would have been required if equipment, such as a floating platform, were to be used. "We told them we weren't going to use any equipment." For two months Kirkpatrick, his volunteer team, and students worked at bringing up the mammoth bones and mapping the site. About 90 percent of the skeleton of one individual mammoth was recovered before the season brought a temporary halt to the project.

While recovering the bones, the team noticed some prominent stones scattered amid the remains of the mammoth. "We spotted a couple and we warned everyone to look for this type of stone," Kirkpatrick said. He suspects that the stones might have been sinkers or anchors, but he emphasizes that more investigation is needed before it will be possible to advance the likelihood that the find represents a Paleoindian meat cache. Such a hypothesis has been suggested by the discoveries of Dr. Daniel C. Fisher in a pond bed in south-central Michigan (*Mammoth Trumpet* 6:4 "Clues to Paleoindian survival: Underwater caches may have supplied meat in winter"). "We're not sure how these sinkers or netstones are associated or even if they are associated with this. You sort of suspect that they are," Kirkpatrick said.

Mapping the possible anchor stones proved diffi-

cult as the crew brought bones and rocks up from the bottom of the lake, a kettle formed during the retreat of the last Pleistocene glacier. Many of the suspect stones were mapped, but the volunteers couldn't plot provenience for all of them. A top priority for Kirkpatrick will be studying the lake bottom for the stones. "We're going to try to determine just where those stones belong."

The team recovered most of the animal's skeleton including skull, mandible and tusks, and Kirkpatrick expects to recover the remainder next spring. Meanwhile, work is under way on the material recovered. An obvious but challenging question is whether the bones display cut marks left by human butchers. He indicates that he is encouraged, but cautions that much more work needs to be done.

"We're still trying to stabilize the bone and preserve it," said Kirkpatrick, who has been conferring with Fisher on the project. Fisher, of the University of Michigan's Museum of Paleontology and Department of Geological Sciences, has taken some tusk of the lake-bottom mammoth for analysis. So far no dates have yet been established for the animal.

Fisher's own site in Michigan is a Pleistocene pond bed where excavations have been under way since 1986. There, the disarticulated remains of a single mastodon buried in typical pond sediments were associated with some unexpected football-sized concentrations of sand and gravel. After careful analysis, evidence indicated that cobbles and coarse clastic materials were artificially introduced into a piece of mastodon intestine. Further evidence

indicated the animal died about 11,000 years ago in the early autumn. Fisher postulated that humans had created intestine anchors to weigh down sections of the mastodon carcass for safe underwater storage in winter.

Ever since the first evidence that early Americans killed mastodons and mammoths for food, researchers have pondered how the human hunters protected their kills from the large, fierce predators and scavengers known to have been plentiful. By sinking meat supplies under water—likely under ice—people would have kept their food away from harm.

Partially burnt wood at Fisher's site in Michigan raises the possibility that people built fires on the frozen surface of the pond to retrieve their food caches from water below the ice.

Besides Fisher, Kirkpatrick has been conferring with John Gardner, conservator at the Carnegie Museum in Pittsburgh, Steven Koob, conservator at the Freer Gallery in Washington, D.C., and Dennis Stanford, conservator of archaeology at the Smithsonian Institution in Washington, D.C.

When Kirkpatrick and his scuba-diving team return to their site at the end of this winter, they are going to be prepared to seek answers for more of the interesting questions the site poses. The team is going to be prepared for underwater work, for some of his students this winter are undergoing the specialized training necessary to do archaeology in scuba diving gear. —DAH



# EDUCATION IS BIGGEST YIELD FROM SITE ON ALASKA COAST

The process may be more important than the discoveries at a recent project near Sitka, Alaska. There, the U.S. Forest Service and Mt. Edgecumbe High School have undertaken a joint project in which high school seniors have excavated an archaeological site and conducted the analysis of recovered material.

Stanley D. Davis, forest archaeologist for the Tongass National Forest, hopes the project will serve as a prototype for programs in archaeology and other fields at high schools elsewhere.

"The most important thing about this project is not the archaeology," said Karen Swanson, "but it's the education." Swanson is one of six archaeologists working with Davis on the joint Forest Service-high school project. The site, a midden in a popular picnic area close to tidewater, was tested by the Forest Service in 1984 and found to have been used from about 800 years ago until the period of historical contact. Under the National Historic Preservation Act the Forest Service was obliged to protect and save information from the site, so when erosion was threatening damage, additional archaeology was indicated.

Meanwhile, educators at Mt. Edgecumbe High School had been looking for a project that could involve students, many of whom are from native Alaskan villages far from Sitka, in multidisciplinary exercises. The archaeology work soon became part of the students' work in science, English, social studies, computer, and video production classes.

Surveying, mapping and photography began in September followed by excavation. A field laboratory was set up in a picnic shelter. The high school students, several of whom are from native fishing villages, brought special knowledge to the field work, as the supervising archaeologists soon learned. Swanson said they frequently showed insights about artifacts and faunal remains they uncovered.

When one found a tooth, another immediately identified it as a seal's. Challenged about his identifi-

*"A lot of learning  
has been going on  
all around."*

cation, the student went into a long explanation that revealed his obvious knowledge of seals.

Field work ended the first week in October and recovered material was taken to a high school room used strictly for a lab. There students learned more about laboratory analysis than some wanted to know. After working for some days with a part of the crew sorting through shells from a sample column

taken from the center of the midden, one of the students voiced her frustration to Swanson. "I had no idea it would be this boring," she said. Another group is doing faunal identification while a third works on artifact descriptions and enters them into the Forest Service's data base.

Mt. Edgecumbe High School students were well practiced on Macintosh computers, but to work with the agency's data storage system, they had to bring an old IBM computer out of retirement. The students came up with their own idea of describing the site, known officially as 49SIT229. With their Macintoshes and Hypercard software, they created a descriptive report. They're also writing a conventional report and if they can raise travel money, they will go to Fairbanks in March for the Alaska Anthropological Association meetings to read a paper, display a poster and show their computer report.

The educational impact of the project has spread beyond the students who are directly involved. As part of their English assignments they have written stories for their local newspapers. Swanson says the students have become sensitive of the danger of vandalism to archaeological sites and what people should do should they find materials that might be of archaeological significance. "A lot of learning has been going on all around," said Swanson. —DAH

## SUGGESTED READINGS

### ON Paleoindians and DNA

Mullis, K. B. 1990 The Unusual Origin of the Polymerase Chain Reaction. *Scientific American* 262:56-65 (April).

Schurr, T. G., S. W. Ballinger, Y-Y. Gan, J. A. Hodge, D. A. Merriwether, D. N. Lawrence, W. C. Knowler, K. M. Weiss, and D. C. Wallace 1990 Amerindian Mitochondrial DNAs Have Rare Asian Mutations at High Frequencies, Suggesting They Derived from Four Primary Maternal Lineages. *American Journal of Human Genetics* 46: 613-623.

Ward, R. H., B. L. Frazier, K. Dew-Jager, and S. Pääbo 1991 Extensive Mitochondrial Diversity Within a Single Amerindian Tribe. *Proceedings of the National Academy of Sciences, U.S.A.* 88:8720-8724.

### ON Ariadne's Thread

Avisé, J. C. 1991 Matriarchal Liberation. *Nature* 352:192.

Gyllenstein, U., D. Wharton, A. Josefsson, and A. C. Wilson 1991 Paternal Inheritance of Mitochondrial DNA in Mice. *Nature* 352:255-257.

Ross, P. E. 1991 Crossed Lines. *Scientific American* 265:30-32 (October).

### ON Interior Alaska Site Rich in Faunal Remains

McDonald, J. N. 1981 *North American Bison, Their Classification and Evolution*. University of California Press, Berkeley.

Wilson, M. 1974 The Casper Local Fauna and its Fossil Bison, 125-171 in *The Casper Site: A Hell Gap Bison Kill on the High Plains*, ed. G. C. Frison. Academic Press, New York.

### On Pre-Clovis Human Prints Found in New Mexico

Brian, A. L. (ed.) 1986 *New Evidence for the Pleistocene Peopling of the Americas*. Center for the Study of Early man, University of Maine, Orono.

MacNeish, R. S. 1976 Early Man in the New World. *American Scientist* 64:316-327.

MacNeish, R. S. 1978 *The Science of Archaeology?* Duxbury Press, North Scituate, Mass.



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See other side for more publications and payment instructions

## Broken Mammoth

continued from page 3

than human hunters could have been responsible for transporting the scales to the site. "If it's the result of humans bringing them in, then why were there no vertebrae?" Yesner then offered one possible answer to his rhetorical question: "Salmon vertebrae don't always preserve well; salmonids are pretty cartilaginous. Who knows?"

In contrast to faunal material, the site has, so far, not proven rich in tools. Holmes is analyzing the artifacts and he says that the oldest layers contain Paleoindian stone points that are similar to the earliest tools found in continental United States. Points from Broken Mammoth are somewhat smaller than those found farther south. Basally thinned Paleoindian projectile points have been found in the middle paleosol, a level dating back about 10,300 years. Yesner and Holmes note that these points are reminiscent of points from Charlie Lake Cave in northern British Columbia that date to about 10,400 years ago. The team speculates that the Paleoindian points may have been made on previously broken, resharpened bifaces. The 1991 excavations produced only one such tool. Artifacts of several lithologies (rhyolite, chalcedony, obsidian, chert, and basalt), including flakes, retouched flakes, flake burins (Donnelly type), burin spalls, microblades, and small wedge-shaped microblade cores (Campus type) were localized in a few of the units investigated in 1990.

A variety of other analysis is in progress this winter. Working with geologist Crossen in analyzing soil sequences and sediments is Thomas Dilley, a former UAA student and instructor, now a graduate student at the University of Arizona. Among the more unusual materials to be analyzed are bird egg

shells. Presence of the shells suggests that the site was used during the waterfowl nesting season. Terrestrial snails and beetle fragments are also being analyzed, along with macrobotanical remains such as seeds. The investigators also hope to establish the season of site occupation through analysis of teeth of the large mammals (bison and elk).

Broken Mammoth and nearby sites offer ideal juxtaposition of geological features, and Yesner believes that similar well-drained places in central Alaska near a source of plentiful wind-deposited soil might be profitably surveyed. "I think there are possibilities for a lot of other areas in the interior with bluff-top sites on south-facing slopes," said Yesner, but he acknowledged that the area near the confluence of Shaw Creek and the Tanana River happens to offer a happy combination of features necessary for the preservation of a Paleoindian site. The team will be looking for more sites and attempting to determine how many more there might be.

As analysis continues, anticipation focuses on next summer's field season when Yesner, Holmes, and their crews will continue to remove the bluff face westward from the 1991 excavation. Support of the National Geographic Society will help expand the investigation. Workers in the coming season will include students in UAA's archaeology field school. Yesner is confident of finding additional sites nearby.

Will future excavations unearth mammoth bones or more clues to bison evolution? Whatever the new discoveries, they will undoubtedly increase our knowledge of the way of life led by early people in that lowland between mountain glaciers and the continental ice sheet that for a time in the late Pleistocene was a corridor into a continent.

—Don Alan Hall



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22. The Adkins Site: A Paleo-Indian Habitation and Associated Stone Structure	_____	\$17.50	\$18.50	_____
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## Pendejo Cave

continued from page 6

cores, blades, endscrapers and spokeshaves. From above the early levels came an obsidian knife, and a variety of points—an Armijo point, a Matamoros point, Pendejo points, a Perdiz point, and a Tesuque point. About 55 percent of the tools are made from rock that occurs inside the cave; the remaining 45 percent are made from stone that has been imported into the cave. The sources of this foreign stone are located as far as 10 miles away.

The stone tools comprise at least three cultural complexes that date before the Clovis era: the Orogrande, MacGregor, and North Mesa complex. The Orogrande complex is the earliest, dating back possibly to 40,000 years ago. It is found in zones N and O, and it has produced 42 artifacts, including 18 choppers and 28 chips. Its tools are predominately pebble tools.

"One of the simplest chipping tools is to take a pebble out of the arroyo, split it in half, and you've got a nice edge and a nice hefty chopper," MacNeish explains. "This seems to be one of the ways [the cave's inhabitants] butchered in their earliest time period."

Among the most telling finds are several examples of projectile points embedded in fossil bone. These finds reinforce evidence that human beings inhabited the cave at very early time periods. One of the examples is a fragment of a spear point sticking in the back of a horse ankle bone. The point extends one centimeter into the bone; according to MacNeish, about a 40-pound thrust would have been required to thrust the point that deeply into the bone. Only a human being could have produced that kind of thrust, MacNeish says.

The presence of stone foreign to the cave is another indication that human beings occupied the cave. No animal other than human beings would carry pieces of stone, including large cores and pebbles, into the cave from sources as far as 10 miles away. "These are decisive evidence, along with the dates, of pre-Clovis man," MacNeish concludes.

In addition to its effect on the Clovis theory of human migration to the Americas, Pendejo Cave is also producing strong evidence that contradicts the Clovis theory of extinction. According to this theory, the human beings who migrated through the Americas some time after 11,000 years ago hunted to extinction dozens of species. However, Pendejo Cave has produced evidence that many of these species became extinct long before the 11,000-year Clovis date.

"We have in our lower levels one kind of animal that became extinct before 30,000 years ago," MacNeish explains, "we have other kinds of animals becoming extinct 20,000 years ago; other animals becoming extinct 10 or 11,000 years ago, and we have very few people around. So it doesn't look like man, in one sudden overkill period, killed all the animals off. For example, the Aztlán rabbit, *Aztlanlagus agilis*, was supposed to have become extinct 11,000 years ago. Well in fact, these were becoming extinct 30 to 35,000 years ago.

"This overkill theory of rapid migration, in terms of our paleontological evidence, just seems to go down the drain. We're not only going to upset the archaeologists, we're going to upset the paleontologists and ecologists!" MacNeish says.

The cave is also producing evidence of environmental change, including at least four environments in the last 40,000 years. An early environment that appears to have existed before 35,000 years ago consisted of a desert or semi-desert grassland environment. At 35,000 to 25,000 years B.P., a forest environment existed near the cave. At 20,000 to 10,000 years ago, a thorn-forest type of desert existed and earlier in the ice age another kind of grassland-semi-forest existed. The cave has also produced evidence of changes during the last 10,000 years.

—Nancy Allison