Early People, Extinction, Vikings

- Humans on the move

- Lots of big animals went extinct 11,000 to 50,000 years ago.
  - What happened?

- New spin on the New World
  - The very early people that came to America
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Roy Jenne
13 June 2001
Humans on the Move

They say that much of literature is composed of only two plots: Someone goes on a trip or a stranger comes to town. The same might be said for the tale of human prehistory. The *Homo* lineage was born in Africa but soon expanded its range outside that continent, reaching Dmanisi, Georgia, by 1.7 million years ago and perhaps Java, Indonesia, even earlier. Members of our genus have been on the move ever since. These migrations began the global impact of humans on ecosystems and also transformed human evolutionary history, in ways researchers are still working to understand. This special issue explores where some of those early migrants went, how they got there, and what may have happened when they arrived.

Although we use the term “migrations,” these journeys were probably nothing like the purposeful flight of a bird seeking winter grounds. Rather, ancient hunting and gathering peoples presumably ventured into new territory as they searched for new resources. These hominids developed progressively more sophisticated technology during their travels, as detailed in a Review by Ambrose, and the “journey” probably took the form of a slow expansion over many generations, leaving genetic “signatures” in descendant populations, as discussed in a Review by Cann. And although the overall movement has been from Africa outward, there were probably back migrations, too.

Colonization of new continents apparently happened not once but several times. Many anthropologists think that there were no fewer than three waves of migration out of Africa: first into the Middle East and Asia, and eventually to Europe. Our own ancestors, the modern humans, later repopulated those areas and also roamed into Australia, the Americas, and the remote Pacific Islands. Four News stories by Michael Balter, Ann Gibbons, and Eliot Marshall track these waves of settlement and probe what happened when later immigrants encountered the descendants of earlier wanderers.

Our understanding of these ancient travels has been invigorated in the past 10 years by genetics, as researchers use genes to trace the original homelands of populations. After years of focus on the maternally inherited mitochondrial DNA, the paternally inherited Y chromosome is now providing complementary data, as discussed in a News story by Elizabeth Pennisi and in a Review by Stumpf and Goldstein, and comparisons between the two are yielding surprises. And the just-published human genome sequence, with its catalog of human genes and listing of the many variations seen in our DNA sequence, offers a new wealth of data for detecting the movement as well as the evolution of our ancestors. Meanwhile, researchers mining traditional data sources—fossils and artifacts—continue to gather rich results, even from such presumably well-surveyed regions as Europe. Given that one of humans’ great ecological advantages is the ability to reshape environments to our liking, perhaps it’s no surprise that these data suggest a powerful and repeated drive to colonize.

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Elizabeth Culotta, Andrew Sugden, Brooks Hanson

2 March 2001

Science
Overkill of Pleistocene Megafauna

The majority of species of large land mammals, reptiles, and birds (mostly greater than 45 kilograms in weight and referred to as the megafauna) on the major continents, such as Australia and North America, went extinct over a time period of thousands of years. This extinction has usually been attributed to the arrival, expansion, and migration of human populations who hunted the megafauna, but it has been difficult to eliminate other possible causes for megafaunal extinction, such as climate change. Two reports provide evidence for anthropogenic overkill as a primary cause in North America and Australia (see the news story by Dayton and the book review by Pimm). Roberts et al. (p. 1888) dated megafaunal burial sites across the Australian continent and estimated extinction around 46,400 years ago; 10,000 years after the arrival of humans, but about 23,000 years before the Last Glacial Maximum. The rapid extinction of some 30 large mammalian herbivore species in North America at the end of the Pleistocene 12,000 to 13,000 years ago has been attributed both to climate change and to hunting by humans. Using a computer simulation model, Alroy (p. 1893) shows that given simple assumptions about human and prey species distributions and ecology, the inference of a major mass extinction caused by hunting might be hard to avoid. The simulation model, which unites population dynamics, ecology, conservation, and anthropology, shows that humans even at low densities are capable of precipitating the collapse of prey populations.

8 June 2001

Climatology

Storms of the Centuries

Although Atlantic hurricanes frequently strike the southeastern United States and the Gulf of Mexico coast, some reach as far north as New England. The most recent devastating hurricane hit New England in 1938; the storm surge covered parts of Long Island, produced widespread destruction, and devastated many coastal areas. Donnelly et al. used the historical records of major New England hurricanes, which extend back to 1635, to develop a 700-year sedimentary record from a salt marsh in Rhode Island. Hurricanes with large storm surges deposited a clear sandy layer in the marsh. Dating these layers showed that major hurricanes, which produced storm surges that flooded the marsh, have occurred about once per century during this period. — BH


Reports

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8 June 2001
Mass Extinctions Pinned On Ice Age Hunters

Until the late Pleistocene era, 11,000 to 30,000 years ago, big, exotic mammals and flightless birds roamed the planet. Then, suddenly, they were gone. Who killed the Pleistocene megafauna? So far the prime suspect in the prehistoric whodunit, Homo sapiens, has walked free, but incriminating new evidence from Australia and North America is tightening the net. If findings reported in this issue of Science convince the scientific jury, humans will be guilty of two counts of serial mass murder, 35,000 years apart, and rival suspects such as climate change will be off the hook.

"I think we have this problem nailed," says John Alroy, an evolutionary biologist at the University of California, Santa Barbara. On page 1893, Alroy describes a detailed computer model of North American ecology during the Pleistocene. The model, which simulates the population dynamics of humans and 41 large herbivores, shows that mass extinctions were "unavoidable" once people showed up, Alroy says.

Meanwhile, scientists led by geochronologist Richard Roberts of the University of Melbourne and mammalogist Timothy Flannery of the South Australian Museum in Adelaide claim to have settled the long-standing question of when the Antipodean megafauna disappeared. On page 1888, they identify a continent-wide extinction of large mammals and birds around 46,400 years ago—a few thousand years after people are believed to have appeared there.

"The bulk of the evidence is now clearly aligned with a human explanation for the [Australian] event," says Gifford Miller, a geochronologist at the University of Colorado, Boulder. Miller also finds Alroy's simulation a "convincing argument" that human beings had a hand in the North American extinctions.

Whatever caused them, the die-offs, like their victims, were colossal. In Australia, 28 genera and 55 species of vertebrates are estimated to have vanished—including fearsome claw-footed kangaroos that weighed in at 300 kilograms and the whopping 100-kilogram Genyornis, the heaviest bird ever known. Ice Age America boasted huge saber-toothed tigers, woolly bison, giant antelopes, and the woolly mammoth. By around 11,000 years ago, more than two-thirds of America's large mammals had died out.

Intriguingly, all the extinctions, north and south, occurred after modern people arrived. But proving humans guilty has been a slow and hotly disputed process. Analyses of past climates, computer modeling, and conventional archaeological and palaeontological studies have failed to provide conclusive evidence.

Hoping to finger a culprit, Roberts dated megafauna-bearing sediments from 28 sites across Australia. Because traditional radiocarbon dating is unreliable beyond about 40,000 years in the past, Roberts used optical and thorium-uranium methods to get ages for rocks and sediment associated with large-animal remains. Optical dating relies on the fact that electrons in buried quartz grains become excited over time to higher energies by radioactive elements in the surrounding sediments. By measuring the cumulative exposure, scientists can estimate how long ago exposure to sunlight last reset the quartz clock to zero—and thus when remains were buried. Thorium-uranium dating provides the date of calcite bands on the floors of caves, above and below the animals. This provides a minimum and maximum age of death. Taken together, the dates show that large animals at the sites were buried between 51,200 and 39,800 years ago, just as human beings were spreading across Australia.

Although the results are not a "smoking gun," Roberts believes they "definitely" implicate people. "If humans hadn't arrived in Australia, the megafauna would not now be extinct," he says. He and Miller think the lethal blow was indirect. Aborigines, they believe, changed vegetation by firing the landscape, possibly to make hunting and traveling easier. The result was less food for big browsing animals, and hunting and climate fluctuations may then have tipped them to oblivion.

In North America, by contrast, hunters may have been in the thick of the faunalicidal fray. That's the idea behind the "blitzkrieg" hypothesis that geoscientist Paul Martin of the University of Arizona, Tucson, proposed in 1967. Martin reasoned that early hunter-gatherers followed their prey across the top of Asia to North America, and then south into the heart of the continent. Hungry hunters caused local extinctions, which ultimately drove total populations down the slippery slope to extinction.

To test Martin's idea, Alroy programmed a computer to run a large-scale simulation of virtual hunters moving into virgin territory in late Pleistocene North America, starting 14,000 years ago. He included a range of parameters that let him specify how quickly the invaders traveled, how efficiently they hunted, and how various prey species competed with one another for food. Alroy found that no matter how he adjusted the variables, mass extinctions ensued. Even the slowest, clumsiest hunters unleashed ecological devastation. Hardest hit were large animals, whose slow growth rates and long gestation periods made it difficult for them to bounce back once their populations slumped.

Not everyone is convinced. At the American Museum of Natural History in New York City, biologists Ross MacPhee and Alex Greenwood blast Alroy's model, because they say overkill can't explain why extinctions stopped 10,000 years ago, when the Pleistocene gave way to the modern Holocene era. If hunters were wiping out species tens of thousands of years ago, MacPhee says, "they should be just as bad through the Holocene." Instead, he and Greenwood suspect that the huge animals succumbed to a "hyperdisease"—a highly contagious, lethal virus introduced by human newcomers. But Alroy counters that MacPhee misses the model's main point: showing that the late Pleistocene extinctions could have occurred even without climate change.

If the two studies hold up, they carry a contemporary message, Alroy says: "The results show how much havoc our species can cause, without anyone at the time having the slightest idea of what is going on, much less any intention of causing harm."

-Leigh Dayton
Leigh Dayton writes from Sydney, Australia.
New Ages for the Last Australian Megafauna: Continent-Wide Extinction About 46,000 Years Ago

Richard G. Roberts,1* Timothy F. Flannery,2 Linda K. Ayliffe,3† Hiroyuki Yoshida,1 Jon M. Olley,4 Gavin J. Prideaux,5 Geoff M. Laslett,6 Alexander Baynes,7 M. A. Smith,8 Rhys Jones,9 Barton L. Smith10

All Australian land mammals, reptiles, and birds weighing more than 100 kilograms, and six of the seven genera with a body mass of 45 to 100 kilograms, perished in the late Quaternary. The timing and causes of these extinctions remain uncertain. We report burial ages for megafauna from 28 sites and infer extinction across the continent around 46,400 years ago (95% confidence interval, 51,200 to 39,800 years ago). Our results rule out extreme aridity at the Last Glacial Maximum as the cause of extinction, but not other climatic impacts; a “blitzkrieg” model of human-induced extinction; or an extended period of anthropogenic ecosystem disruption.

Twenty-three of the 24 genera of Australian land animals weighing more than 45 kg (which, along with a few smaller species, constituted the “megafauna”) were extinct by the late Quaternary (1–3). The timing and causes of this environmental catastrophe have been debated for more than a century (4, 5), with megafaunal extirpation being attributed to the impact of the first human colonizers (1, 5–8), who arrived 56 ± 4 thousand years ago (ka) (9–13), or climate change (4) [in particular, increased aridity at the Last Glacial Maximum (19 to 23 ka) (14)]. A resolution to this debate has been thwarted by the lack of reliable ages for megafaunal remains and for the deposits containing these fossils. The disappearance of one species of giant bird (Geornysseus newtonii) from the arid and semi-arid regions of southeastern Australia has been dated to 50 ± 5 ka, on the basis of >700 samples of eggshell (8), but no secure ages for extinction have been reported for the giant marsupials or reptiles, which constitute 22 of the 23 extinct genera of megafauna weighing >45 kg. Here we present burial ages, obtained using optical and 230Th/234U dating methods, for the remains of several megafaunal taxa (mostly giant marsupials; see Table 1) discovered at sites located in the humid coastal fringe and drier continental interior of Australia and in the montane forest of West Papua (Fig. 1), which was joined to Australia by a land bridge at times of lowered global sea level.

Most major biogeographic and climatic regions, and all five main groups of fossil sites (14), are represented in our survey. Most of the sites in southwestern Australia are caves that have acted as pitfall traps,

Fig. 1. Map of the Australian region showing the megafauna sites dated in this study. Site numbers: 1, Ned’s Gully; 2, Mooki River; 3, Cox’s Creek (Bando); 4, Cox’s Creek (Kenilo); 5, Tambar Springs; 6, Cuddie Springs; 7, Lake Menindee (Sunset Strip); 8, Willow Point; 9, Lake Victoria (site 50); 10, Lake Victoria (site 51); 11, Lake Victoria (site 73); 12, Montford’s Beach; 13, Lake Weering; 14, Lake Corangamite; 15, Lake Weeranganuk; 16, Lake Colongulac; 17, Warmambool; 18, Victoria Fossil Cave (Grant Hill); 19, Victoria Fossil Cave (Fossil Chamber); 20, Wood Point; 21, Lake Callabonna; 22, Devil’s Lair; 23, Kudjal Yolgha Cave; 24, Mammoth Cave; 25, Moondyne Cave; 26, Tighl Entrance Cave; 27, Du Boulay Creek; 28, Kelangur Cove. The bold dashed line crossing the continent indicates the approximate present-day boundary between the zones dominated by summer rainfall from monsoonal activity (north of the line) and winter rainfall from westerly storm tracks (south of the line). The stippled area indicates the zone that receives less than 500 mm rainfall per year and where potential evapotranspiration exceeds monthly evapotranspiration year-round with negligible runoff. Climatic data are from (24, 38) and references therein.
A Multispecies Overkill Simulation of the End-Pleistocene Megafaunal Mass Extinction

John Alroy

A computer simulation of North American end-Pleistocene human and large herbivore population dynamics correctly predicts the extinction or survival of 32 out of 41 prey species. Slow human population growth rates, random hunting, and low maximum hunting effort are assumed; additional parameters are based on published values. Predictions are close to observed values for overall extinction rates, human population densities, game consumption rates, and the temporal overlap of humans and extinct species. Results are robust to variation in unconstrained parameters. This fully mechanistic model accounts for megafaunal extinction without invoking climate change and secondary ecological effects.

More than half of the large mammal biota of the Americas disappeared in a cataclysmic extinction wave at the very end of the Pleistocene (1, 2). This dramatic event, unparalleled in the deeper fossil record and unmatched in other continents at the same time, has been attributed to the direct effects of human predation: the first solid evidence of large human populations in the Americas is at 13,400 years before the present (yr B.P.) (3), near the beginning of the extinction spasm, and humans are known to have hunted extinct megafauna (1, 2). Computer simulations of human population growth in the continental United States have been used to test the overkill model ever since Martin (1) first proposed it. Some of the key questions are whether population growth could have been sufficiently rapid (4), and hunting rates sufficiently high, to have driven 73% of large herbivore species into extinction (5–10).

Some human population growth models have not addressed the overkill problem directly (4, 11), whereas others have assumed a single, homogenized prey "species" (5–10) and have tested whether every last individual in this lumped population could have been exterminated. Ecological principles suggest that such a "total overkill" scenario is unlikely because of feedback between human and prey species population sizes (9); in any event, several large herbivore species did survive. The real questions, then, are whether a realistically scaled burst of human population growth could have resulted in a realistic number of extinctions, and whether such a model can correctly predict the extinction and survival of particular species on the basis of their ecological properties (1, 12). Here, I simulate human population growth, hunting patterns, and the population dynamics of 41 large mammalian herbivores—30 of them now extinct—across the Pleistocene-Holocene transition. The model tracks each species separately within each of 754 grid cells measuring 1° latitude by 1° longitude.

Many parameters and causal interactions could have been important in the extinction crisis, and the current model includes only the most clear-cut ones (13–28). Values that are known with reasonable certainty include differences among prey species in geographic ranges, body masses, and population densities; body mass–dependent differences among species in population growth rates; rates of production and caloric values of plant and small game (i.e., secondary) food resources; human nutritional needs; the maximal rate of increase of human populations; and the time of first appearance of substantial human populations in the United States.

Additional values that are not strongly constrained fall into four categories (28): (i) The initial number of humans entering the region was set at an absolute minimum of 100, following several previous studies (4, 7), and humans spread across the continent following a standard reaction-diffusion equation (4). (ii) Hunting ability was varied systematically (Table 1; trials 1 through 16 and 18 through 33) to determine the effect of different parameter values. The model mathematically implies that this parameter will strongly control the maximal rate of population increase and the ultimate population carrying capacity. Hunting effort was assumed to be nonselective and limited by food handling time and nutritional requirements (9, 21), so per capita kill rates never exceeded a low ceiling. (iii) Competition among prey species for food might have an indirect effect on extinction outcomes, so a master competition parameter was varied between extreme values (trials 34 through 43). (iv) Geographic dispersal of prey species was modeled in two opposed ways: with dispersal between grid cells forbidden for all species, and with complete annual mixing among cells, which implies high dispersal rates (trials 1 through 16 versus 18 through 33).

The simulation results are unambiguous (Fig. 1 and Table 1). Human population growth and hunting almost invariably leads to a major mass extinction. In fact, it is hard to find a combination of parameter values that permits all species to survive. These few scenarios (trials 1 through 3 and 18 through 21) require very low final human population densities of <0.13 people/100 km², an order of magnitude below the observed range for modern hunter-gatherers (4).

Furthermore, a single best-fit scenario (trial 8) simultaneously makes accurate predictions about extinction outcomes, extinction timing, and human ecology. It involves fast geographic dispersal of prey populations, full competition among prey species, and only modest rates of human hunting ability. It correctly predicts the fates of 32 out of 41 species (78%). The exceptions are six "surviving" species that actually are extinct and three "extinct" species that actually survive (Fig. 1).

By comparison, predicting survival strictly on the basis of body mass by declaring all species heavier than 180 kg to be extinct would identify 23 of 30 extinct and 7 of 11 surviving species, for a prediction success rate of 73%. This too is significantly better than a random guess (G = 4.020, P < 0.01). Thus, the mechanistic model does succeed in replicating the observed pattern of differential extinction across the body mass spectrum (1, 2, 12), but without making any ad hoc assumptions about human preferences for large game. Indeed, additional simulations demonstrate that the only way to prevent a size-selective mass extinction is to assume that humans strongly prefer to hunt small game.

Extinction times are another accurate prediction of the best-fit model (Fig. 1). The median extinction occurs 1229 years after the initial invasion of humans. The earliest is at 801 years, and all but three take place by 1640 years. These figures amount to dozens of human generations, far longer than the normal span of oral history. Furthermore, it takes 260 years for the human population to exceed 1000 individuals, and 410 to exceed 10,000, so we might not expect the archaeological record to show evidence of humans before those times. Thus, a 1000- to 1200-year overlap of humans and megafauna might
If your understanding of American history begins in 1492 with the arrival of Christopher Columbus, then you'll be surprised to learn that scientists consider him a latecomer to our shores.

Yes, Native Americans were here first, but fresh findings indicate that man may have walked the North American continent thousands of years before anyone thought. And genetic research suggests a heretofore unknown European immigration centuries before the first ships from Spain appeared on the horizon.

Deep in the interior, the excavation of a lost city near St. Louis, Missouri, shows Native American society a millennium ago was more advanced and perhaps on par with its Mayan counterpart in Mexico.

At the same time, on the Atlantic seaboard, Vikings may have been colonizing the country they called Vinland in greater numbers and for a longer period than previously thought.

Come meet five scientists who are rewriting American history. While they are not acting in concert, together they are putting a new spin on the New World.—F.V.
Scientists are rewriting American history, changing our perceptions of the New World before 1492.

New Spin on the New World

By Gunjan Sinha, Dawn Stover, and Frank Vizard

The X-Files

DNA evidence shows that some Native Americans might have come from Europe.

JUST AS AMERICA was settled by waves of immigrants in search of greener pastures, the prehistoric New World, it now seems, was likely populated in much the same way.

The standard theory held that somewhere around 12 to 13 thousand years ago, people from Northeast Asia trekked across the Bering Land Bridge near Alaska, and became today’s Native Americans. But the latest genetic evidence, bolstered by recent archeological finds, suggests that people wandered into the New World as early as 20 to 30 thousand years ago and, contrary to conventional thought, the new arrivals made love, not war.

Based on analysis of mitochondrial DNA—a specific type of DNA found inside cells called mitochondria—scientists classify 97 percent of Native Americans into four
The People Eaters

What’s for lunch? Maybe some prehistoric guests, evidence suggests.

OF ALL THE CONTROVERSIAL theories about early Americans, one of the most hotly contested questions is whether they engaged in cannibalism. Some scientists point to disjointed, cut-marked, and burned human bones unearthed at a few prehistoric Pueblo sites in the Four Corners region of the Southwest as evidence that the macabre ritual existed. But questions remained over whether people actu-
ally ate the victims of such assaults—until Richard Marlar came along.

Last year, Marlar published the most powerful evidence to date that cannibalism did occur, however rarely. Marlar, a pathologist at the University of Colorado School of Medicine at Denver, and an archaeologist by avocation, examined the biochemical makeup of fossilized human feces found at a small, approximately 850-year-old Puebloan site, and found it contained human myoglobin—a muscle protein. When Marlar tested cooking pots for the protein's presence, one turned up positive.

Among other remains along a site known as Cowboy Wash in southwestern Colorado were the littered, scorched, and disjointed bones of seven people, male and female, of various ages. Stone cutting tools were also stained with traces of human blood.

In the American Southwest, only a handful of sites show evidence of cannibalism, and all date between 1150 and 1175. Curiously, the site at Cowboy Wash was left as though the occupants had departed in a hurry. Normally, says Marlar, people tended to take all salvageable items with them. But at this site, tools and cooking utensils were left intact, as was the pithouse roof, which was normally burned or scavenged.

Whether the bone butchering was the work of a prehistoric serial killer, tribal warfare, or some other uniquely turbulent localized event is unknown. But Marlar hopes that the evidence will convince other scientists to “stop arguing over whether cannibalism happened, and start focusing on why it happened.”—G.S.

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Lost Metropolis

The largest archaeological site in the United States reveals an advanced, urban Native American society.

THE POPULAR PERCEPTION of Native American life before Columbus is a picture of seminomadic people living in small groups. But outside of St. Louis, Missouri, there is ample evidence of a permanent metropolis that was home to as many as 10,000 people a millennium ago.

The Cahokia Mounds is the largest U.S. archaeological site and is all that remains of what was once the most advanced and complex Native American society north of the Rio Grande.

“Cahokia is the pinnacle of a mound-building culture in the Mississippi Valley that dates back thousands of years,” explains John Kelly, an archaeologist with Washington University who coordinates work on the site. The current goal is to trace the path of a palisade whose walls date to 1175.

This palisade was about 15 feet high and stretched for 2 miles and may provide a clue to the city’s demise.

Perhaps the most interesting structure at the site is Monks Mound. Researchers believe the 100-foot-high mound was constructed in stages as a series of terraces, capped by a huge building that served as a temple. Some observers liken the structure to a pyramid, but no connection to Mayan culture has been made.

Kelly hopes new remote sensing technologies will allow him to learn more while at the same time preserving the structure.

The people of Cahokia also had a taste for astronomy. A circle of 48 wooden posts, dubbed “Woodhedge,” allowed plotting of the equinoxes.

The Cahokia civilization disappeared by 1400.—F.V.
IF YOU COULD go back in time more than 16,000 years, to a protected rock ledge above a creek in what is now southwestern Pennsylvania, you would find a small group of prehistoric Americans camping there. So says anthropologist James Adovasio, leader of a team that has studied the Meadowcroft rock shelter for almost 28 years. His radiocarbon dates for encampments at Meadowcroft challenge a long-held theory of when and how humans began to populate the Americas, but they continue to gain support as other ancient sites are uncovered.

Until the late 1970s, most anthropologists believed that humans arrived in North America no earlier than 11,500 years ago—by trekking across the Bering Land Bridge and then spreading rapidly throughout the Western Hemisphere in pursuit of mammoths and other big game. These hunters are known as the Clovis people because of their distinctive fluted stone spear points—first discovered near Clovis, New Mexico, in 1932.

At the Meadowcroft site, Adovasio's team has excavated to a depth of about 16 feet, studying geological strata dating back to the end of the last Ice Age. "You have a remarkable record here of 22,000 years of environmental and cultural change," says Adovasio, who is the director of the science division at Mercyhurst College in Erie, Pennsylvania.

The rock shelter, which covers about 66 square yards but was once much larger, does not appear to have been a permanent home for early Americans. But fire pits, stone tools, basket fragments, and the remains of nuts and seeds show that the shelter was used as a way station for hunters and gatherers, says Adovasio. Much of this smaller fare—plants and small mammals—may have been collected by children, women, and the elderly. His team has retrieved some 956,000 bits of animal bones from the site, and 1.4 million plant remains. Human remains include teeth and a few skull fragments, dating back to about 13,000 years ago.

Meadowcroft is not the only site
with pre-Clovis radiocarbon dates that have now come to be widely accepted. At Cactus Hill, adjacent to the Nottoway River in Virginia, scientists have unearthed remains and stone tools suggesting people lived there at least 15,000 years ago. Near Topper, South Carolina, scientists have found stone blades and scraping tools buried in deeper, older layers of earth than Clovis points found at the same site.

Now that "the Clovis curtain has been lifted," as Adovasio puts it, anthropologists are proposing a number of possible explanations for how humans reached the Americas. For example, there may have been multiple migrations from Asia and elsewhere, and early immigrants may have arrived by sea rather than land.

These artifacts indicate that prehistoric cultures and technologies may have been much more diverse than scientists had realized, he says. "In another 10 years, our views will probably be transformed again. Science is about changing your mind."—D.S.

Land of the Vikings
Thor Heyerdahl suggests the Vikings inhabited America in larger numbers than the archaeological evidence indicates.

WHEN we think of Vikings, images of fierce warriors in low ships raiding the coasts of Europe come to mind, but a new theory suggests they may have sailed up and down the East Coast of North America in greater numbers than supposed, even traveling as far south as New York City.

It's now generally accepted that Vikings settled in L'Anse aux Meadows, Newfoundland, around the turn of the 11th century, hundreds of years before Columbus. Archaeological evidence suggests the site was occupied by about 500 people for a decade. But this may be shortchanging the Vikings.

Norwegian anthropologist Thor Heyerdahl thinks the borders of Vinland, the Viking name for America, may have been as far north as Canada's Baffin Island and as far south as New York's Long Island. He further believes the Viking population in North America spanned centuries and may have peaked at 25,000.

Heyerdahl, now 86, is famous for his 1947 Kon-Tiki raft voyage from Peru to Polynesia, made to illustrate his theory that native South Americans could have colonized the Pacific islands.

Aside from a coin found in Maine, there's little physical evidence to support Heyerdahl's claim. Heyerdahl bases his theory largely on Icelandic sagas and records in the Vatican library that mention Vinland as early as 1070. The Catholic Church appointed bishops for Greenland and the surrounding lands, which would include Vinland, from 1112 to 1450.

"The population estimate for Greenland, according to Vatican reports, is far higher than that estimated by modern archaeologists," Heyerdahl says, "because the bishopric of Greenland included adjacent lands. The estimate of the church was based on church taxes collected; the archaeologists' is based on the ruins they have found."

Leif Erikson is credited with discovering Vinland between 997 and 1003 but also introduced Greenland to Catholicism, says Heyerdahl. Most records concerning Vinland were housed in Greenland but were later destroyed in a variety of calamities. Other Catholic sources in Scandinavia were lost during the Protestant Reformation, when connections to the Vatican were severed.

Heyerdahl's controversial theory was published in a book called No Boundaries in Norway last fall. A revised version with additional data is expected this fall, with an English translation shortly thereafter.—F.V.

Sailing West
Viking voyagers from Iceland and Greenland eventually established a settlement in Newfoundland, according to the archaeological record.
Europeans Trace Ancestry To Paleolithic People

Y chromosome data show that living Europeans have deep roots in the region—and researchers say genetic markers may be linked to archaeological cultures.

About 8000 years ago, the people living in Franchthi Cave in southern Greece experienced a dramatic change of lifestyle. On the floor of the cave where hunter-gatherers had been dropping stone tools and fishbones for thousands of years, the remains of a new kind of beast appear: traces of wheat, barley, sheep, and goat, which can only be the result of farming and herding animals. Within the next 3000 years, the same abrupt transition ripples through archaeological sites along the shoreline of the Mediterranean, eventually reaching Europe, where settled villages of mud-brick houses appear. “The consequences of the transition were fundamental—village settlement, new beliefs, different social structure,” says archaeologist Colin Renfrew of the University of Cambridge in England. “A behavioral revolution took place.”

But which people made that revolutionary European transition? Did farmers move into Europe from the Fertile Crescent in the Middle East, or did local hunter-gatherers learn to trade and farm themselves? And if Neolithic newcomers brought farming technology, did they replace most of the locals, or did those Paleolithic locals survive and become the primary ancestors of modern Europeans?

Now, after years of debate, these questions are being answered not only by ancient remains but also by the genes of living Europeans. In a report on page 1155, an international team reports that a wealth of data from the Y chromosome show that it was the local hunter-gatherers who passed on more of their genes. More than 80% of European men have inherited their Y chromosomes—which are transmitted only from father to son—from Paleolithic ancestors who lived 25,000 to 40,000 years ago. Only 20% of Europeans trace their Y chromosome ancestry to Neolithic farmers. Thus, only enable researchers to trace the movements of the first farmers, they also paint a remarkably detailed picture of the identity and movements of ancient Europeans. The Y chromosome team, led by geneticists Ornela Semino of the University of Pavia in Italy and Giuseppe Passarino of Stanford University, also took the bold step of explicitly connecting genetic and archaeological data—a move that is already drawing some fire. The researchers link two early migrations recorded by the Y chromosome to two Paleolithic cultures, the Aurignacian and Gravettian, each famous for their spectacular art and artifacts (see map). “This paper shows us that molecular genetics is beginning to show us which genetic markers are coordinated with climatic events and population dispersals,” says Renfrew.

The earliest glimpse of European genetic origins came from protein markers; more recently, researchers studied the mtDNA of European women. But the results were divided: One group of researchers that included Stanford geneticist L. Luca Cavalli-Sforza, a co-author of the new Y chromosome study, found similar markers in Europeans and Middle Easterners, which declined from east to west and looked like the signature of the Neolithic expansion. But other researchers proposed that several European genetic markers were too old to have been introduced with the Neolithic newcomers.

The obvious way to reconcile the sometimes heated debate was to look at men’s genetic history as recorded on the Y chromosome. By comparing the variations, called polymorphisms or markers, at one site on the chromosome, and the frequency at which those variations occur in different populations, geneticists can sort out which populations are most closely related. They can then build a phylogenetic tree that traces...
the inheritance of the Y chromosome markers in different populations. And by using average mutation rates, researchers can estimate how long ago particular mutations appeared, thus dating various population splits and movements.

Using samples from 1007 European men, the Y chromosome team got clear results: Most of the men could be sorted into 10 different Y chromosome variants or haplotypes. The researchers sorted these haplotypes on a phylogenetic tree and used the geographic distributions of modern markers to trace the evolution and spread of the ancient markers. For example, they found that four modern haplotypes, which account for 80% of European men’s Y chromosomes, were descended from two now-vanished haplotypes. One, M173, arose more than 40,000 years ago from an even older marker called M45. Apparently M45 was present in men living in Asia, for other descendants of this haplotype are now seen in Siberians and Native Americans. Meanwhile, the descendants of the M173 marker are found at the highest frequency today in Europe. So the researchers conclude that M173 is an ancient Eurasian marker that moved into Europe about 35,000 to 40,000 years ago.

The authors note that this is just the time of the advent of the Aurignacian, an advanced culture that reached its height in Western Europe about 35,000 years ago and is well-known for its sophisticated rock-art paintings and finely crafted tools of antler, bone, and ivory. Archaeologists have hotly debated whether these people originally came from Europe, Asia, or the Middle East. Now the authors propose that haplotype M173 is the “signature of the Aurignacian,” and that these people came from central Asia. If the team is right, then half of modern European men still carry the genetic signature of these ancient artists.

Using similar reasoning, the researchers report that the next wave of migration into Europe, marked by a mutation known as M170, occurred about 22,000 years ago from the Middle East. The authors link this wave to the so-called Gravettian culture, known for its Venus figurines and small, delicate blades, which first appeared in the area that is now Austria, the Czech Republic, and the northern Balkans. But archaeologist Alison Brooks of George Washington University in Washington, D.C., warns that there were many cultures in Europe at these times, such as the Solutrean from Iberia, and that it’s risky to link genes to a particular culture.

Once in Europe, the timing and geographical distribution of markers suggests that Aurignacian people dominated Western and southern Europe, while the Gravettian people thrived in Eastern and Central Europe. But when the climate worsened during the Last Glacial Maximum 24,000 to 16,000 years ago, people carrying the “Aurignacian” marker apparently concentrated in refuges in the Iberian peninsula and the Ukraine. Meanwhile, the Gravettian people apparently moved to the Balkans. After the glaciers retreated, the geneticists say that these people moved out of the refuges and their populations expanded rapidly. That fast expansion is why these markers now account for such a large proportion—80%—of modern Europeans. But the mtDNA data also suggest the presence of ice age refuges in Iberia and, to a lesser extent, southern Europe. “This fits completely with the mitochondrial data that show an expansion out of Iberia,” says Antonio Torroni, a geneticist at the University of Urbino in Italy who proposed the idea of an Iberian refuge in 1998.

The new Y chromosome data enhance the existing picture, says Renfrew. “The mitochondrial work showed us the way, but the Y is making it even more clear,” as the Y chromosome data reveal geographical sources of origin more clearly. This is probably because in many societies women move to join their husband’s families, while related men cluster more closely geographically. And because some men have many, many children, they leave more offspring with identical Y chromosomes—and a sharp geographical signal.

But those features also mean that there is less diversity in Y chromosome lineages around the world than in mtDNA, notes Cavalli-Sforza. That lack of diversity makes dating the Y chromosome mutations more difficult: In their calculations, researchers assume that low genetic diversity means that less time has passed—but instead, men’s mating habits might be creating a pool of very similar DNA and swamping the data. That would cause researchers to underestimate the age of genetic and population events.

Some researchers are particularly wary of connecting these roughly dated markers to cultures known from the archaeological record. Although he praises the basic Y chromosome results, "I don’t like attaching genetics to archaeological evidence," says Mark Jobling, a geneticist at the University of Leicester in England who also studies the Y chromosome in Europeans. “It appeals to the imagination, but the mutation rates on the Y [and therefore the dating of genetic events] have wide confidence margins.”

Cavalli-Sforza agrees that genetic dates have large margins of error. But because even these preliminary dates from different genetic lineages correspond well with each other and with major migrations suggested by the archaeological record, it is hard to resist making the connections. “Genetic dating is in its infancy,” says Cavalli-Sforza. “We have to start somewhere. The future will bring new evidence.”

ANN GIBBONS
Indian identity becomes divisive

By DAVID FOSTER
Associated Press

With his blue eyes and sandy blond hair, Richard Sneliding hardly resembles the classic American Indian of Hollywood films and history books. But he may be the Indian face of the future.

Sneliding has one-sixty-fourth Kaw blood—enough for membership in Oklahoma's Kaw Nation tribe, if not for complete acceptance from Indian friends who call him "Casper" and "Wonder Bread."

There's more to being an Indian than a pedigree, the 22-year-old says: "What you feel inside of you is what's important."

He doesn't have to look far for an argument. With gambling profits raising the stakes of tribal membership, deciding who is a "real" Indian has become one of the most divisive issues facing American Indians today.

Never mind the New Age pretenders who claim kinship to a Cherokee princess they saw in a dream. More nettlesome for the nation's 554 federally recognized tribes is what to do with their own sons and daughters.

Often, their Indian ancestry is unquestioned, but generations of intermarriage have crowded their family trees with non-Indians as well.

Many tribes are easing membership requirements just to survive, prompting worries that tribal traditions will fade along with blood levels.

One federal study estimated that the percentage of Indians who are full-blooded—60 percent in 1980—will fall to 34 percent by 2000 and to 0.3 percent by 2080.

But even as bloodlines thin, being Indian has never been so popular. The number of people identifying themselves as American Indian has nearly tripled since 1970, rising from 827,000 to more than 2.2 million, census figures show.

In Connecticut, the 383 members of the Mashantucket Pequot tribe share profits from a casino that clears more than $1 million a day.

The tribe gets about 50 calls a month from people who figure they must have Pequot blood in them. "Some of them can't even pronounce the name of the tribe," tribal spokesman Bruce MacDonald said.

Early Southwest shows signs of cannibalism

Indian dwellings yield bones with cut marks

By MATT CRENSON
Associated Press

NASHVILLE, Tenn. — One spring around the year 1150, the people of what's now known as Cowboy Wash met a horrible end.

In a jumbled collection of bones, tools and pottery, archaeologists have uncovered grim evidence that attackers slaughtered, butchered and perhaps even cannibalized the long-ago inhabitants of the American Southwest.

The discovery adds to the growing debate over the possibility of cannibalism among the Anasazi Indians, whose spectacular, apartmentlike cliff dwellings are now a major tourist attraction.

"We feel very strongly that this is a case of cannibalism. If it's not, we don't know what else it could be that would produce this set of remains," said Brian Billman, part of a team of archaeologists who excavated the site from 1992 to 1996 in the Ute Mountains of southwestern Colorado.

Inside two of the three small dwellings they unearthed were the bones of at least seven people scattered amid the everyday pottery and tools of 12th-century Southwestern life. Cut marks on the bones suggest that the bodies were butchered about the time of death, and darkened areas on some of them suggest cooking as well.

"Certainly people were mutilated, and it seems to be the case that they were eaten," said Patricia Lambert, a Utah State University archaeologist.

Lambert, Billman and archaeologist Banks Leonard presented the results of the Cowboy Wash dig on Thursday at the annual meeting of the Society for American Archaeology.

Hopi tribal archaeologist Kurt Dongoske said the evidence from Cowboy Wash and the 30-plus other Southwestern sites where dismembered remains have been found doesn't prove that human flesh was consumed.

The bones could be the result of attacks in which people were hacked apart but not eaten, he said. They could also be those of people suspected of witchcraft, who in many cultures are dismembered or otherwise destroyed after death. In colonial New England, for example, suspected witches were burned.
Kennewick Man: More Bones to Pick

Last week, scientists added another bit of bone to the skeleton of Kennewick Man, the oldest, most complete—and most disputed—ancient human from the Pacific Northwest. A partial rib of the 9300-year-old skeleton was found when independent scientists, Native Americans, and the Army Corps of Engineers cooperated in a limited study of the Columbia River beach where the other remains were recovered. But the chip of rib, like everything else connected to this ancient American, is a bone of contention. With the rest of his skeleton, it has been locked away in a vault, pending the outcome of a suit filed by a group of scientists against the corps for the right to study the remains (Science, 11 July 1997, p. 173).

Kennewick Man's new bone is the latest twist in a strange saga that occasionally verges on farce, as various groups vie for access to his bones and history. Since the skeleton's discovery about a year and a half ago on corps land leased to the city of Kennewick, archaeologists have longed to study the skeleton, which reputedly has "Caucasoid" rather than modern Native American traits. Native American groups, however, regard the skeleton as the remains of an ancestor, and they want it given to them for burial under the 1990 Native American Graves Protection and Repatriation Act (NAGPRA). Citing NAGPRA, the corps has limited scientists' access to the skeleton, forcing them to subsist on rumors about its significance and even its authenticity—while both Indians and latter-day Norse pagans have visited it.

The newest addition to the skeleton, a 2-centimeter-square piece of rib, was found along the reservoir's beach by James Chatters, an independent archaeologist who led the original recovery of Kennewick Man in July 1996. Chatters was part of the long-ago three-team effort coordinated by the corps to study the site's geology and archaeology. The rib joins three other bones that have been added to the skeleton since its discovery—and at least one does not belong to Kennewick Man. According to corps spokesperson Nola Conway, the other bones turned up during two corps surveys of the site this past year, done with members of the Umatilla Tribe. A metatarsal, cervical vertebra, and pubis bone were found and put in the vault, says Conway. The Native Americans, in keeping with their beliefs, also put incense cedar boughs in the box with the bones.

All this came to the attention of scientists last fall via newspaper accounts, after members of the Asatru, a group of Norse pagans who claim Kennewick Man was a descendant of early Norse in North America, were allowed to visit their putative ancestor. The scientists criticized the corps for possibly harming the skeleton, saying that moisture from the cedar boughs might

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We're Protectin' Them Dry Bones

In his commentary "The 9,400 Year-Old Man" (Taste page, Weekend Journal, Jan. 8), Mark Lasswell mischaracterizes the government's efforts to protect and preserve the human remains known as the Kennewick Man. The article contains at least four major flaws.

First, the author incorrectly states as fact that the remains are 9,400 years old, and falsely implies that because the remains "may appear" physically unrelated to modern American Indians, that they are, in fact, not Native American. But those are the very questions that the Interior Department, in cooperation with the U.S. Army Corps of Engineers, is working to answer as required by law—the Native American Graves Protection and Repatriation Act (NAGPRA). Indeed, Interior is studying the remains to determine their exact age, whether they are Native American, and whether they are culturally affiliated with a tribe, which would mandate their return to the tribe.

Second, the author suggests that the government poured dirt over the archeological dig to prevent anyone from ever discovering any remains there again. But that is wrong. To ensure that the site is available for further study and not washed away by spring floods, the Corps of Engineers stabilized the archeological site.

Third, Mr. Lasswell implies that the government was unaware of the theft of several bone fragments. In fact, federal authorities discovered the missing fragments after they compared the remains and inventories against earlier photographs. The Justice Department has opened an investigation into the matter.

Fourth, the author falsely implies that the government testified against certain legislation because it did not want scientists to examine the remains. But an Interior official testified against the new legislation simply because current law already allows some scientific study to determine whether the remains are Native American, as defined by the law.

Mr. Lasswell falsely concludes that the government wants to stop scientists from learning about the remains. In fact, we are simply trying to conduct the scientific studies in a way that is sensitive to the strongly held religious beliefs of Native Americans, who believe these remains should be reburied immediately.

Lois J. Schiffer
Assistant Attorney General
Environment and Natural Resources Division
Washington

Letters to the Editor

Indian

Jan 29, 1999

Wall Street Jent
This would not be the first old skeleton to be reburied under the terms of the Native American Grave Repatriation and Protection Act, but it is arguably the most interesting. It is widely believed that the earliest immigrants into America crossed what is now the Bering Strait during the last ice age—when the sea level was lower and the strait was dry land. Three separate migrations are believed to have happened. The first, some 16,000 years ago, brought people all the way down to Tierra del Fuego. The other two are thought to have supplied the ancestors of tribes such as the Navajo and Apache of the American west, and the Inuit and Aleut of northern Canada and Greenland.

This tale seems to agree with the one told by genetics. Comparisons of DNA show that the closest relatives of modern American Indians live in Asia. But things may not be quite so straightforward. Since the middle of this century, a few old skeletons with distinctly Caucasian features have turned up in North America. In the mid-1980s, for instance, George Gill of the University of Wyoming found a 5,000-year-old skeleton at a site in the Great Plains of the American mid-west. Like the other putative Caucasians, its teeth did not have the typical profile of Mongoloid ones, and its skull was longer and narrower. It looked, in Dr Gill's words, "like a French trapper."

Until recently, such discoveries have been largely ignored, at least in part because they could not be explained. But now the idea that several Caucasians might have arrived well before 1492 has come back into fashion. And Kennewick Man could provide one of the strongest pieces of evidence to support this view.

Where such Caucasians might have come from, and what became of them, are difficult questions. Most likely, their ancestors travelled over the Bering land bridge too. This idea has been made more plausible by the discovery of mumified Caucasian bodies in the Taklimakan Desert in China, which proves that early Caucasians spread to Asia as well as Europe. Another possibility, according to Robert Bonnichsen, director of the Centre for the Study of the First Americans at Oregon State University, is that Europeans in skin-covered boats crossed the North Atlantic ocean. Given that 10,000 years ago the sea was some 100m (300 ft) lower than it is today, such a voyage would have been considerably shorter than now.

What caused the Caucasians' demise? One theory is that they were wiped out by a drought that struck much of the American west about 9,000 years ago. Another is that interbreeding with later Asiatic immigrants may have swamped their distinctive racial characteristics.

One thing is clear: it is very unlikely that Kennewick Man, or any other Caucasian, is an ancestor of the Umatilla tribe or any of its neighbours. This bears strongly on the other, legal, controversy. The intention of the repatriation act was to prevent the desecration of sites with which existing Indian groups had some cultural connection. Grover Krantz, an anthropologist at Washington State University and one of only three scientists to have seen Kennewick Man thus far, believes that a close reading of the act puts this skeleton outside its jurisdiction. According to Dr Krantz, a spear point found in the man's hip (the wound had healed and was not the cause of his death) could not have come from a culture related to the Umatilla. Their claim to the bones, therefore, is dubious.

The argument over Kennewick Man highlights a dispute that is not unique to North America: the thorny question of who owns the past. North American tribes, angered by the insensitive way in which some museums display their collections of bones and artefacts, say that the repatriation act protects their ancestors from being treated as little more than curiosities.

There is also a cultural conflict between Western science and traditional religious beliefs. All tribes have their own creation myths, which often pinpoint the time and the place that a particular people came into being. Science, with its talk of migrations and racial inter-mixing, directly confronts such myths and usually debunk them.

Like fundamentalists in other religious traditions, some Indians find this hard to swallow. In the words of Armond Min- thorn, a member of the Umatilla tribe and a staunch advocate of repatriation: "Our oral history goes back 10,000 years. We know how time began and how Indian people were created. They can say whatever they want, the scientists."

**Climatology**

**Fire and ice**

After two weeks, the eruptions have ceased. Under the Vatnajokull, a glacier in south-east Iceland, the volcanic fissure that has been belching sporadically like a windy baby has finally calmed down. But its incandescent breath has already melted some three cubic kilometres (0.7 cubic miles) of the glacier above, and the resultant 3 billion tonnes of water is looking for somewhere to go. As The Economist went to press it was sitting in the Grimsvotn, a volcanic crater under the ice. Soon it will burst its confines and thunder down
Most archaeologists have long viewed war as a disease of civilization. Only kingdoms and states with great armies, the theory goes, slaughtered opponents for economic ends and left battlefields littered with corpses. Tribal societies, such as those that flourished across prehistoric North America, were thought to have fought mainly for sport and to have halted hostilities after only a few deaths because they lacked resources for extensive battles. Political correctness, too, has favored the idea that native peoples lived in harmony. But new studies of prominent Southwestern cultures clash with this vision of a peaceful past.

Clever new ways to read the subtle marks of periodic warfare in such features as the arrangement of villages and the placement of wells, plus direct evidence of massacres (see sidebar), are persuading archaeologists that ancient North American societies made war as fiercely as any nation states. In order to acquire scarce resources, particularly when the climate turned harsh, combatants slaughtered women and children, razed settlements, and inflicted stunningly high casualty rates. The turnaround in thinking is most dramatic in the Southwest. There, cultures once idealized as peaceful, such as the Hohokam of southern Arizona and the Anasazi of the Colorado Plateau, now seem to have been shaped by warfare, researchers argued this week at a special symposium at the Society for American Archaeology (SAA) meetings in Seattle.

"There's been more and more evidence coming forward that the levels of violence in prehistoric times were quite high," says Jon Driver, an archaeologist at Simon Fraser University in Vancouver and SAA program chair. Such studies are changing many anthropologists' minds about war in tribal societies, he says. "Now that we're seeing different types of warfare around the world, I think people are opening up more to warfare" as an explanation for prehistoric events.

Not everyone, though. Skeptics such as Linda Cordell, director of the University of Colorado Museum in Boulder, argue that particularly in the Southwest, warfare advocates have yet to present convincing proof that ancient hostilities claimed many lives. "I'm looking for good syntheses and good reports with lots of bodies," she says. Much of the new evidence for war is open to less sensational interpretations, agrees Charles Adams, an archaeologist at the University of Arizona, Tucson. Warfare proponents, he notes, have "taken a body of information and mixed all sorts of stuff in there. It could be the result of warfare, but they haven't demonstrated it."

Even those arguing for tribal warfare, such as Hohokam expert Glen Rice, director of Cultural Resource Management at Arizona State University in Tempe, admit that their ideas are "still controversial." But for a growing number of scientists, the evidence can no longer be ignored. Says Rice, one of the new converts, "I've flopped recently from being very unconcerned about warfare to being very concerned that it is an important factor."

From farmers to warriors
Although there are new signs of prehistoric warfare across North America, some of the newest and most controversial data come from the river valleys of Arizona. The Hohokam, who flourished there from A.D. 300 to 1450, have long been idealized as peaceful maize farmers who cooperated to build canals. But now Rice argues that not only did the Hohokam fight, conflicts over water actually defined their society.

The Hohokam cremated their dead, so Rice can't rely on broken bodies to make his claim. Rather, he makes a more inferential argument based on what seems to be the Hohokam social system. From architecture and other clues, Rice argues that Hohokam society was organized to require constant readiness for battle, in an arrangement also seen in highly warlike societies like Sudan's Nuer and Central America's Quiche Maya. This structure, known to social scientists as "segmentary organization with complementary opposition," is more simply described as "me against my brother, me and my brother against my father, and me and my brother and my father against my uncles," says Neal Ackerly, an archaeologist with Dos Rios Consultants in Silver City, New Mexico. He and other experts agree: If the Hohokam had this structure, then they must have been warriors.

Rice's ideas are based on his studies of major Hohokam irrigation canals east of Phoenix, some of which stretch as long as 15 kilometers along valley floors and sustained as many as seven separate Hohokam communities each. He and others wondered how water was parceled out among the communities during droughts, when canal water levels dropped.

Some researchers theorized that a powerful centralized authority lived in the village nearest the canal head gate on the river and peacefully controlled water and economic life along the canals. But in Hohokam settlements east of Phoenix, Rice found no trace of centralized wealth and authority. Instead, in the architecture atop large earthen mounds at the center of Hohokam communities, he found public council rooms that were in paired and opposing arrangements. This, plus traces of distinct ceremonial regalia, indicated the presence of two or more opposing elites, he says. And some communities contained two or more of these mounds, each with its own sets of elites. That implies that there were modular segments of society that could be organized into bigger units—a hallmark of segmentary organization, explains Jeffrey Dean, a Southwest specialist at the University of Arizona, Tucson.

With no controlling central authority, reasoned Rice, canal-end communities could only obtain water by resorting to occasional force and constant threats against upstream communities. Yet they cooperated with those same communities during times of canal maintenance. "It doesn't have to be a con-

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**Defensive buildup.** A massive wall, now highlighted by green growth, protects a Hohokam platform mound east of Phoenix.
Crow Creek's Revenge

In A.D. 1325, prehistoric warriors stormed a palisaded village in South Dakota along the Missouri River, razed its earth lodges, and slaughtered many of its estimated 800 inhabitants. The 550 dead, mainly men and children, were later tossed into a mass grave. Nearly 95% of the intact skulls bore cut marks from scalping.

Now known as Crow Creek, the village and its grave were discovered in the 1970s; the unfortunate villagers have been identified as the ancestors of a historic tribe called the Arikara. But for years, with prehistoric America seen as a peaceful place (see main text), Crow Creek was generally thought to be an extreme and isolated case of violence. Now, new analyses suggest that this massacre was merely one act in a long-running life-and-death struggle between Crow Creek and the ancestors of two neighboring tribes: the historic Mandan and Hidatsa.

In research still in progress, Douglas Owsey, a physical anthropologist at the National Museum of Natural History (NMNH) in Washington, D.C., has found clear traces of massacres at two 14th-century villages within striking range of Crow Creek. In a village known today as Tony Glass, built by the ancestors of the Mandan and Hidatsa, he found the remains of at least 50 people in one earth lodge. Most died between the ages of 15 and 25, and most were women. There were fractures caused by blows to the head and mouth and breakage of skulls after death, including “cut marks and intentional fragmentation of bone, intentional mutilation,” says Owsey.

A nearby village called Helb, also inhabited by ancestors of the Mandan and Hidatsa, shows signs of a similar disaster—burned houses, an unfinished palisade, and a scattering of human remains, says Marvin Kay, an archaeologist at the University of Arkansas, Fayetteville, who excavated the site. "Those [remains] have cut marks from being scalped," notes Owsey. "The evidence is consistent with a massacre."

To both Owsey and Kay, the evidence points to a desperate struggle between the two groups of farmers. Kay thinks the climate cooling of the 14th century led to crop failures, sparking battles over the narrow zone of arable land in the Missouri River Trench, which was "on the fringe or northern limits for prehistoric agriculture," he says. Like many bitter wars before and since, it seems that the Crow Creek massacre and its companion slaughters were fought for land.

-HP.
The largest expansion of human Lebensraum in the past half-million years was the colonization of the New World by pre-decessors of modern American Indians ('native Americans'). If we knew when, whence and in how many waves those colonists had arrived, we would have the key to several questions in human genetics, anthropology and linguistics. A drastic and heavily criticized reclassification of native American languages by Joseph Greenberg (Language in the Americas, Stanford University Press, 1987) bears upon all of these questions. At a conference in Colorado — an appropriate venue for an academic shootout in the Old West — scholars from diverse fields assembled to assess Greenberg's hypothesis*.

To grasp the difficulty of the problem, reflect that about a thousand native American languages have been described, and as many more may have disappeared between the arrivals of European explorers and of linguists. Sister languages diverge with time so that relationships become difficult to detect after about 6,000 years, yet America was colonized at least 11,000 years ago. Most scholars recognize native American languages as falling into about 150 distinct families. They are sympathetic to the likelihood of relationships among those families, but they conclude that techniques for detecting them after such a long time are inadequate (L. Campbell and M. Mithun The Languages of Native America, University of Texas Press, 1979). Enter Greenberg (Stanford University, Stanford), whose reclassification of African languages was also highly controversial but is now praised and accepted. After similarly revising the morass of New Guinea languages, Greenberg turned his attention in the 1950s to the Americas. In each case he employed a broad-brush method termed multilateral (or mass) comparison, in which whole sets of possibly related languages, rather than just selected pairs, are compared with respect to vocabulary and grammar. Greenberg's reasoning is that each sister language of a family may lose different inherited features, with the result that family properties and membership can be deduced only from study of the whole set. Protein chemists who have studied evolutionary relationships among retroviruses or acyl-amino-acid transfer-RNA synthetases will immediately appreciate this reasoning.

Greenberg concluded that all native American languages belong to one of three stocks (see map, over). Two of these are small North American stocks already recognized by most linguists: Eskimo-Aleut and Na-Dene, consisting of about nine and 34 languages respectively. What is controversial is Greenberg's conclusion that all other native languages in North and South America belong to one gigantic stock which he terms Amerind.

Most linguists reject not only Greenberg's conclusions but also his methods. Instead, they consider recognition of sound correspondences between lan-
guages (for example the English 'th' and the German 'd') as a prerequisite for identifying relationships. Without such recognition, one might not recognize that 'star' (English) and 'êtoile' (French) are derived from the same proto-Indo-European root. L. Campbell (Louisiana State University, Baton Rouge) objected that Greenberg's methods would have classified Finnish as Amerind if some native American group had spoken Finnish, while S. Starostin (USSR Academy of Sciences, Moscow) noted a large number of errors resulting from the neglect of sound correspondences in some of Greenberg's comparisons. Greenberg's response was that one cannot search for sound correspondences until one has a hypothesis about which languages to compare, and that recognition of now-accepted stocks such as Indo-European preceded rather than followed the study of sound correspondences. Nevertheless, sound correspondences will surely be the route pursued by most other linguists for testing or refining Greenberg's conclusions.

The issues dividing Greenberg and his critics flared up most often in an argument over pronouns used in the native American languages. Greenberg noted first- and second-person pronouns based on 'n' and 'm' respectively in all branches of his Amerind family. In one type of attack this claim was dismissed as mere 'mama/papa stuff' and not indicative of language relations. That is, 'm' and 'n' are particularly stable consonants, among the first to be pronounced by infants (possibly as a result of infant muscular activity and sucking noises), and hence are likely to lead not only to the almost worldwide term 'mama' but also to preference for 'm' and 'n' in pronouns (J. Nichols, University of California, Berkeley, and L. Campbell). Not explained by this point is why such 'mama/papa stuff' would affect pronouns especially in the Americas. So a second criticism was that 'n-' and 'm-' pronouns are not peculiarly American. Campbell reported ten sets of examples from non-American languages from half-an-hour's browsing in the library, though Greenberg described such pronouns as disproportionately common in the Americas, and M. Dryer (State University of New York, Buffalo) computed an incidence of 17 per cent in the Americas, 7 per cent everywhere.

Astonishingly to non-linguists at the conference, none of the disputants had calculated whether there is a statistically significant difference in 'n-' and 'm-' pronoun frequencies between native American and other languages. In fact, use of even the most elementary statistics was conspicuously absent at the conference, as it is from the tradition of historical linguistics, which must contribute to linguists' difficulty in resolving questions about whether languages A and B or A and C are more closely related.

If Greenberg's hypothesis is correct, it implies that the vast majority of native Americans derived from a single colonization, the rest from two later colonizations. This suggestion has stimulated great interest among geneticists, anatomists and archaeologists. Genetic evidence provided by L.L. Cavalli-Sforza et al. (Proc. natn. Acad. Sci. U.S.A. 85, 6002-6006; 1988), as well as evidence from tooth morphology (C. Turner, Arizona State University, Tempe), appears to be strikingly concordant with Greenberg's tripartite view. If the first colonists of America were the so-called Clovis hunters of 11,000 years ago, as some archaeologists believe, pre-Amerind might have been the Clovis language. But there is increasing evidence for pre-Clovis occupation of the Americas (D. Stanford, Smithsonian Institution; R. Gruhn, University of Alberta, Edmonton; T. Dillehay, University of Kentucky, Lexington). If Greenberg is correct about the unity of the Amerind stock, and if archaeologists can date the first human arrival, linguists will then have a unique opportunity to calculate the rate of language evolution over much longer times than those of the oft-cited diversifications of the Bantu and Polynesian languages. Other predictions follow from Greenberg's tentative conclusion that the Amerind stock is comprised of 11 subgroups of languages. Many subgroups have strikingly disjunct distributions, implying long-distance movements followed by massive extinction and replacement. For example, Greenberg construes the Paezan subgroup of South America as having a remote outlier in Florida, while the Gulf-Penutian group of the southeastern United States has an outlier in California. These controversial proposals will receive especial scrutiny from linguists, but they also beg for archaeological confirmation of the movements that could have produced them.

As controversial as Greenberg's tripartite theory, and his subgroupings within Amerind, are his attempts to connect his three native American language stocks with stocks of northeast Asia, from which the Americas must have been colonized. Given the difficulties of recognizing stocks that broke up at least 12,000 years ago, it is even more daring to try to identify putative 'macrostocks' that broke up earlier. Most linguists consider that such identifications are not feasible, a view that Greenberg dismisses as belief in the "immaculate conception of Indo-European". Greenberg, Starostin and others are pursuing this work and have thereby won themselves the equally dismissive label of 'supergroupers'. Greenberg's present view is that Eskimo-Aleut is a member of, and Amerind more distantly related to, a widespread Eurasian macrostock that he sees as including Indo-European, Uralic, Altaic, Japanese and four other stocks. Na-Dene may be related to Sino-Tibetan. Thus the first arrivals, the Amerinds, occupied the whole hemisphere; the second arrivals, the Na-Denes, are still largely confined to northwest North America; and the most recent arrivals, the Eskimo-Aleuts, still live only at the latitudes of their far-northern port of entry into Alaska from Siberia.

Whether Greenberg's supporters or his much more numerous critics prove correct, the debate marks a new era in linguistics. With the present explosion of molecular genetic studies of human evolution, historical linguistics is moving back to centre stage.

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Those interested in the study of native American languages should turn to "Then and Now" (back page) for an intriguing slice of the history of their subject.

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