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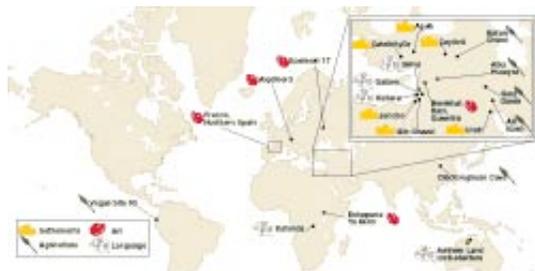
INTRODUCTION TO SPECIAL ISSUE

**ARCHAEOLOGY:
 Transitions in Prehistory**

Tim Appenzeller, Daniel Clery, and Elizabeth Culotta

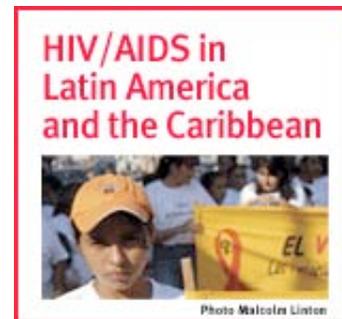
If any archaeologists are around tens of thousands of years from now to dig through the leavings of our culture, they will be overwhelmed with evidence. Revolutions from the rise of the automobile to the fall of the Soviet Union will be easy to decipher from the rich mounds of junk created by our way of life. But the biggest revolutions in the history of our species happened 9000 or more years ago and left only sparse and equivocal traces. The four News stories in this special issue describe how archaeologists are struggling to build a picture of crucial transitions that made us who we are today: the emergence of language, art, agriculture, and settled life in villages and towns.

Because the evidence is scanty, new digs and techniques can transform long-held views. A 9000-year-old settlement in Anatolia was once hailed as the earliest city, with shared institutions, a division of labor, and a reliance on agriculture. But as Michael Balter describes on page 1442, a meticulous new excavation of the site is showing something startling: The people of this high-density settlement, and other early communities, still depended heavily on hunting and gathering and may have settled down for some still-mysterious cultural reason.



Geography of revolution. A map shows sites mentioned in this special section, along with the kind of transition they shed light on.

Another assault on the view that settlements and agriculture emerged together in a



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single "Neolithic Revolution" comes from new techniques for tracing the rise of farming. On page [1446](#), Heather Pringle explains how tiny plant fossils are allowing archaeologists to spot the first signs of crop domestication thousands of years earlier than had been thought, and to find them in unexpected places, such as the South American rainforest. In many regions, settlements came thousands of years after crops, implying a long, slow transition to the agrarian way of life.



Further back in time, the revolutions are, if anything, more momentous: the advent of language and of the ability to think symbolically, expressed most clearly in art. To most archaeologists, both art and complex language are part of a behavioral revolution that swept the Old World some 40,000 years ago. But the evidence leaves room for debate. As Tim Appenzeller and Constance Holden describe (pp. [1451](#) and [1455](#)), a handful of sites and artifacts, scattered widely in time and space, have convinced some archaeologists that this was no revolution at all, and that well before 40,000 years ago, humans were already making art and speaking much like us.

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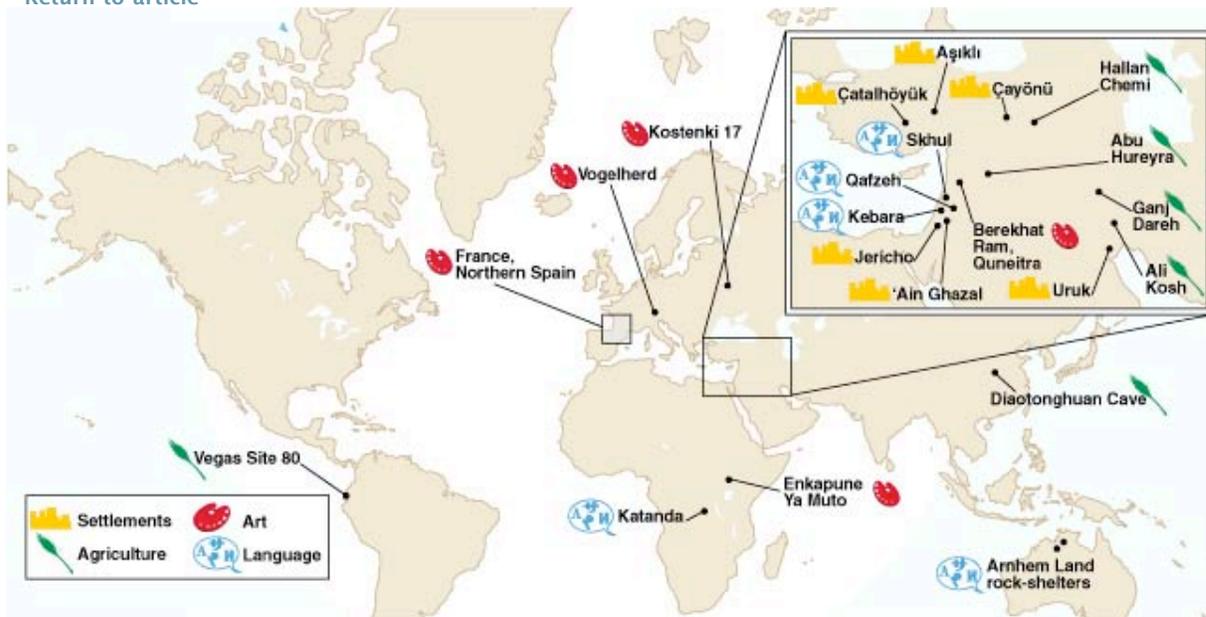
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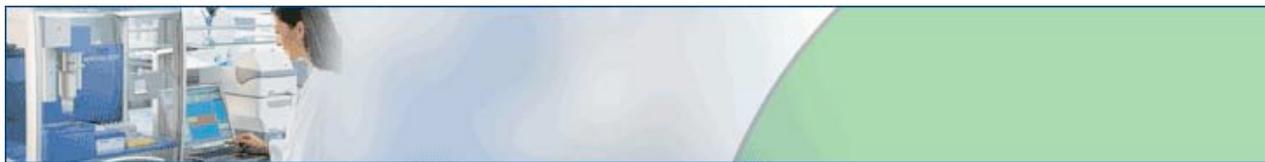
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NEWS

THE FIRST CITIES: Why Settle Down? The Mystery of Communities

Michael Balter

Archaeologists had long believed that farming prompted our nomadic ancestors into the first settlements. But how could the rudimentary agriculture of 9000 years ago have drawn 10,000 people to settle in Çatalhöyük?

ÇATALHÖYÜK, TURKEY--Archaeologist Shahina Farid can barely contain her excitement. While excavating an ancient rubbish deposit, her team of diggers found the skeleton of an adult male. Of course, many dozens of skeletons have been uncovered at this 9000-year-old site over the past few years. Yet this one is different. The others were all found buried under the floors of the mud-brick houses in which the people of this early farming settlement once lived. But this body seems to have been deliberately placed outside. Farid looks out at the wheat fields that surround this isolated mound in the middle of the Central Anatolian plain, wiping her brow against the heat. Would this be the exception that proves the pattern wrong?

The skeleton is carefully removed and taken down to the lab at the base of the mound. There, anthropologists working at the site discover a possible explanation. The man was terribly deformed and probably very ill when he died. An outcast, perhaps? Yet even if this riddle is solved and the burial pattern holds, so many other questions remain unanswered at Çatalhöyük: Why did they bury their dead under the floors? What is the meaning of the vivid painted murals on their walls? Why did thousands of people give up the itinerant life of hunting and gathering and cram themselves into houses so tightly packed that they entered through holes in the roofs? Indeed, why did people bother to come together at all, eventually building the towns and cities that so many of the world's people live in today?

Earlier this century, archaeologists thought they had the answer: The rise of agriculture required early farmers to stay near their crops and animals. But these new excavations are challenging the long-held assumption that the first settlements and the transition from hunting and gathering to farming and animal domestication were part of a single process--one that the late Australian archaeologist V. Gordon Childe dubbed the "Neolithic Revolution" (see p. [1446](#)). Çatalhöyük and other sites across the Near East are making it clear that these explanations are too simple and that other factors--including, possibly, a shared cultural revolution that preceded the rise of farming--might also have played a key role.

HIV/AIDS in
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British archaeologist James Mellaart discovered Çatalhöyük, near the modern city of Konya, in 1958. In the 1960s his excavations of this Neolithic, or New Stone Age, settlement electrified the archaeological community. The age of the site, 4500 years older than the Egyptian pyramids, was staggering. At the time, only the traces of a few small villages could claim seniority as the world's oldest permanent settlements. Yet this was no tiny hamlet: Çatalhöyük covered more than 12 hectares and may have harbored as many as 10,000 people. Over the 1000 years the site was occupied, its inhabitants rebuilt their houses one on top of the other until they had created a mound 20 meters high. Some, including Mellaart, hailed it as the world's oldest known city.

The details of the find captured imaginations. Mellaart uncovered vivid painted murals on the plastered walls of the houses, sometimes in bas-relief: vultures attacking headless men, an erupting volcano, a band of hunters pulling the tongues and tails of wild deer. An animal bone expert declared that Çatalhöyük was a hub of cattle domestication, the earliest known in the Near East. And clay figurines of obese women found at the site prompted Mellaart to claim that Çatalhöyük had been a major religious center, where people worshiped a Mother Goddess--an assertion that today inspires regular pilgrimages of latter-day goddess worshipers from as far away as California.

Since Mellaart ended his work at Çatalhöyük more than 30 years ago, many more Neolithic settlements have been excavated in the Near East. Yet only a few of these sites--such as 'Ain Ghazal in Jordan, which covered the same area but probably had a smaller population (*Science*, 1 April 1988, p. 35)--can match Çatalhöyük's size and importance. And over the years, the mysteries of Çatalhöyük--most of all, the question of what brought so many people together on this isolated plain--have continued to nag at the minds of archaeologists.

Now, in the 1990s, an army of excavators has again descended upon Çatalhöyük, seeking answers to these questions. The 90-member team, directed by Ian Hodder of Britain's Cambridge University and including a large platoon from the University of California, Berkeley, led by Ruth Tringham, represents one of the greatest concentrations of scientific firepower ever focused on an archaeological site. Seasoned excavators, who are slowly sifting through at least 12 successive layers of occupation, have been joined by experts from every field of archaeological science, including specialists in human and animal remains, fossil plants, pottery, and stone tools. Moreover, the dig at Çatalhöyük has become a showcase for the relatively new field of micromorphology, which puts archaeological remains under the microscope to provide the maximum amount of information about how people lived--and how they died.

"Mellaart did a fantastic job at getting the big picture of Çatalhöyük," Hodder says. "But the techniques available back then were relatively limited. Times have moved on and the questions have changed." And although some of Hodder's interpretations of what his team is finding at Çatalhöyük may be controversial (see sidebar on p. 1444), archaeologists agree that the site could help solve some of the mysteries surrounding the origins of settled life.

An overgrown village?

Permanent settlements developed independently in several parts of the world, including the Near East, China, and the Americas. The oldest village known, just outside present-day Jericho in Palestine, may have sprung up around a shrine used by roving bands of hunter-gatherers. By 10,500 years ago it had evolved into a small farming village. Yet many more millennia passed before the first undisputed cities--such as Uruk, in Mesopotamia--were established, about 5500 years ago. And although the expansion of these first settlements roughly coincided with the rise of farming, whether agriculture directly fueled their growth--as Childe proposed--is

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now hotly debated by archaeologists. Indeed, one of the great attractions of Çatalhöyük is that its multilayered remains--which are remarkably well preserved for a site so old--might help answer this critical question.

"Çatalhöyük is *the* dig of the new millennium," says Colin Renfrew, also of Cambridge University. Mark Patton, at the University of Greenwich in London, says that "people are watching very closely" as the excavations unfold--a vigilance made easier by the dig's detailed Web site (catal.arch.cam.ac.uk/catal/catal.html). Çatalhöyük watchers will need to be patient, however. In contrast to Mellaart, who excavated more than 200 buildings over four seasons, the new team is excavating only one or two houses each year. "We are going very slowly," says team member Naomi Hamilton of Edinburgh University in the U.K. "We have learned a huge amount about a few buildings, instead of a moderate amount about 200."

Because of its unusual size, Mellaart often referred to Çatalhöyük as a "Neolithic city," and the notion that the settlement was an early metropolis is often repeated in media accounts of the ongoing excavations. But the new dig has already reinforced a suspicion long held by many archaeologists: Çatalhöyük is not a city, nor even a town, even though many modern towns cannot boast its substantial population. "Çatalhöyük may be the largest Neolithic settlement in the Near East, but it's still just an overgrown village," says Guillermo Algaze of the University of California, San Diego. Which only makes the site all the more perplexing: Why did the people cram their houses together rather than spread them out across the landscape?

For archaeologists, the difference between a village and a city is not just a matter of size but hinges on the social and economic relationships within a population. Thus the earliest cities in Mesopotamia--such as Uruk--were made possible by agricultural surpluses that allowed some people to quit farming and become full-time artisans, priests, or members of other professions. Meanwhile, the farmers who provided food for these urban centers continued to live in outlying villages. "A key defining feature of a town or city is that farmers don't live in them," says Patton.

But the new excavations at Çatalhöyük have uncovered little evidence for division of labor. Although the layout of the houses follows a very similar plan, Hodder's team has found signs that the inhabitants did their own construction work rather than relying upon Neolithic building contractors. Microscopic studies of plaster and mud bricks from different houses done by Wendy Matthews, a micromorphologist at the British Institute of Archaeology in Ankara, show great variation in the mix of soils and plants used to form them--the opposite of what would be expected if they had been fashioned by specialist builders using standard techniques.

And although Mellaart believed that the production of the beautiful obsidian objects found at Çatalhöyük--such as finely worked blades and the earliest known mirrors--was carried out in specialist workshops, the new team has found what Hodder calls "masses of evidence" from microscopic residues of obsidian flakes on floors and around hearths that a lot of obsidian work was carried out in the individual dwellings. Nor has the new dig revealed another important feature of cities: public architecture, such as temples and other public buildings, which Uruk and other early urban centers had in abundance.

But Mellaart, who retired some years ago from the Institute of Archaeology in London, does not necessarily agree. He told *Science* that because he only dug about 4% of the settlement--and Hodder's team has so far excavated considerably less than that--it is too early to tell whether large communal buildings might be hidden in another part of the mound. Other observers, including Algaze, raise similar cautions. But Hodder says a detailed study of the entire mound suggests that there are no temples or other monuments waiting to be discovered. Using standard archaeological survey techniques--including meticulous scraping of the topsoil and searching for local

variations in Earth's magnetic field that might be caused by buried structures--the team failed to find any structures other than the myriad small, mud-brick dwellings.

Based on this and other evidence about what was going on in the houses--including the pattern of burials under the plastered floors--Hodder has tentatively concluded that the basic social units at Çatalhöyük were extended families grouped together in clusters of four or five houses, which carried on their daily activities more or less autonomously. "It is hard to imagine that 10,000 people, minimally 2000 families, were going out and doing their own thing, but that is what we see."

The Neolithic Revolution

This new view of Çatalhöyük as a decentralized community with minimal division of labor is reinforced by evidence that agriculture was still at a relatively early stage here. A survey of the area surrounding Çatalhöyük by a team of physical geographers, led by Neil Roberts of Britain's Loughborough University, suggests that the site was founded on the bank of a now-dry river that flowed here during Neolithic times and that frequent flooding of its banks created a lush wetlands environment. The plant remains found in and around the houses suggest that the people ate both wild and cultivated plants and seeds, including tubers, wild grasses, lentils, hackberries, acorns, and pistachios. Even the cereals likely to have been under cultivation, such as wheat and barley, may not have required irrigation in these wet conditions, and there is no evidence that grain was ground for bread.

A reanalysis of animal remains adds to the impression that Çatalhöyük's agriculture was not terribly advanced. Çatalhöyük had long been heralded as an early center of cattle domestication, based on a study of animal bones from the site by the late American faunal expert Dexter Perkins Jr. (*Science*, 11 April 1969, p. 177). In general, domestic cattle are much smaller than the now-extinct wild oxen, or aurochs, from which they are descended. By comparing cattle bones from Çatalhöyük with both earlier and later archaeological sites in Anatolia, Perkins concluded that cattle were probably domesticated early in the life of Çatalhöyük, and also that cattle represented the most numerous domesticated species.

But so far, at least, the animal bones emerging from the new excavations do not confirm this pattern. A study of the faunal remains by Nerissa Russell of Cornell University in Ithaca, New York, and Louise Martin at the Institute of Archaeology in London is showing that cattle made up only about 25% of the species present. Most of the animal bones represent sheep, which were domesticated much earlier than cattle across most of the Near East. Although Russell says it is too early to conclude whether the cattle were domesticated, "Çatalhöyük no longer appears to be a cattle-centered economy, which was a supporting argument for cattle domestication."

These findings, along with similar evidence from some other Near East sites, are challenging the original concept of the Neolithic Revolution. Many archaeologists are parting company with the view that settled life and agriculture were closely linked. "We have always thought that sedentism and agriculture were two sides of the same coin," says Algaze. "But as we start getting into the nitty-gritty details across the world, it becomes increasingly clear that while they are very much related, they are not necessarily coterminous."

Even stronger evidence for this conclusion comes from excavations at another site, called Asikli, in Central Anatolia. Since 1989, a team from the University of Istanbul, led by Ufuk Esin, has been excavating Asikli, a village that appears to be about 1000 years older than Çatalhöyük and was home to several hundred people at its height. Although it is smaller, Asikli has a more complex arrangement of buildings than Çatalhöyük. A large collection of mud-brick houses is partly surrounded by a stone wall, and Esin has found a large cluster of public buildings that may have been a temple complex, as well as a pebbled street running through the settlement. Most

amazingly, Esin's team has now excavated 10 successive occupation layers and found that the arrangements of the houses and the street are exactly repeated at each level. Yet, Esin told *Science*, most of the plant and all of the animal remains were wild. In essence, Asikli was a large, highly stable settlement that subsisted mostly on hunting and gathering.

"This is the new thing that Çatalhöyük is starting to give us, and that Asikli makes absolutely crystal clear," says Algaze. "You can have a major site, with a large population, on the basis of very little domestic agriculture. This goes against every paradigm we have ever had." It also runs counter to common sense, says Hodder. He argues that the rich wetland resources around Çatalhöyük would have been more easily exploited by a dispersed population in small settlements rather than by packing thousands of people into a village so crowded that they entered their houses through the roofs. "What you end up with," says Hodder, "is trying to understand why these people bothered to come together."

Coming together

To get at this crucial question, Hodder says, "we first have to understand Çatalhöyük on its own terms. Let's not try to categorize it, as a city or a village, but first try to find out how it works." As a leader of the "postprocessual" movement in archaeology, Hodder believes that deciphering the symbolic and religious life of the settlement is key to understanding what held its social fabric together.

It may also be a clue to understanding the transition to farming in general, says Jacques Cauvin of the Institute of Eastern Prehistory in Jalès, France, who argues that the Neolithic Revolution in agriculture was preceded by a "cultural revolution" in religious practices and the use of symbolism. "The origin of these [farming] changes was more cultural than economic," Cauvin told *Science*. Hunter-gatherer societies underwent a "mental transformation" that allowed them to see their environment differently and exploit it "more selectively and more actively," he says--a transformation that may be recorded at Çatalhöyük.

That symbolism was a defining element of Çatalhöyük is clear from the large number of spectacular artworks unearthed at the site, including a few figurines--of which the most famous is a seated woman with her hands on the heads of two leopards--which Mellaart believed represented a Mother Goddess. Hodder and other archaeologists at Çatalhöyük say the evidence to support goddess worship is scant. Instead, the team has focused on two striking features of life and death at the site, which might give insights into how its people viewed the world and their place in it: the habit of burying the dead under the floors, and the murals painted on the plastered walls, which often featured wild animals and hunting scenes.

Mellaart's excavations had established that at some point during the life of a house, its roof was taken down, part of the walls dismantled, and the rooms filled in, leaving the burials, wall murals, ovens, storage bins, and other features intact. Last year, while excavating a large building, the team discovered more than 70 bodies buried under its floors. A study of the ages of the skeletons and the order in which they were buried, carried out by anthropologists Theya Molleson and Peter Andrews of the Natural History Museum in London, suggested that the life cycle of the house coincided with the life of an extended family. Thus the earliest burials appear to be of infants and children, while the later burials are mainly people who survived into adulthood and even old age.

In addition, all of the murals were found on the walls around a raised platform in one corner of the room that covered a large concentration of burials. Paintings were especially common on earlier layers of plaster that coincided in time with the burials of children. Hodder and Berkeley's Tringham believe that this close association between paintings and burials is no coincidence. Arguing from so-called ethnographic

evidence, which uses knowledge of present-day cultures to shed light on past societies, they suggest that the art might have represented a ritualistic attempt to assuage the spirits that had taken the lives of the community's young people, or perhaps an effort to protect the living from the spirits of the dead. Similar practices exist today among the San hunters of southern Africa, nomadic tribes in northern Asia, and the Nuba of Sudan. There are also striking parallels with the burial practices of the Tikopia people of Polynesia, who buried their dead under the floors as well.

The habit of keeping the remains of the dead close to the living is mirrored at other digs across the Near East. At Jericho, for example, human skulls molded with plaster to represent real people were found during excavations there in the 1950s, and a recent dig at the site of Çayönü in southern Turkey, led by Mehmet Özdoğan of the University of Istanbul, uncovered piles of human skulls in the cellars of a building. In addition, extraordinary painted statues, which may represent mythical ancestors, were found buried under a house at 'Ain Ghazal.

Hodder also sees parallels between the murals of Çatalhöyük and the scenes of hunting and wild animals that dominate the earlier cave art produced by hunter-gatherers. He suggests that the transition to settled life required "the domestication of the wild by bringing it into the house, at least the symbolism of the wild, and controlling it." This shared cultural transformation, combined with the creation of large family groups tied together by their links to their ancestors, might have been the "glue" that held the early society at Çatalhöyük together.

Of course, archaeology, which attempts to understand past societies from the shards of bone and artifacts they left behind, cannot--and does not--claim to be an exact science. And Hodder admits that these ideas are only hypotheses, which may or may not be supported by further excavation. But if all goes as planned, archaeologists might not have to wait until the next millennium to learn more about what made the people of Çatalhöyük come together. Although Mellaart dug through a dozen successive occupation levels, core samples from the mound indicate that he stopped about 5 meters before reaching unoccupied virgin soil. Next year, if special funding for the project comes through, the team plans to extend its normal 2-month summer season to 8 or 9 months. This should be long enough to dig a deep trench through one section of the mound, right to its very bottom. There, by the bank of an ancient river, the founding mothers and fathers of Çatalhöyük may well lie buried.

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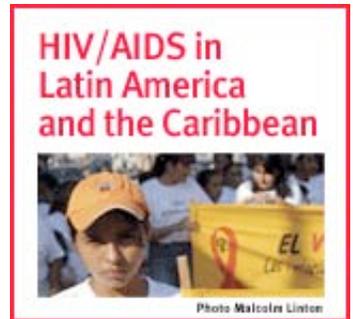
**THE FIRST CITIES:
Digging Into the Life of the Mind**
Michael Balter

CAMBRIDGE, U.K.--As a student at London's Institute of Archaeology in the 1960s, Ian Hodder heard James Mellaart lecture about his excavations at Çatalhöyük, a huge Neolithic settlement in present-day Turkey. The aspiring archaeologist was entranced. "Mellaart was a fantastic speaker, and he left an indelible impression of the site on my mind," Hodder says. Now, 3 decades later, Hodder himself is in charge of major new excavations at Çatalhöyük, which are expected to take the next 25 years ([see main text](#)). The new dig is being closely watched by the archaeological community--yet as much for the way it is being dug as for what it is finding.

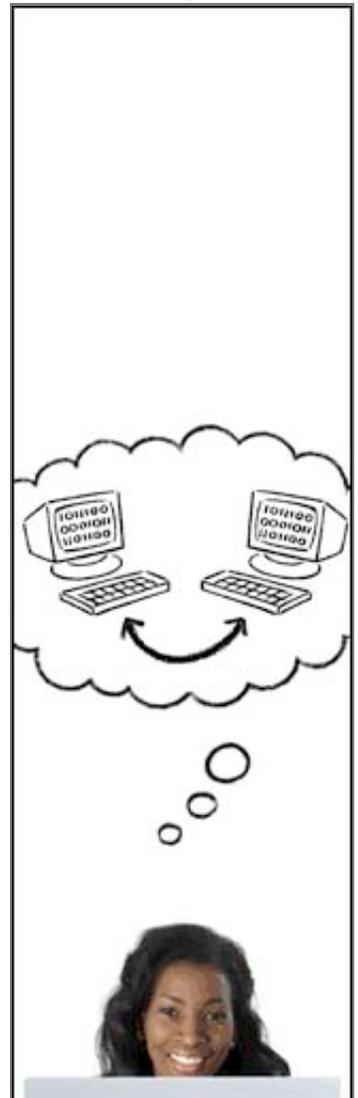
Hodder--now at Cambridge University--has spent much of his career leading a theoretical revolt against established archaeological thought. This movement of mostly British and some American archaeologists--which has been greatly influenced by postmodernist trends in the humanities--is usually referred to as "postprocessualism." It puts much more emphasis on studying the symbolic and cognitive life of ancient peoples than did earlier approaches and argues for the need to accept and even welcome differing interpretations of an archaeological site.

The new school is in part a rebellion against what used to be called the New Archaeology, a movement sparked in the 1970s by Lewis Binford in the United States and the late David Clarke in the United Kingdom. The New Archaeology--which is now usually called processualism, because of its concern with processes of social change--was in turn a reaction against what was seen as the static, unscientific, and speculative approaches of the previous generation of archaeologists. But Hodder and others began to feel that the processualists were focusing too narrowly on questions that could most easily be answered by scientific method, such as adaptation to the environment, economy, and trade, to the neglect of religious and social beliefs. "Humans adapt to their environment partly through system of beliefs or preconceptions of the world," Hodder says. "Culture and mind contribute something; we don't just respond to the environment the way animals do."

The debate over these issues often turned acrimonious, with processualists accusing postprocessualists of embracing "relativism" and being antisience, and the latter countering with charges of "scientism" and "positivism." More recently, however, the discussion has taken a calmer tone, although there are still occasional flare-ups in the



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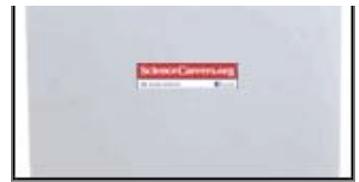
pages of archaeological journals. Colin Renfrew of Cambridge University comments that "processual archaeology had its own rhetoric, and I think the 'postprocessualists' have quite successfully deflated a little of that. But that hasn't prevented them from introducing whole balloonfuls of rhetorical wind of their own."

Hodder is putting a strong emphasis on scientific methods at Çatalhöyük, bringing in dozens of experts who are literally putting the site under the microscope--an approach that some archaeologists take as an ironical indication that he has at last seen the processual light. "Everybody is very impressed with Ian Hodder's descent from the lofty heights of theory to the nitty-gritty of actually getting something done," says Guillermo Algaze of the University of California, San Diego. But Hodder insists that he is using science in a much different way: Rather than focusing only on issues that can be resolved by hypothesis testing, such as the details of economy and trade, he is trying to understand ancient belief systems by using the scientific evidence as pieces of a "jigsaw puzzle" that can never be solved with certainty.

Thus unlike most digs, where excavators excavate and archaeological specialists make short visits to the site or stick to their labs and work on specimens, Hodder has brought in a large team of full-time experts who sometimes work side by side with excavators, interpreting what they see as they go along. Indeed, everyone is encouraged to try to make sense of what they uncover rather than simply collecting data. "People here are pushed to make their own interpretations, to look for patterns," says team member Nerissa Russell, an archaeologist at Cornell University in Ithaca, New York.

Hodder fully realizes that excavating the large and well-preserved site at Çatalhöyük is the best chance he will ever have to prove that the postprocessual approach can work. "That's why I am prepared to spend the next 25 years of my life working here," he says. "This is really a test of whether we can do it."

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NEWS

NEOLITHIC AGRICULTURE: The Slow Birth of Agriculture

Heather Pringle*

New methods show that around the world, people began cultivating some crops long before they embraced full-scale farming, and that crop cultivation and village life often did not go hand in hand

According to early Greek storytellers, humans owe the ability to cultivate crops to the sudden generosity of a goddess. Legend has it that in a burst of goodwill, Demeter, goddess of crops, bestowed wheat seeds on a trusted priest, who then crisscrossed Earth in a dragon-drawn chariot, sowing the dual blessings of agriculture and civilization.

For decades, archaeologists too regarded the birth of agriculture as a dramatic transformation, dubbed the Neolithic Revolution, that brought cities and civilization in its wake. In this scenario, farming was born after the end of the last Ice Age, around 10,000 years ago, when hunter-gatherers settled in small communities in the Fertile Crescent, a narrow band of land arcing across the Near East. They swiftly learned to produce their own food, sowing cereal grains and breeding better plants. Societies then raised more children to adulthood, enjoyed food surpluses, clustered in villages, and set off down the road to civilization. This novel way of life then diffused across the Old World.

But like many a good story, over time this tale has fallen beneath an onslaught of new data. By employing sensitive new techniques--from sifting through pollen cores to measuring minute shape changes in ancient cereal grains--researchers are building a new picture of agricultural origins. They are pushing back the dates of both plant domestication and animal husbandry (see sidebar, p. [1448](#)) around the world, and many now view the switch to an agrarian lifestyle as a long, complex evolution rather than a dramatic revolution.

The latest evidence suggests, for example, that hunter-gatherers in the Near East first cultivated rye fields as early as 13,000 years ago.* But for centuries thereafter, they continued to hunt wild game and gather an ever-decreasing range of wild plants, only becoming full-blown farmers living in populous villages by some 8500 B.C. And in



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some cases, villages appear long before intensive agriculture (see p. [1442](#)). "The transition from hunters and gatherers to agriculturalists is not a brief sort of thing," says Bruce Smith, an expert on agricultural origins at the Smithsonian Institution's National Museum of Natural History in Washington, D.C. "It's a long developmental process"--and one that did not necessarily go hand in hand with the emergence of settlements.



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Similar stories are emerging in South America, Mesoamerica, North America, and China. Although cultivation may have been born first in the Near East, the latest evidence suggests that people on other continents began to domesticate the plants they lived with--squash on the tropical coast of Ecuador and rice along the marshy banks of the Yangtze in China, for example--as early as 10,000 to 11,000 years ago, thousands of years earlier than was thought and well before the first signs of farming villages in these regions. To many researchers, the timing suggests that worldwide environmental change--climate fluctuations at the end of the Ice Age--may well have prompted cultivation, although they are still pondering exactly how this climate change spurred people around the world to begin planting seeds and reaping their bounty.

Cultivating the green hell

Perhaps the most dramatic and controversial new discoveries in ancient agriculture have emerged from the sultry lowland rainforests of Central and South America. These forests, with their humid climate, poor soils, and profusion of pests, were long considered an unlikely place for ancient peoples to embark upon the sweaty toil of farming, says Dolores Piperno, an archaeobotanist at the Smithsonian Tropical Research Institution in Balboa, Panama. "If people were going to have a hard time living in [these forests], how were they ever going to develop agriculture there?" she asks. And most research suggested that these forest dwellers were relative latecomers to agriculture, first cultivating crops between 4000 to 5000 years ago.

But tropical forests harbor the wild ancestors of such major food crops as manioc and yams. Back in the 1950s, American cultural geographer Carl Sauer speculated that these regions were early centers of plant domestication, but there was little evidence to support the idea, as the soft fruit and starchy root crops of these regions rapidly rot away in the acid soils. The better preserved evidence found in arid regions, such as seeds from grain crops in the Near East, captured the attention of most archaeologists.

In the early 1980s, however, Piperno and colleague Deborah Pearsall, an archaeobotanist from the University of Missouri, Columbia, began searching the sediments of rainforest sites in Panama and Ecuador for more enduring plant remnants. They focused on phytoliths, microscopic silica bodies that form when plants take up silica from groundwater. As the silica gradually fills plant cells, it assumes their distinctive size and shape. Piperno and Pearsall came up with ways to distinguish phytoliths from wild and domestic species--domestic plants, for example, have larger fruits and seeds, and hence larger cells and phytoliths. Then they set about identifying specimens from early archaeological sites.

This spring, after nearly 20 years of research, the team published its findings in a book entitled *The Origins of Agriculture in the Lowland Neotropics*. In one study, they measured squash phytoliths from a sequence of layers at Vegas Site 80, a coastal site bordering the tropical forest of southwestern Ecuador. From associated shell fragments as well as the carbon trapped inside the phytoliths themselves, they were able to carbon-date the microfossils. A sharp increase in phytolith size indicated that early Ecuadorians had domesticated squash, likely *Cucurbita moschata*, by 10,000 years ago--some 5000 years earlier than some archaeologists thought farming began there. Such timing suggests, she notes, that people in the region began growing their own plants after much local game went extinct at the end of the last Ice Age and tropical

forest reclaimed the region. "I think that's the key to the initiation of agriculture here," says Piperno. If this find holds up, the Ecuador squash rivals the oldest accepted evidence of plant domestication in the Americas--the seeds of another squash, *C. pepo*, excavated from an arid Mexican cave and directly dated to 9975 years ago (*Science*, 9 May 1997, pp. [894](#) and [932](#)).

The phytolith technique is also pushing back the first dates for maize cultivation in the Americas, says Piperno. Phytoliths taken from sediment samples from Aguadulce rock-shelter in central Panama by Piperno and her colleagues and carbon-dated both directly and by analyzing shells from the same strata imply that maize cultivation began there as early as 7700 years ago. That's not only more than 2500 years earlier than expected in a rainforest site, it's also 1500 years earlier than the first dates for maize cultivation anywhere in the more arid parts of the Americas. Almost certainly, the oldest partially domesticated maize at the site came from somewhere else, because the wild ancestor of corn is known only from a narrow band of land in Mexico. But the squash data raise important questions, says Piperno, about where agriculture first emerged in the Americas. "Clearly tropical forest is in the ball game."

But the community is split over whether to accept the phytolith evidence. Some critics question the dating of the phytoliths themselves, saying that carbon from other sources could have become embedded in the cracks and crevices on the fossil surfaces, skewing the results. Others such as Gayle Fritz, an archaeobotanist at Washington University in St. Louis, point out that the shells and other objects used to support the dates may not be the same age as the phytoliths. "I would be as thrilled as anyone else to push the dates back," says Fritz, "but my advice now is that people should be looking at these as unbelievable."

However, proponents such as Mary Pohl, an archaeologist at Florida State University in Tallahassee, note that the Piperno team typically supports its claims with multiple lines of evidence, so that even if one set of dates is suspect, the body of work makes it clear that some domestication took place startlingly early in the rainforest. "The data seem irrefutable to my mind," she says.

If so, they overturn some basic assumptions about the relationship between village life and agriculture in the tropical forest. For years, says Piperno, researchers believed that the first farmers there lived in villages, like the well-studied Neolithic grain farmers of the Near East. "Because settled village life is just not seen in [this part of the] Americas until 5000 years ago, [researchers thought] that means food production was late too," says Piperno. "But it doesn't work." In her view, farming in the region came long before village life. For thousands of years, she says, "you had slash-and-burn agriculture instead of settled village agriculture."

Taming wild rice

At the same time as early Americans may have been planting their first squash, hunter-gatherers some 16,000 kilometers east along the banks of the Yangtze River were beginning to cultivate wild rice, according to new studies by archaeobotanist Zhijun Zhao of the Smithsonian Tropical Research Institution and colleagues. Rice, the most important food crop in the world, was long thought to have been cultivated first around 6500 years ago in southern Asia, where the climate is warm enough to support luxuriant stands of wild rice. But in the 1980s, ancient bits of charred rice turned up in a site along the banks of the middle Yangtze River, in the far northern edge of the range of wild rice today. Directly carbon-dated to 8000 years ago, these grains are the oldest known cultivated rice and suggest that the center of rice cultivation was actually farther north.

Now the dates have been pushed back even farther, revealing a long, gradual transition to agriculture, according to work in press in *Antiquity* by Zhao. He has analyzed a sequence of abundant rice phytoliths from a cave called Diaotonghuan in

northern Jiangxi Province along the middle Yangtze, which was excavated by Richard MacNeish, research director at the Andover Foundation for Archaeological Research in Massachusetts, and Yan Wenming, a Peking University archaeologist in Beijing.



Neolithic evolution. Around the world, societies tamed the plants and animals at hand, but didn't embrace full-scale farming until thousands of years later.

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Radiocarbon dates for the site seemed to have been contaminated by groundwater, so Zhao constructed a relative chronology based on ceramic and stone artifacts of known styles and dates found with the phytoliths. In recent weeks, Zhao has further refined his *Antiquity* chronology as a result of a joint study with Piperno on paleoecological data from lake sediments in the region.

To trace the work of ancient cultivators at the site, he distinguished the phytoliths of wild and domesticated rice by measuring minute differences in the size of a particular type of cell in the seed covering. With this method, which Zhao pioneered with Pearsall, Piperno, and others at the University of Missouri, "we can get a 90% accuracy," he says.

By counting the proportions of wild and domesticated rice fossils, Zhao charted a gradual shift to agriculture. In a layer dated to at least 13,000 years ago, the phytoliths show that hunter-gatherers in the cave were dining on wild rice. But by 12,000 years ago, those meals abruptly ceased--Zhao suspects because the climate became colder and the wild grain, too tender for such conditions, vanished from this region. Studies of the Greenland ice cores have revealed a global cold spell called the Younger Dryas from about 13,000 to 11,500 years ago. Zhao's own studies of phytoliths and pollen in lake sediments from the region reveal that warmth-loving vegetation began retreating from this region around 12,000 years ago.

As the big chill waned, however, rice returned to the region. And people began dabbling in something new around 11,000 years ago--sowing, harvesting, and selectively breeding rice. In a zone at Diaotonghuan littered with sherds from a type of crude pottery found in three other published sites in the region and radiocarbon-dated to between 9000 and 13,000 years ago, Zhao found the first domesticated rice phytoliths--the oldest evidence of rice cultivation in the world. But these early Chinese cultivators were still hunting and gathering, says Zhao. "The cave at that time is full of animal bones--mainly deer and wild pig--and wild plants," he notes. Indeed, it was another 4000 years before domestic rice dominated wild rice to become the dietary staple, about 7000 years ago.

It makes sense that the transition to farming was slow and gradual and not the rapid switch that had been pictured, says MacNeish. "Once you learn to plant the stuff, you must learn to get a surplus and to get the best hybrid to rebreed this thing you're planting," he notes. "And when this begins to happen, then very gradually your population begins going up. You plant a little bit more and a little bit more." At some point, he concludes, the hunter-gatherers at sites like Diaotonghuan were unable to gather enough wild food to support their burgeoning numbers and so had little choice but to embrace farming in earnest.

The cradle of civilization

In the Near East, archaeologists have been studying early agriculture for decades, and it was here that the idea of the Neolithic Revolution was born. Yet even here, it seems there was a long and winding transition to agriculture. And although settled village life appeared early in this region, its precise connection to farming is still obscure.

The latest findings come from Abu Hureyra, a settlement east of Aleppo, Syria, where the inhabitants were at least semisedentary, occupying the site from at least early spring to late autumn, judging from the harvest times of more than 150 plant species identified there to date. Among the plant remains are seeds of cultivated rye, distinguished from wild grains by their plumpness and much larger size. University College London archaeobotanists Gordon Hillman and Susan Colledge have now dated one of those seeds to some 13,000 years ago, according to unpublished work they presented at a major international workshop in September.[†] If the date is confirmed, this rye will be the oldest domesticated cereal grain in the world.

These dates are nearly a millennium earlier than previous evidence for plant domestication. And the rye is not even the first sign of cultivation at the Abu Hureyra site: Just before the appearance of this domestic grain, the team found a dramatic rise in seed remains from plants that typically grow among crops as weeds. All this occurs some 2500 years before the most widely accepted dates for full-scale agriculture and populous villages in the Near East. Although the semisedentism of the inhabitants fits with earlier ideas, the long time span contradicts ideas of a rapid agricultural "revolution."

The early date for plant domestication in the Near East is not entirely unexpected, says Ofer Bar-Yosef of Harvard University. For example, inhabitants of Ohalo II in what is now Israel had made wild cereal seeds a major part of their diets as early as 17,000 B.C., according to published work by Mordechai Kislev, an archaeobotanist at Bar Ilan University in Ramat-Gan, Israel. Moreover, as close observers of nature, these early foragers were almost certain to have noticed that a seed sown in the ground eventually yielded a plant with yet more seeds. "These people knew their fauna and flora very well," says Bar-Yosef, "and they probably played with planting plants long before they really switched into agriculture."

Just what spurred hunter-gatherers to begin regularly sowing seeds and cultivating fields, however, remains unclear. For several years, many Near Eastern experts have favored the theory that climate change associated with the Younger Dryas was the likely trigger. Bar-Yosef, for example, suggests that inhabitants of the Fertile Crescent first planted cereal fields in order to boost supplies of grain when the Younger Dryas cut drastically into wild harvests.

And at Abu Hureyra, Hillman thinks that the drought accompanying the Younger Dryas was a key factor. Before the jump in weeds and the appearance of domestic rye, the inhabitants relied on wild foods as starch staples. Over time, they turned to more and more drought-resistant plants--and even these dwindled in abundance. So "progressive desiccation could indeed have been the impetus for starch cultivation," says Hillman.

But new dates for the cold spell in the Near East paint a more complex view. At the Netherlands workshop, Uri Baruch, a palynologist at the Israel Antiquities Authority in Jerusalem, and Syze Bottema, a palynologist at the Groningen Institute of Archeology in the Netherlands, announced that they had redated a crucial pollen core at Lake Hula in northern Israel. Their original published estimate put a retreat in the region's deciduous oak forest--due to cool, dry conditions believed to be the local manifestation of the Younger Dryas--starting about 13,500 years ago. But after correcting for contamination by old carbon dissolved in the lake water, they found that the cold spell in the Near East was a bit later, starting around 13,000 years ago and ending around 11,500 years ago.

These dates suggest that farmers of Abu Hureyra may have begun cultivating rye before the Younger Dryas set in, at the very end of the warm, moist interval that preceded it. "The domesticated rye dates and the pollen core don't match up so well at this time," says Mark Blumler, a geographer at the State University of New York, Binghamton.

Moreover, others point out that the clearest evidence for the domestication of grains such as wheat and barley in the Near East comes around 10,500 years ago, after the Younger Dryas had waned and the climate had improved again. By then, says George Willcox, an archaeobotanist at the Institut de Prehistoire Orientale in St-Paul-le-Jeune, France, other factors could have contributed to the transition. Hunter-gatherers in the region, for example, had settled year-round in small villages between 12,300 and 10,500 years ago. There, he says, rising human populations and overexploitation of wild foods could have driven people to take up farming. "Because people at this time appear to be living in one place," says Willcox, "they could use up all the resources in a particular area."

Putting the evidence from around the world together, a new picture of the origins of agriculture begins to emerge. In the Near East, some villages were born before agriculture and may even have forced its adoption in some cases. But elsewhere--China, North America, and Mesoamerica--plants were cultivated and domesticated by nomadic hunter-gatherers, perhaps to increase their yield during the dramatic climate shifts that accompanied the final phase of the last Ice Age. Either way, it no longer makes sense to suppose a strong causal link between farming and settled village life, Piperno says.

Indeed, in many regions, settled agriculturalists emerged only centuries or millennia after cultivation, if at all. Many ancient peoples simply straddled the middle ground between foraging and farming, creating economies that blended both (see sidebar, p. [1447](#)). "For so long, we've put everybody in black boxes" as farmers or hunter-gatherers, notes Joanna Casey, an archaeologist at the University of South Carolina, Columbia, and a specialist in agricultural origins in western Africa. But mixed cultivation and foraging is not necessarily a step "on the way" to full-scale farming--it was a long-term lifestyle for many groups. "These societies in the middle ground are certainly not failures," says the Smithsonian's Smith. "They are not societies that stumbled or stuttered or got frozen developmentally. They're societies that found an excellent long-term solution to their environmental challenges."

Eventually, for reasons still unclear, many of the early domesticators did become true agriculturalists--by 10,500 years ago in the Near East, 7000 years ago in China, and later in the Americas and Africa. And during this transition, human populations did indeed soar, and hamlets became villages. Archaeological sites in the intensively studied Fertile Crescent, for example, increased more than 10-fold in size, from 0.2 hectares to 2.0 to 3.0 hectares, during this period of transition. The combination of settlement and reliable food probably brought about "a longer period of fertility for the now better fed women," says Bar-Yosef, setting the stage for cities and civilization.

So it seems that the ancient Greek legends got it half right when they told how seeds fell throughout the world, sparking independent centers of domestication on many continents. But cities and civilization did not necessarily arrive at the same time as the seeds. Demeter's priest apparently gave out only one blessing at a time.

[Heather Pringle is a science writer in Vancouver, British Columbia.](#)

[* All dates are calendar years.](#)

[† The Transition From Foraging to Farming in Southwest Asia, Groningen, the Netherlands, 7–11 September.](#)

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Neolithic evolution. Around the world, societies tamed the plants and animals at hand, but didn't embrace full-scale farming until thousands of years later.

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NEWS

**NEOLITHIC AGRICULTURE:
The Original Blended Economies**

Heather Pringle*

In the textbooks, preindustrial societies typically have two different ways to make a living: farming or hunting and gathering. But archaeologists studying ancient cultures are finding new evidence that people cultivated crops long before they settled down in one place or adopted full-blown farming (see main text). Recently anthropologists have found vivid examples of this middle way in historic cultures, which offer clues to how such mixed societies might have been organized in the past. Particularly in the Americas, many historic societies once labeled as hunter-gatherers turn out to have done a surprising amount of plant cultivation and management.

Some cultures actively planted seeds, like the historic Cocopa people of northwestern Mexico, who supplemented their diets of wild game by sowing two species of panic grass on the floodplain of the Colorado River after the waters receded, says National Museum of Natural History archaeologist Bruce Smith. Other peoples simply altered the landscape to change the mix of plants. The historic Kumeyaay people of southern California, for example, burned ground cover to eliminate competitors for their favored wild plants. "In a lot of environmental, social, and cultural situations, populations aren't forced into a developmental trajectory that leads to agriculture," says Smith. "They find solutions that are a better fit."

One of the most dramatic examples comes from published ethnographies of the Owen Valley Paiute in eastern California. Based on descriptions given by Paiute elders during the 1920s and '30s to American anthropologist Julian Steward, these writings describe how the Paiute propagated wild hyacinth, nut grass, and spike rush--root crops that thrived naturally in swampy meadows bordering the Owen River. Each year, Paiute men dammed tributary creeks in nearby hills and built irrigation ditches up to 6 kilometers long to the swampy meadows in the valley, thus creating hectares of new habitat for the crops. Even though they didn't plant seeds, notes Smith, "they're expanding the habitat of naturally occurring plants to increase their yield and productivity."

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The Paiute dismantled their dams every year, so without historic records their work would have been invisible to archaeologists. But as researchers begin to look for the signs of such low-level food production, ancient examples are turning up. In the American Southwest, for example, Suzanne Fish, an archaeologist at the Arizona State Museum in Tucson, has recently identified rock mulching beds that prehistoric peoples in Arizona built nearly 1500 years ago for stands of agave, cultivated for both food and fiber. These early food producers, says Fish, "were transplanting the agave to lower elevations in areas where it's too hot and dry for it to normally grow. Mulching gives it a moisture advantage." Smith agrees, concluding, "It really is one of those rare situations where this shows up archaeologically."



[Heather Pringle is a science writer in Vancouver, British Columbia.](#)

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NEWS

NEOLITHIC AGRICULTURE: Reading the Signs of Ancient Animal Domestication

Heather Pringle*

Over the millennia, humans seeking a steady source of food, hides and wool, and companionship have tamed everything from wolves to turkeys to guinea pigs. Learning when--and why--each of the more than two dozen domesticated animals was brought under human rule has been a continuing quest for archaeologists. Now researchers are shaking up their old conclusions by using more sensitive techniques, such as tracing demographic patterns in bone assemblages, to tease out the signature of human handling. So far such methods are pushing back the dates of domestication of one animal--pigs--revealing animal husbandry in what is now southeastern Turkey long before cultivation began there. More examples may follow. The findings are "causing quite a stir," says Bruce Smith, an archaeologist at the National Museum of Natural History in Washington, D.C. "People are now going back and looking at other animal species."

Traditionally, the first farm animals were thought to be wild goats and sheep, tamed in southwest Asia around 10,000 years ago* by sedentary cereal farmers who had wiped out the local wild game and needed new sources of meat and hides. Domestic pigs and cattle followed around 9000 years ago. And the earliest firm evidence of dairy farming, from art and written texts, isn't until about 6000 years ago, although new dates could come from a new method for identifying milk fat residues on pottery sherds, reported on page 1478 of this issue.

Most archaeologists rely on a more mundane characteristic to identify domestic herds: size. Researchers assume that early domestic goats, sheep, pigs, and cattle were smaller than their wild cousins. Early pastoralists, the theory goes, kept their animals in worse conditions than in the wild and selected for smaller, more easily subdued males. "Who would you choose?" asks Melinda Zeder, curator of Old World archaeology and zooarchaeology at the Smithsonian Institution. "The nerdy goat with the glasses or the bully on the playground?"

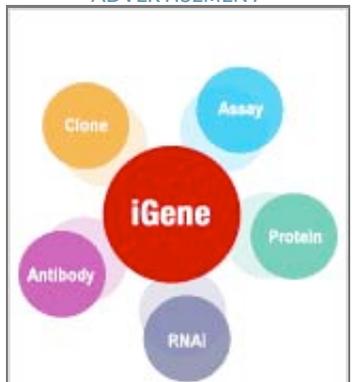
But in a controversial new study, as yet unpublished, Zeder tests both the size idea and a newer indicator--a distinctive pattern of mortality that distinguishes herds from hunter's prey. Brian Hesse, a zooarchaeologist at the University of Alabama, Birmingham, reasoned that ancient pastoralists, like modern ones, probably tried to

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Photo: Malcolm Linton

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get as much meat as they could from their goats while still ensuring the herd's survival. The obvious strategy is the one still used around the world today for managing livestock: raising females to maturity and keeping them until they quit producing offspring, while butchering most males young and keeping only a few older males as breeding stock. "So there should be a very distinctive marker in the demography," says Zeder, "and that should be instantaneous with the early period of managing."

To hone her strategy for spotting this transition, Zeder examined nine different bones of a control group of 40 modern-day wild and domestic goats of known sex from Iran and Iraq, where goats are thought to have been first domesticated. She could reliably distinguish goats from sheep and determine the animals' age at death, based on the sequence of bone fusion from 10 to 36 months. She could also determine the animals' sex, because the bones of the males were consistently bigger than those of similar-aged females.

Encouraged, she turned to tens of thousands of goat bones from eight sites in Iran and Iraq, ranging from Paleolithic hunter-gatherer caves to two Neolithic villages. She found little size difference between goats at the 9800-year-old Neolithic village of Ganj Dareh and goats hunted by Middle and Upper Paleolithic bands more than 40,000 years earlier.

But she did find a significant difference in mortality patterns. In the early sites, almost all the male goats were 36 months old or older at the time of death; the less numerous females were younger, suggesting that hunters had targeted male goats in their prime. But at Ganj Dareh, few billies lived past 24 months, while almost all nannies survived to 36 months or more. This suggests that "they are allowing the females to live as breeding stock," says Zeder.

The only evidence Zeder found for size reduction came at the Neolithic village of Ali Kosh, which new radiocarbon dates place at 9000 years ago. Zeder suggests that the animals were smaller there because it lies south of wild goats' natural range, so the animals were kept in hotter, harsher conditions--and females could no longer be bred with big wild males. Thus size reduction, rather than being the first sign of domestication, might instead indicate that animals had been transported beyond their original range or were no longer being bred with the wild type, Zeder suggests.

Not everyone is persuaded. For example, Harvard University faunal analyst Richard Meadow argues that some of the bones Zeder used, in particular the toe bones, don't accurately reflect an animal's size; he's not ready to give up on size reduction as an indicator of domestication. But other researchers, such as Curtis Marean, a zooarchaeologist at the State University of New York, Stony Brook, say Zeder's analysis is an important step forward. "It shows that the old idea that body size of the animals is directly related to domestication really doesn't fit the evidence," says Marean.

Zooarchaeologist Richard Redding of the University of Michigan, Ann Arbor, agrees, and indeed Zeder's demographic patterns fit well with his recently published study of ancient pig bones at the site of Hallan Chemi in southeastern Turkey. For years, faunal analysts pointed to the declining size of pigs' second and third molars as a key trait for some reason associated with pig domestication, and they traced the earliest domestic pigs to a 9000-year-old village in Turkey. But Redding now believes he has found earlier evidence, by applying demographic criteria like Zeder's.

He analyzed animal remains found in layers at Hallan Chemi and noted that in early layers dating to about 11,500 years ago, pig bones made up just 10% to 15% of the fauna and were almost evenly split between male and female. But in the later layers, dating from 11,000 to 10,500 years ago, pig bones climbed to 20%. "They also become very heavily biased toward female, and they become very young. So the



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inhabitants are killing suckling pigs," Redding says. All this happened before domestic cereal grains appear at the site, indicating that the people at Hallan Chemi were herding pigs before they began to farm grain. If Redding is right, the inhabitants of Hallan Chemi are the world's first known herders--and pigs, not goats or sheep, were the first farmyard animals to start on the long road to full domestication.

[Heather Pringle is a science writer in Vancouver, British Columbia.](#)

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NEWS

ART: Evolution or Revolution?

Tim Appenzeller

Human artistic ability burst forth in an explosion of creativity 38,000 years ago in ice age Europe--but was this the world's first flowering of artistic talent?

Sometime around 250,000 years ago, an early human living on the Golan Heights in the Middle East picked up a lump of volcanic tuff the size of a plum and started scratching at it with a harder stone, deepening its natural crevices. Not long afterward, a volcanic eruption buried the soft pebble in a bed of ash, preserving it from erosion. A quarter of a million years later, in 1980, archaeologists dug it up, and since then, the pebble has been the object of rapt attention--far more, perhaps, than it got when it was new. By chance or design, those long-ago scratchings created what looks like a female figure--and a puzzle for the archaeologists who study the beginnings of art.

To many archaeologists, art--or symbolic representation, as they prefer to call it--burst on the scene after 50,000 years ago, a time when modern humans are widely thought to have migrated out of Africa to the far corners of the globe. These scholars say the migrants brought with them an ability to manipulate symbols and make images that earlier humans had lacked. An explosion of art resulted, its epicenter in ice age Europe starting about 40,000 years ago, when most anthropologists believe modern humans were replacing the earlier Neandertal people. The new Europeans decorated their bodies with beads and pierced animal teeth, carved exquisite figurines from ivory and stone, and painted hauntingly lifelike animals on the walls of deep caves.

Some recent discoveries have strengthened this picture. Hints of art and personal ornaments have been found in Africa from just a few thousand years before the artistic explosion in Europe, supporting the idea that a worldwide migration of protoartists did begin 50,000 years ago in Africa. As Richard Klein of Stanford University puts it, "There was a kind of behavioral revolution [in Africa] 50,000 years ago. Nobody made art before 50,000 years ago; everybody did afterward."

But other developments have raised awkward questions about this "big bang" theory

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of art, as some critics call it, hinting that art and the sophisticated cognitive abilities it implies may have a longer history. After years of doubt, most archaeologists accept that the so-called Berekhat Ram object from the Golan Heights is the work of human hands, although there is no consensus about what--if anything--it means. Neandertal sites in Europe, some of them well over 40,000 years old, have yielded a polished plaque split from a mammoth tooth, bones that may have been incised for decorative purposes, and layers of ochre--a red pigment that early humans may have used to decorate their bodies. Ochre is also abundant at early sites in Africa, and ochre "crayons" have turned up at ancient rock-shelters in northern Australia, in layers that may be nearly 60,000 years old. "We're seeing more and more of these things popping up all over the place," says Paul Bahn, an independent archaeologist in England.

And 3 years ago, cave art specialists were stunned when carbon dating showed that virtuoso paintings at Grotte Chauvet in France may be more than 32,000 years old, meaning they were created not long after modern humans arrived in Europe. "I simply cannot conceive of the Grotte Chauvet paintings appearing out of nothing," says Bahn.

Perhaps most telling, many archaeologists now think an array of grooved teeth and other ornaments from a cave called the Grotte du Renne, at Arcy-sur-Cure in central France, is the handiwork of Neandertals. The age of the Arcy deposits is in dispute; most archaeologists think they date to around 35,000 years, a time when modern humans were already spreading into Europe and making stunning art of their own. But the date could be as early as 45,000 years ago, before modern humans arrived. To some researchers Arcy puts the lie to arguments that nonmodern humans like the Neandertals did not--perhaps could not--express themselves in art and ornament. It supports the view that artistic habits going back tens or even hundreds of thousands of years could have prepared the ground on which the ice age explosion took place.

The debate is more about the significance of this early evidence than about its reality. Traditionalists--call them explosion theorists--don't doubt that humans before 50,000 years ago sometimes left artifacts that appear decorative or symbolic. But they argue that the objects are so rare and crude that they can hardly be taken seriously as part of a systematic symbolic representation of the world. As Paul Mellars of the University of Cambridge puts it, "Everything that's ever claimed to be Neandertal is so amorphous, so lacking in crisp representation. ... There's always this massive question of whether it's just someone doodling." What impresses him, he says, "is the contrast between that and the clarity you get in the Upper Paleolithic"--the time after 40,000 years ago when modern humans populated Europe.

Art's big bang

Even for archaeologists who focus on earlier times and other continents, there's no denying the artistic explosion that took place in ice age Europe. Some of the earliest confidently dated signs, from a site called Kostenki 17 in Russia, are 38,000-year-old beads and pendants of stone, animal teeth, and marine fossils. After that, ornaments and imagery proliferated. In well-dated 35,000-year-old deposits at a rock-shelter called Abri Castanet in southwestern France, says Randall White of New York University, "I have more material in a few square meters than [there is] in all the rest of the world up until then."

The ornamental objects at Abri Castanet are beads--thousands upon thousands of them, in all stages of manufacture, made of mammoth ivory and soapstone. And within a few thousand years, the artistic range of these first modern Europeans had broadened to expressive carvings of animals, enigmatic figurines of women in the last stages of pregnancy, and the painted lions, rhinos, bears, and other animals that romp across the walls at Grotte Chauvet. "Between 38,000 and 33,000 years, everything is there, including Grotte Chauvet," says White.



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But what could have touched off this explosion? Klein and a few others think the answer lies in biology--some change in the wiring of the brain that enabled humans to innovate, think symbolically, and make art. "My view is that modern human behavior was a biological advance," he says. Human ancestors in Africa looked anatomically modern by 150,000 years ago. But Klein thinks an additional evolutionary step, hidden in the brain, came 50,000 years ago. It gave modern humans the cognitive wherewithal to migrate to the distant reaches of Europe and Asia, replacing archaic human populations as they went.

And, gratifyingly for Klein, Africa is where some of the earliest indisputable body ornaments are turning up. In last April's *Journal of Archaeological Science*, Stanley Ambrose of the University of Illinois, Urbana-Champaign (UIUC), describes his excavations at a rock-shelter in the Rift Valley of Kenya, at a site called Enkapune Ya Muto. There he found a cache of beads made of ostrich eggshell, blanks, and shell fragments. Some of the beads, says Ambrose, "are shiny, obviously worn, as if someone was wearing them as part of some ornament." They must have served as symbolic markings, he says, "expressing an awareness of the self and how to enhance it."

It's the same phenomenon seen in Europe 38,000 years ago--but it may be several thousand years earlier at Enkapune Ya Muto, says Ambrose, who has carbon-dated the shells and come up with an age of at least 40,000 years. "These early ostrich eggshell beads are perhaps the earliest indicator" of symbolic behavior anywhere, says Klein. "And it's very important that they first appeared in Africa," just as expected if the crucial biological innovation had occurred there.

Other archaeologists agree with Klein about the sudden flowering of art but reject his biological explanation. "I don't think it's a mutation for the art gene," says Olga Soffer of UIUC. "We're totally on the wrong track when we're asking the question of biology." White agrees. "I think that what we call art is an invention, like agriculture, which was an invention by people who were capable of it tens of millennia before."

What spurred the invention is a matter of speculation, although many archaeologists think that, at least in Europe, it could have been part of a social change triggered by a challenging new environment. Chasing wide-ranging herds in the shadow of the ice sheets, modern humans thrived by developing an intricate social system, with a complex division of labor and long-distance ties. "That's one way to survive in an environment where you've got scattered and somewhat unpredictable resources," says Philip Chase of the University of Pennsylvania, Philadelphia. Body ornaments and art might have helped express those new social relations.

Or they may have served to distinguish modern humans from the other kinds of people they were meeting as they moved into new and perhaps hostile territory. Says White: "I have a hard time thinking it's coincidental that all of this was going on [in Europe] at a time when you have quite a different hominid moving into territory occupied for 300,000 to 400,000 years [by earlier humans]. A major concentration of art is right where Neandertals were being replaced by modern humans, all the way from the Russian plain to the Iberian peninsula." Modern humans naturally sought ways to distinguish themselves from their neighbors and strengthen their own cultural ties, he suggests, and art was one solution.

It's old, but is it art?

A few researchers, however, think they have a more natural explanation for the ice age explosion: It was grounded in a tradition going back tens or even hundreds of thousands of years and glimpsed fitfully in sites around the world. Alexander Marshack, for instance, an archaeologist associated with the Peabody Museum at Harvard University, has campaigned for years to persuade his colleagues that ice age Europe can't be the beginning of the story.

Thirty years ago, he took his first close look at 30,000-year-old ivory animals from Vogelherd, in Germany, then considered to be some of the earliest art. What he saw, he says, were works "so sophisticated they couldn't have happened instantaneously. Making them required thousands of years of technology, of symboling, of making stories about the animals." Early cave paintings also showed signs of a rich cultural context that, he believed, simply could not have emerged full-blown in a few centuries. Other archaeologists argue that a few centuries is plenty of time for culture to blossom. But Marshack concluded that "there had to be a long prior history, so I began looking for earlier objects."

Here and there, in material from sites around the world, he has found them. From Quneitra in Israel comes a bit of flint incised with concentric arches some 54,000 years ago. From a site called Tata in Hungary comes an enigmatic plaque made of polished mammoth tooth, 50,000 to 100,000 years old, its crevices filled with red ochre. At a 250,000-year-old rock-shelter site in the Czech Republic, archaeologists found a bed of ochre and the rubbing stone used to make the powder--not art, but perhaps the means of making it. And then there is the 250,000-year-old carving from Berekhat Ram, which Marshack has studied closely and interprets as the figure of a woman with an elaborate coiffure.

To Marshack, the Berekhat Ram object, like the later artifacts from Tata and Quneitra, is a trace of a capacity for making symbols that was well developed long before the ice age explosion. True, he says, it's just one piece of "art" from a span of tens of thousands of years, but it should not be dismissed. "It may be unique, but its complexity raises questions that have to be addressed." It suggests, he adds, that other symbolic objects have simply been lost from the record: "Chances are that if they were making images of volcanic tuff, they were making images of wood," which would have decayed. One reason ice age art is so abundant, he adds, is that modern humans in Europe worked durable materials such as mammoth ivory and bone.

Marshack isn't the only one coming up with such evidence. A smattering of suggestive artifacts have come from Neandertal sites in Europe and Russia: bits of bone with what look like decorative markings, even a 43,000-year-old bone "flute" from Slovenia. But many of those claims have withered as researchers including Francesco d'Errico and Paola Villa of the Institute of Quaternary Prehistory and Geology in Talence, France, have taken a close look at the artifacts. Animal digestion, butchery marks, and even the tracks of blood vessels can easily explain many of the bone markings, says d'Errico. And both d'Errico and Chase have concluded that, as d'Errico puts it, the supposed flute "is absolutely natural and is the result of gnawing by animals."

Some of Marshack's artifacts, however, have held up better. His analysis of the Berekhat Ram object, published last year in *Antiquity*, seems to have convinced most of his colleagues that it was shaped artificially, and a few of them even accept it as an image. "It's extremely clear that it's humanly enhanced. It's definitely an art object," says Bahn. D'Errico and April Nowell of the University of Pennsylvania, Philadelphia, actually tested Marshack's claims by going to the site and comparing the object with hundreds of other bits of tuff. They, too, are persuaded that it is human handiwork. "No other pieces have this kind of modification," d'Errico says.

But he isn't ready to call it art. "I'm not sure the people who made the grooves were people using symbols. Also, one case does not explain a lot." Exactly, says Cambridge's Mellars. The uniqueness of artifacts like the Berekhat Ram carving "totally undermines their role in a symbolic communication system," he says. Chase sums up the doubts about Berekhat Ram and similar artifacts: "Was it just a kid who was sitting there scratching on something? Or did it have some function we can't recognize?"

Artful Neandertals?

One set of decorative objects apparently made by nonmodern humans can't be dismissed as anomalies, however. At the Neandertal site of Arcy-sur-Cure, archaeologists in the 1950s and 1960s excavated not just one or two but dozens of animal teeth pierced and grooved for use as ornaments, along with a handful of ivory beads and pendants. No other Neandertal site has held anything like this trove of symbolic objects. The same site also yielded bone tools and stone points made by more modern techniques than those of earlier Neandertals. But most of the doubts about whether Neandertals were responsible for these objects faded when Neandertal bones were identified first at another site with the same "Châtelperronian" tool technology and then, 2 years ago, at Arcy itself.

Now archaeologists are debating what the Neandertal ornaments at Arcy mean for the ability of nonmodern humans to traffic in symbols and make art. Although the exact age of the Arcy deposits is uncertain, most carbon dates from the site overlap with dates for modern humans in France and Spain. That leaves plenty of room for archaeologists to argue over whether the Arcy Neandertals developed art on their own or were imitating their trendy neighbors.

At one pole is João Zilhão of the University of Lisbon in Portugal, who published an assessment of Arcy with d'Errico and others in the June issue of *Current Anthropology*. Zilhão says that at other Châtelperronian sites, the Neandertal deposits always underlie the layers of artifacts left by modern humans, implying that the Neandertal activity came first. And he puts his money on the earliest of the widely varying carbon dates obtained from the layers at Arcy, roughly 45,000 years old--a date that would mean the Neandertals made the objects well before modern humans were around to set an example. Zilhão says the evidence is clear: "Strictly empirically, Neandertals invented [ornaments] first."

At the opposite pole is Paul Mellars, who says Zilhão is wrong about the timing. "Most if not all of the Châtelperronian is post-38,000 radiocarbon years," he says. "It's a phenomenon that occurs after the arrival of moderns in northern Spain." The fact that Châtelperronian artifacts are found below those of modern humans just shows, he says, that the moderns moved into the abandoned caves and rock-shelters after the Neandertals vanished. In the meantime, the two groups could have had plenty of contact along a frontier that probably ran along the Pyrenees, with Neandertals to the north and modern humans to the south.

It's there that the Neandertals would have taken their artistic cues from their new neighbors, says Mellars. "Here were these 'supermen' coming over the hill, wearing fancy beads, with better weapons, better hunting skills--the Neandertals would have to be staggered by this." They would inevitably try to copy what they saw, if only because the modern style, pierced fox teeth and all, had cachet. The artifacts that resulted should not be taken as a sign of an independent artistic capacity, says Mellars. "To say that the beads must have had exactly the same symbolic meaning to Neandertals as they did to moderns--that's a non sequitur."

Most archaeologists agree with Mellars about the timing. But some note that the Neandertal beads aren't direct imitations of what nearby modern humans were making. The people at Arcy chose different kinds of animal teeth and used different techniques to work them, which leads these archaeologists to suggest that the Neandertals were drawing inspiration from their neighbors rather than simply mimicking them--making beads in their own way, for their own cultural purposes.

If so, the Arcy deposits could still have unsettling implications for the idea that art, and the complex culture it implies, is unique to modern humans. Says Chase, "If this really is symbolism, and taken at face value it is, then you've got Neandertals who were capable of the same symbolic behavior as modern humans." Klein is also mystified. "I want the Neandertals to be biologically incapable of modern behavior. So

[the Châtelperronian] is a real problem."

Zilhão and others hope to do more dating of the Arcy deposits, which might settle the issue if it shows that the ornaments really do predate modern humans in Europe. In the absence of such a tie breaker, the dispute will continue--pitting big bang theorists against gradualists, and archaeologists who stress the overall pattern of evidence against those who focus on the puzzling exceptions. After all, the real answer about what is art and what is not lies in the minds of its makers--and they are long gone.

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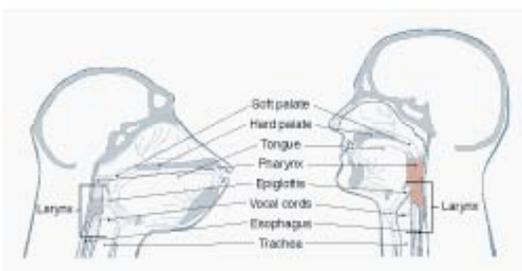
ANTHROPOLOGY: No Last Word on Language Origins

Constance Holden

Human beings were anatomically ready to speak more than 150,000 years ago-- but clear evidence that they were doing so does not appear for 100,000 years afterward

Nothing is more human than speech. Our closest primate relatives, chimpanzees, use tools, have intricate social lives, and show signs of self-awareness. But they lack spoken language, and all the capacities it implies, from rapid and flexible manipulation of symbols to the ability to conceptualize things remote in time or space. For archaeologists eager to learn how we became human, when and how language emerged is a crucial question.

Unfortunately, "speech does not fossilize," notes anthropologist John Shea of the State University of New York, Stony Brook. Writing appears 6000 years ago, and there is scant evidence for the existence of notation before 13,000 years ago. How long might language have been around before that? The only evidence is indirect, and it suggests two wildly different answers.



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Center in New York City, African hominids had cranial bases "identical to [those of] modern humans." The larynx had also descended, signifying that the tongue was no longer confined to the vocal cavity but was now rooted in the throat, a development necessary for rapid and versatile vocalization. "By 100,000 to 150,000 years ago, you know you've got modern speech--there's no other reason to retain this crazy morphology," says Lieberman. He points out that the speech package is costly--not only is the big brain an energy gobbler, but a dropped larynx offers no benefits other than speech, and it raises the risks of choking.

Words and deeds

And thereby hangs a mystery. Even though modern humans were equipped to talk up a storm, there are few definitive signs, for tens of thousands of years, of any of the behaviors anthropologists associate with language: complex tool technology and other signs of conceptualization and planning, trade, ritual, and art. Indeed, in the Middle East, where modern humans co-existed with the more archaic Neandertals for tens of thousands of years starting perhaps 90,000 years ago, the two groups behaved pretty much alike, says Klein, even though Neandertals may not have been capable of complex speech (see [sidebar](#)).

All that changes about 40,000 years ago, in the Upper Paleolithic revolution. Art and personal ornaments, which proliferate at about this time in Europe (see p. [1451](#)), are far and away the clearest sign, says Ian Tattersall of the American Museum of Natural History in New York. "Empathy, intuitive reasoning, and future planning are possible without language," he says. So are impressive tools such as the aerodynamically crafted 400,000-year-old wooden spears reported last year to have been found in a German coal mine. But "it's difficult to conceive of art in the absence of language," says Tattersall. "Language and art reflect each other." Both involve symbols that are not just idiosyncratic but have "some kind of socially shared meaning," adds Randall White of New York University.

"Socially shared meaning" shows up around 40,000 years ago in other realms besides art--such as tools. Harold Dibble of the University of Pennsylvania, Philadelphia, explains that until that time, the stone tools made by human ancestors don't fall into specialized types or vary much from one region to another. "The same three or four tools exist all over the Old World," he says, adding that what have been described as different types of tools are often the same things at different stages of resharpening and reduction. "There is nothing in these kinds of technologies that necessarily forces us to assume a linguistic mode of transmission," says Dibble.

But at the beginning of the Upper Paleolithic, new qualities become evident. The transition was especially abrupt in Europe, where so-called blade technology, based on standardized "blanks" that can be modified to make a wide range of tools, took over. Highly standardized tools for specific purposes, such as hunting particular kinds of animals, appear--and specialized tools, says Paul Mellars of Cambridge University, are a clue to "specialized language" on the part of their makers. Toolmakers also began exploiting new materials, namely bone and ivory, which demanded sophisticated carving skills that soon led to a proliferation of styles and designs. Once tools start to show "stylistic variability," says Dibble, we are witnessing the injection of culture into tools. And transmission of culture in any meaningful way requires language.

To some researchers, these dramatic transformations imply that one more biological change, beyond the expansion of the brain and the change in throat anatomy, had taken place, making humans capable of fully modern language. Klein, for example, posits a "fortuitous mutation" some 50,000 years ago among modern humans in East Africa that "promoted the modern capacity" for rapid, flexible, and highly structured speech--along with the range of adaptive behavioral potential we think of as uniquely human. He doesn't see how anything else, such as a social or technological development, could have wrought such "sudden and fundamental" change, which

modern humans then carried out of Africa and around the world.

Steven Mithen of the University of Reading in the U.K. also believes evolution did a late-stage tinkering with the brain, one that produced what he calls "fluid" human intelligence. Both apes and early humans, he believes, operate with what he calls a "Swiss army knife" model of intelligence. That is, they have technical, social, and "natural history" or environmental modules, but there's little cross talk between them. This could explain, for example, why humans were deft at shaping stones to butcher animals, but it never occurred to them to transform an animal bone into a cutting tool. At some point around the 40,000-year mark, Mithen believes the walls between these modules finally collapsed, leaving *Homo sapiens* furnished with the ability to generalize, perceive analogous phenomena, and exercise other powerful functions of the integrated human intelligence. Only then would language have been fully mature.

Others say that instead of reflecting a final step in brain evolution, language might have crystallized as part of a social change, perhaps triggered by population growth. "I don't subscribe to the cognitive model of a new bit gets added on," says Clive Gamble of Cambridge University. "I would argue it's changes in the social context"--for example, the complexity of behavior needed for large numbers of people to live together.

The revolution that wasn't?

Or maybe there was no linguistic watershed 40,000 years ago after all. Alison Brooks of George Washington University in Washington, D.C., and Sally McBrearty of the University of Connecticut, Storrs, have called the Upper Paleolithic revolution "the revolution that wasn't," arguing that at least in Africa, the modern behaviors thought to go hand in hand with language emerged gradually, well before 40,000 years ago. Their case rests in part on a set of barbed bone spear points that Brooks and her colleagues found at Katanda, in the Democratic Republic of Congo (*Science*, 28 April 1995, pp. 495, 548, 553). Bone technology is associated with the Upper Paleolithic in Europe, says Brooks--and yet these bone points have been dated to between 80,000 and 90,000 years ago. And stone points designed to tip spears or arrows, although very rare in Europe at this time, show up in various places in Africa more than 100,000 years ago, she says.

The Katanda site also showed other signs of sophistication: "seasonal scheduling" of freshwater fishing, says Brooks, as revealed by the remains of large catfish--and no sign of juveniles--suggesting they were caught at spawning time. Elsewhere in Africa, there is evidence of a large "trading network" as early as 130,000 years ago, say Brooks and McBrearty. Two sites in Tanzania have yielded pieces of obsidian, used to make points, found 300 kilometers away from their origin in Kenya's Central Rift Valley. Brooks also cites "a tremendous elaboration in pigment use" in the form of red ochre, presumably used for decoration and body adornment, notably at a 77,000-year-old site in Botswana.

Brooks believes all these lines of evidence spell the existence of language. All the signs are in the record, she says, including "complicated exchanges ... planning depth, and capacity for innovation." As for "stylistic variability" in tools, Brooks says there's plenty in 80,000-year-old African stone points. "You can pick up a stone point ... and in eight cases out of 10 say what region it came from," she says.

Brooks and McBrearty's case for the early emergence of modern behavior and language is controversial, especially as it rests heavily on the presumed antiquity of the bone points, whose age was gauged by dating of surrounding sediments and nearby hippo teeth. Scientists have reservations about the dating techniques (*Science*, 10 October 1997, p. [220](#)). Among the skeptics is Klein, who does excavations in South Africa. Of the bone points, he says, "I don't think those things are even remotely likely to be" 90,000 years old--especially because "the next oldest occurrence" of similar points is dated at 12,000 years ago. He also discounts the ochre data, saying "red ochre is all over the place" at early sites, including Neandertal ones, and could well have been used

for some purpose other than decoration. Mellars is also skeptical, saying about the obsidian trade: "Human beings move around quite a lot. Even if there was some deliberate exchange, I don't see that necessarily as an index of anything exciting cognitively."

The hints of early language use don't end there, however. Two 90,000-year-old burials in Israel containing anatomically modern humans--from a time when the Middle East was ecologically an extension of Africa--unequivocally show ritual behavior and the use of language that implies, says John Shea. One burial, at a site called Qafzeh, held a child buried with a deer antler. At the other, Skhul, the skeleton was found clasping the jawbone of a wild boar to its chest. Although any deliberate burial represents going "beyond the minimal necessary action for body disposal," says Shea, the inclusion of grave goods casts the action into another realm of meaning--the socially shared meaning of arbitrarily assigned symbols that is at the heart of language.

To some people, such as Brooks, these burials strengthen the case that modern behavior was well under way before the Upper Paleolithic revolution. Mithen sees them as a sign that the transition from Swiss army knife minds to "cognitive fluidity" was under way. Klein, on the other hand, is still dubious about the putative grave goods, saying it is extremely difficult to "distinguish what was an intentional act and a situation where something was accidentally incorporated."

There's one accomplishment that everyone agrees would qualify humans as fully modern, language-using people: getting to Australia. Even in the recent ice age, when sea level was lower, at least 100 kilometers of open water separated Australia from the nearest part of Asia. To reach Australia, humans had to build and provision sturdy boats--a sign not only of technological advancement and navigational skill but also of high levels of planning and cooperation, says Gamble.

Some archaeologists believe there is persuasive evidence that people managed to do all this by 60,000 years ago, based on dating at two stone tool sites in Northern Australia. But on this as on so many other hints of modern behavior, consensus is elusive. The dating was done by thermoluminescence, a technique that has not always proven reliable. Gamble says that the more reliable technique of radiocarbon dating, although capable of going back at least 40,000 years, has never identified an archaeological site in Australia older than 35,000.

Even if the uncertainties about artifacts and dates can be resolved, the question of whether fully modern language emerged in a sudden biological or cultural step 40,000 years ago or gradually, over the preceding tens of thousands of years, won't be settled. "The fundamental problem here is there is only one species on the planet who has language," says Duke University anthropologist Matt Cartmill. "We have one data point. With so many things unique to humans, we don't know what language is necessary for or what is necessary for language."

And there will still be plenty of room to argue that the scarcity of evidence for symbolic behavior before 40,000 years ago doesn't prove it wasn't happening. Leslie Aiello of University College London, for example, says the evidence might have all perished--after all, she notes, it would be very difficult to pick up signs of symbolic abilities from the archaeological record of the historical California Indians, who had a complex culture but produced very few artifacts in durable materials like stone.

Shea agrees, noting that an archaeologist "is like the drunk in the old joke who looks where the light is good" for his lost keys. Future finds could alter the hominid story: Although there are more than 100 excavated sites in southwestern France alone, Brooks notes, all of East Africa, the likely birthplace of modern humans, has just a dozen; and in Asia the record is mostly a big question mark. Thus paleoanthropology is a game for philosophers as well as scientists, and there is plenty of room for free play of the romantic imagination.

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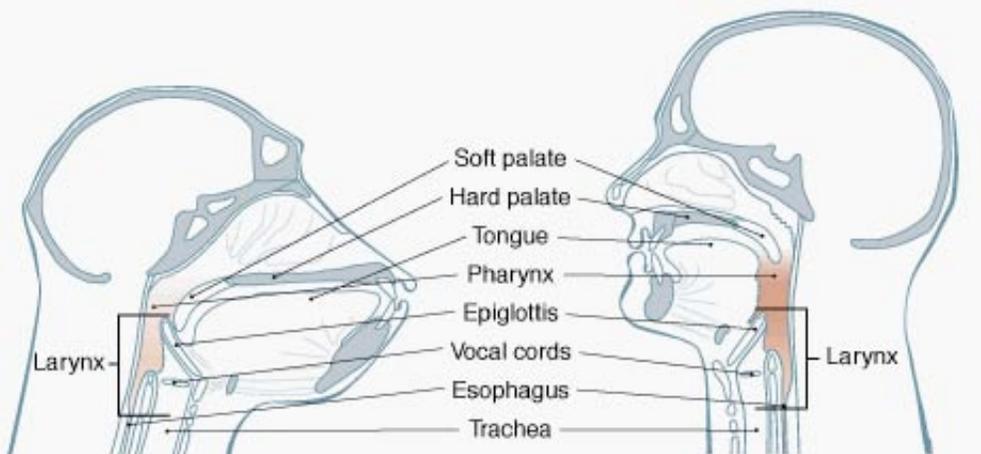
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Sound systems. The human upper respiratory tract made speech possible as the high larynx seen in species like the chimp (left) dropped, creating an expanded pharynx (red).

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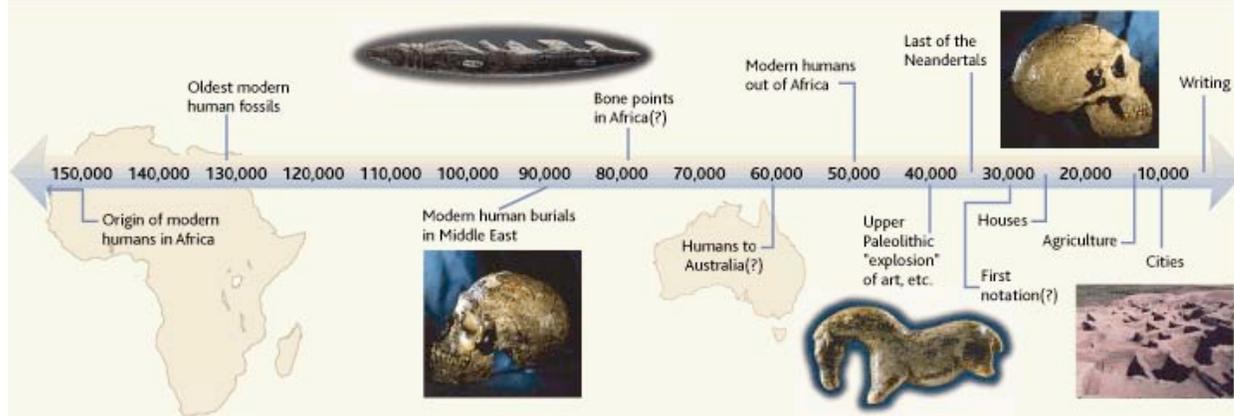
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Delayed takeoff. The anatomy needed for speech was in place before 150,000 years ago, but the signs of complex language don't proliferate until around 40,000 years ago.

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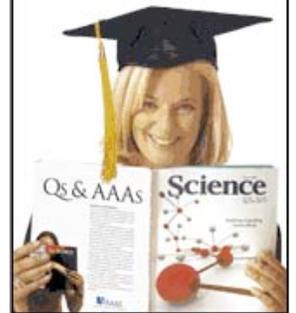
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NEWS

**ANTHROPOLOGY:
How Much Like Us Were the Neandertals?****Constance Holden**

Next to our own selves, there is no more interesting hominid than the Neandertal. Neandertals are the humans manqué, the evolutionary dead end: eerily like us, but different in major ways. And they are the subject of one of the hottest ongoing debates in anthropology.

How smart were these big-brained, stocky-bodied people, who inhabited Europe and the Middle East starting about 200,000 years ago? And what caused their relatively abrupt disappearance by 30,000 years ago? The Neandertals' reputation has oscillated over the years, and new evidence has sharpened the debate. Genetic data suggest a sizable gulf between Neandertals and modern humans, while recent discoveries hint that Neandertals had a brief technological golden age before vanishing.

Last year, DNA testing of a Neandertal bone showed that these beings probably branched off the human line a half-million years ago, perhaps qualifying them as a separate species (*Science*, 11 July 1997, p. [176](#)). But other lines of evidence have encouraged speculation that they may have been like us in one crucial respect: speech. One is the discovery in 1989 of a Neandertal hyoid bone--the bone that supports the larynx--in Kebara cave in Israel. Because it is a lot like a human one, it indicates, says archaeologist Francesco d'Errico of the Institute of Quaternary Prehistory and Geology in Talence, France, that "Neandertal abilities were also quite similar."

Earlier this year, anthropologists at Duke University reinforced that notion with a comparative analysis of the hole that carries motor nerves to the tongue, called the hypoglossal canal, in several hominid skulls. Chimp-sized in the 2-million-year-old australopithecines, the canal is significantly larger, falling in the modern human range, in both Neandertals and an earlier, 300,000-year-old skull. This suggests that "the vocal capabilities of Neandertals were the same as those of humans today," Richard Kay and colleagues wrote in the 28 April *Proceedings of the National Academy of Sciences*.

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Cognitive scientist Philip Lieberman of Brown University disputes these claims. First, he says, you can't predict tongue shape--the critical factor for modern speech--from an isolated hyoid bone. Moreover, he says the Duke team based their calculations of the relative sizes of different species' hypoglossal canals on incorrect estimates of human tongue size and shape. Lieberman himself argues, from his 1971 analysis of a Neandertal skull from Chapelle-aux-Saints in France, that proportions such as the distance between the hard palate and the spinal column would have made it impossible for Neandertals to speak with the clarity modern humans possess.

Kay says that his finding still holds, and that Neandertals might have had speech "in every way as complicated as modern humans." But others say Lieberman's conclusions are reinforced by Neandertals' other behavioral limitations. Harold Dibble of the University of Pennsylvania, Philadelphia, for example, says "the lack of art and the lack of clear evidence of symboling suggests that the nature of [Neandertal] adaptation [to their environment] was significantly different" from that of their successors. The difference shows up, for example, in their stone tools.

Neandertals could do stone-knapping with the best of them, says Stanford University archaeologist Richard Klein. But over thousands of years this practice never seemed to lead to clear differentiation in types of tools. "They didn't make tools in the [different] standardized patterns you see later," coming from the modern people who arrived in Europe about 40,000 years ago, says Klein. To him this difference suggests that the Neandertals "were only interested in a point or an edge" rather than conceptualizing a particular product.

Then there is the Neandertal hunting record. In a special Neandertal supplement of the journal *Current Anthropology* in June, for example, archaeologist John Shea of the State University of New York, Stony Brook, defends Neandertal hunting prowess. He argues that their tool assemblages show they engaged in "intercept" hunting, which would require a knowledge of animal migration routes. On the other hand, according to Erik Trinkaus of Washington University in St. Louis, the high rate of broken bones and early death among Neandertals suggests that they engaged in more close-quarter combat with large animals than did modern humans, who had figured out safer strategies.

In the past, some have claimed that Neandertals held ritual burials, which would have implied highly developed social behaviors and possibly even religion. But that belief was largely based on a 60,000-year-old Neandertal burial at Shanidar cave in Iraq, where pollen grains were taken to imply that the body had been covered with flowers. Many scientists now believe the plant material is an incidental intrusion. In reality, "the number of claimed Neandertal burials is extremely low," and none has yielded convincing evidence for grave goods, says Dibble.

As archaeologists learned in 1996, however, the Neandertals in France and Spain showed surprising new talents at the end of their evolutionary career after 40,000 years ago. They began making more sophisticated and diverse tools, and even, at one site, an array of beads and pendants (see p. [1451](#)). These artifacts have led to a new surge of debate over whether Neandertals were finally expressing their symbolic potential or were just imitating their modern human neighbors.

Whatever the answer, it may have been a case of too little, too late. For shortly after that, the Neandertal record vanishes. What drove them to extinction? Many scientists say that even without a difference in brainpower, the Neandertals would have been at a disadvantage. Archaeologist Ezra Zubrow of the State University of New York, Buffalo, has made a mathematical model based on skeletal data on the life-spans of the two populations. From it he concluded that with only a slight disadvantage in life expectancy, "it was easy to drive Neandertals to extinction under a wide range of conditions" because of their small populations. Shea adds that with their heavy frames and active lifestyle, their voracious energy needs might have hurt them "in competition with more energetically efficient modern humans."



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Debates about Neandertal abilities have become colored with notions of political correctness, say archaeologists. "I've been accused of being racist for saying the Neandertals couldn't speak like us," says Lieberman. Clive Gamble of the University of Southampton in the U.K., for one, doesn't understand why people need to make Neandertals something they weren't. "Neandertals are fantastic ways of realizing the alternative ways of humanness."

Also see this week's [NetWatch](#) page, which surveys some of the Internet's archaeology offerings to complement this special section.