

Biography of Richard G. Klein

As long as 160,000 years ago, people who looked like modern humans roamed Africa. For more than 100,000 years, these populations remained small in number and were confined largely to Africa. Approximately 50,000 years ago, despite no apparent physical change, a subset of these people dramatically altered their behavior, producing the first artifacts unequivocally deemed to be jewelry and inventing new technologies, such as projectile weapons, that allowed them to fish and to hunt dangerous prey. Over the next 15,000 years, these Stone Age hunter-gatherers spread from Africa to Europe, and, wherever they appeared, the Neanderthals, who previously inhabited Europe, rapidly disappeared.

For the last 35 years, Stanford paleo-anthropologist Richard G. Klein has intensively investigated the artifacts and animal bones that he and others have excavated at South African Stone Age sites, helping to illuminate the behavioral leap that led to the modern human's expansion out of Africa. He has pioneered the analysis of animal bones in understanding human culture. His research has painted a detailed portrait of the behavior and ecology of the more primitive hunter-gatherers who lived more than 50,000 years ago during the Middle Stone Age (MSA) and of the more sophisticated people who succeeded them in the Later Stone Age (LSA).

Klein takes pride in being an integral part of the archaeological community in South Africa. In July 2002 he was elected president of the South Africa Archaeological Society. In 2003 Klein was elected to membership in the National Academy of Sciences. His Inaugural Article, published in this issue of PNAS, describes animal remains and stone artifacts that date from the MSA in a South African rockshelter (1). Klein and his colleagues suggest that the people who lived in the shelter exploited coastal resources much less effectively than later people, providing further evidence that a major advance in hunting and gathering took place approximately 50,000 years ago in Africa.

Inferring an Ancient Mindset

Klein was born in 1941 in Chicago, where he has fond memories of going to the Field Museum of Natural History as a child. The museum's dioramas of Neanderthals and other prehistoric people always fascinated him. "From childhood



Richard G. Klein

I've been interested in the Neanderthals and what happened to them, but I never thought I could study that professionally. I didn't think it was something an adult could do," he said.

Klein went to college at the University of Michigan (Ann Arbor) in 1958, the year after the Soviets put Sputnik 1 into orbit. He originally decided to study the Russian language and physics, thinking them more practical fields than human evolution. However, a course on human evolution and prehistory reignited his interest in the Neanderthals, and he approached his professor, biological anthropologist Frank Livingstone, about the feasibility of pursuing graduate work in paleoanthropology. At Livingstone's suggestion, Klein entered graduate school in 1962 at the University of Chicago to study with F. Clark Howell, a Neanderthal expert. At the time, Klein says, anthropologists were divided into two camps: those who believed the Neanderthals had evolved into the Cro-Magnons, the earliest fully modern Europeans, and those who believed the Neanderthals had become extinct when the Cro-Magnons migrated to Europe and replaced them. "I favored the replacement theory, but there wasn't a whole lot of evidence," Klein said.

Because Klein knew Russian, Howell suggested that he study Neanderthal artifacts discovered in Russia. At the time, Neanderthal artifacts in France were the ones best known to Western researchers, Klein recalls. "We knew almost nothing about the artifacts in Russia," Klein said. "There was the language barrier,

and the Cold War was a very real thing. There wasn't much exchange between Russian scientists and those in the United States or France."

Howell advised Klein to prepare for working in Russia by studying Neanderthal artifacts in France. After completing his master's degree in 1964, Klein went to the University of Bordeaux to study with François Bordes, a renowned professor of prehistory. Bordes had worked out a system of 62 categories for classifying Neanderthal tools (2). "His work had an enormous influence on me," Klein said.

Bordes took Klein to see sites that had been occupied first by the Neanderthals and then by the Cro-Magnons, including La Quina and La Ferrassie caves in southwest France. The Cro-Magnon layers lay directly on top of the Neanderthal layers, and Klein became convinced that the shift from Neanderthals to Cro-Magnons 40,000 to 35,000 years ago had been a sudden change rather than a gradual evolution.

Looking at Neanderthal and Cro-Magnon artifacts was an eye-opening experience, Klein says. Cro-Magnon artifacts were clearly more sophisticated than those of the Neanderthals. For instance, only the Cro-Magnons had made ornamental objects out of bone and ivory. When he tried to classify stone

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artifacts, Klein was struck by the difference between the two peoples. He found that he could easily sort the Cro-Magnon artifacts into many different categories, such as projectile points, engraving tools, knife blades, and drilling and piercing tools. The Neanderthal artifacts, by contrast, were often difficult or impossible to classify.

"With the Cro-Magnons, it was as if they went to a hardware store to get special-purpose tools," he said. "The boundaries between different kinds of

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Neanderthal tools were much fuzzier, and I often couldn't figure out which category a tool belonged to." When Klein went to Moscow and Leningrad in 1965 to study artifacts excavated in Russia, he found the same contrast. "It was depressing how hard the Neanderthal artifacts were to sort, because I wanted to get a Ph.D., and I didn't think I was getting useful results."

Eventually Klein decided that something profound lay beneath these negative findings. In his Ph.D. work, he said, "I came to the conclusion that the Neanderthals had a very different mindset from mine or Bordes—that they had very different cognition from modern humans" (3, 4). This conviction strengthened Klein's belief that the Neanderthals and Cro-Magnons were too different to make it plausible that Cro-Magnons evolved from Neanderthals in a short time span. Today, most paleoanthropologists agree that the Cro-Magnons came from Africa (5). DNA evidence suggests that the Neanderthals contributed few if any genes to modern humans (6, 7).

Analyzing Bones, Not Stones

By the time Klein earned his Ph.D. from the University of Chicago in 1966, he had become frustrated with working in Russia. Because of travel restrictions on foreigners in the Soviet Union, Klein was permitted only to look at artifacts, not to do excavations or visit archaeological sites. On the advice of J. Desmond Clark, an eminent University of California (Berkeley) archaeologist who was a reader of Klein's dissertation, he decided to go where most researchers now believe fully modern humans originated: Africa.

Klein briefly held positions at the University of Wisconsin (Milwaukee), Northwestern University (Evanston, IL), and the University of Washington (Seattle), before becoming a professor at the University of Chicago in 1973. Twenty years later, he moved to Stanford University (Stanford, CA), where he teaches now. Regardless of his home base, Klein has managed to travel to South Africa each year for the last 35 years to study its ancient hunter-gatherers. When he first went to South Africa, he says, his plan was to focus on the artifacts people had left behind over the last 100,000 years. He soon realized, though, that animal bones could tell as interesting a story as artifacts.

In his early excavations, Klein discovered animal bones spanning the last 20,000 years that showed that the local environment had changed dramatically at the end of the last Ice Age, approximately 12,000 years ago (8). He asked



Richard G. Klein (wearing a white hat in the second row) and his field crew at the Duinefontein site just north of Cape Town, South Africa.

Brett Hendey, a paleontologist at the South African Museum in Cape Town, to identify the bones. Instead, Hendey offered Klein a table in the museum. "He said I should identify them myself," Klein said. "Since that time, that's what I do."

Klein was pleased to find that classifying bones was easier and less subjective than classifying artifacts. "There's no problem deciding if something is an arm bone or a leg bone," he said.

He rapidly became a leader in the field of bone identification. In 1984 Klein coauthored *The Analysis of Animal Bones from Archaeological Sites* (9), a book that archaeologists now often use to teach their students how to interpret animal remains. He has become a "central repository" for excavated bones in South Africa, he says, with other researchers passing on the bones from their digs to him.

Animal Bones and Archaeology

As an example of the kind of evidence animal remains can provide, Klein cites analyses he carried out in 1973 of animal bones from the Klasies River caves, approximately 700 km east of Cape Town (10). He discovered that, during the MSA, the Klasies hunters concentrated on eland—large antelopes—instead of the more dangerous buffaloes, although buffaloes probably outnumbered eland in the local environment. In more recent sites, by contrast, buffalo bones dominate those of eland. "Something happened after 50,000 years ago that allowed people to hunt buffaloes," Klein said. The likely explanation, supported by artifacts, is that the hunters figured out how to make projectile weapons, which could be hurled at dangerous animals from a safe distance.

Although Klein is presently focused on the transition that happened between the Middle and Late Stone Age, he has also investigated much older Stone Age people. In the 1990s, he published the results of his research at the Elandsfontein site (11), located approximately 100 km north of Cape Town, and the Duinefontein site (12), approximately 50 km north of the city. People and animals were attracted to both sites by the presence of water holes approximately 500,000 years ago at Elandsfontein and 300,000 years ago at Duinefontein. At

Klein concluded that Neanderthals had "very different cognition from modern humans."

both sites, people left hand axes and other stone tools that are scattered among the bones of buffaloes, zebras, and other large mammals. To determine whether the hand axe makers had killed or eaten the animals, Klein and his colleagues analyzed damage to the bones. "We found that marks from the teeth of carnivores such as hyenas and lions were very common, but stone tool marks were very rare," he said. "That suggested that carnivores got most of the meat and marrow, and the people got relatively little. We concluded that people 500,000 to 300,000 years ago were not particularly good at either hunting or scavenging."

In his PNAS Inaugural Article, Klein and his colleagues report on animal remains and artifacts that date between

115,000 and 50,000 years ago at Ysterfontein 1, a crevice-like rockshelter on the west coast of South Africa (1). The researchers found that the inhabitants of the shelter obtained a variety of marine and terrestrial mammals and birds but a relatively limited range of shellfish species. Notably, the researchers collected few, if any, fish. In more recent sites on the same coast, the range of shellfish species is greater and fish bones abound. In more recent sites, individuals of key shellfish species also tend to be much smaller, which is the predictable result if the human shellfish collectors had become much more numerous. Based on these findings, Klein and his colleagues conclude that the Ysterfontein people exploited coastal resources much less intensively than later people, probably because their technology was less sophisticated and their populations were smaller. The new work bolsters the evidence that a major advance in hunting and gathering took place approximately 50,000 years ago in Africa.

Klein has advanced a controversial theory for what caused the sudden increase in innovation and talent in Africans approximately 50,000 years ago: a genetic mutation, he postulates, altered the organization of their brains, giving them greater adaptability and, perhaps, the capacity to think symbolically (13, 14). The fact that Neanderthals appear to have contributed few or no genes to today's humans supports his idea, Klein says, because it suggests that the Neanderthals were unable to adopt the more advanced way of living of the humans who arrived in Europe from Africa. "The most economical explanation is that a genetic change allowed the Africans to reach a modern intellectual standard that was beyond the Neanderthals," he says.

Behavioral and Anatomical Synthesis

In addition to reporting the results of his own research, Klein has written influential summary articles in which he integrates his findings on human evolu-

tion with those of other paleoanthropologists (15–17). "My goal has always been to understand the broad pattern of human evolution and the relationship between changes in anatomy and changes in behavior," he said.

In 1989, Klein wrote *The Human Career* (18), a book that details human evolution, from fossil non-human primates through the development of modern humans. The book, about to go into a third edition, has become a standard reference on human evolution and has been described as "by far the best book of its kind" (19). Two years ago, Klein coauthored another book, *The Dawn of Human Culture* (13), which is aimed at a more general audience.

"I'd like to think that if I've made a contribution, it's to the synthesis of all the information we have about human evolution, both anatomical and behavioral," Klein says.

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