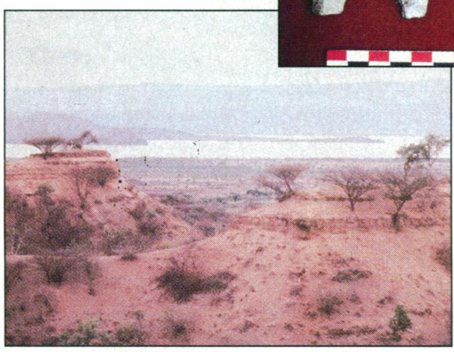
ARCHAEOLOGY

Do Kenya Tools Root Birth of Modern Thought in Africa?

Modern human history, textbooks have it, began with a French revolution. It was heralded not by a mass uprising, but by the carved bone points and elaborate stone blades that suddenly appeared in southwest France between 40,000 and 50,000 years ago; the archaeological record before that held little but crude axes and simple rock flakes. The abrupt shift—known as the Upper Paleolithic transition, which soon spread across Europe—seemed to mark a critical mental advance, a mastery of abstract thought and form lacking in our older ancestors.

But now a group of archaeological sites some 5000 miles away from Europe, and with tools perhaps five times older, seems to be telling a different tale—one of evolution, not revolution. In Kenya, University of Connecticut anthropologist Sally McBrearty has found evidence that our African forebears took the first steps toward modernity as early as 240,000 years ago. This week at the annual meeting of the American Anthropological Association in Washington, D.C., and in a forthcoming paper in the *Journal of Human Evolution*, McBrearty reports the discovery of

SALLY MCBREARTY



ANDREW HILL

Glimmers of modernity. (*Above*) The 250,000 year-old Kapthurin formation in Kenya is forcing researchers to rethink the European birth of modern culture. (*Top*) Stone tools taken from the site show careful shaping that some see as a harbinger of modern abstract thought.

blades of that age made from long, thin slivers of stone. An extraordinary feature of these tools is that they seem to have been carefully shaped even before they were knocked off a rock core—and that, McBrearty contends, indicates a solid form of abstract thought. Moreover, she argues that similar sites show signs of modern behaviors such as carefully planned resource use and hunting. "Look," she says, "I admire the Paleolithic archaeology of Europe. It's very wonderful. But if you want to learn about the origins of modern human behavior, you don't look there."

Alison Brooks of George Washington University, who has found modern-looking bone points in Zaire dated to 90,000 years ago (*Science*, 28 April, pp. 495, 548, and 553), says that McBrearty's finds do indeed look modern and that this period in Africa, known as the Middle Stone Age, has long been overlooked by archaeologists with a "Eurocentric" bias. Michael Mehlman, a Middle Stone Age archaeologist at the University of California, Santa Cruz, agrees that "this bias absolutely needs to be challenged" and calls McBrearty's arguments "provocative." Adds Brooks: "What we hope most fervently is that people will understand two things: that the human revolution wasn't a revolution, and that it wasn't European."

Yet the true meaning of these pointed stones is itself a point of dispute. Other researchers say the African artifact record shows no signs that such tools later developed into enhanced forms and thus can't compare with what happened in Europe. And Richard Klein of Stanford University in Palo Alto, California, says the Kenya blades seem almost casually flaked, while the blades made in the European Upper Paleolithic show signs of more precise geometry. "I've never seen anything like that in the Middle Stone Age of Africa," he says, "and I'm not Eurocentric."

The tools engendering this controversy come from the Kapthurin formation, near Kenya's Lake Baringo. The formation, a 125-meter-thick stack of sediments, is interleaved with volcanic deposits, or tuffs. These tuffs have been dated with potassium/argon dating, a well-established and reliable method, and the tuff that caps the formation is about 250,000 years old. McBrearty's artifacts came from just below it.

The Kapthurin blades are long and thin (averaging 10 centimeters in length and less than 1 centimeter in thickness), and in many cases were struck from cores whose surface had been preshaped by flaking. McBrearty has also found the cores to which they can be refitted—as many as a dozen blades to one core—as well as hand axes. And the appearance isn't the only clue to their sophistication, she argues. The blades are made from phonolite, a tough lava that is "a very difficult material to work," she says. It is so tricky, in fact, that Pierre-Jean Texier, a specialist in stone tool manufacture whom she brought to Kenya to try to recreate the fabrication methods, was at first hard-pressed to replicate them at all, although he eventually mastered the preshaped cores.

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Other African Middle Stone Age sites, McBrearty says, also contain signs of sophistication. Mehlman, for example, has found evidence at cave sites in Mumba, Tanzania, that the raw materials for tool-making were imported over great distances, signaling advanced planning on the part of the inhabitants. And Brooks has surveyed campsites in Botswana with bones of large and dangerous animals, such as giant zebra, warthog, and water buffalo, indicating the campers were skilled hunters. Individually these don't mean much, McBrearty admits, but taken together they add up to a signal that the ground of East Africa holds the early stirrings of modernity.

Just who might have been doing that stirring is still debatable. Human fossils were found well below McBrearty's blade levels in the late 1970s, but the remains—a few scraps of jaw, an arm bone, and some toes—have proved difficult to pigeonhole taxonomically. Over the years, they've been called everything from *Homo erectus* (an ancient member of our genus, dating back to 1.5 million years ago) to a transitional form called archaic *Homo sapiens*. McBrearty suspects, "on intuition," that the Kapthurin toolmakers may actually have been anatomically modern *Homo sapiens*, because early members of the species have been found in Ethiopia and in South Africa at least 130,000 years ago. And Klein agrees they could easily have been around 100,000 years before that.

He concurs on little else, however. Comparisons between European Upper Paleolithic blades and McBrearty's finds are like night and day, he says. "The European blades are sort of peeled off the core," he explains, adding that the complex technique used to make them involves not merely knocking one stone against another, but using a piece of hide or antler to distribute the force. In addition, manufacture of European blades results in a so-called prismatic core, a distinctive and sharply geometric form not found in Africa.

The argument for a continuum of technology starting in Africa also has a troubling gap, others point out. There are many younger sites in the Later Stone Age of Africa, says University of Arizona anthropologist Steve Kuhn, but neither these blades nor enhanced forms appear in any of them. If the blades really do provide the "early glimmerings" of the modern mental condition, he says, "it would be more comforting if they had spread, instead of popping up and disappearing."

That spread, which does occur in Europe, signals that something dramatic was happening which hasn't been found in Africa, according to J. Desmond Clark of the University of California, Berkeley: a change not just in technology but communication. "There's no doubt that blades go back for a very long time in Africa, and that's very interesting," he says. But the African tradition seems isolated; the appearance of the sophisticated European tool kit within a few thousand years all over the map, in contrast, means that toolmakers must have also developed language. And that cultural advance, he says, is truly revolutionary.

But McBrearty doesn't buy the idea that blade tools and language had to come in a revolutionary package. "You can point to a lot of so-called revolutions that happened over a long period of time," she says. "As an undergrad I was taught that bipedality, the big brain, and tool use all happened at once; now we know bipedality preceded the big brain by 2 million years." Likewise, she believes, language acquisition could have been a stepwise process, with the simpler African blades the product of its early stages.

She and Brooks both note that archaeologists really have no idea about the spread of technology in the African Middle Stone Age because they haven't looked in many places. Brooks notes that the European record is more elaborate because it's been extensively studied for 150 years, beginning with some of the founding fathers of archaeology, such as Edouard Lartet. "One problem with standing on the shoulders of giants," she observes, "is that you don't have that much choice about what direction you're walking in."

The direction McBrearty plans to go is back to Kenya, where she and her colleagues plan to search for more sites and more tools. "You know how textbooks say that early evolution happened in Africa, but the minute there's any behavior that smacks of being sophisticated, suddenly you're in France?" she says. "If I can change the last chapter in those textbooks in my lifetime, I'll be satisfied."

–JoAnn Gutin

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MATERIALS SCIENCE

Nanotubes Show Image-Display Talent

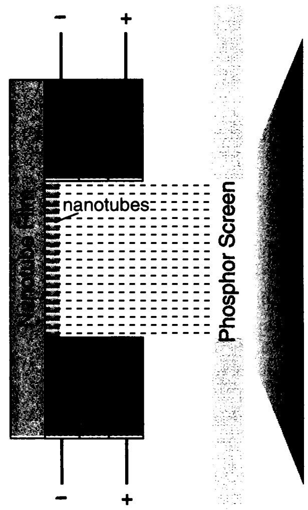
Nanotubes may be good for something after all. Ever since the tiny all-carbon hollow cylinders—less than 15 billionths of a meter in diameter—were discovered in 1991, researchers have published countless papers on their synthesis, properties, and potential for becoming everything from drug carriers to nanowires. But potential is a long way from product, and thus far nanotube wares have remained a distant vision.

On page 1179 of this issue, however, a report from a Switzerland-based research group brings one potential nanotube application within clearer sight: inexpensive, high-quality, flat screen displays. The team—led by physicists Walt de Heer and André Châtelain at the Ecole Polytechnique Fédérale de Lausanne and Daniel Ugarte at the Laboratório Nacional de Luz Síncrotron in Campinas, Brazil—turned an array of vertically aligned nanotubes into tiny but powerful electron emitters, functioning much like the ubiquitous cathode ray tubes (CRTs) in television and desktop computer displays. Simpler to make and much lighter than conventional technology, the nanotubes "could make a big impact on flat screen display technology," says physicist Andrew Rinzler of Rice University in Texas.

That's because they might provide the first good substitute for the large electron guns that create a CRT's color picture by firing a beam of electrons at a display screen coated with color phosphors. These devices are too heavy and bulky for portable laptop computer displays and flat screen TVs. So most popular flat screen displays use liquid crystals and a series of color filters—but they aren't as bright and can't be seen at sharp viewing angles. Experimental displays using thousands of tiny electron emitters, known as field effect devices, have been explored, but these electron emitters are made of silicon wafer and circuitry like computer chips, and thus are relatively expensive and cumbersome to manufacture.

That's where nanotubes come in. Researchers have known for years that nanotubes are good electrical conductors, and their long, narrow shape helps concentrate electric current to a small area, which is essential for efficient electron emission. In order to make a nanotube-based imaging device, however, scientists needed a way to get tens of thousands of nanotubes oriented in precisely the same direction, then induce these arrays to fire electrons at the same time.

De Heer and his colleagues met the first of these requirements earlier this year, when they created an electrically conducting polymer film with tens of thousands of nanotubes sticking up from it, like straws stuck precisely in a foam block (*Science*, 12 May, p. 845). And in the current experiment, the researchers took the next step, by showing that such nanotube arrays could emit enough electrons simultaneously to make a powerful stream.



Display model. A field effect device based on nanotubes would shoot electrons (–) at a phosphor display, triggering light emission.

SOURCE: W. DE HEER

The step, de Heer admits, was rather straightforward. The researchers first wired a ground electrode to the polymer film containing the nanotubes. On top of the film, they then layered a screenlike grid of a thin insulating sheet of mica, followed by a grid made of copper, a very good conductor. The copper and the ground electrode were then connected to opposite poles of a 200-volt battery, copper to positive and polymer to negative. The 200-volt difference forced electrons into the conducting polymer and then out the nanotubes. Detectors revealed that the electrons came streaming from the array at the same moment. And that stream was "a nice big current," says Rice physics professor Richard Smalley, who has also studied nanotube electron emission—strong enough, he estimates, to elicit an image from a phosphor-coated display.

Still, the researchers do have a way to go before nanotube emitters are ready to challenge liquid crystal displays. Scientists must still figure out how to control the electron emission independently from small patches of nanotubes, which would allow them to turn each picture element, or pixel, on and off separately. They will also have to show that nanotubes in different sections of the array emit equally strong electron streams, insuring constant brightness across the picture. But if successful, a nanotube-based device would have important advantages. The hexagonal arrangement of carbon atoms that forms nanotube walls is easy to fabricate. As well, any nanotube-based display will be able to piggyback on decades of research that has gone into perfecting CRT displays, giving it a strong boost in product development. "Unlike other flat screen technologies," says de Heer, "we wouldn't have to start from scratch."

–Robert F. Service