WHY DID *HOMO SAPIENS* ALONE SURVIVE TO THE MODERN ERA?

PART 2

Us and Them

LAST HOMININ STANDING

BY KATE WONG :: *ILLUSTRATION BY YUKO SHIMIZU*

A T THE DAWNING OF *HOMO SAPIENS,* OUR ANCESTORS WERE BORN INTO a world we would find utterly surreal. It's not so much that the climate and sea levels or the plants and the animals were different, although of course they were—it's that there were other kinds of humans alive at the same time. For most of *H. sapiens*' existence, in fact, multiple human species walked the earth. In Africa, where our species got its start, large-brained *Homo heidelbergensis* and small-brained *Homo naledi* also roamed. In Asia, there was *Homo erectus,* a mysterious group dubbed the Denisovans and, later, *Homo floresiensis*—a hobbitlike creature, tiny but for its large feet. The stocky, heavy-browed Neandertals, for their part, ruled Europe and western Asia. And there were probably even more forms, as yet undiscovered.

IN BRIEF

Until recently, the dominant model of human origins held that *Homo sapiens* arose in a single region of Africa and replaced archaic human species throughout the Old World without interbreeding with them.

New findings from archaeology, paleontology and genetics are rewriting that story.

The latest research suggests that *H. sapiens* emerged from groups located across Africa and that interbreeding with other human species contributed to our success.

By around 40,000 years ago, based on current evidence, *H. sapiens* found itself all alone, the only remaining member of what was once an incredibly diverse family of bipedal primates, together known as hominins. (In this article, the terms "human" and "hominin" both refer to *H. sapiens* and its extinct relatives.) How did our kind come to be the last human standing?

Until a few years ago, scientists favored a simple explanation: *H. sapiens* arose relatively recently, in more or less its current form, in a single region of Africa and spread out from there into the rest of the Old World, supplanting the Neandertals and other archaic human species it encountered along the way. There was no appreciable interspecies fraternizing, just wholesale replacement of the old guards by the clever newcomer, whose ascendancy seemed inevitable.

Yet mounting evidence from fossil and archaeological discoveries, as well as DNA analyses, has experts increasingly rethinking that scenario. It now looks as though *H. sapiens* originated far earlier than previously thought, possibly in locations across Africa instead of a single region, and that some of its distinguishing traits—including aspects of the brain—evolved piecemeal. Moreover, it has become abundantly clear that *H. sapiens* actually did mingle with the other human species it encountered and that interbreeding with them may have been a crucial factor in our success. Together these findings paint a far more complex picture of our origins than many researchers had envisioned—one that privileges the role of dumb luck over destiny in the success of our kind.

THEORY UNDER THREAT

DEBATE ABOUT THE ORIGIN of our species has traditionally focused on two competing models. On one side was the Recent African Origin hypothesis, championed by paleoanthropologist Christopher Stringer and others, which argues that *H. sapiens* arose in either eastern or southern Africa within the past 200,000 years and, because of its inherent superiority, subsequently replaced archaic hominin species around the globe without interbreeding with them to any significant degree. On the other was the Multiregional Evolution model, formulated by paleoanthropologists Milford Wolpoff, Xinzhi Wu and the late Alan Thorne, which holds that modern *H. sapiens* evolved from Neandertals and other archaic human populations throughout the Old World, which were connected through migration and mating. In this view, *H. sapiens* has far deeper roots, reaching back nearly two million years.

By the early 2000s the Recent African Origin model had a wealth of evidence in its favor. Analyses of the DNA of living people indicated that our species originated no more than 200,000 years ago. The earliest known fossils attributed to our species came from two sites in Ethiopia, Omo and Herto, dated to around 195,000 and 160,000 years ago, respectively. And sequences of mitochondrial DNA (the tiny loop of genetic material found in the cell's power plants, which is different from the DNA contained in the cell's nucleus) recovered from Neandertal fossils were distinct from the mitochondrial DNA of people today—exactly as one would expect if *H. sapiens* replaced archaic human species without mating with them.

Not all of the evidence fit with this tidy story, however. Many archaeologists think that the start of a cultural phase known as the Middle Stone Age (MSA) heralded the emergence of people who were beginning to think like us. Prior to this technological shift, archaic human species throughout the Old World made pretty much the same kinds of stone tools fashioned in the so-called Acheulean style. Acheulean technology centered on the production of hefty hand axes that were made by taking a chunk of stone and chipping away at it until it had the desired shape. With the onset of the MSA, our ancestors adopted a new approach to toolmaking, inverting the knapping process to focus on the small, sharp flakes they detached from the core—a more efficient use of raw material that required sophisticated planning. And they began attaching these sharp flakes to handles to create spears and other projectile weapons. Moreover, some people who made MSA tools also made items associated with symbolic behavior, including shell beads for jewelry and pigment for painting. A reliance on symbolic behavior, including language, is thought to be one of the hallmarks of the modern mind.

The problem was that the earliest dates for the MSA were more than 250,000 years ago—far older than those for the earliest *H. sapiens* fossils at less than 200,000 years ago. Did another human species invent the MSA, or did *H. sapiens* actually evolve far earlier than the fossils seemed to indicate?

In 2010 another wrinkle emerged. Geneticists announced that they had recovered nuclear DNA from Neandertal fossils and sequenced it. Nuclear DNA makes up the bulk of our genetic material. Comparison of the Neandertal nuclear DNA with that of living people revealed that non-African people today carry DNA from Neandertals, showing that *H. sapiens* and Neandertals did interbreed after all, at least on occasion.

Subsequent ancient genome studies confirmed that Neandertals contributed to the modern human gene pool, as did other archaic humans. Further, contrary to the notion that *H. sapiens* originated within the past 200,000 years, the ancient DNA suggested that Neandertals and *H. sapiens* diverged from their common ancestor considerably earlier than that, perhaps upward of half a million years ago. If so, *H. sapiens* might have originated more than twice as long ago as the fossil record indicated.

ANCIENT ROOTS

RECENT DISCOVERIES at a site called Jebel Irhoud in Morocco have helped bring the fossil, cultural and genetic evidence into better alignment—and bolstered a new view of our origins. When barite miners first discovered fossils at the site back in 1961, anthropologists thought the bones were around 40,000 years old and belonged to Neandertals. But over the years continued excavations and analyses led researchers to revise that assessment. In June 2017 paleoanthropologist Jean-Jacques Hublin of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and his colleagues announced that they had recovered additional fossils from the site, along with MSA tools. Using two dating techniques, they estimated the remains to be roughly 315,000 years old. The researchers had found the oldest traces of *H. sapiens* to date, as well as the oldest traces of MSA culture—pushing back the fossil evidence of our species by more than 100,000 years and linking it to the earliest known appearance of the MSA.

Not everyone agrees that the Jebel Irhoud fossils belong to *H. sapiens*. Some experts think they may instead come from a close relative. But if Hublin and his collaborators are right about the identity of the bones, the constellation of skull traits that distinguish *H. sapiens* from other human species did not all emerge in lockstep at the inception of our kind, as supporters of the Recent African Origin theory had supposed. The fossils resemble modern humans in having a small face, for example. But the braincase is elongated like those of archaic human species rather than rounded like our own dome. This shape difference reflects differences in brain organization: compared with fully modern humans, the Jebel Irhoud individuals had smaller parietal lobes, which process sensory input, and a smaller cerebellum, which is involved in language and social cognition, among other functions.

Neither do the archaeological remains at Jebel Irhoud exhibit the full complement of MSA features. The people there made MSA stone tools for hunting and butchering gazelles that roamed the grasslands that once carpeted this now desert landscape. And they built fires, probably to cook their food and warm themselves against the chill of night. But they did not leave behind any traces of symbolic expression.

In fact, on the whole, they are not especially more sophisticated than the Neandertals or *H. heidelbergensis*. If you could journey back in time to our species' debut, you wouldn't necessarily pick it to win the evolutionary sweepstakes. Although early *H. sapiens* had some innovations, "there weren't any big changes at 300,000 years ago that indicate they were destined to be successful," observes archaeologist Michael Petraglia of the Max Planck Institute for the Science of Human History in Jena, Germany. "In the beginning with *sapiens*," Petraglia says, "it looks like anyone's game."

GARDENS OF EDEN

THE TOTAL *H. SAPIENS* PACKAGE, many researchers agree, did not coalesce until sometime between 100,000 and 40,000 years ago. So what happened in the intervening 200,000 years or more to transform our spe-

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cies from run-of-the-mill hominin to world-conquering force of nature? Scientists are increasingly thinking about how the size and structure of the early *H. sapiens* population might have factored into the metamorphosis. In a paper published online in July in *Trends in Ecology & Evolution,* archaeologist Eleanor Scerri of the University of Oxford and a large interdisciplinary group of co-authors, including Stringer, make the case for what they call the African Multiregionalism model of *H. sapiens* evolution. The scientists note that the earliest putative members of our species—namely, the Jebel Irhoud fossils from Morocco, the Herto and Omo Kibish fossils from Ethiopia, and a partial skull from Florisbad, South Africa—all look far more different from one another than people today do. So much so that some researchers have argued that they belong to different species or subspecies. "But maybe early *H. sapiens* was just ridiculously diverse," Scerri offers. And maybe looking for a single point of origin for our species, as many researchers have been doing, is "a wild goose chase," she says.

We may actually owe our extinct relatives a substantial debt of gratitude for our success.

When Scerri and her colleagues examined the latest data from fossils, DNA and archaeology, the emergence of *H. sapiens* began to look less like a single origin story and more like a pan-African phenomenon. Rather than evolving as a small population in a particular region of Africa, they propose, our species emerged from a large population that was subdivided into smaller groups distributed across the vast African continent that were often semi-isolated for thousands of years at a time by distance and by ecological barriers such as deserts. Those bouts of solitude allowed each group to develop its own biological and technological adaptations to its own niche, be it an arid woodland or a savanna grassland, a tropical rain forest or a marine coast. Every so often, however, the groups came into contact with one another, allowing for both genetic and cultural exchange that fed the evolution of our lineage.

Shifting climate could have fueled the fracturing and rejoining of the subpopulations. For instance, paleoenvironmental data have shown that every 100,000 years or so, Africa enters into a humid phase that transforms the forbidding Sahara Desert into a lush expanse of vegetation and lakes. These green Sahara episodes, as they are known, would have allowed populations formerly isolated by the harsh desert to link up. When the Sahara dried out again, populations would be sequestered anew and able to undergo their own evolutionary experiments for another stretch of time until the next greening.

A population subdivided into groups that each adapted to their own ecological niche, even as occasional migration between groups kept them connected, would explain not only the mosaic evolution of *H. sapiens*' distinctive anatomy but also the patchwork pattern of the MSA, Scerri and her co-authors argue. Unlike Acheulean tools, which look mostly the same everywhere they turn up throughout the Old World, MSA tools exhibit considerable regional variation. Sites spanning the time between 130,000 and 60,000 years ago in North Africa, for example, contain tool types not found at sites in South Africa from the same interval, including stone implements bearing distinctive stems that may have served as attachment points for handles. Likewise, South African sites contain slender, leaf-shaped tools made of stone that was heated to improve its fracture mechanics—no such implements appear in the North African record. Complex technology and symbolism become more common over time across the continent, but each group acts its own way, tailoring its culture to its specific niche and customs.

H. sapiens was not the only hominin evolving bigger brains and sophisticated behaviors, however. Hublin notes that human fossils from China dating to between 300,000 and 50,000 years ago, which he suspects belong to Denisovans, exhibit increased brain size. And Neandertals invented complex tools, as well as their own forms of symbolic expression and social connectedness, over the course of their long reign. But such behaviors do not appear to have become as highly developed or as integral to their way of life as they eventually did in ours, observes archaeologist John Shea of Stony Brook University, who thinks that advanced language skills allowed *H. sapiens* to prevail.

"All these groups are evolving in the same direction," Hublin says. "But our species crosses a threshold before the others in terms of cognitive ability, social complexity and reproductive success." And when it does—around 50,000 years ago, in Hublin's estimation—"the boiling milk escapes the saucepan." Forged and honed in Africa, *H. sapiens* could now enter virtually any environment on the earth and thrive. It was unstoppable.

CLOSE ENCOUNTERS

HUNDREDS OF THOUSANDS of years of splitting up from and reuniting with members of our own species might have given *H. sapiens* an edge over other members of the human family. But it was not the only factor in our rise to world domination. We may actually owe our extinct relatives a substantial debt of gratitude for their contributions to our success. The archaic human species that *H. sapiens* met as it migrated within Africa and beyond its borders were not merely competitors—they were also mates. The proof lies in the DNA of people today: Neandertal DNA makes up some 2 percent of the genomes of Eurasians; Denisovan DNA composes up to 5 percent of the DNA of Melanesians. And a recent study by Arun Durvasula and Sriram Sankararaman, both at the University of California, Los Angeles, published on the preprint server bioRxiv in March, found that nearly 8 percent of the genetic ancestry of the West African Yoruba population traces back to an unknown archaic species (researchers have yet to recover DNA from any archaic African fossils for comparison).

Some of the DNA that *H. sapiens* picked up from archaic hominins may have helped our species adapt to the novel habitats it entered on its march across the globe. When geneticist Joshua Akey of Princeton University and his colleagues studied the Neandertal sequences in modern human populations, they found 15 that occur at high frequencies, a sign that they had beneficial consequences. These high-frequency sequences cluster into two groups. About half of them influence immunity. "As modern humans dispersed into new environments, they were exposed to new pathogens and viruses," Akey says. Through interbreeding, "they could have picked up adaptations from Neandertals that were better able to fight off those new pathogens," he explains.

The other half of the Neandertal sequences that Akey's team found at high frequency in modern human populations are related to skin, including genes that influence pigmentation levels. Researchers have previously theorized that *H. sapiens* individuals from Africa, who presumably had darker skin to protect against harmful ultraviolet radiation from the sun, would have had to evolve lighter skin as they entered northern latitudes to get enough vitamin D, which the body acquires mainly through sun exposure. Skin genes from Neandertals may have aided our predecessors in doing exactly that.

Neandertals are not the only archaic humans who gave us useful genes. For example, modern-day Tibetans have the Denisovans to thank for a gene variant that helps them cope with the low-oxygen environment of the high-altitude Tibetan plateau. And contemporary African populations have inherited from an unknown archaic ancestor a variant of a gene that may help fend off bad bacteria in the mouth.

Interbreeding with archaic humans who had millennia to evolve adaptations to local conditions may well have allowed invading *H. sapiens* to adjust to novel environments faster than if it had to wait for favorable mutations to crop up in its own gene pool. But it's not all upside. Some of the genes we obtained from Neandertals are associated with depression and other diseases. Perhaps these genes were advantageous in the past and only began causing trouble in the context of modern ways of life. Or maybe, Akey suggests, the risk of developing these diseases was a tolerable price to pay for the benefits these genes conferred.

Archaic humans may have contributed more than DNA to our species. Researchers have argued that contact between divergent human groups probably led to cultural exchange and may have even spurred innovation. For example, the arrival of *H. sapiens* in western Europe, where the Neandertals long resided, coincided with an uncharacteristic burst of technological and artistic creativity in both groups. Previously some experts suggested that Neandertals were simply aping the inventive newcomers. But maybe it was the interaction between the two groups that ignited the cultural explosion on both sides.

In a sense, the fact that *H. sapiens* mixed with other human lineages should not come as a surprise. "We know from many animals that hybridization has played an important role in evolution," observes biological anthropologist Rebecca Rogers Ackermann of the University of Cape Town in South Africa. "In some cases, it can create populations, and even new species, that are better adapted to new or changing environments than their parents were because of novel traits or novel combinations of traits." Human ancestors show a similar pattern: the combination of different lineages resulted in the adaptable, variable species we are today. "*Homo sapiens* is the product of a complex interplay of lineages," Ackermann asserts, and it has flourished precisely because of the variation that arose from this interplay. "Without it," she says, "we simply wouldn't be as successful."

How often such mingling occurred and the extent to which it might have helped drive evolution in *H. sapiens* and other hominins remain to be determined. But it may be that the particular environmental and demographic circumstances in which our species found itself in Africa and abroad led to more opportunities for genetic and cultural exchange with other groups than our fellow hominins experienced. We got lucky—and are no less marvelous for it. SA

MORE TO EXPLORE

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