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By Ryan McRae and Briana Pobiner, edited by Andrew S. Cale

In 2023, the field of human evolution benefited from a plethora of new discoveries. In this article, Drs. Briana Pobiner and Ryan McRae of the Smithsonian Institution National Museum of Natural History detail some of the most interesting and impactful discoveries. -ASC

The year 2023 was another exciting year for research in human evolution. Many of the top stories this year tell us more about our early ancestors' and relatives' diet, tool use, and the environment in which they lived. Others provide evidence for behaviors: hunting, making jewelry, and interacting with each other in previously unexplored ways. Whether by taking a new look at previously excavated fossils or uncovering new evidence altogether, all of these stories expand the breadth of knowledge about our shared ancient past and bring to light more information about what it means to be human.

Lions, Elephants, and…Crabs? (Oh My!): Neanderthals as the resident gourmands of ancient Eurasia

Neanderthals are probably the most well-known hominins and among our closest relatives. How they lived and why they went extinct while modern humans survived is a topic of great scientific and public interest. New research this year gives us more clues about how Neanderthals lived, hunted, and what they might have eaten. First up is a study from October by Gabriele Russo and team[1]. Analyzing the bones of a 48,000-year-old cave lion from Siegsdorf in southern Germany, they discovered a clear puncture mark on one of the ribs, three marks potentially left from wooden projectile weapons, and multiple cut marks across other bones. They also analyzed additional cave lion remains from Einhornhöhle in northern Germany, concluding based on cut-marked toe bones (phalanges) that Neanderthals were utilizing cave lions for access to their hides, or skin. Altogether, this shows that Neanderthals were hunting and butchering cave lions, an apex predator, which would have been a high-risk target. The consumption of meat from apex predators is one hypothesis for why Neanderthals had a unique nitrogen-rich dietary signature, as nitrogen isotopes get concentrated up the food chain. Furthermore, the ability of Neanderthals to successfully hunt high-risk prey suggests the potential for communication, planning, and cooperation in hunting.

Speaking of high-risk prey, another study in February found that 125,000 years ago in central Germany Neanderthals were hunting and butchering giant now-extinct elephants! Sabine Gaudzinski-Windheuser and colleagues[2] studied a massive collection of over 3,000 bones from 70 individual straight-tusked elephants from the site of Neumark-Nord 1 originally excavated in the 1980s. Cut marks on bones from all across the elephants' bodies indicate that Neanderthals accessed meat, brains, and even fat from the elephants' foot pads. Most of the elephants butchered were large adult males, which in modern elephant groups often live alone – so they may have been a lower-risk, higher-return prey target. Straight tusked elephants were the largest animals in Europe at the time, growing up to 13 feet tall and weighing up to 13 tons. The researchers estimated that just one of these large male elephants could have yielded 4 tons of meat, fed 25 Neanderthals for 3 months, and taken 3-5 days for a group that size to process. This huge amount of meat suggests that Neanderthals may have gathered in larger groups, perhaps seasonally, and/or had some kind of food storage or preservation techniques. Furthermore, the dating of elephant bones at the site covers a span of about 2,000 years, demonstrating a behavior continued in the same place across generations. In December, this research team published similar evidence of straight tusked elephant butchery at two additional, contemporary Neanderthal sites at Gröbern and Taubach in Germany[3,] indicating that Neumark-Nord 1 was not a one-off; Neanderthals on the North European plain routinely exploited straight-tusked elephants during the Last Interglacial Period.

> At Gruta de Figueira Brava, a cave site in coastal Portugal, Neanderthals were cooking and eating brown crabs as early as 90,000 years ago. Black burn marks on some of the crab carapaces and pincers indicate that they were subjected to temperatures up to 300-500 degrees Celsius (~600-900 Fahrenheit), indicative of being roasted on coals.

Lastly, although they may not be as "high-risk" as lions or elephants, a third research study published in February by Mariana Nabais and colleagues[4] provides evidence for Neanderthals exploiting marine resources: crabs. While small prey like rabbits, birds, and shellfish may not return as many calories per animal as larger prey, they are typically easier to acquire and more reliable to access at different times and in different seasons. At Gruta de Figueira Brava, a cave site in coastal Portugal, Neanderthals were cooking and eating brown crabs as early as 90,000 years ago. Black burn marks on some of the crab carapaces and pincers indicate that they were subjected to temperatures up to 300-500 degrees Celsius (~600-900 Fahrenheit), indicative of being roasted on coals. The type of fracture on the crab pincers support this interpretation, and it appears that the Neanderthals there particularly went after larger crabs. Consumption of marine foods by Neanderthals casts doubt on the hypothesis that eating shellfish led to modern humans in sub-Saharan Africa evolving uniquely large brains. Gathering of marine resources also implies swimming and/or knowledge of the tides. These three studies together shed new light on Neanderthal behavior and diet, increasingly showing that our closest extinct relatives are not that different from us.

Guess Who's Coming for Dinner?: Cut marks on a 1.45 million year old leg bone are potential evidence for hominins butchering and eating each other

It seems Neanderthals may not have been the only ones with eclectic taste buds… While finding cut marks on animal bones is fairly common after the advent of stone tools in the archaeological record, finding cut marks on hominin bones is much more surprising. A paper published by Briana Pobiner and colleagues[5] in June presents evidence for the earliest cut marks on a hominin postcranial (below the head) bone. Dating to 1.45 million years ago from Koobi Fora, Kenya, this tibia (shin bone), originally found by Mary Leakey in 1970, has been previously ascribed to two species: either *Paranthropus boisei* or *Homo erectus*. The marks, which are all in a group and generally facing the same direction, are all the same color as the surrounding bone, indicating that they were not made during excavation. Nine of the eleven marks were straight in trajectory and V-shaped, consistent with marks made by stone tools. The remaining two most closely resemble lion tooth marks based on comparison to modern specimens with tooth marks of different predators, although the authors can't rule out the possibility that the tooth marks may have been left by a hominin. In the absence of clear hominin tooth marks on the bone, cut marks like these are the strongest evidence of potential anthropophagy, or cannibalism – one member of a species eating another. Since

we aren't sure what species the tibia belongs to, and we can't know which species made the cut marks, it's also possible that this is an instance of predation of one hominin species by another.

Homo vs. *Paranthropus*: Stone tools and animal fossils provide new perspectives on contemporaneous hominin genera

Stone tools can tell us a lot about hominins beyond just what they were eating. The presence of stone tools shows where hominins were, and coupled with hominin fossils and geological context, can shed new light on non-dietary behaviors. A study from October uses stone tools along with butchery marked bones to expand our understanding of earlier hominin diets and ranges. Tom Plummer and colleagues[6] describe sites from Nyayanga, Kenya dating to around 3 million years ago containing Oldowan stone tools. This expands the range of where these tools are found at the time by over 1300 kilometers and also pushes the date for Oldowan tools back by as much as 400,000 years. These stone tools were likely used to butcher an ancient hippopotamus, as cut-marked hippo bones were found in the same layer. The Oldowan has traditionally been associated with the species *Homo habilis*, as it was found at the same site as Oldowan tools in Olduvai Gorge, Tanzania in 1964. Since then, fossils of *Paranthropus boisei* have also been found at sites with Oldowan tools in eastern Africa, including at Olduvai Gorge. At Nyayanga, there are two *Paranthropus* molars in the same layer as the Oldowan tools and butchered hippo bones – but there are no *Homo habilis* fossils known from this excavation. Knowing which species made and used stone tools is difficult when there are multiple hominins on the landscape at the same time, but this study suggests that ruling *Paranthropus* out as a possible tool-maker is unwise.

Plank You Very Much: Earliest use of wood for structural purposes discovered in Zambia

Although stone tools get much of the attention in human evolution, ancient tools were sometimes made from other materials that do not preserve as well as stone. A study published in September by Lawrence Barham and colleagues[7] presents evidence for the oldest structural use of wood: logs used to build a structure dating to 476,000 years ago! The team excavated two interlocking wooden logs with intentionally carved notches at Kalambo Falls in Zambia, as well as other wooden objects including a digging stick, a wedge, and a chopped log. Multiple stone tools were also found at this site. The waterlogged context of Kalambo Falls allowed for unusually good preservation of organic material, including wood. While tools using a single element (flaked stone, wooden stick, etc.) are fairly common and relatively simple to construct, the invention of complex, multi-part tools, like arrowheads hafted onto spears, is much more cognitively demanding and occurs more recently in our evolutionary history. This study suggests that the first multi-part manufactured objects may

have been structures or dwellings rather than butchery tools or weapons. Considering that the earliest fossil evidence for modern humans currently dates to around 300,000 years ago, this structure was likely not made by our own species.

A Penchant for Pendants: Researchers use ancient jewelry to unravel the story of human migration and behavior

Of course, tool use doesn't have to be confined to purely practical purposes. Modern human cultural expression is characterized by the production and aesthetic significance of jewelry, clothing, and other items. Two stories from this year use jewelry and personal adornments specifically to better unravel the story of human migration and existence. First, a study published in July by Thais Pansani and colleagues[8] investigates the remains of giant sloths from Santa Elina in central Brazil. At this site, abundant stone tools are intermixed with the fossils of the extinct ground sloth *Glossotherium phoenesis*, which grew to be 10 to 13 feet long and weighed 1.1-1.6 tons. These fossils include thousands of osteoderms, bones found in the skin similar to the armor on an armadillo, to whom sloths are closely related. Strikingly, three of these osteoderms had holes drilled into them by humans, which the authors interpret as fashioning them into pendants to be worn. These drill holes were also made prior to the bones becoming fossilized, meaning that humans must have existed alongside these megafauna to have access to their fresh bones. The dating of the oldest human activity at this site, including these giant sloth bone pendants, to around 27,000 years ago means that modern humans reached central Brazil prior to the last glacial maximum around 20,000 years ago. This study contributes to the growing body of evidence demonstrating that modern human migration into the Americas is much older than previously accepted.

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A second paper from May by Elena Essel and colleagues[9] uses a deer tooth pendant dating to 19,000-25,000 years ago from Denisova Cave in Siberia, the home of the enigmatic Denisovans, as well as humans and Neanderthals, to investigate something completely different. This team used a nondestructive method to extract ancient DNA from objects to investigate the identity of the person that may have made and/or worn the object. This novel method involves gradually heating the artifact in a special solution to extract DNA that is trapped inside. From this, the researchers were able to identify the mitochondrial genomes of both the deer the tooth pendant came from and the ancient human that either wore or made the pendant. They determined that the pendant wearer was a woman belonging to a known ancient Eurasian population that was previously only thought to live in eastern Siberia. This new method allows for great expansion of ancient DNA analyses outside of fossils and sediments and, since it's nondestructive, it could be used on human fossils in the future.

Furthermore, the successful application of this method to objects means that researchers can bridge the gap between DNA and archaeology, linking the manufacture and use of cultural and utilitarian objects to individual people. So cool!

It Takes a Village!: *Homo sapiens* originates from two or more African paleo-populations

As always, this year was an exciting year for even more ancient DNA studies! Rather than using deer tooth pendants, however, Aaron Ragsdale and colleagues[10] looked at the genomes of modern Africans to try to gain clues about the origins of our species, *Homo sapiens*. While genetic and fossil evidence indicates that our species' origin was in Africa, exactly how early ancient human populations interacted and contributed to living populations is less clear. This research team used DNA to work backwards in time and studied 289 modern human genomes from across Africa, including some from Great Britain as an outgroup, as well as a Croatian Neanderthal genome as an additional outgroup. They used computer modeling to suggest that our species arose from at least two African populations that interacted and interbred with each other. Fossils from these populations would likely be physically and genetically similar. This study indicates that our species did not arise from a single geographically isolated origin population in Africa.

Ancient Human Hol-LAO-day: New fossils place *Homo sapiens* in southeast Asia thousands of years earlier than expected

While ancient DNA allows researchers to investigate our species' African origins, new fossils and archaeological sites can shed light on when our ancestors migrated to new places outside of Africa. A paper published in June by Sarah Freidline and colleagues[11] describes new fossils and dates for members of our own species, *Homo sapiens*, reaching southeast Asia sometime between 86,000 and 68,000 years ago. The fossils include a partial frontal bone (including brow ridge) from the cranium, and the shaft of a tibia, or shin bone, from Tam Pà Ling in northern Laos. The frontal bone is remarkably gracile in shape, lacking robust muscle attachments and large bony protrusions. This indicates that the individual it belonged to did not have recent admixture (interbreeding) with other, more robust populations like Neanderthals or Denisovans, but was directly descended from an ancestral *Homo sapiens* population in Africa or the Near East. Interestingly, current genetic evidence points to a single successful rapid expansion of *Homo sapiens* out of Africa around 50,000 years ago. That would imply that this cranium dated to at least 67,000 years ago may represent an earlier, failed migration ofour species. More early finds like these fossils in Asia will help shed light on the details of early human expansion out of Africa.

Were Our Deepest Roots in Grasses or Trees?: Miocene apes evolved in more heterogeneous habitats including early grasslands

The earliest evidence for the evolution of bipedality (walking upright on two legs), which may have enabled the earliest hominins to expand into new habitats, is from around 6-7 million years ago. While this new locomotor regime was originally hypothesized to result from looking out for predators in grasslands, part of the 'savanna hypothesis', a more recent idea is that the evolution of bipedality is related to reaching up and eating fruit from terminal branches in trees. This new idea is driven by earlier hominin species like *Ardipithecus ramidus*that lived in more heavily forested habitats. A pair of papers published in April challenge this narrative. Grasses follow a distinct form of photosynthesis known as the C4 pathway, while woody vegetation, like trees and bushes, follow a different C3 pathway. These pathways can be derived from the chemistry of fossil animal teeth and bones, which allows scientists to determine what sort of plants different animals ate, and therefore what plants were available on the landscape. The first paper by Daniel Peppe and colleagues[12] shows that the expansion of grasses, driven by a cooler, more arid climate, occurred about 10 million years earlier than previously thought in Africa. This means that grasslands were locally abundant, creating more variable habitats outside of dense canopy forests where early apes lived. The companion paper by Laura MacLatchy and colleagues[13] examines the fossils of *Morotopithecus*, an ancient ape ancestor that lived 21 million years ago. This study found that while *Morotopithecus* was still living in trees, it was adapted to eating leaves instead of fruit and lived in habitats with extensive grass coverage, more like a mosaic forest-grassland than a tropical rainforest. Together, these studies provide evidence for an earlier expansion of grasslands and variable habitats that may have driven the evolution of upright torso posture in Miocene apes as early as 20 million years ago, around 12 million years before the oldest potential hominins.

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