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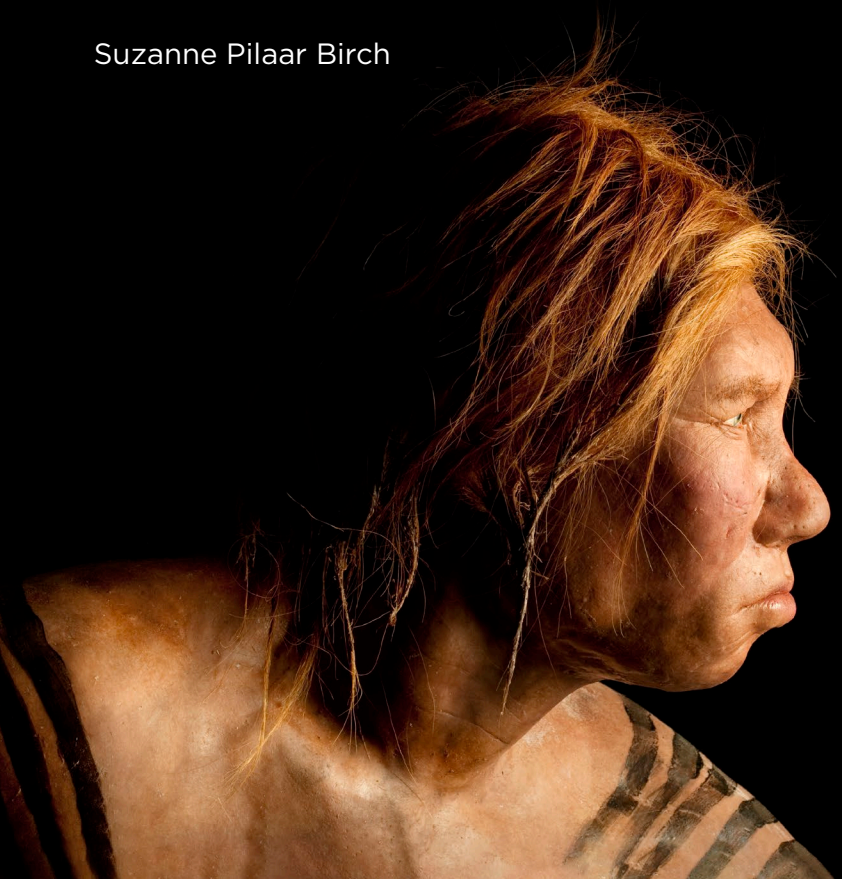
Course Guidebook

Suzanne Pilaar Birch



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01 WHAT DOES IT MEAN TO BE HUMAN?

Humans have been farming for only around 12,000 years of the almost 200,000 years of human prehistory. The Society for American Archaeology defines archaeology as “the study of ancient and recent human past through material remains.” During this course, you will meet some of your ancient ancestors face-to-face and examine a fascinating but distant and elusive past: life before agriculture. It’s part of a much larger story that couldn’t be told without the work of archaeologists and other scientists worldwide. As you journey through these lectures, you’ll follow in their footsteps in an attempt to address some of the questions that have fascinated humans almost since the beginning of time: Who are we, and how did we come to be this way?

Homo sapiens

Our species, *Homo sapiens*, is believed to have emerged in East Africa in what is now Ethiopia. In the Middle Awash region of Ethiopia, archaeologists discovered one of humanity's first ancestors: the fossil Lucy, who belongs to a species known as *Australopithecus afarensis*, which existed nearly 3.2 million years ago. Like us, Lucy walked upright but did not use tools. She stood only about three feet tall.

Around 3 million years after Lucy, two *Homo sapiens* adults and a seven-year-old child lived and died in the same part of Ethiopia. Their remains became fossilized in a geological formation that is estimated to be about 160,000 years old. The *Homo sapiens* stood taller, had larger brains in rounded skulls, and, notably, used stone tools. The skulls show signs of having been modified after

death, in what is interpreted as some of the earliest evidence for the symbolic treatment of the dead. Further south, between the Omo and Kibish Rivers in Ethiopia, Omo I and Omo II lived and died even earlier, about 195,000 years ago. They, too, exhibit a large, dome-shaped braincase, tall stature, and stone tool use. They are the oldest commonly accepted examples of our species.

Telling Geologic Time

To tell the story of humanity's past, specific terminology is used to organize time into understandable chunks. The geologic time scale is a system of dating that is used to understand the relationship of different time periods to one another, as defined by major changes in Earth's history. We currently live in the Holocene, which began 11,700 years ago and is characterized by relatively warm temperatures and stable environments. The Pleistocene epoch is the time period immediately before the Holocene and lasted from about 2.6 million years ago to 11,700 years ago. It encompassed a series of dramatic ice ages that occurred on a long-term scale that shaped our development as a species via physical, social, and technological adaptation to the environment.

The archaeological record is defined by changes in human culture and is usually marked by the types of technology found in a particular era. For instance, the Stone Age refers to a period when tools were made of chert or obsidian. It began roughly 3 million years ago and lasted throughout the Pleistocene—and, in some parts of the world, well into the Holocene. It can further be divided into the Early, Middle, and Late Stone Ages, which are also referred to as the Paleolithic, Mesolithic, and Neolithic, respectively. Derived from the Greek term *lithikós*, *lithic* means "of stone." In turn, *paleo*, *meso*, and *neo* correspond to "old," "middle," and "new," respectively.

Agricultural lifestyles first developed in the Neolithic, as early as around 12,000 years ago. In fact, agriculture is one of the main characterizations of the period. It was during this time when the appearance and evolution of ground-stone tool technologies—such as mortars and pestles—occurred for

processing grains that had been domesticated and were starting to be grown as early crops. The term *Epipaleolithic* is commonly used to describe the period between the Paleolithic (old) and Neolithic (new) Stone Ages.

People began to domesticate plants and animals all around the world at around the same time: during the early Holocene, between 12,000 and 10,000 years ago. Although it's likely that climate conditions are why the development of agriculture became possible, there were widely different environmental and cultural variables at play in each region. Thus, while ground-stone tools and the appearance of agriculture are among the main ways to define the Neolithic period in Southwest Asia, the other critical defining characteristic is pottery. Pottery is also used to describe different time periods within the Neolithic in East Asia but not South America. There, pottery did not originate until long after agriculture.

The agricultural revolution stands as one of the most important moments in human history. Scholars still don't understand all the different factors leading to its origin, development, and spread. To understand how agriculture developed, you have to go back in time, before it all began.

Geologic Change

Stone Age archaeology is often referred to as "stones and bones." Luckily, the development of archaeological science over the last 70 years has allowed researchers to more closely interrogate the physical evidence that they have to work with. That's due in part to the physical chemist Willard Libby, who worked on the Manhattan Project during World War II. In 1949, he developed the most widely used scientific dating method in archaeology: radiocarbon dating, which measures time using the known rate of radioactive decay of the carbon-14 isotope. His work ushered in a new era of discovery and development, as archaeologists pushed back accurate dating 50,000 years.

To understand human adaptation to environmental change, it's important to know what kind of setting you're talking about and to think about how large-scale transitions—taking place over time as well as across archaeological phases—affected daily lives. As the last ice age began to wind down around 15,000 years ago, the Adriatic Sea didn't exist as we know it today. In fact,

most of the world's shorelines were completely different. The sea level was about 120 meters (or almost 400 feet) lower due to the amount of water locked up in glaciers at the Earth's poles and atop mountain ranges.

During this time, a region called Doggerland connected the British Isles to mainland Europe. Elsewhere, Australia, Tasmania, and New Guinea formed a supercontinent called Sahul. The Great Adriatic Plain connected Italy to the Balkans and extended one-third of the way down what is now the Adriatic Sea. Massive meltwater rivers flowed across the Po Plain from the Italian Alps. Underground rivers from the Dinaric Alps in the east formed and expanded caves throughout the karstic—or limestone—bedrock of Croatia.

Scholars argue whether the Great Adriatic Plain was a rich landscape full of plants and animals or a barren, saline wasteland before it eventually became flooded and the modern-day shoreline formed around 8,000 years ago. They have to rely on sites surrounding the region of interest—the hinterland. In the case of the Adriatic, the Dalmatian Islands and Istrian Peninsula of Croatia represent former high points at the edges of the Great Adriatic Plain. As such, cave sites in these areas are the best bet for understanding human-environment dynamics at the time.

As the sea level rose, so did average global temperatures. The regional environment responded accordingly. Instead of long, cold, dry winters, the seasons became shorter, warmer, and wetter. This led to the growth of forests, with trees such as pine and birch. Shrubs began to encroach on the grasslands. Then, as the freshwater table rose further and temperatures warmed, broad-leaved forests with trees such as oak spread at higher elevations. The plain became a marshy wetland.

All of this occurred at a rapid pace, geologically speaking—over a few thousand years. Even then, people would have noticed their surroundings changing. There would have been fewer horses galloping across open grassland as the forests grew, bringing more deer and wild boar to hunt. Later, their great-great-grandchildren might have collected cattails in the marsh and harvested shellfish in still water, while their great-great-grandchildren lived on an island, fishing and catching small game. Somewhere along the way, they stopped following the herds of migrating elk. These animals probably became

a less reliable resource as they altered their migration pathways in response to the changing landscape. People stayed put for more than one season at a time and hunted and gathered a wider range of species.

Archaeological Methods

How do archaeologists know all this? To start, consider the rate at which the sea level rose and where and when the coast took shape. There are many ways to determine this, and one of them has to do with underwater caves. The stalagmites and stalactites in caves, along with other similar formations, are formally known as speleothems. They form in distinct layers as water evaporates, leaving calcium carbonate behind. Maša Surić and her colleagues collected speleothems from several caves and dated the last layer to find out when they stopped growing. This revealed the date when the caves filled with water instead of air, due to flooding from the rising sea level. This helped them determine a timeline for the formation of the modern coast.

How can archaeologists talk about whether a landscape was covered in grassland or forest and what kind of trees grew? The answer is pollen. Pollen is made of a nearly indestructible substance called sporopollenin. This means that it preserves well in a variety of conditions. It also comes in distinctive shapes depending on the pollination method of the plant. Maybe it needs to be carried across large distances by the wind or to stick to a pollinator, such as a bee. Eventually, some portion of the pollen floating around becomes trapped at the bottom of lakes, mixed up with dirt and other debris, and forms layers of sediment. Scientists can core lake bottoms to retrieve and analyze this sediment, identify pollen spores based on shape, and spend hours using a microscope to count and calculate relative proportions of different plant species. With radiocarbon dating, which measures the amount of carbon-14 to establish the sample age, along with sophisticated computer modeling, researchers can use the data to reconstruct what types of vegetation covered the landscape during a given period.

Knowing what hunter-gatherers hunted long ago might seem relatively straightforward: Look at the bones. However, only a small proportion of the hunted animals was preserved in the archaeological record. In an ancient city, you might find 10,000 bone fragments in one small area, accumulated over the course of 300 years. In a cave, you might find only 10,000 total,

accumulated over the course of 3,000 years. Furthermore, how do you know that the bones excavated at a site found their way there because of human activity and not because a carnivore lived there?

One way is to study taphonomy, which considers all of the processes that have affected a specimen from the time of death to the time of analysis. For example, does the bone show signs of red or black discoloration, suggesting burning? Are there cut marks, such as those found on the early *Homo sapiens* skulls in Ethiopia? Maybe the bones are shattered into pieces, suggesting that people were breaking them open to extract the marrow to eat or boiling them to produce grease.

In some cave sites of the eastern Adriatic, there is a shift in hunter-gather lifestyles from the late Pleistocene—the end of the last ice age—into the warming of the early Holocene. The people went from hunting elk that preferred marginal habitats and were seasonally migratory to focusing on wild boar and other smaller-bodied animals that lived in forests and were available year-round. Moreover, the encroachment of the coastline becomes clearer through the appearance and increase of shellfish such as mussels, clams, and sea snails in the archaeological record.

How do archaeologists know whether these species were migrating 10,000 years ago? Like the speleothems and sediment at the bottom of the lake, teeth form in layers too—over the span of weeks and months. Analyzing the fluctuating ratio of certain chemical elements in teeth layers allows researchers to track whether an animal migrated. This is because those ratios are related to variations in temperature, rainfall, and even geologic bedrock that an animal might have traveled through.

People living at the head of the Adriatic adapted to the significant climate and environmental changes around them 15,000 to 7,000 years ago by settling in and diversifying their diets. A previous study demonstrated an increased population in the Balkans around 8,200 years ago, related to a global climate event. This likely laid a foundation for the regional transition from hunting and gathering to herding and farming and the adoption of other aspects of Neolithic life, such as pottery.

Reading

Pilaar Birch, Suzanne E., Preston T. Miracle, Rhiannon E. Stevens, and Tamsin C. O'Connell. "Late Pleistocene/Early Holocene Migratory Behavior of Ungulates Using Isotopic Analysis of Tooth Enamel and Its Effects on Forager Mobility." *PLOS ONE* 11, no. 6 (2016): e0155714. https://doi.org/10.1371/journal.pone.0155714.

Renfrew, Colin, and Paul Bahn. *Archaeology Essentials: Theories, Methods, and Practice*. 4th ed. Thames & Hudson, 2018.

02
STONES AND BONES: THE FIRST FOSSIL FAMILIES

Recent research leads archaeologists to believe that human lineage is like a meandering river, with many tributaries and streams that may feed back into the main stream or lead to dead ends. By 4 million years ago, there were the upright-walking australopithecines, *Australopithecus afarensis* and *Australopithecus africanus*, and their larger, strong-jawed cousins, *Paranthropus boisei* and *Paranthropus robustus*. About 2.5 million years ago came the human genus, *Homo*. The current wisdom is that *Homo habilis* is the earliest member of this genus. This lecture will address the burning question of what distinguishes the genus *Homo* from the relatives that came before.

What Makes Us Human?

Language is one of the first requirements of humanity that comes to the minds of many people. However, language likely didn't arise until more than 2 million years later, though our ancestors still had ways of communicating. Walking upright is another popular guess. However, even the australopithecines did that. Opposable thumbs? No, we maintained the primitive primate body structure, with five digits capable of a power grip and thumbs adding a precision grip necessary for making tools.

An omnivorous diet and diversified teeth would have played a role in our early nourishment. However, these, too, would have been shared with other primates. Primates generally also emphasize learning and sociality and living in familial groups. Moreover, their reproduction is characterized by long gestation periods, single births, long periods of infancy, and greater longevity than many other mammals. These features are preexisting conditions coded in our DNA and possessed by generations of apes before us that likely set the scene for *Homo*'s success.

The development of language sometime later was likely facilitated by our elaboration of both vision (meaning increased emphasis on sight) and the neocortex (the gray matter that accounts for about three-quarters of our brain), along with a reduced emphasis on our sense of smell. It's that brain that set us apart, growing relatively larger as we, our genus, branched away from the head of the river into our own stream. *Homo habilis*'s brain made up less than 2% of its body weight, metabolically consuming 20% of its available energy. Yet this was an increase of about 50% over the australopithecines. This larger brain size likely played a role in *Homo habilis*'s adaptability—its ability to survive in a variety of locations, navigating different environmental conditions and climate shifts.

Bipedalism

The ability to habitually walk on two feet is seen as the root adaptation for *Homo* because it facilitated more efficient foraging and freed the hands to carry food supplies and tools. A reconnaissance-focused theory suggests that while apes were able to walk on two legs once in a while (known as facultative

bipedalism), hominins began to exploit non-forested savannah environments while seeking food. This led to habitual walking on two legs and, eventually, evolutionary divergence.

Charles Darwin's original hypothesis on the development of humans argued that tool use was a fundamental adaptation that led to evolutionary divergence. It allowed individuals to stay on the ground safely. Later, the anthropologist Clifford Jolly put forward a seed-eating hypothesis based on his observations of gelada baboons in the highlands of Ethiopia. Seed eating was thought to lead to larger molars, reduced canines, increased manual dexterity, and sitting upright while eating. These are all visible traits in the skeleton of early *Homo*.

Meanwhile, the anthropologist Owen Lovejoy argued for a socio-reproductive hypothesis: If females walked upright, this would have concealed when they were ovulating and most fertile. Competition between males in the form of displays of aggression was reduced, simultaneously decreasing the need for larger body size and sharp canines. Sexual dimorphism was reduced. Instead, the provision of resources became more important, and those who could venture further out on two legs were more successful in reproducing. It's difficult to argue for monogamy as a strong selective force in the evolutionary development of bipedalism, however, because of the sexual dimorphism exhibited by *Homo habilis*. Males were larger than females in weight and height. This is common in species that compete for access to females and where one male might mate with multiple females rather than practice monogamy.

Richard Wrangham's "cooking with fire" hypothesis states that the ability to use fire—and, importantly, cook meat on it—led to hominin groups being able to sleep on the ground with protection. Thus, they also had access to better nutrition and, subsequently, grew larger brains.

Evidence is sparse for any one of these theories. Moreover, the hypotheses must be consistent with the timing of the origin and duration of each species and the morphology of each species in the fossil record. In the end, the emergence of *Homo habilis* was likely the result of a combination of many of these factors over long periods of time.

The entirety of human history and prehistory takes place throughout the Pleistocene and Holocene. The Pleistocene began about 2.6 million years ago and ended 11,700 years ago, which is when the Holocene, our current geological epoch, begins. The archaeologically defined Early Stone Age—or the Lower Paleolithic—occupies a majority of the Pleistocene. The earliest undisputed evidence for purposely made stone tools dates to that boundary of 2.6 million years, stretching forward in time to 200,000 years ago.

The emergence of anatomically modern humans, *Homo sapiens*, occurred during the Middle Stone Age, or Middle Paleolithic, which lasted from 200,000 until about 50,000 years ago. After that, we entered the Late Stone Age, or Upper Paleolithic. In some regions, this lasted until the Holocene at 11,700 years ago and the advent of agriculture, and in other areas, it lasted until nearly modern times. Within that long expanse of time, there are divisions of archaeological periods related to stone tool technology. This far back, it's usually the only evidence there is. Thus, it's no surprise that the major defining characteristics of the period are what people ate (bones) and how they hunted it (stones).

Bones

What did *Homo* eat? It's argued that meat would have been important in the diet and that this nutritive source helped to grow proportionally larger brains. In early *Homo*, there's no evidence for the "hyper chewing" for processing nuts and tubers as suggested by the large molars and strong jaw muscles seen in earlier relatives such as *Paranthropus*. The incisors were larger, with smaller premolars and molars. One significant debate regarding meat eating is the extent to which *Homo* was dominant or subordinate in its ecosystem. In the African savannah, there were many large predators at every turn.

Hunting or active scavenging could have posed a tricky prospect amid so many competitors. Thus, was early *Homo* a passive scavenger, approaching an abandoned kill and taking what was left? One way of telling is to look at whether cut marks on the bone made by *Homo* are under or on top of tooth marks made by carnivores. Much of the debate originated before archaeologists knew what they do now about chimpanzees and how they hunt in groups to kill small colobus monkeys and share the meat. It's not improbable that these early humans were also out hunting. They might have

obtained meat using a variety of methods. Whether the food itself was hunted or scavenged doesn't necessarily matter. It's the consumption of all that protein that let us grow our larger brains.

Stones

Tool use played a role in obtaining those much-needed calories, as the cut marks on the bones show. Having the opposable thumb was key again, as was the ability to utilize the power and precision grips in making and using tools. Stone tools were curated, meaning they were conserved, saved after use, and transported. The distance between the source rock and the deposition of these artifacts is often used as a metric to understand the range and movement of hominins. Even unmodified cobbles, or manuports, transported from the riverbeds where they originated can be taken to represent human activity.

Importantly, the creation of stone tools and the movement of unmodified source material require forethought. Making a stone tool requires the cognitive ability to see what you will make before it emerges, to visualize a sharp edge and a place to grip. In stone tool manufacture, hammerstones are used to shape the core stone. Flakes are knocked off the stone to create the tool. The debris that results is debitage. The appearance of hammerstones, flakes, and debitage helps paleoanthropologists and archaeologists piece together when and how our earliest ancestors started to make tools.

How do archaeologists know the tools are human-made? One of the most distinctive ways to detect purposeful manufacture is the presence of a striking platform and the all-important bulb of percussion: a distinctive bulge in the rock, created by the pressure of the angled strike when the tool was being made. Stone tool production was likely so important that hominins had a home range focused near a raw material source that they could access on a regular basis.

The earliest evidence for these Mode 1—or Oldowan—stone tools comes from Gona, Ethiopia. Jack W. K. Harris, along with his Ethiopian PhD student Sileshi Semaw, published these finds in 1997. They used potassium-argon and argon-argon dating to estimate the age of the stone tools. Because it takes 1.3 billion years for half of the potassium in a sample to decay into argon, this technique works well for dates ranging in the millions of years.

In addition, because Earth's magnetic field is constantly shifting—and sometimes even flips—periods of different or reversed polarity can be identified by measuring the direction of magnetic minerals in rocks when they form or are heated to a certain temperature. Harris and Semaw paired this method of paleomagnetism with potassium-argon dating to verify that these were, indeed, the earliest known stone tools.

In 2015, a group of researchers led by Sonia Harmand published the discovery of proto-Oldowan stone tools at a site called Lomekwi in Kenya, dating to as old as 3.3 million years ago. This discovery predates the earliest known fossils of the genus *Homo* by a substantial amount. The tools would have had to have been made by *Australopithecus* or yet another related species, *Kenyanthropus platyops*. Other hominins might have used rudimentary tools too. Wooden digging sticks have been suggested as a precursor to stone tools.

Olduvai Gorge

Olduvai Gorge in Tanzania is where Mary and Louis Leakey and their children held their excavations. It is located in a dry valley on the western margin of the eastern African Rift Valley. More than 20,000 stone artifacts have been unearthed there, in addition to more than 25,000 vertebrate animal specimens and more than nine hominin individuals. Why are there so many more animal bones than hominin ones? Our skeletons don't tend to preserve as well as the remains of similar-sized creatures with denser bones. Also, populations of hominins at this time were likely quite small. The lowermost bed, or geological layer, with the earliest material at Olduvai Gorge has been dated as between 2 million and 1.7 million years old.

All individual hominin fossils from this site start with the letters OH, which stands for Olduvai Hominid, and a number that indicates the order in which they were found. The first of the genus *Homo* to emerge from Olduvai was OH 7. Jonathan Leakey found this fossil in 1960. It's sometimes referred to as Johnny's Child since it's thought to have been about 12 years old at the time of its death. It is the *Homo habilis* fossil representative against which all other specimens are compared, also known as a type specimen. It consists of a lower jaw with 13 teeth, a single additional upper molar, two parietal (or skull) bones, and 21 assorted fragments of the hand and wrist. The surrounding sediment is about 1.8 million years old. OH 7's braincase would have been

about 680 cubic centimeters in size if it had reached adult age. Over the years, as more specimens of *Homo habilis* were discovered, a consensus was reached that it should be considered its own unique genus and species and that it derived from *Australopithecus*.

The hominin fossil OH 8, which was also found in 1960 and is about 1.8 million years old, consists of foot bones, though it's missing part of the heel (or calcaneus) and a few toes. This specimen supports the argument for *Homo habilis* as capable of habitual bipedalism because it has the all-important arch found in the foot of modern-day humans. OH 13—nicknamed Cinderella, or Cindy—was found a few years later by the Kenyan Ndibo Mbuika. This find from 1963 consists of a lower jaw and teeth as well as maxillary and cranial fragments. It was thought to be female because of its size. It also dates to 1.6 million years old—a few hundred thousand years later than the earlier *Homo habilis* finds. Yet, despite the passing of 200,000 years, there was no significant change in the size of the brain, coming in at around 650 cubic centimeters.

OH 16—or George—was found the same year. It consists of some teeth and a fragmented skull and is estimated to be about 1.7 million years old, with a braincase size of 640 cubic centimeters. OH 24—Twiggy, discovered with a crushed yet relatively complete adult cranium and teeth—was found in 1968. She's about 1.8 million years old, with a slightly smaller cranial capacity of about 600 cubic centimeters. OH 62 was found in 1986. It consists of multiple skull fragments, teeth, and a few arm and leg fragments, and it also dates to 1.8 million years old.

The other major fossil locality for this time period is Koobi Fora, located on the margins of Lake Turkana in Kenya. Specimens here are labeled as KNM for Kenya National Museums and then as ER for East Rudolph. This site is important because while it's generally accepted that the genus *Australopithecus* led to *Homo habilis*, it doesn't necessarily follow that the species *Homo habilis* led directly to our next ancestor, *Homo erectus*. Another candidate has been suggested: *Homo rudolfensis*.

KNM-ER 1470—a 1.9-million-year-old, relatively complete fossil skull discovered in 1972—is argued to be exactly that. Its large cranial capacity of 750 cubic centimeters and early date make it difficult to reconcile as the same species as the smaller-brained *Homo habilis* further south. Indeed, two other notable KNM-ER specimens, 1805 and 1813, have much smaller braincases—600 cubic centimeters and 510 cubic centimeters, respectively. This puts them in the range of the previously discovered *Homo habilis* and supports the case for sexual dimorphism, with larger males and smaller females.

Finally, in South Africa, the cave of Sterkfontein has yielded one potential *Homo habilis*. This is remarkable because it would mean that *Homo habilis*'s range spread more than 3,000 miles. STW-53 consists of cranial fragments and teeth and had a small brain. It's dated between 1.5 and 2 million years old. As an isolated find, it might instead represent yet another lost member of our family tree. Some have suggested it should be called *Homo gautengensis*.

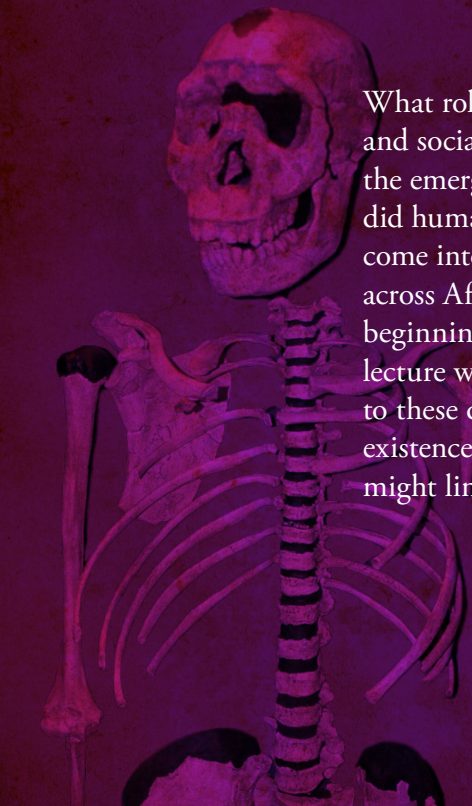
Reading

Harmand, Sonia, Jason E. Lewis, Craig S. Feibel, Christopher J. Lepre, Sandrine Prat, Arnaud Lenoble, Xavier Boës, et al. "3.3-Million-Year-Old Stone Tools from Lomekwi 3, West Turkana, Kenya." *Nature* 521, no. 7552 (2015): 310–315. https://doi.org/10.1038/nature14464.

Leakey, Meave, and Samira Leakey. *The Sediments of Time: My Lifelong Search for the Past*. Boston: Mariner Books, 2020.

Stanford, Craig Britton, John S. Allen, and Susan C. Antón. *Biological Anthropology: The Natural History of Humankind*. Pearson, 2017.

03
BIO-CULTURAL ADAPTATION AND *HOMO ERECTUS*



What role did fire, cooking, tool use, and socializing have as catalytic factors in the emergence of human culture? How did humans' close relation *Homo erectus* come into being as the genus *Homo* spread across Africa during the Early Stone Age beginning 2.5 million years ago? This lecture will provide the extant answers to these questions as well as unveil the existence of various other *Homo* species that might link *Homo erectus* to *Homo sapiens*.

Homo erectus

The discovery of *Homo erectus* took place in 1891 in Trinil, Java, by a team led by Eugène DuBois. He called it *Anthropopithecus erectus* and, later, *Pithecanthropus erectus*—"erect man-ape" and "erect ape-man," respectively. He identified his Java man as the missing link between apes and humans. After later finds of the so-called Peking man in Beijing and other Javanese specimens at Sangiran and Mojokerto, it was reclassified in 1950 as *Homo erectus*.

That first find of *Homo erectus* was believed to be between 700,000 and 1 million years old based on biostratigraphy. This specimen stood about five feet, eight inches tall. That first find consisted of a braincase with a 900-cubic-centimeter cranial capacity; a long, flat forehead; distinct brow ridges; and a sagittal keel. The sagittal keel is where the masseter (or chewing) muscles attach to and is notably developed as a bone crest in gorillas today as well as in our earlier cousins, *Paranthropus*. Perhaps *Homo erectus* retained this primitive trait from an earlier lineage while still consuming substantial plant matter alongside meat. Its cranium was also quite thick. Moreover, a femur was found, whose morphology confirms that this individual walked upright. This finding led to the moniker of *erectus*, which means "erect" man.

Homo erectus was the first to leave the continent of Africa and settle across the Old World. More than 200 *Homo erectus* fossils were recovered from at least 40 individuals at the "Peking man" cave site of Zhoukoudian, near Beijing. It was a veritable gold mine of fossil discoveries throughout the 1920s and 1930s. This discovery expanded archaeologists' knowledge about the duration of the existence of this species. Moreover, cranial capacity estimates range from 915 to 1,225 cubic centimeters—as much as doubling that of early *Homo* in Africa.

Homo erectus vs. *Homo ergaster*

Another 800,000 years back in time, *Homo erectus*—or, arguably, what's considered its earlier form, *Homo ergaster*—first appeared in Africa. How are *Homo erectus* and *Homo ergaster* defined? How are they different than *Homo habilis*, *Homo rudolfensis*, and *Homo sapiens*?

Essentially, the label *ergaster*, or "working man," pertains to *Homo erectus*, such as fossils dating to the earliest part of their temporal range (about 1.8 to 1.7 million years ago), primarily in the area surrounding Lake Turkana in Kenya. That's where archaeologists also find the earlier *Homo rudolfensis*. The designation of *ergaster* has been in dispute since its inception. Some scientists think it should remain separate from *Homo erectus*. Others have argued for it to be considered a subspecies. To still others, *Homo ergaster* is a way of saying "African *Homo erectus*."

Whether *Homo ergaster* and *Homo erectus* are considered the same species, one thing is for certain: With its appearance, there is clearer evidence for bio-cultural adaptation in the fossil record. That is, changes in the fossils' physiology reflect advances in the technology used at the time. For example, *Homo erectus* possessed a marked decrease in teeth and jaw size from previous hominins. That was likely the result of more advanced food preparation, including cooking. It had modern, humanlike body proportions, with relatively elongated legs and shorter arms. It was able to walk and possibly even run. By this time, it was almost certainly living in open savannah environments.

The archaeology itself is marked by an increase in the functional range of technology, with a relatively large tool kit. Moreover, there's that obvious increase in braincase and, therefore, brain size, suggesting increased cognitive complexity and ability. Taken together, this suggests that *Homo ergaster* and *Homo erectus* were capable of developing more advanced tools and methods of using them than their predecessors.

Homo erectus was one of the longest-lasting hominin species. As such, it was likely highly adaptive to a whole suite of environmental challenges. It persisted for more than 1.5 million years, from 1.8 million years ago to as recently as 200,000 years ago. It overlapped with multiple human species that developed during this same period, potentially giving rise to several of them.

In terms of *Homo erectus* anatomy, the forehead is relatively flat and angled toward the back. The term used to describe this is *platycephaly*, or "flat head." In contrast, modern humans have vertical, upright foreheads. Moreover, *Homo erectus* had a bump on the back of the skull known as an occipital torus, or occipital bun. For the most part, modern humans do not have this. Likewise, *Homo erectus* had a brow ridge, whereas modern humans tend to have a small or no supraorbital torus. In the mouth area of *Homo erectus*, the

teeth projected out somewhat in front. It lacked a chin, and this created a slightly obtuse angle at the mouth. This is alveolar prognathism. In contrast, modern humans have a minor to no angle at the mouth, and some of us have quite distinctive chins. This is likely associated with a decrease in teeth and jaw size due to food preparation.

Next, the raised ridge across the top of *Homo erectus*'s skull, where muscles attached for powerful chewing, is completely nonexistent in modern humans. Finally, *Homo erectus* possessed a thick skull. In the past few years, work by the physical anthropologist Lynn Copes has shown that this was likely due to phenotypic plasticity. This is the idea that certain physical traits are controlled or influenced more by the environment than by genes. In this case, experiments in mice demonstrate that when multiple generations are reared in cold-climate conditions, they tend to have thicker cranial vaults. Likewise, the thick skulls in *Homo erectus* were likely an adaptation to living in colder climates after leaving Africa.

Turkana Boy

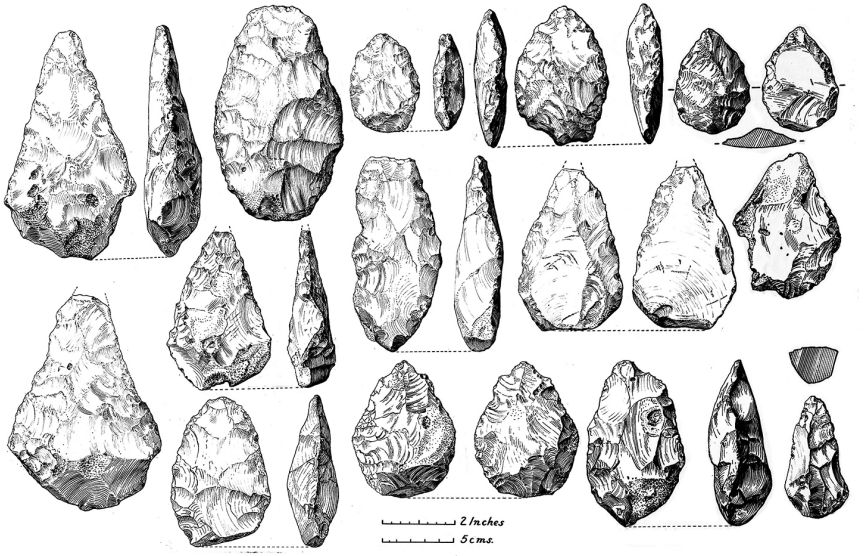
To date, the best-known and most complete example of *Homo ergaster* or *erectus* and its anatomy is that of Turkana Boy—also known as Nariokotome Boy or KNM-WT 15000. He was discovered in 1984 in Kenya by the fossil hunter Kamoya Kimeu, who worked with members of the Leakey family. This specimen is 1.6 million years old and would have been between 7 and 11 years of age at the time of death. The remains consist of 108 bones.

When alive, the individual stood about five feet, three inches tall. Based on bone measurements, it's calculated that his growth rate would have been faster than that of *Homo sapiens* but slower than that of chimpanzees. This provides clues as to when our rates of development might have started slowing down.

Turkana Boy shows that *Homo erectus*, in contrast to *Homo habilis*, possessed essentially modern limb proportions, with a complete loss of arboreal characteristics. It had narrow thoracic vertebrae and a flattened cranium, large enough to suggest some capacity for verbal communication. At first, scientists studying Turkana Boy's spine thought that he showed signs of scoliosis. However, new studies suggest this was perhaps the typical structure of the vertebrae for *Homo erectus*.

Our Growing Brains

The beginnings of food preparation and modification likely had an impact on the structure of our skull and the size of our brain. An essential part of this would have been having the right tools. Mode 1, or Oldowan, stone tool production lasted from about 2.5 to 1.8 million years ago. It is thought to have been created by *Homo habilis*. Mode 2, or Acheulean, stone tool production, which is thought to have facilitated the shift in food preparation, began about 1.8 million years ago, with the appearance of *Homo erectus*. It persisted until about 200,000 to 100,000 years ago.



The geographic distribution of Acheulean stone tools stretches throughout the African continent; across Europe; across the Near and Middle East, India, and China; and south into Indonesia— basically everywhere *Homo erectus* has been found. Hand axes were the Acheulean's primary stone tool form. These can range from simple to elaborate and are bifaced, or flaked on both sides. They were crafted from many different materials. The Acheulean tool kit also included cleavers: bifaces with a straight, sharp edge opposite the base of the

tool. The chain of production was complex. Large, unfinished stone flakes have been found and are considered to have been blanks for further knapping, or shaping, as the need arose.

It's assumed that wooden implements were also used during the period, although no evidence remains of that until much later in the archaeological record. There likely wasn't any intent to combine stone and wood to create spears. Instead, hand axes might have been thrown, allowing our ancestors to become more successful at securing large game in addition to smaller prey. That would have increased our meat consumption, too, helping us grow even larger brains. We do have some traces of polish on the edges of these stones, which were used to remove meat from bone.

There has even been some discussion of hand axes as a sort of social currency—this idea is called the sexy hand-axe theory. One's ability to knap (or shape) a symmetrical axe might have signaled cognitive capacity and manual dexterity. It also might have given one a better chance than otherwise at securing a mate. Regardless, paleoanthropologists see the tools as signifying a mental leap that would forever alter our way of interacting with the natural environment and add to our mastery of it. *Homo erectus* was able to exploit a greater diversity of habitats and landscapes than before.

The fact that *Homo erectus* had a larger brain is evidence that the species had access to sophisticated means of obtaining the necessary nutrition to maintain it through not only hunting but also cooking. It's possible this increased nutrition also led to increased life spans. Although it's postulated that the australopithecines, who lived approximately 3 to 4 million years ago, had a maximum life span of 50 years compared to our maximum of about 100, *Homo erectus* likely fell somewhere in between.

Some scholars, such as biological anthropologist Molly Fox, support another theory to explain longer life spans: the grandmother hypothesis. It suggests that because female lactation has high metabolic needs, kin groups that include postmenopausal females enhance reproductive success because these individuals (grandmas) support mothers. This leads to shorter periods of time between births. Thus, women might have a child every two or three years instead of every five, not only increasing population numbers overall but also passing on their genes for longevity to more individuals. Pair-bonding, where the male provisions the female, would also enhance reproductive success.

The Missing Link(s)

As humans moved from the jungle to the savannah, what was the savannah like at this time? *Homo erectus* lived from about 1.8 million to perhaps around 200,000 years ago. That was firmly in the Pleistocene epoch, geologically speaking, and the Lower Paleolithic, archaeologically speaking.

The Pleistocene was a time of ice ages. The best way to categorize ice ages is through the use of stable isotope ratios of oxygen trapped in tiny, microscopic, single-celled organisms called foraminifera, buried deep in marine sediment. These marine oxygen isotope stages (MISs) are used to define glacials, or cold periods, when Earth's polar regions expanded to cover much of the northerly latitudes with ice; and interglacials, or warm periods separating glacial periods, when ice would recede. There are also intervals called stadials, or geologically brief cold periods within interglacials that are not cold enough to be glacials; and interstadials, or warm periods within glacials not quite warm enough to be interglacials. There are 104 MISs going back to the earliest years of the Pleistocene epoch. *Homo erectus* appeared around the time of MIS 62 (1.8 million years ago) and lasted potentially until as recently as MIS 6 (about 200,000 years ago).

In Africa, ice age fluctuations might have been evident as changes in moisture and aridity, known as pluvials, or wet periods, and non-pluvials. At the time of the earliest *Homo erectus*, the northwest tip of Africa was covered in a Mediterranean scrub-type environment. The Sahara was a mostly dry, steppe-like environment. A mixed savannah-woodland-type environment stretched across the eastern African Rift Valley and into South Africa, looping around into West Africa. The area known today as the tropical Congo rainforest would have extended further east. The Kalahari region of southern Africa would have consisted of desert steppe.

Homo erectus found its way from the northernmost reaches of the continent to the tip of South Africa, mastering all of these novel environments. In fact, one of the earliest alleged *Homo erectus* fossils—between 2 and 1.95 million years old—was found at the Drimolen Quarry in South Africa. Its mastery of the elements paved the way for leaving Africa. However, where did the *Homo erectus* lineage lead in Africa, and is *Homo erectus* our direct ancestor?

The Daka skull, which is about 1 million years old and hails from the Awash, was found in Ethiopia in the late 1990s and consists of only the calvaria. It has a reconstructed cranial capacity of about 995 cubic centimeters—well within the range expected of *Homo erectus*. However, based on its shape and other measurements, this transitional fossil has been used to argue for a direct evolutionary relationship between *Homo erectus* and *Homo sapiens*. Fast-forwarding another 500,000 years in the same region, the discovery of a much later example—the Gawis cranium—has been presented as yet another transitional form, demonstrating the link between *Homo erectus* and *Homo sapiens*.

Paleoanthropologists have named multiple other species that could serve as transitional types. For example, the Ndutu cranium—discovered on the shores of Lake Ndutu at Olduvai in Tanzania—dates to between 400,000 and 600,000 years old. Like *Homo erectus*, it has a sloping forehead and a thick skull. However, it lacks the sagittal torus and is slightly bulbous, more like the skull of *Homo sapiens*. As a result, this specimen has been proposed to belong to yet another taxon: *Homo rhodesiensis*. This species was named in 1921, when Zambia was called Northern Rhodesia.

Homo rhodesiensis is also used to describe the famous fossil of Kabwe 1, or Broken Hill. The remains consist of a complete cranium, a sacrum, a tibia, and two femoral fragments. Today, it's thought to be about 300,000 years old. Rather than looking like something between *Homo erectus* and *Homo sapiens*, this sample has some Neanderthal-like characteristics as well, begging the question as to whether *Homo rhodesiensis* might be ancestral to the Neanderthals rather than to our own species. Another relative, the Bodo cranium—discovered in the Awash of Ethiopia and dating to 600,000 years before present—might be a more likely candidate for an *erectus-sapiens* link. However, it's also considered a member of the *Homo rhodesiensis* group. This species is potentially synonymous with a European form called *Homo heidelbergensis*, after a specimen discovered in Germany.

The oldest currently accepted specimens of *Homo sapiens*, Omo 1 and Omo 2, were discovered in 1967. They are close to 195,000 years old. What makes them so distinctive is their rounded, dome-like skulls; thin brow ridges; chins; and, most importantly, an even larger brain than before, at 1,400 cubic centimeters. The other earliest *Homo sapiens* specimens, sometimes referred

to as *Homo sapiens idaltu*, or "first born," discovered in the late 1990s from Herto in the Middle Awash, share similar anatomical features and large braincases. They've been argued to be directly ancestral to us.

Reading

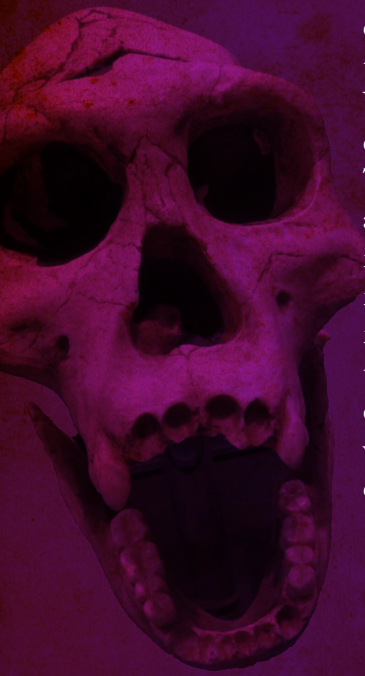
Dubois, Eugene. "On *Pithecanthropus Erectus*: A Transitional Form between Man and the Apes." *The Journal of the Anthropological Institute of Great Britain and Ireland* 25 (1896): 240–255. https://doi.org/10.2307/2842246.

Hassett, Brenna. *Growing Up Human: The Evolution of Childhood*. London: Bloomsbury Sigma, 2022.

Shen, Chen, Xiaoling Zhang, and Xing Gao. "Zhoukoudian in Transition: Research History, Lithic Technologies, and Transformation of Chinese Palaeolithic Archaeology." *Quaternary International* 400 (May 2016): 4–13. https://doi.org/10.1016/j.quaint.2015.10.001.

Wrangham, Richard. *Catching Fire: How Cooking Made Us Human*. New York: Basic Books, 2009.

04
HOW *HOMO SAPIENS* LEFT AFRICA



How did *Homo sapiens* adapt to new environments by changing its diet and technology as it spread across the Old World? How does the archaeological evidence compare to that from DNA? The bones and stone tools found so far are minute traces of all that happened in humankind's distant past. More recently, the study of prehistory through molecular genetics, or archaeogenetics, has transformed archaeologists' understanding of the human fossil record. However, as you will learn in this lecture, it has also, to some degree, confounded it.

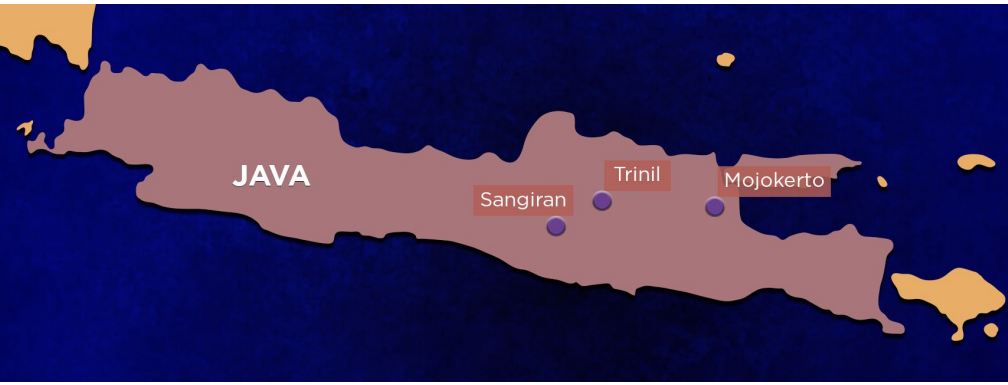
Hominins outside Africa

Homo erectus was the first of our genus to leave Africa. Traces of it have been discovered living as far away as the Caucasus 1.8 million years ago, which is almost as early as it has been identified in eastern Africa. The famous site of Dmanisi in the Republic of Georgia, where these discoveries were made, is nestled between Europe and Asia. The star fossils at Dmanisi include five roughly contemporaneous skulls that exhibit extraordinary variation in size and morphology.

In the past, there were likely many different species of hominins living in a variety of habitats. The finds at Dmanisi in Georgia were thought to be so unique that they were at first classified as their own species, *Homo georgicus*. Today, however, they're commonly accepted as a subspecies of *Homo erectus*: *Homo erectus georgicus*. These skulls are intriguing because they share many of the traits associated with *Homo erectus* but have extremely small brains. The largest braincase at Dmanisi, Skull 1—probably belonging to an adult male—is only 775 cubic centimeters. The rest are even smaller. Skull 5, the most recent to be discovered, has a braincase of just under 550 cubic centimeters. Both Skull 5 and Skull 4 lived to old age. Archaeologists know this because the teeth of Skull 5 are worn to stumps, whereas the healed tooth sockets of Skull 4 indicate that this individual lost its teeth years before dying.

So far, these are the earliest hominins discovered outside Africa. In Indonesia, there is other, more solid evidence for a relatively early and rapid dispersal out of Africa, though it's still more recent than 2 million years ago. The first specimen of *Homo erectus* to be discovered—Java man—dates to between 700,000 and 1 million years ago. This significantly postdates Dmanisi. Thus, it's not particularly remarkable that it took between 800,000 and almost 1 million years for *Homo erectus* to travel nearly 9,000 kilometers from mainland Europe to island Southeast Asia. Other *Homo erectus* fossils from Java have pushed this date back further. Remains from the site of Sangiran, in central Java, come from a geological context dated to between 1 million and 1.6 million years old.

The Mojokerto child, discovered in 1936, was originally thought to be no more than 1 million years old. In the mid-1990s, however, the skull was dated with argon-argon dating, which provides a measurement based on radioactive



decay. In this case, the date returned was 1.8 million, with an error of plus or minus 40,000 years. This early date presented another problem: Could the skull be as old as the Dmanisi hominins and Turkana Boy? How could multiple individuals of this species appear so far apart so early in time, without any other geographic evidence for such early dispersal? As it turned out, the date measurement was conducted on material from a site where the sediment was thought to match what had been found in the skull rather than on the skull. This made the early date controversial.

A few years later, the New Zealand archaeologist Michael Morwood redated the skull using fission-track dating. This method works by measuring the decay of uranium-238 as rock cools after forming. It works best on samples older than a million years in age. To conduct his test, Morwood returned to the locality that the earlier date had been derived from. However, he dated different layers that seemed to better correspond to the original excavation records. He subsequently obtained a date of 1.5 million years (plus or minus 130,000) for the specimen. This seems more reasonable for timing the expansion of *Homo erectus* as far east as Java. It means they traveled that 9,000 kilometers in about 300,000 years instead of the earlier estimate of up to 1 million.

Gene Flow

It's important to distinguish the difference between diaspora and migration. *Diaspora* means a movement of an entire population from its homeland. *Migration* means the movement of individuals or groups of individuals.

The difference plays into important concepts of gene flow, bottlenecks, and founder effects that are essential to understanding how humans came to be dispersed worldwide. Most everything about humans is controlled by our genes, which can be expressed differently in response to a given environment. Each gene has multiple variants, or alleles. You might be homozygous dominant: two copies, one from each parent, of a dominant gene. You could be heterozygous dominant: One parent gave you the dominant gene, the other gave you the recessive gene, and you have one copy of each. Alternatively, you can be homozygous recessive: two copies of the recessive gene.

Many deleterious genes are homozygous recessive. Moreover, different alleles selected based on certain events, such as a pandemic, might create a genetic bottleneck with unexpected consequences later. Genetic bottlenecks occur when large numbers of individuals die or otherwise fail to reproduce such that certain genes may become present in higher frequencies in a given population while others may be eliminated. For instance, the mutation of one gene responsible for the behavior of white blood cells, CCR5-delta32, appears to confer resistance to HIV and AIDS. This genetic mutation occurs in approximately 10% to 15% of contemporary Europeans and those of recent European descent. Those with at least one copy of the mutation were able to survive and reproduce during the bubonic plague, and those without it died. This is selective pressure.

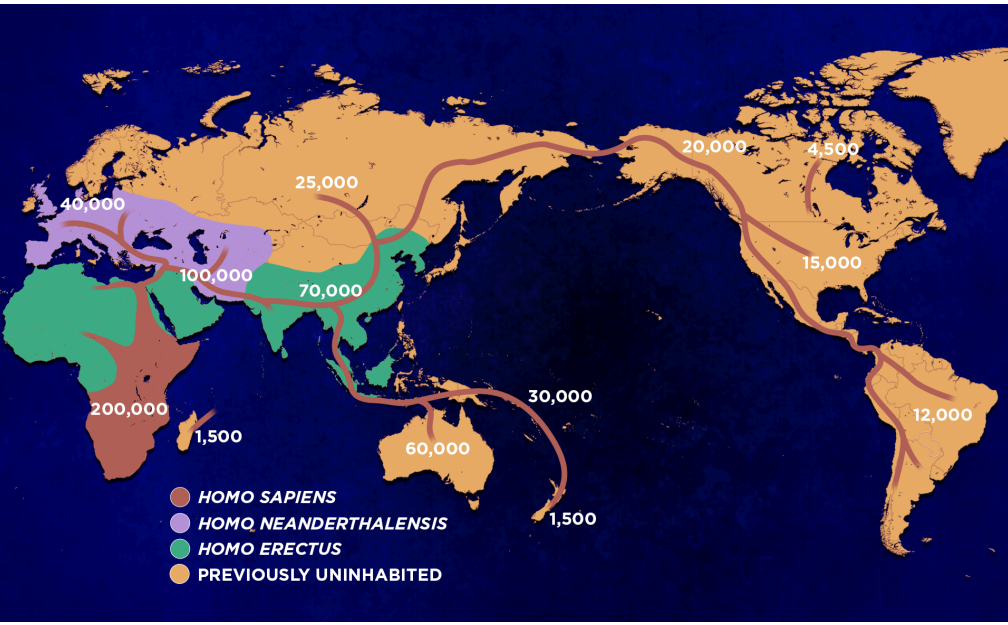
However, say that only a small number of people from a given population were to migrate and settle elsewhere—10 or 20 of them. Odds are that only 1 or 2 of them would carry this mutation. Since it's a recessive trait, it wouldn't be likely to be passed on to the next generation. This might occur with several alleles such that genetic variation in the new population would be greatly reduced. This phenomenon is the founder effect. This process likely occurred again and again throughout evolutionary history. A population will eventually become genetically distinct from the original ancestral one without significant external genetic admixture, selective pressure, or mutations. Given enough time and isolation, this can even lead to a new species.

When considering the dispersal of *Homo sapiens* out of Africa, you have to consider the existing populations of hominins already in place from earlier migrations. This is because multiple populations of different hominin species spread across Eurasia thanks to that movement of *Homo erectus* from Africa

nearly 2 million years earlier. In some cases, these populations became genetically and anatomically distinct. What was the role of gene flow and the exchanges of artifacts, ideas, territory, and social structure? What roles did diaspora, migration, and interaction with other species play in the shaping of our own?

Explaining *Homo sapiens*'s Origins

One explanatory framework for the origin of *Homo sapiens* is the contested multiregional hypothesis, which, to some extent, appears to have been debunked. It states that there was an initial "out of Africa" event occurring close to 2 million years ago, when *Homo erectus/ergaster* dispersed into other parts of Africa as well as Europe, Asia, and Australasia. Over the next million years, interbreeding occurred between all of these populations at a high enough rate that our genus was somewhat globalized. There was substantial gene flow between all populations. Slowly, in multiple regions, we stopped being *Homo erectus* and became *Homo sapiens*.



The multiregional hypothesis allows for regional variation in phenotype due to differing environmental conditions but emphasizes the importance of genetic admixture throughout time. When the American paleoanthropologist Milford Wolpoff first proposed it in 1984, he sought to explain why we saw such longevity and also variation in the human fossil record leading up to the widespread appearance of our species. At the time, there simply was not yet firm enough DNA evidence to the contrary.

In the late 1980s and early 1990s, another theory began to develop: that of "recent African origins," or "out of Africa II." This theory proposed that while *Homo erectus* might have evolved into multiple lineages outside Africa (such as Neanderthals and Denisovans), these were evolutionary dead ends. All modern humans derive instead from an ancestral population of *Homo sapiens* originating in Africa, which spread throughout the Old World only recently, beginning approximately 200,000 years ago. Under this theory, *Homo sapiens* replaced these other species of humans.

This theory was bolstered by fossil discoveries in Ethiopia—at Omo in the late 1960s and early 1970s and at Herto in 1997. It was further refined and substantiated through advances in genetic sequencing and biomolecular dating in the 1990s and early 2000s. Eventually, it appeared that we all descended from a genetic last common ancestor: a "Mitochondrial Eve."

Mitochondria produce energy within our cells and contain a short, circular strand of DNA with a set of instructions controlling only 37 genes—about 16,500 base pairs. There are hundreds to thousands of copies of mitochondrial DNA within each cell, making it more likely than nuclear DNA to be preserved in archaeological samples. It also has a higher mutation rate, which helps researchers determine when certain genes may have originated. Humans are astonishingly homogenous, with relatively little genetic variation according to contemporary DNA. This is especially true for mitochondrial DNA, which is inherited only through the maternal lineage.

The highest level of genetic variation in mitochondrial DNA occurs in modern African populations. That implies that *Homo sapiens* arose first in Africa and, therefore, had a longer period of time to accumulate genetic diversity there. Populations outside of Africa show reduced genetic diversity overall, following a mechanism similar to the founder effect, in which genetic

variation is reduced when a small subset of a large population establishes a new population. This means that various different gene mutations can accumulate over time.

Researchers see this when analyzing modern DNA. The "molecular clock" can be used to date the genetic distance between different populations as a measure of time, using a calculated rate of mutation. Based on DNA alone, the hypothetical origins for *Homo sapiens* in eastern Africa are suggested to be between 100,000 and 400,000 years ago. This premise is partly substantiated by the 200,000-year-old fossil finds at Omo and Herto.

The low amount of genetic variation in the modern human population suggests that our origins reflect a relatively small founding population for *Homo sapiens*. Perhaps a small population of *Homo sapiens*, numbering 10,000 to 50,000 people, left Africa between 50,000 and 100,000 years ago. DNA samples from living humans suggest that Neanderthals and modern humans separated more than 400,000 years ago. During the time of this hypothetical split, the world was deep in the throes of a glacial maximum, with cold conditions in Europe and dry conditions in Africa. The earliest Neanderthal fossils are about 180,000 to 200,000 years old, or about as old as the earliest definitive evidence of anatomically modern humans in Africa—during MIS 6, the glacial maximum of the second-to-last ice age.

How Did We Thrive?

It's reasonable to assume that there was less population mobility, and perhaps more genetic conservatism, during this time. However, as we entered MIS 5—the last interglacial, around 100,000 years ago—it appears that the earliest circum-Africa dispersals began to occur. Genetics provide evidence of demographic expansion of African populations alongside *Homo sapiens* sites in the Near East and Mediterranean. This genetic evidence supports some of what is seen archaeologically later in time, too. The last approximately 60,000 years saw the demographic expansion of Eurasian populations, coinciding with the movement of *Homo sapiens* into Australasia and, later, North America.

The Toba super-eruption, which occurred on what is now Sumatra, Indonesia, about 75,000 years ago, possibly changed the course of our species' trajectory. It likely caused a genetic bottleneck and perhaps the extinction of the last

remnants of *Homo erectus* living in Asia. It's postulated that the eruption might have caused a 10-year global volcanic winter, spurring an additional 1,000-year cooling period. It likely had a significant influence on our species in some way or another. Some researchers suggest that genetic data show that all living humans today are descended from no more than 10,000 individuals who lived approximately 70,000 years ago and survived the volcanic eruption.

Paleoenvironmental records across Southeast Asia support a distinctive shift in vegetation. Adapting to this dramatic shift in environment might have spurred sociocultural developments in *Homo sapiens* that gave them the leading edge when it came to succeeding over other species. Some tempting evidence comes from the rock shelter of Jwalapuram, India, where stone tools are found from layers dating both to before and after the Toba event. The recovery of these tools suggests that the hominins living there persisted in the face of adversity. However, the tool types and forms also changed after the event, shifting to smaller "microblade" technology. Would this adaptation have allowed increased mobility amid arid conditions after the eruption?

A revised—but still controversial—multiregional hypothesis published in 2003 conceded that although modern humans might have originated in Africa, they likely interbred with other archaic human populations whom they met along the way, incorporating some of their genetic material into our own. This would have allowed for the preservation of one central tenant of Wolpoff's theory: that modernity was approached over a long time period and that successful new features and behaviors appeared in different places in response to different challenges. The adaptations spread across the human range precisely because people migrated and exchanged genes, albeit on small scales.

After *Homo sapiens*'s origin in Africa approximately 200,000 years ago, genetic and fossil evidence shows that cultural adaptations began to supersede physical change in our direct ancestors. These people had vertical foreheads, rounded occipitals, and a reduced brow ridge. They had an overall reduced facial skeleton that was more gracile and lacked the midfacial projection seen in earlier species. For the first time, we had a strong chin. The rest of the skeleton was less robust, and their lower limbs were as long as or longer than their upper limbs—like us. However, they don't appear to have begun to act like us until about 50,000 years ago.

Most aspects of this research are still highly theoretical. For example, some archaeologists model increased social interconnectedness through time via our ancestors' use of stone tools and the role stone tools played in our technological and sociocultural evolution. Lower Paleolithic Mode 1 tools consisted of relatively simple implements that were made with local resources. This may point toward a relatively small, low-density population that had weak patterns of social interconnectedness. By Mode 2, there was increased complexity in stone tool form, additional functions in the tool kit, and a wider variety of source material in their manufacture. This has been used to suggest that population levels were relatively larger and at a more moderate density, with regular and stronger levels of social interconnectedness. By Mode 3, the Mousterian, there was a large general population, greater density, and strong incidences of social interconnectedness. Perhaps these strong social bonds led anatomically modern humans to prevail.

Reading

Clarkson, Chris, Clair Harris, Bo Li, Christina M. Neudorf, Richard G. Roberts, Christine Lane, Kasih Norman, et al. "Human Occupation of Northern India Spans the Toba Super-Eruption ~74,000 Years Ago." *Nature Communications* 11, no. 1 (2020): 961. https://doi.org/10.1038/s41467-020-14668-4.

López, Saioa, Lucy Van Dorp, and Garrett Hellenthal. "Human Dispersal out of Africa: A Lasting Debate." *Evolutionary Bioinformatics* 11s2 (January 2015): EBO.S33489. https://doi.org/10.4137/EBO.S33489.

05
X-WOMAN! MEET OUR ANCIENT RELATIVES

Homo sapiens, as our family tree, looks like a winding river, with many streams and tributaries. Recent discoveries have added to it. These include the Denisovans, or *Homo denisova*, across mainland Asia; *Homo floresiensis*, the so-called Hobbits of Flores Island in Indonesia; *Homo luzonensis*, found in the Philippines; *Homo naledi*, discovered in a South African cave; and Neanderthals and *Homo antecessor* in Europe. This lecture will discuss how human they were, why they didn't make it, and what they can reveal about modern humans.

The Denisovans

The Denisovans were discovered in a cave in Siberia in 2008. The tip of a pinky finger—the third phalanx—was found and tested. When the excavators got the results, they were stunned. Its mitochondrial DNA did not correspond to any known species in our family tree. They named the specimen X-woman. Other remains from the cave included three teeth and a long bone fragment. These belonged to four other individuals. Subsequent genetic sequencing of those specimens confirmed that this was indeed the discovery of a novel species, now called *Homo denisova*.

Originally, the remains were thought to be about 50,000 years old, which is toward the end of the Neanderthal line. Stone tools found in the cave where the fingertip was discovered appear to have belonged to the Mousterian stone tool industry, typical for the Middle Paleolithic period about 200,000 to 50,000 years ago. Thus, the explorers were expecting to find a Neanderthal. However, rigorous dating showed that while X-woman did indeed live between 50,000 and 70,000 years ago, her cave companions were from much earlier in time, ranging up to 200,000 years old.

In the cave, a tiny long bone fragment—which was nicknamed Denny and is believed to have belonged to a 13-year-old female—revealed an even more shocking result: The DNA was neither Denisovan nor Neanderthal but both. It is now known, based on modern genetics, that we interbred with Neanderthals. However, it appears that Denisovans, too, are part of our genetic heritage. What makes Denny so special is that she is an example of interbreeding. She was the first-generation offspring of a Neanderthal mother (from further west) and a Denisovan father. This discovery directly challenges current notions of what defines a species and to what extent they contribute to our own lineage.

In 2019, another fragment was discovered, this time a flat piece of skull bone: the parietal. It, too, was genetically sequenced and found to be another Denisovan individual, bringing the total up to five (and a half) individuals at the time.

Recently, one other specimen—a lower jaw from Baishiya Karst Cave in Tibet, from 160,000 years ago—yielded protein evidence suggesting that it is also a Denisovan. Unfortunately, the DNA is not well enough preserved

for analysis. The Baishiya Karst Cave site was discovered at above 10,000 feet in elevation, yielding the earliest evidence of a hominin at this altitude. Although the Denisova cave is located at only slightly more than 2,000 feet in elevation, the mountain range it's located in has peaks up to 15,000 feet high. This has led to speculation that *Homo denisova* might have been well adapted to living in high-elevation, low-oxygen alpine environments.

Two skullcaps were discovered in Lingjing, China, in 2017 and are estimated to be about 100,000 years old. This raises the question of whether they, too, could be Denisovans. Unfortunately, attempts to extract DNA from the specimens have failed.

Denisovan DNA has been found to be present in modern human populations as well. In Melanesian and Australian Aboriginal populations, representation is as high as 3% to 5%, suggesting there was significant intermixing. However, it is not prevalent in mainland Asia, where Denisovan DNA contributes less than 0.2% to the genetic makeup of modern populations. As for the origins of the Denisovans, they remain murky. They appear to have split off from a common ancestor with Neanderthals between 550,000 and 750,000 years ago.

Homo floresiensis

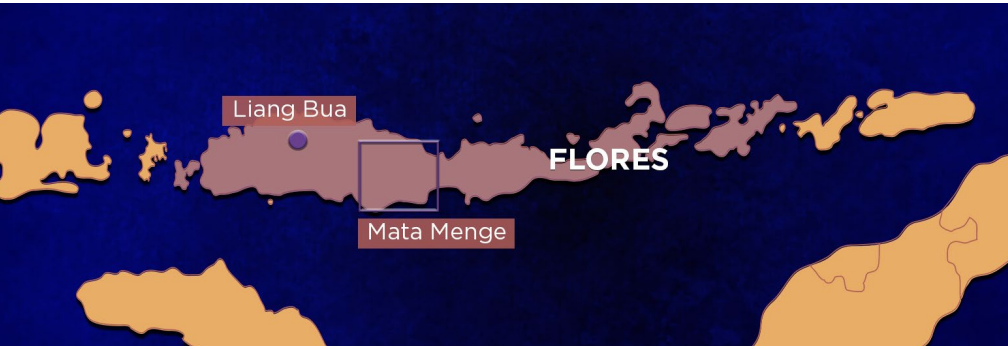
Homo floresiensis possesses extremely distinctive anatomical traits that do not belong to any other species of human. However, as of yet, researchers have been unable to obtain DNA from a single specimen. New Zealand archaeologist Michael Morwood discovered *Homo floresiensis* on the tropical island of Flores, Indonesia, in 2003 and 2004.

The first of the specimens—Liang Bua 1, LB1, or Flo for short—consists of a relatively complete skeleton of a 30-year-old female who stood three feet, seven inches tall. She displayed a suite of primitive characteristics, evolutionarily speaking, including a lack of chin, shoulders that suggest she would have been comfortable spending time up in trees, and a small brain: about 400 cubic centimeters, half the size of that of *Homo erectus* and more in line with what you'd expect from an extinct australopithecine or even a chimpanzee. Yet the cave demonstrated signs that *Homo floresiensis* used fire and made stone tools.

Controversy erupted almost immediately. Was this another species of human, or was it an individual with a rare medical condition? For example, one study surmised that Flo's unusual features might reflect a case of microcephaly. The condition might have caused an abnormally small head, along with decreased cognitive capacity and a shorter life span. However, what are the odds that this individual displayed a genetic disorder as compared to representing a new species of human? It didn't help the controversy that there were also allegations of research misconduct and damage to the specimens.

In subsequent years, the story has changed. Additional skeletal remains have been unearthed, representing as many as 12 individuals who lived 60,000 to 100,000 years ago. Stone tools recovered at the site suggest the cave might have been used even further back in time, up to 200,000 years ago. After further anatomical studies, the bones, including LB1, showed discrepancies in morphology. These support the argument for evolutionary divergence of this species from an ancestral population—perhaps *Homo erectus*—as much as 800,000 to 1 million years ago. Their small size might have been due to island dwarfism, an evolutionary process by which certain species become smaller on islands. However, this decrease in size would not have occurred in only a few generations. Thus, who might this ancestral population have been?

Some compelling evidence that might help answer this question comes from elsewhere on the island of Flores in Indonesia, at the site of Mata Menge. The evidence consists of a mandible fragment and six isolated teeth from at least three individuals dating to 700,000 years ago. The specimens were described in 2016, in the journal *Nature*. The mandible revealed that a wisdom tooth



had already erupted and, hence, that it belonged to an adult. One of the teeth appeared to be even smaller than that of *Homo floresiensis*. Again, based on the shape of the mandible and the loose teeth, the authors were able to say that they felt that the owner or owners demonstrated a greater affinity to Asian *Homo erectus* than any other earlier species.

Other recoveries at the site included fossil remains of a dwarf stegodon (an elephant-like creature), a giant rat, freshwater mollusks, and some simple stone tools. The twin evolutionary phenomena of island dwarfism and island gigantism are well documented around the world. The ecological constraints of islands often preclude the presence of large mammalian carnivores. Thus, birds, rodents, and reptiles are able to grow much larger than they otherwise would. In contrast, the limited forage available for large-bodied herbivores means that individuals with smaller body sizes, and requiring less food, were probably more successful over multiple generations, leading to the occurrence of dwarfed versions. Thus, it's not unreasonable to think that dwarfism could happen to hominins too.

Homo luzonensis

Homo luzonensis, discovered in 2007 on the island of Luzon in the Philippines (and named in 2019), appears to be yet another new family member. Its remains consist of teeth and hand and foot bones that are at least 50,000 years old. Although attempts at DNA extraction have failed, it seems likely that *Homo luzonensis*, too, might have descended from an earlier population of *Homo erectus* on the island as early as 700,000 years ago, according to evidence from the stone tools and butchered animal remains found there.

The hominin remains are small, especially the teeth—smaller than those of *Homo floresiensis*—with many primitive features. As for their technology, no tools have been found associated with the hominin remains, though butchered deer bones suggest tool use. One critical aspect of human development that archaeologists have learned more about thanks to this find is the ability of our predecessors early in time to cross large bodies of water. However, was it accidental or on purpose?

When it comes to discussions of migration, scholars often talk about the feasibility of coastal and inland routes. As ice ages waxed and waned, so did these coastlines. Regions that once were completely submerged might later have been revealed, only to eventually be underwater again. This applied to some regions more than others depending on the slope of the coast and rate of sea level rise. Thus, some islands were accessible because they were once part of the mainland, while other islands never were.

Getting to Luzon would have required crossing water—a major barrier. This is such a distinct problem for most plant and animal species in the Central Indo-Pacific region that there is a biogeographic term for it: the Wallace Line, described by the British naturalist Alfred Russel Wallace on his mid-19th-century journey through the South Pacific and Oceania. The reason why most Australian flora and fauna is so different from that in the rest of the world is that there was never any land bridge to facilitate biotic exchange in this region. It was isolated for tens of millions of years. Thus, either *Homo erectus* possessed the forethought and cognitive capacity to journey to Luzon or a small founding population ended up there by coincidence and was savvy enough to adapt to—and survive on—the island.

Homo naledi

In 2013, the paleoanthropologist Lee Berger posted an ad on Facebook about a new kind of excavation, this time in South Africa. His announcement made headlines. Berger was looking for expert cavers—preferably with relatively petite physiques—who could depart on an expedition within the month. Six women from the United States, Canada, and Australia entered Rising Star Cave through an 18-centimeter opening. Their names were Marina Elliott, Elen Feuerriegel, Lindsay Eaves, Alia Gurtov, Hannah Morris, and Becca Peixotto.

Ultimately, a large team of more than 60 people made the amazing discovery there: a new member of the extended human family, *Homo naledi*. In about a week of excavating, more than 1,500 fragments of hominin fossil remains were recovered from at least 15 individuals. After the remains were processed and cataloged, an open-invitation conference was organized for early-career researchers and established academics alike to meet and evaluate the remains.

It appeared that *Homo naledi* stood between 4.5 and 5 feet tall, weighed less than 100 pounds, and walked on two feet. Its femora—the thigh bones—displayed distinctive ridges that had never before been recorded for any other fossil hominin species. Its shoulders suggested it was a prolific climber, like

Homo floresiensis. Its hands were similar to ours, but the size of its skull—approximately 500 cubic centimeters on average, less than half of *Homo sapiens*'s—was closer to that of *Australopithecus*'s. This suggested that *Homo naledi* might be as much as 1 to 2 million years old and had lived alongside *Homo habilis* and *Homo erectus*.

No stone tools associated with the species have been discovered yet. However, based on the structure of its hands and the powerful grip this structure suggests, there was some conjecture that *Homo naledi* might have made Acheulean-type tools, spanning between 1.5 million and 200,000 years ago, or even Oldowan-type tools, as early as 2.6 to 1.7 million years ago.

The principles of stratigraphy dictate that older layers are deeper than younger layers, and this guides researchers' understanding of site formation and time scale. However, in many cave systems, stratigraphy is difficult because natural geological processes occurring within the cave cause the layers to become topsy-turvy. One useful guidepost is the presence of speleothems, formed as calcium carbonate precipitates in limestone cave systems. They require exactly the right amount of moisture, or they stop growing. Over hundreds and thousands of years, speleothems might grow anywhere from an inch to a foot, stopping and starting, depending on how wet or dry the cave is. In some cases, yet another type of formation called flowstone grows. It's produced when sheets of water cover the floors and walls of a cave. Speleothems and flowstone both form in thin layers.

In addition to the calcium carbonate sequestered in the stone, other trace elements include uranium. This decays into the daughter element thorium. By measuring the ratio of uranium to thorium in each layer, scientists can date speleothems and flowstone. With multiple dates, they can model their rate of growth such that sediments alongside these formations can also be dated by association.

This type of dating requires careful excavation and a highly technical and costly process. At Rising Star Cave, this approach was combined with paleomagnetic dating and electron spin resonance, performed on the teeth of the fossils. Taken together, they provided a verdict on the age of *Homo naledi* and its significance for understanding human evolution: *Homo naledi* lived between 236,000 and 335,000 years ago. Its persistence of archaic traits, such as that small brain, so far forward in time suggests that there were certain early *Homo* populations—whether *habilis* or *ergaster/erectus*—that were isolated enough to become their own species.

Right now, it appears that all of the remains in the cave belong to a single stratigraphic context, formed over several hundred years. How did *Homo naledi* get there? The cave's remote setting, along with the lack of stone tools and bones of any prey or predators, has led to the suggestion that the remains were purposely placed there by other members of the species in a display of early ritual behavior.

Reading

Berger, Lee R., John Hawks, Darryl J. de Ruiter, Steven E. Churchill, Peter Schmid, Lucas K. Delezene, Tracy L. Kivell, et al. "*Homo naledi*, a New Species of the Genus *Homo* from the Dinaledi Chamber, South Africa." Edited by Johannes Krause and Nicholas J. Conard. *ELife* 4 (September 2015): e09560. https://doi.org/10.7554/eLife.09560.

Détroit, Florent, Armand Salvador Mijares, Julien Corny, Guillaume Daver, Clément Zanolli, Eusebio Dizon, Emil Robles, Rainer Grün, and Philip J. Piper. "A New Species of *Homo* from the Late Pleistocene of the Philippines." *Nature* 568, no. 7751 (2019): 181–186. https://doi.org/10.1038/s41586-019-1067-9.

Douka, Katerina, Viviane Slon, Zenobia Jacobs, Christopher Bronk Ramsey, Michael V. Shunkov, Anatoly P. Derevianko, Fabrizio Mafessoni, et al. "Age Estimates for Hominin Fossils and the Onset of the Upper Palaeolithic at Denisova Cave." *Nature* 565, no. 7741 (2019): 640–644. https://doi.org/10.1038/s41586-018-0870-z.

Sutikna, Thomas, Matthew W. Tocheri, J. Tyler Faith, Jatmiko, Rokus Due Awe, Hanneke J. M. Meijer, E. Wahyu Saptomo, and Richard G. Roberts. "The Spatio-Temporal Distribution of Archaeological and Faunal Finds at Liang Bua (Flores, Indonesia) in Light of the Revised Chronology for *Homo floresiensis*." *Journal of Human Evolution* 124 (November 2018): 52–74. https://doi.org/10.1016/j.jhevol.2018.07.001.

06
DID THE NEANDERTHALS REALLY GO EXTINCT?

Humans share a great deal in common with Neanderthals, our most recent living relatives, including up to 3% of our DNA. Moreover, 40,000 years ago, this shared DNA was three times higher at 9% as the result of interbreeding as early as 100,000 years ago. Although some of these shared genes are positive, many are negative or do not affect humans at all. This lecture will cover what the differences and similarities between humans and Neanderthals mean when it comes to solving that age-old question of why humans flourished as a species while Neanderthals went extinct.

What Did Neanderthals Look Like?

In 1856, a Neanderthal skull was discovered at Feldhofer Cave in the Neander Valley of Germany. In 1864, it became the first hominin species outside our own, *Homo sapiens*, to be named: *Homo neanderthalensis*. Two earlier specimens had been found—in Belgium and Gibraltar—but they weren't recognized as Neanderthals until after the Feldhofer Cave discovery. What made these fossils distinct enough from us to consider them another species?

To start, they had a large skull with heavy brow ridges, angled cheekbones, no chin, and a large nasal opening. The mid-region of their face protruded further out than ours; this is called midfacial prognathism. They had the occipital bun, as did our other earlier relatives. However, they possessed much larger brains, averaging around 1,500 cubic centimeters, in contrast to ours, which are about 1,200 to 1,350 cubic centimeters. We are still the winners when it comes to proportion, though, suggesting that we possess higher intelligence.

The Neanderthals' incisors were large and often show extensive wear, likely due to their use as an additional tool when hide-working. Their molars were robust—a clue, in addition to the structure of their skulls, that they were adapted to heavy chewing. As for the rest of their bodies, they were shorter and stockier than us, averaging about five feet, five inches in males and about five feet tall in females. Their limb bones were thick-walled, and their rib cage was conical. These traits, as well as the large nose and face shape, are physical manifestations of the fact that they were extremely well adapted to the cold conditions they lived in.

In early 2010, researchers announced that they had produced the first complete genome sequence of our Neanderthal relatives, based on the bones of three females who lived some 40,000 years ago. Sequencing shows what kind of genetic information is carried in a particular segment of DNA. This provided an enhanced understanding of the species' gene expression. A mutation of the *MC1R* gene, which controls pigmentation, caused pale skin and red hair to develop independently in Neanderthals and modern humans alike. This suggests it was an advantageous trait, as it increases vitamin D absorption in northern latitudes, which receive less sunlight. Still, Neanderthals likely featured a wide range of skin, hair, and eye color, as modern humans do today.

What Did Neanderthals Eat?

Thanks to archaeological evidence, researchers know Neanderthals used hearths. That suggests they had use of—and control over—fire. A nuanced look at what they might have been cooking comes from animal bones and limited plant remains. In addition to visually identifying all of the different species that were consumed, archaeologists can also understand the relative importance of meat in the diet using stable isotope analysis. This measures the ratios of different chemical elements present in the bones and teeth of Neanderthals, such as carbon, nitrogen, oxygen, and even zinc.

Neanderthal diets were likely protein-heavy and fat-rich, consisting of red deer, bison, reindeer, horse, woolly rhinoceros, and mammoth among other things. It's estimated that Neanderthals needed between 3,500 and 5,000 calories a day to survive. Thus, even a small group of them would have needed to hunt a substantial amount of game.

Researchers have examined the stable isotope record of remains at various Neanderthal archaeological sites, including at Vindija Cave in Croatia. They concluded that Neanderthals operated at the top of the food chain, dining on meat more predominantly than did other species such as foxes, wolves, and bears. At Spy Cave in Belgium, a large number of juvenile mammoth bones, in conjunction with isotopic analysis of Neanderthal remains, suggests that between 30% and 50% of the Neanderthal cave dwellers' diet there came from these massive beasts. Faunal remains also include the bones of marmots, rabbits, and beavers. For many years, it was argued that Neanderthals were merely scavengers. This claim is now refuted by the fact that carnivore gnaw marks on animal bones overlay the cut marks made by Neanderthals' stone tools.

To hunt their prey, Neanderthals employed an advanced stone tool industry known as Mousterian, named after its discovery at the cave of Le Moustier in France. This tool kit improved the efficiency of the previous stone tool types by up to 500%. The Mousterian tools produced more than two feet of cutting edge per pound.

This was achieved using a method called the Levallois, or prepared-core, technique. It involves striking off several small flakes from a stone (the core) to achieve a specific shape, followed by breaking off the final flake, which

is the desired end product. In this way, the knapper—the individual who is creating the stone tool—can control the size and shape of the finished product. This method can be used to create stone points as well, which could then be hafted, or attached to wood, to create a spear. The Levallois technique appears to have been widespread throughout the Mousterian period, from about 200,000 to 40,000 years ago. It might have developed independently at multiple sites throughout this time.

Different theories exist as to why there is such variation in the stone tool record. François Bordes, a prominent French Paleolithic archaeologist, felt that the variation represents cultural differences among different populations of Neanderthals. In contrast, the American archaeologists Sally Binford and Lewis Binford argued that the variation represents different functionality—different tools for different tasks. Harold Dibble, another American archaeologist, put forward the notion that the stone tools recovered at Le Moustier showcase different stages of the production process.

Neanderthal Society

Increasingly, the archaeological evidence stacks up to suggest that the Neanderthals had rich, multifaceted lives. Their behavior must have been close enough to ours that when interbreeding occurred, their offspring were able to survive and pass on their genes. One interesting possibility, put forward by the archaeologists Steven Kuhn and Mary Stiner, is that Neanderthal society was organized in a fundamentally different way than ours, with implications for their eventual extinction. This theory argues that in many modern hunter-gatherer societies, the day-to-day tasks of survival are divided on the basis of gender: Men hunt, while women tend to the hearth and prepare the food. Children and older adults assist in these activities and might engage in non-gender-specific activities, e.g., supplemental gathering or tool-making.

This social strategy increases reproductive fitness because only males of a certain age are out taking the risks associated with hunting, while females are relatively safe at home. Although a single male might produce many offspring, a female is limited in her ability to produce large numbers of children. Thus, protecting the female means protecting the core of your population.

However, what if Neanderthal males and females participated equally in the risk of hunting? Neanderthal females would then have had overall higher mortality rates. In this way, a Neanderthal female might have borne only two, one, or no children before dying, whereas a *Homo sapiens* female might have produced two, three, or four. Throughout successive generations, it might have been increased reproductive rates for *Homo sapiens* and lower reproduction rates for Neanderthals that led modern humans to emerge victorious in the long race for species survival.

Neanderthal Societal Practices

One of the earliest fossil discoveries of a Neanderthal child was at Devil's Tower, Gibraltar. The English archaeologist Dorothy Garrod discovered the fossil Gibraltar 2, or the Devil's Tower Child, in 1926. A study of his teeth carried out in the 1990s found that they had much more significant wear than would be common for a human child of a similar age—around four years old at the time of death. Based on the appearance of microscopic striations on the surface of his teeth, researchers hypothesized that his diet was mostly carnivorous. This agrees with what archaeologists now know about the Neanderthals' diet based on isotopic evidence.

Other fossils of Neanderthal children suggest they lost their baby teeth sooner than human children do—suggesting a faster physical growth rate for the Neanderthals. However, other indicators contradict this, including, notably, brain

development. What is concluded is that Neanderthal children likely matured physiologically earlier than *Homo sapiens* children would but perhaps without reaching comparable mental complexity.

One aspect of Neanderthal culture that archaeologists have learned more about in recent years is the fact that they cared for their elderly and buried their dead—sometimes in what appears to have been a highly ritualized manner that probably included occasional cannibalism. One site that has led researchers to reach such conclusions is Shanidar Cave, in the Zagros Mountains of Iraq. Shanidar is one of those places that humans seem to have come back to again and again. It provides evidence for 75,000 years of human use. In 1957, the American archaeologists Ralph and Rose Solecki began to excavate Shanidar in a study that forever transformed the understanding of Neanderthals from brutish cavemen to empathetic individuals.

The fossil find Shanidar 1—known as Nandy—tells a 65,000-year-old story of hardship but also of caring. As a child, Nandy received a blow to the left side of the head that would have impaired his vision. In addition, his right arm was withered from a badly healed multiple fracture and possibly had been amputated. Moreover, his right leg showed signs of damage, and he had a healed fracture in his right foot. More recent analysis shows that Nandy was also likely partially deaf as the result of bony growths in his ear. Despite these difficulties, Nandy lived until he was 35 to 45 years old. This age would have been impossible to attain without the support of a family or strong social group. This is one of the first signs of compassion that have been discovered in Neanderthals.

In 1960, the fossilized remains of a 30- to 45-year-old male, Shanidar 4, were uncovered. Shanidar 4 was lying on his left side in a partial fetal position, suggesting deliberate burial. Nearly a decade later, sediment samples around the presumed grave were analyzed and revealed pollen from a variety of plants with medicinal properties. By the late 1990s, reanalysis of the burial showed that the presence of the pollen was likely due to a small burrowing rodent known as the Persian jird.

Since 2015, new excavations have uncovered several more Neanderthal remains at Shanidar, and multiple of these individuals appear to have been deliberately buried. Thus, Neanderthals might have buried their dead. They also appear to have sometimes engaged in cannibalism. Evidence for this

stretches from Krapina Cave in Croatia, where the rite of cannibalism among Neanderthals was first identified in 1899, to El Sidrón in Spain and Le Moustier in France.

Cannibalism doesn't appear to have occurred among Neanderthals outside of the known European sites. One possible explanation for this is that cannibalism was necessary among the European populations of Neanderthals due to scarcity or starvation caused by harsh climatic conditions. However, in the European sites where cannibalism is suspected, many of the Neanderthals' remains don't appear to have been treated as regular food items. For instance, the body parts showing signs of butchery aren't the most nutritious. Evidence of cannibalism among European Neanderthals appears to have occurred during relatively warm climactic periods as well as cold ones.

Other theories explaining the Neanderthals' cannibalistic practices include social aggression and the elimination of group outsiders or competitors. However, these explanations have been discounted as well. Anatomical studies and stable isotope analyses show that many of the deceased individuals who were cannibalized appeared to have been related or were from the same region. Also, they were not necessarily killed violently prior to being butchered. What, then, would be the motivation for these cannibalistic practices? Wragg Sykes, in her book *Kindred*, looks for answers in the behavior of our other distant relatives: chimpanzees and bonobos. In these species, the dead are sometimes consumed as a way of coping with death, even grieving.

Neanderthal Clothing and Art

The Neanderthals seem to have expressed themselves through clothing and personal adornment. Clothing was likely a must during the ice ages. Based on models of modern hunter-gatherers, Neanderthals would have needed to cover at least 80% of their bodies during cold periods—especially their hands and feet—to survive.

Evidence of Neanderthals' tooth wear suggests that they used their incisors to work with leather. It's likely that they fashioned clothing from long strips (or thongs) of leather that they then stitched together. Moreover, DNA evidence from human body lice suggests that the lice evolved as early as 170,000 years ago, further supporting evidence for Neanderthals wearing clothing. At the

Neumark-Nord archaeological site in Germany, residue adhered onto the stone portion of a wood-hafted tool suggests that the material was soaked during a hide-tanning process 100,000 years ago, causing the handle to get wet and leaving the trace evidence behind. This is further evidence for the use of textiles as well as the cognitive complexity required to create composite (or multicomponent) tools.

Evidence at multiple sites points to personal adornment as another facet of Neanderthal life. For example, at the Grotta di Fumane site in northern Italy, archaeologists have learned that Neanderthals living 44,000 years ago harvested feathers. They know this from the recovery of more than 660 wing bones belonging to 22 species of birds with no clear culinary value, such as falcons and vultures. The bones show the impact of stone tools, including cutting, peeling, and scraping.

Neanderthals at Cueva Anton in Spain might have devised early forms of jewelry with seashells that they appear to have perforated to create beads, which they decoratively stained with pure, finely ground hematite powder. There is also some evidence of other early art forms by Neanderthals. For instance, at the El Castillo site in the Cantabrian region of Spain, explorers have discovered thousands of years of cave art, ranging from depictions of animals to handprints to abstract red ochre discs. Based on uranium-thorium dating, the red ochre discs are presumed to have been made by Neanderthals prior to the arrival of modern humans there 40,000 years ago.

Reading

Kuhn, Steven L., and Mary C. Stiner. "What's a Mother to Do? The Division of Labor among Neandertals and Modern Humans in Eurasia." *Current Anthropology* 47, no. 6 (2006): 953–981. https://doi.org/10.1086/507197.

Wragg Sykes, Rebecca. *Kindred: Neanderthal Life, Love, Death and Art*. London: Bloomsbury Sigma, 2020.

07
SAILING TO AUSTRALIA 60,000-PLUS YEARS AGO

Perhaps as early as 70,000 years ago, humans first ventured into a completely novel environment: the mega-continent formed by Australia, Tasmania, and Papua New Guinea known as Sahul. Once humans landed there, they impacted the environment in extraordinary ways, arguably driving to extinction several unique Australian megafauna. As you will learn in this lecture, the reason why the flora and fauna found in Australia are still so distinctive from the rest of the world is that this island continent has been isolated geologically for tens of millions of years.

How Did We Reach Australia?

By the early 20th century, land bridges had been proposed as migratory routes for animals, if not our own early ancestors. However, if there were land bridges between mainland Asia and Australia, this could not explain why Australian flora and fauna is so different from the rest of the world. Plate tectonics—referring to the idea of continents floating on Earth's outer crust and gradually separating—was an alternative theory and the correct one. Yet humans were somehow able to set foot on Australia as early as 70,000 years ago. How did we get there?

During glacial periods in Earth's history, sea levels dropped dramatically. Once the world's water was locked up in polar ice caps, previously submerged coastlines were revealed that would be unrecognizable to us today. During the last ice age, the sea level went down by nearly 120 meters. Australia, Papua New Guinea, and Tasmania were connected by land, forming the Sahul mega-continent. Likewise, many Indonesian islands were connected to mainland Asia, or Sunda. Since Sunda and Sahul were never connected, *Homo sapiens* would have had to travel by boat.

The British naturalist Alfred Russel Wallace noted the disparate biogeography of this region while traveling around the world in the mid-1800s. In the Indonesian archipelago, he observed a biogeographical boundary: the so-called Wallace Line, which cuts across present-day Indonesia. It distinguished Asian fauna from that of Australasian origin.

When the first people arrived in Sahul, they would have found a landscape populated by exotic species that have not survived to the present day, such as giant kangaroos. In terms of predators, 23-foot-long crocodiles and goannas and thylacines would have competed for dinner with people and perhaps posed a direct threat to them. Up to 90% of these Pleistocene species are estimated to have gone extinct closer to 40,000 years ago. Depending on the archaeological evidence you look at, that timing is suspiciously close to *Homo sapiens*'s arrival on the continent.

To what extent were the First Australians responsible for the extinction of its megafauna? Aboriginal people historically practiced a type of controlled burning—fire-stick farming—that allowed them to extensively control the landscape. Sediment records in lake cores and the pollen preserved therein

indicate that it's likely that this practice played some role in modifying the Pleistocene landscape, compounding climate changes that facilitated the extinction of the megafauna tens of thousands of years ago.

On the question of when the First Australians got to Australia, estimates vary. The earliest documented site is the rock shelter Madjedbebe (formerly known as Malakunanja II) on Mirarr country in Arnhem Land. An early date of 65,000 years ago (give or take 5,000 years) has been proposed for the occupation of this site. Nearby, the site of Nauwalabila I has also yielded stone tools, animal bones, charcoal, and ochre originating between 50,000 and 60,000 years ago. This lends support to theories that propose early dates for human occupation in this region.

Those early dates would mean an early departure date for *Homo sapiens* leaving Africa. Current evidence suggests departure was quite close to 70,000 years ago. However, with a dispersal event around this time, humans would have had to have moved rapidly across the Eurasian continent, down into Sunda, across Sahul, and into the interior of Australia within only a few thousand years. The supervolcanic eruption at Lake Toba in Sumatra, Indonesia, about 75,000 years

ago would have made such swift passage difficult. It's also debated whether humans at the time had the cognitive capacity to purposely navigate large bodies of water when they could not see the land they were sailing to.

When Did We Arrive?

Finds at Madjedbebe, the earliest known site of human habitation in Australia, include stone tools, both flaked and ground. This suggests that the first people who lived there were not only hunters but also processed plant foods. The presence of animal bones, shells, and seeds at the site is supporting evidence of human settlement. One type of seed recovered at Madjedbebe is the pandanus nut, which was used in a landmark study to reconstruct rainfall at the site at the time of its earliest occupation. The stable carbon isotope ratios found in the endocarp were used to gauge how wet or dry the environment was when the seed formed. Thus, looking at the average carbon ratios of seeds found at the site gave researchers an idea of how rainfall changed over time. The study revealed that the climate was dry—but not arid—during the time of the estimated initial settlement 65,000 years ago. Later, the climate became wetter. That's when additional evidence for settlement of archaeological sites throughout Sahul starts to appear, when climate conditions became more favorable.

Estimated dates for the earliest colonization of the Australian continent coincide with the limits of radiocarbon dating. The radioactive isotope of carbon, carbon-14, decays at a known rate following the death of an organism. Cosmic rays generate free-ranging neutrons in the upper atmosphere. These interact with nitrogen-14 to produce carbon-14, which is unstable. Animals and plants ingest some of this carbon-14 naturally—through breathing, eating, drinking, and, in the example of plants, photosynthesis. Once an organism dies, the radioactive carbon begins to decay back into nitrogen-14. After about 5,730 years, only half the original amount of carbon-14 remains. After 11,460 years, only a quarter. Once you hit about 17,000 years ago, you're down to one-eighth the original amount of carbon.

The further back in time, the harder it is to detect that trace amount of carbon-14. Today, radiocarbon dating can be pushed back to 50,000 years, with greater accuracy and precision. The limit of 50,000 years is right around when some archaeologists argue the earliest settlement of the Australian continent occurred. However, what if that's because radiocarbon dating doesn't allow them to go back any further?

Enter the science of optically stimulated luminescence (OSL). This method of dating operates on the principle that granules of quartz, commonly found in rock and sand, absorb electrons when exposed to sunlight. The electrons become trapped in the quartz's crystal structure. When the sediment layer containing the quartz is buried and the quartz is no longer exposed to light, electrons stop being trapped. This starts the clock, so to speak. At the laboratory, in darkroom conditions, the sample is exposed to radiation. The trapped electrons are now released and measured, and a date for the archaeological site formation can then be calculated. OSL can reach as far back as 100,000 years ago. However, it usually leaves a few thousand years' margin of error.

One of the most important early archaeological sites in Australia is Lake Mungo, on Paakantji, Ngiyampaa, and Mutthi Mutthi country in the state of New South Wales. The surrounding landscape uniquely consists of a series of large lunette dunes. These formed as several lakes dried up during the late Pleistocene period and wind blew sediment to one side. The lunettes hid the archaeological remains until their discovery in the second half of the 20th century. Reaching Lake Mungo in ancient times required humans to cross much of Australia after having made landfall on its northwest coast. That is a distance of about 2,500 miles. It has been proposed that people made use of not only the coasts but also interior waterways to migrate throughout Australia.

The first burial discovered at Lake Mungo was Mungo Lady, or Lake Mungo 1. She was discovered in 1969 by the Australian geoarchaeologist Jim Bowler. Radiocarbon dating of a hearth above the burial site gave a date of approximately 26,000 years ago. The remains themselves were not dated due to their poor state of preservation, partly because they were cremated. This burial represents the oldest known cremation in the world.

In 1974, Bowler returned to the site and found additional human remains eroding out of the sand dunes. One of these—Mungo Man, or Lake Mungo 3—was laid to rest in a ritualized manner. He was found lying on his back, his hands clasped at the waist and knees bent. He was covered in red ochre, but he had not been burnt or cremated. It's estimated that he was about 50 years old when he died. Initially, Mungo Man was thought to have lived between 28,000 and 32,000 years ago, based on the stratigraphy of the site. The dating method of thermoluminescence (TL) was subsequently applied to the remains. TL is a trapped-electron method that tells you when something was last heated above a certain temperature. The test

result yielded a date of between 25,000 and 43,000 years ago. The sample was then subjected to another method, electron spin resonance, which measures electrons. It also gave a date of between 25,000 and 43,000 years ago.

Uranium-thorium dating was applied to the carbonate in the skeleton's teeth. It gave back a much different date: 68,000 years ago. Again, this early date does not agree with what scholars know about the timing of human dispersal out of Africa around 70,000 years ago, not to mention arriving in Australia and then traveling far into the continent's interior. Eventually, a reevaluation was made of when both Mungo burials likely took place. The new tests considered all available lines of archaeological evidence. They concluded the buried man and woman were likely similar in age and had lived about 40,000 years ago.

Early Arrival or Rapid Dispersal?

The skeletal remains found at Lake Mungo are currently the earliest to be discovered in Australia. However, the first of the archaeological human remains to be unearthed there is known as the Talgai skull, located on Keinjan country. It was found in the winter of 1866 by William Naish when he saw a skull encrusted in calcium carbonate emerging from an eroding bank of a gully. Naish turned the skull over to the landowner, who gave it to E. H. K. Crawford. Crawford sought unsuccessfully to sell the skull to the Australian Museum in Sydney. It did not receive further scientific attention until 1914.

E. H. K. Crawford again petitioned for some scientific recognition of the Talgai skull. Two scientists associated with the Australian Museum examined the skull once more and presented it as a new find at an international scientific meeting convened in Australia. It was argued that the skull represented a "primitive" form of human, based on its prognathic face and the shape of its teeth. One presenter argued that the skull was 20,000 years old. The carbonate encrusting the skull would later be dated, revealing that it was no more than 11,000 years old. The skull belonged to a 14-year-old boy—a modern human. The deformation of the skull once used to argue for its "primitive" origin was likely caused by the burial and preservation process.

Another controversial example of the treatment of early human remains is that of the Kow Swamp burials, located on Yorta Yorta country. Kow Swamp is another lunette dune lake site, this one southwest of Lake Mungo in the

province of Victoria. It was excavated in the late 1960s and 1970s. The skeletal remains of at least 22 people were recovered there. These individuals appeared to have robust physical features, causing researchers to suggest a direct relationship between the population there and *Homo erectus*. This would have necessitated settlement of the continent even earlier than previously argued.

Scientific dating identifies the remains as much more recent, at about 13,000 years old, than the gracile skeletons at Mungo. OSL dating puts them a bit older, at around 20,000 years ago. However, contemporary thinking holds that they are likely no more than about 15,000 years old. The features that the original researchers argued to be primitive—resembling the sloped foreheads of *erectus*—are now thought to potentially be the result of purposeful cranial deformation.

The rock shelter site of Warratyi, located on Adnyamathanha country in the state of South Australia, sheds some light on how quickly early humans might have made their way across the continent. Warratyi is a recent discovery by archaeologists. It contains thousands of artifacts. Preservation is unusually good there, extending to the remains of fibrous plants. Radiocarbon and OSL data support an estimate of the earliest time of occupation there as 49,000 years ago and of sporadic use from 40,000 to 10,000 years ago. If a later date for the arrival of people in Australia is accepted—closer to 50,000 years ago—that means that diffusion throughout the continent occurred quickly. Otherwise, these dates seem to support the argument for an earlier start closer to 70,000 years ago, as suggested by the finds at Madjedbebe.

Likewise, on the west coast of Australia, the cave site of Devil's Lair on Noongar country provides credence to an argument for an early arrival—or rapid dispersal—of people throughout Australia. This cave has yielded stone tools and animal bones dating back 48,000 to 50,000 years ago, in a well-dated stratigraphic sequence. This includes the remains of the Tasmanian devil, which have not been born in the wild on the Australian mainland for thousands of years now.

The southernmost extent of Sahul —once connected but now known as the island of Tasmania or lutruwita—was also occupied by Aboriginal communities relatively early. The cave site of Kutikina in the highlands has yielded hundreds of thousands of bone fragments (many of them belonging to wallabies) and tens of thousands of artifacts. This rich archaeological record shows that people were able to adapt and live there at the last glacial maximum 20,000 years ago, when the environment would have been quite

harsh. More recently, excavations at other sites in Tasmania have pushed back earliest occupation of the region to about 35,000 years ago. Moreover, modern genetics proves that all indigenous Australians descended from the *Homo sapiens* who left Africa between 70,000 and 50,000 years ago.

Treatment of Human Remains

A legacy of scientific racism runs through the narrative of Australian archaeology. The treatment of Aboriginal remains has a history of controversy. Early archaeologists did not work with traditional custodians, and many sacred sites were violated. Through the concept of the Dreamtime, Australian Aboriginal communities have a deep connection with the peopling of the continent and, therefore, a direct connection to many of the archaeological sites.

Today, many human remains recovered in excavations have been repatriated to indigenous communities and reburied appropriately (although, to date, the Talgai skull is still held at the Australian Museum in Sydney). Moreover, the site of Kutikina was returned to its original owners through the Aboriginal Lands Act in 1995. Now, it is becoming standard for archaeologists to work with Aboriginal groups from the outset. Indeed, there are today a growing number of Aboriginal archaeologists in Australia.

Reading

Florin, S. Anna, Andrew S. Fairbairn, May Nango, Djaykuk Djandjomerr, Ben Marwick, Richard Fullagar, Mike Smith, Lynley A. Wallis, and Chris Clarkson. "The First Australian Plant Foods at Madjedbebe, 65,000–53,000 Years Ago." *Nature Communications* 11, no. 1 (2020): 924. https://doi.org/10.1038/s41467-020-14723-0.

Perrottet, Tony. "A 42,000-Year-Old Man Finally Goes Home." *Smithsonian Magazine*, September 2019. https://www.smithsonianmag.com/history/mungo-man-finally-goes-home-180972835/.

08
THE ORIGINS OF LANGUAGE AND MUSIC

As in many areas, DNA science increases understanding of the archaeological record beyond physical limits. The combination of fossil and DNA evidence might even tell researchers something about where and when language evolved. However, grasping the full range of early human communications—including music and singing—is one of the hardest problems in archaeology. You might assume that the field of linguistics is better suited to tackle questions about the origin and evolution of language, but historically, the topic has been neglected. Only in the last few decades have some linguists turned their attention to questions about the origins of language. Still, answers remain elusive.

Language Development

If you view material culture as the embodiment of the human experience, then you can start to get at reconstructing things such as the mutual understanding, communication, and sophistication of cognition necessary for the development of language. Material culture is the "stuff" and "things" we create and leave behind as we navigate our experience on this planet. As material culture grows more sophisticated, it reflects more complex cognitive behavior and capability.

Art began to flourish and humans adopted intentional burial during the Upper Paleolithic period as early as about 45,000 years ago. This can be seen in their increasingly complex tool kits and interpreted as behavioral modernity. However, the material record alone doesn't answer the question of when spoken language came to be.

Early theories looked at the spread of language as linked to the spread of material culture much later in time than the Paleolithic era. For example, the British archaeologist Colin Renfrew theorized how agriculturalists spread from modern-day Turkey across the Near East and Europe beginning around 9,000 years ago, focusing on the spread of the roots of Indo-European, the parent of many modern languages.

Some theories focus on the social mechanism of language development. For example, the mother tongue theory argues that language originally developed between mothers and their children and then extended to others in the familial group. However, critics of this notion focus on the need for humans to communicate outside of their kinship groups as well. Another theory, based on reciprocal altruism, proposes that communal language requires trust. Thus, the earliest creation of language would reflect this need and develop based on interactions within a group of individuals.

Perhaps the most plausible theory goes back to the notion of the coevolution of ritual and speech, whereby language is generated by symbolic thought and created in context. You can think of the term *ritual* as something closer to habit: the things we do every day, in a certain way. However, moving from instinctive to deliberate actions—and from thoughts to words—required the development of greater complexity in the human brain.

Humans alive today are capable of speaking any language in existence. If we begin at infancy, we are able to make all the necessary sounds. Biologically, that means the human capacity for language evolved prior to the dispersal of *Homo sapiens* throughout the globe. It was part of the evolution of modern *Homo*. The case of Australia offers some of the best evidence in support of this hypothesis. As humans likely first reached Australia as early as 65,000 years ago and remained isolated for many tens of thousands of years, this lends support to the argument that the earliest *Homo sapiens* migrating out of Africa 70,000 years ago already possessed the biological and physiological capacity for language. Indeed, fossil evidence suggests the ability for speech developed even earlier.

Concerning anatomy, it's been shown that the ability to create most sounds in human speech relies on the shape of our vocal tract. It is uniquely L-shaped, forming a 90-degree angle. Human infants lack the distinctive arrangement of the adult larynx, which descends below the pharynx in a vertical position. Infants possess a more horizontal structure with an obtuse angle, making it possible for them to breathe and swallow milk at the same time. This prevents the formation of many sounds that a child will develop the ability to make later, once they start to sit up and walk upright. Incidentally, these two things tend to develop together, at close to one year of age.

The unique arrangement of the human voice box—the pharynx and larynx—seems to have been made possible by (or may be the result of) bipedalism. Bipedalism has resulted in the skull sitting on top of the neck. This is seen in the placement of the occipital foramen: the hole through which our spinal cord passes from our brain into our spine. It is also seen in the modified shape of our cervical vertebrae, which the skull rests upon. This rearrangement of anatomy also affected soft tissues.

Language Criteria

Which of our fossil ancestors was the first to talk? The earliest indisputable biped in our family history was *Australopithecus afarensis* nearly 2 to 4 million years ago. It was perhaps physically able to make something near to the range of sounds necessary for human speech. However, it was not yet cognitively capable of something as complex as human language.

Thus, standing upright alone is not enough of a criterion for language. Instead, you also need to look at the evolution of the arrangement of the human head and neck. The interpretation of some early skull fossils has allowed scholars to estimate that the larynx was nearly in its current position by the time *Homo heidelbergensis* had emerged some 600,000 years ago. This suggests that something resembling language was possible for our early ancestors. It implies that the Neanderthals, who appeared as early as 400,000 years ago, were likely able to communicate in a somewhat sophisticated manner as well. The bases of their skulls are more arched than in modern apes but less so than in humans. Thus, it's difficult to pinpoint how similar their capacity would have been to create the same sounds as us.

The human hyoid bone—a small U-shaped bone that floats in our neck, adjacent to the throat—might shed more light on this question. Due to its fragility, this bone is rarely found in fossilized form. Only one Neanderthal hyoid has ever been recovered, from the cave of Kebara in Israel. It dates to about 60,000 years ago. Scientists were able to model the relative position of the hyoid in the Neanderthal neck as compared to ours using CT scan technology, employing multiple layers of x-rays to create a 3D image. They found the Neanderthals' hyoid would have been slightly forward as compared to ours and argued that Neanderthals would have been able to make most of the same sounds as us—with some exceptions.

Scientists have also wondered whether the ear bones and the structures surrounding them might have something to tell us. In a study published in early 2021, a team of researchers modeled Neanderthal hearing based on five fossil Neanderthal skulls found from Israel to Croatia to France. They recreated the eardrum, ear canal, and several other variables to evaluate the kinds of sounds that Neanderthals would have been able to process. They found that these sounds would have been similar to what we are used to hearing. From this finding, the research concluded Neanderthals were likely capable of producing speech similar to ours.

Ancient *Homo sapiens* did breed with Neanderthals and Denisovans—enough so that their genes appear in our genome at significant levels. This suggests family units might have communicated with each other in some way. The sequencing of the human genome was completed in 2003. Subsequently, researchers began to unlock many mysteries in our DNA. One gene in particular has been of interest in the search for language origins. Known as *FOXP2*, this gene exists in many vertebrate species. The protein it codes for

differs in chimpanzees and humans by the substitution of only two amino acids. Mutations in the *FOXP2* gene have been found to be the root cause of a present-day language disorder, which has led to the recognition of the part this gene plays in speech. It appears to have been important in the evolution of language.

Recent DNA analysis of Neanderthal remains suggests that Neanderthals and Denisovans shared the same variant as modern humans. Thus, this mutation occurred in a common ancestor prior to the branching of the family tree, potentially as early as 700,000 years ago. Thus, it seems likely that some form of linguistic communication has existed for the better part of the last million years and, likely, the last 500,000.

Early Instruments

Scholars don't know much about the origins of singing. Still, it's perhaps telling that the first instruments they've found archaeological evidence for are wind instruments requiring the use of the mouth. The cave site of Hohle Fels in Germany yielded one of the earliest known flutes. Crafted from a griffon vulture wing bone, the flute has five holes at equal distance along the natural curve of the bone. It's estimated to be about 35,000 years old. At the nearby cave of Geissenklösterle, three more flutes were found, one made of mammoth ivory and the other two from the bones of a swan. These date to between 30,000 and 42,000 years old.

More than 100 flutes and whistles have been documented at Upper Paleolithic sites across Europe. About half of these specimens are made of bird bones, while a select few are mammoth ivory. It's somewhat more difficult to identify another early instrument, the panpipe, since these don't need to have pierced holes to produce sound. This means archaeologists might not recognize bones used as pipes, even if they likely existed.

The evidence for whistles is somewhat clearer. Perhaps the most common of these is the phalangeal whistle. It's made from the toe bone (or phalanx) of animals such as reindeer. A single hole pierced through the shaft of the bone allows for a whistle tone to be produced. Depending on the bone's size and shape, it can produce different pitches. Arguments for these being whistles—serving a utilitarian purpose as opposed to a musical purpose—are supported by ethnographic evidence. Modern hunter-gatherer groups use

them in hunting and ritual contexts. Moreover, experimentation with some reconstructions of ancient phalangeal whistles demonstrates that they could have been heard one kilometer (more than half a mile) away. This suggests they might have been used for communication.

Evidence for the first known horn in existence was published in early 2021. Estimated to be about 18,000 years old, it was crafted from a conch shell and was found at the Marsoulas Cave site in France. The shell is elaborately decorated with pigments and shows external signs of human modification. Using CT scanning, researchers were able to see inside the shell and detect various additional modifications that made the shell capable of creating three different musical notes.

Bullroarers, another ancient musical instrument and communication device, also have extensive ethnographic documentation. This type of sound maker consists of a flat object attached to a string, which is then spun to create sound. It's difficult to positively identify objects that might have been used for this purpose since a bone or stone might have incidentally been modified to resemble a bullroarer rather than having been used as one. About 10 well-documented examples of bullroarers are in existence, all from the south of France. A notable bullroarer example comes from the site of La Roche de Lalinde, which likely dates to around 14,000 years ago. Carved from a reindeer antler, it was engraved with grooves and covered with ochre. Its large size supports the argument that emitting sound was its intended use.

There is also evidence for percussion instruments such as rasps. This includes a 20,000-year-old example from Spain and a 35,000-year-old example from Italy. Both appear to have been deliberately incised for producing sound when scraped. This type of instrument is represented in contemporaneous art. For example, a 25,000-year-old carving of a woman at the rock shelter of Laussel in the Dordogne region of France depicts an animal horn with 13 incised lines. One interpretation is that the incised horn is a rasp.

The Ukraine site of Mezin in the Dnieper valley, dating to 20,000 years ago, offers one of the few concrete examples there are for drums. It's likely that alternative or earlier forms—created using organic materials—did not preserve. At Mezin, two rattles made of ivory and a drum beater made of a reindeer antler were found. These were accompanied by mammoth bones that showed signs of being used as the drums. At Mezhirich—also in Ukraine and dating slightly later in time at about 15,000 years ago—archaeologists uncovered a mammoth skull elaborately painted with ochre and accompanied by drumstick beaters made from long bones.

Reading

Bannan, Nicholas, ed. *Music, Language, and Human Evolution*. Har/Com ed. Oxford: Oxford University Press, 2012.

d'Errico, Francesco, Paola Villa, Ana C. Pinto Llona, and Rosa Ruiz Idarraga. "A Middle Palaeolithic Origin of Music? Using Cave-Bear Bone Accumulations to Assess the Divje Babe I Bone 'Flute.'" *Antiquity* 72, no. 275 (1998): 65–79. https://doi.org/10.1017/S0003598X00086282.

Tomlinson, Gary. *A Million Years of Music: The Emergence of Human Modernity*. New York: Zone Books, 2015.

09
HANDPRINTS IN TIME: EARLY ART AND OBJECTS

If defined as the human modification of physical material for aesthetic purposes, art first emerged nearly 50,000 years ago. As you will learn in this lecture, it surfaced everywhere that humans are found. Early people around the world found ways to communicate with each other and express themselves through interpretive modifications of physical materials, from cave paintings to rock art and figurines. There is even evidence of humans working with pigments much earlier than 50,000 years ago. Although these early individuals might not have looked exactly like modern humans, they were beginning to behave like them—at least in some ways.

Early Art Precursors

A constellation of caves in South Africa has provided some insight into perhaps the earliest expressions by individuals through deliberate modification of physical material. An assemblage at Blombos Cave, dating to between 100,000 and 70,000 years ago, consists of about 1,500 sizable pieces of ochre. These nodules of ochre show wear from use, and some of the pieces are engraved. Notably, one piece of silcrete (a naturally occurring fine-grained cement) appears to have been drawn on with an ochre crayon, marking a crosshatched pattern estimated to be 73,000 years old. This makes it the earliest known deliberate marking by a human discovered so far.

Elsewhere, archaeologists found an unnatural accumulation of nearly 1,000 pieces of ochre at the site of Klein Kliphuis. Again, a single piece of ochre engraved with a crosshatch pattern was discovered. This one is estimated to date somewhere between 50,000 and 80,000 years ago. At the site of Klasies River Mouth Cave 1, also in South Africa's Eastern Cape region, another engraved piece of ochre has been found, this one with parallel lines. It dates to between 85,000 and 100,000 years ago, and it appears to have been deliberately made using a stone tool.

Importantly, the engraved markings on these pieces of ochre have not been shown to have resulted from use. For example, ground pieces of ochre—smoothed or worn on the edges—were also found at these sites. However,

these ground pieces are not generally regarded as being significant because the grinding modification is probably incidental to the process of creating ochre powder. This powder then could have been used for painting or other purposes.

Taken together, these three South African sites provide evidence that the people who lived there so long ago certainly possessed the cognitive capacity to alter an object deliberately—and in a systematic, patterned way. Furthermore, because these three Middle Paleolithic sites date to nearly 100,000 years ago, they defy the 20th-century assumption of Europe as the birthplace of Upper Paleolithic art.

Early Mineral Pigments

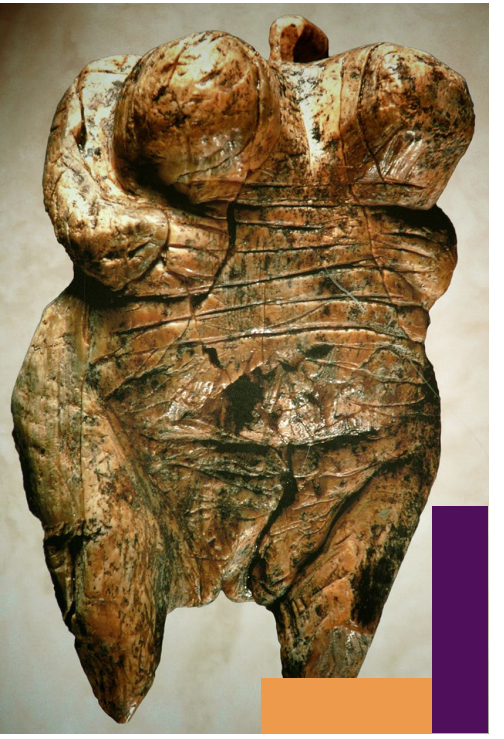
You might wonder what other evidence exists to bolster an argument for the sophistication of thought among our human ancestors at these archaeological sites. So far, throughout all of South Africa, archaeologists have recovered only nine modern-looking teeth dating to this portion of the Middle Stone Age, approximately 80,000 to 100,000 years ago, all from Blombos Cave. Nevertheless, there is some additional evidence at Blombos for what researchers have called a workshop for ochre processing. Here, a pigment-rich mix was made in abalone shells some 100,000 years ago.

Several high-tech analyses were carried out to substantiate this premise. The sediments surrounding the finds were dated using OSL. Meanwhile, the suspected pigment residues, which consisted of ochre along with multiple other components, were analyzed using scanning electron microscopy (SEM). SEM produces high-resolution images of microscopic materials. The pigments themselves were also subjected to various elemental and mineralogical analyses.

Although no paintings or human remains bearing the pigment have been discovered, this substance was likely used to decorate something, whether organic material or human bodies. The ochre pigment might have also been used to modify shell beads. Numerous specimens of shells belonging to a small marine snail known as *Nassarius kraussianus* have been found with puncture marks near their openings, apparently made by a bone tool. Trace amounts of the ochre-based pigment have also been detected inside the shells. One context at Blombos has yielded a grouping of 24 perforated shells. This suggests they were strung with something at the time they were buried.

Sites in sub-Saharan Africa offer tantalizing hints as to still-earlier origins for the use of mineral pigments. For instance, the site of Twin Rivers Kopje in Zambia has yielded pieces of hematite and limonite with flattened portions dating to approximately 250,000 years ago. The presence of these mineral chunks is far from concrete evidence of symbolic thought. However, researchers argue that their distinctive flattened surfaces could have been created by rubbing or grinding. To create the beautiful art imagined as typical of the Upper Paleolithic period beginning around 45,000 years ago, our human ancestors first needed to learn how to create and experiment with pigments from natural minerals. What makes these finds in Zambia particularly remarkable is that they date well before our own species, *Homo sapiens*, which emerged around 200,000 years ago.

Defining Art



In archaeology, researchers generally categorize art into one of two types: portable or stationary. Portable art tends to be small. In addition, art can be figurative or nonfigurative. Figurative art depicts a person or an animal. If it doesn't, it's nonfigurative. Most Upper Paleolithic portable art tends to be figurative and either zoomorphic, representing animals, or anthropomorphic, representing the human form. When you see human forms depicted, they are most frequently female. The Venus figurine is an iconic example.

About 200 anthropomorphic figures dating from 40,000 years ago to as recently as 10,000 years ago have been found across Europe and throughout Russia. Many of these figures have exaggerated

breasts, hips, and buttocks. The decision to label Paleolithic finds as Venus figurines holds a double connotation referring not only to fertility but also to the conceived primitiveness of the women represented. That has led to an unfortunate lack of creativity in their interpretation.

One of the most fascinating examples of figurative art is the Löwenmensch, or Lion Man, from the Hohlenstein-Stadel cave in Germany. Although the ancient Egyptians famously depicted their gods with animal heads on human bodies some 5,000 years ago, the Lion Man predates them by more than 30,000 years. Carved from mammoth ivory, this figurine shattered into hundreds of pieces when discovered in 1939. In the early 1980s, German paleontologist Elisabeth Schmid combined fragments found in excavations from the 1960s and 1970s into the Lion Man statuette. Schmid's reconstruction revealed the extent of the figure's feline features. She argued that it was a Höhlenlöwin, or a lioness. Others struggled to accept the idea that a female would be represented by anything other than a voluptuous Venus figure. Either way, the combination of human and animal features in this statuette shows humankind's ability to imagine something that did not exist. This required a creative mind and is evidence of fully modern cognition some 40,000 years ago.

Not all portable figurative art is limited to figurines. At the Late Upper Paleolithic site of La Madeleine in France, dating to around 15,000 years ago, researchers discovered an incised reindeer bone fragment depicting a reindeer and a carved piece of mammoth ivory depicting a mammoth. These were likely conceived and produced as they would be in modern times: The artist selected a suitable piece of bone and a stone tool with a special tip—called a burin—to engrave a drawing as the artist pictured it in their mind.

Not all portable art in the Paleolithic period was made from stone or bone, either. People living 20,000 to 30,000 years ago knew how to make ceramics. The people living at the Dolní Věstonice site in what is now the Czech Republic made goods that you would recognize as art today. The most famous of these pieces is the Venus of Dolní Věstonice. More than 7,000 ceramic fragments have been recovered at the site, which had two kilns. Ceramic art was also discovered at the nearby site of Pavlov I, dating to about the same

time. Many of these items appear to have been deliberately destroyed and broken, leaving researchers to question whether they were made exactly for that purpose, e.g., as part of a ritual or prayer.

The Czech Republic sites were excavated in the mid-20th century. For a long time, they held the distinction of being the oldest—and the only—known Paleolithic sites with ceramic art. That changed in the early 2000s with the discovery of clay figurines at the cave site of Vela Spila, on the island of Korčula in Croatia. Dr. Rebecca Farbstein studied 36 ceramic fragments that had been excavated a few years earlier, dating from approximately 15,000 to 17,500 years ago. These fragments represented the completely novel, independent invention of ceramic production.

Although the Czech ceramics were sculpted from single pieces of fired clay, the pieces from Croatia were formed from multiple individual pieces and pinched together, e.g., a leg attached to a central body. This meant they were more prone to break back into their individual components. However, it was clearly the intent of the individuals creating these pieces to form something out of the clay. Such feats represented an independent early invention and application of a technology that would not become commonplace for another 5,000 years, when people began living in villages.

Stationary Art

Stationary art, or art in a fixed location, appears where people would have lived or returned to time and again. This art might sometimes have been less for aesthetic purposes and more for the sake of marking territory and wayfinding. Many themes of earliest art include food, the hunt, and fertility. There's been musing as to the purpose of these depictions.

As an example, take the depiction of horses—a popular motif seen on cave walls, particularly throughout France and Spain. Some of those horses, such as those found in Chauvet Cave from as far back as 37,000 years ago, appear to be running wild. Their outlines in dark charcoal suggest movement. Their coats are also painted black. Although researchers might not know the intentions of early artists, their art clearly demonstrates humans' capacity for abstract thinking, and it encapsulates a form of communication.

In some cases, recent advances in DNA analysis allow scholars to address the extent to which some ancient art represents reality. One study that sampled bones from horses across Europe and Siberia found that there were genes for black, bay, and leopard-spotted colored coats reflecting essentially all horses depicted in the ancient cave paintings across Europe. This suggests that the paintings constitute reflections of the natural environment of humans at the time. Although the art might signal some symbolic or storytelling power, the representations were grounded in reality.

Cave art goes far beyond depictions of animals. At the Cave of a Hundred Mammoths in Rouffignac, France, thousands of squiggle lines, swirls, and undulating waves—all known as types of finger fluting—decorate the cave walls. In the early 2000s, researchers realized that these lines were made by children. Dr. Jessica Cooney Williams used measurements of finger widths belonging to children and adults to estimate that children between the ages of three and seven made these lines more than 13,000 years ago. The research also concluded that a five-year-old girl was the most prolific artist. This phenomenon is not unique or geographically limited. Examples of Paleolithic finger fluting occurred in multiple other caves in France and Spain, some of them also by children. The practice has also been documented at the archaeological site of Koonalda Cave in South Australia, dating as early as 20,000 years ago.

European cave art dominated the study of prehistoric art throughout the 20th century. However, in the last few decades, as more evidence of the ubiquity of this practice came to light around the world, researchers learned that some of it predates examples at the European sites. Indonesian caves in the Maros-Pangkep karst region on the island of Sulawesi now hold the record for the earliest cave art in the world, based on uranium-series and uranium-thorium dating methods.

The Maros-Pangkep cave complex contains fascinating examples of both finger fluting and figurative depictions 18,000 to 45,000 years old. Scientific dating of the calcite deposits on the cave walls—some on top of the rock art itself—provided these minimum and maximum date ranges. Also discovered were hand stencils going back 40,000 years; a hunting scene dated to 44,000

years ago; and multiple depictions of babirusa and warty pigs, the latter pushing 46,000 years. After its discovery, this last example was deemed the earliest known cave painting.

Reading

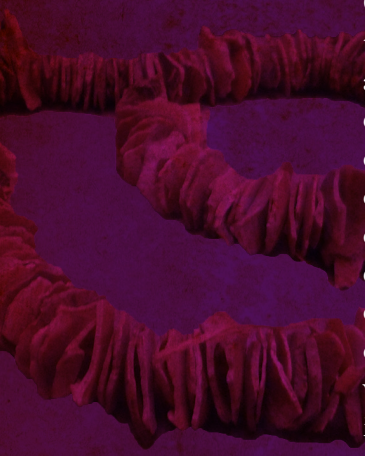
Farbstein, Rebecca, Dinko Radić, Dejana Brajković, and Preston T. Miracle. "First Epigravettian Ceramic Figurines from Europe (Vela Spila, Croatia)." *PLOS ONE* 7, no. 7 (2012): e41437. https://doi.org/10.1371/journal.pone.0041437.

Farbstein, Rebecca. "Technologies of Art: A Critical Reassessment of Pavlovian Art and Society, Using Chaîne Opératoire Method and Theory." *Current Anthropology* 52, no. 3 (2011): 401–432. https://doi.org/10.1086/660057.

Henshilwood, Christopher S., Francesco d'Errico, Karen L. van Niekerk, Laure Dayet, Alain Queffelec, and Luca Pollarolo. "An Abstract Drawing from the 73,000-Year-Old Levels at Blombos Cave, South Africa." *Nature* 562, no. 7725 (2018): 115–118. https://doi.org/10.1038/s41586-018-0514-3.

Stannard, Melissa K., and Michelle C. Langley. "The 40,000-Year-Old Female Figurine of Hohle Fels: Previous Assumptions and New Perspectives." *Cambridge Archaeological Journal* 31, no. 1 (2021): 21–33. https://doi.org/10.1017/S0959774320000207.

10 ANCIENT JEWELRY AS EXTENSIONS OF THE MIND



How did humans first express themselves? Genetic evidence from body lice suggests that humans were wearing clothes as early as 170,000 years ago. By comparison, the earliest indisputable evidence for art is only about 45,000 years old. Given these dates, it seems that we began modifying ourselves for aesthetic purposes much earlier. Consider what this means for the distinction between modern and ancient cognition and our sense of self. This lecture will focus on the material traces of personal identity in everyday life—and the evidence for our ancestors' sense of self in the material, archaeological record.

Jewelry

In his book *Origins and Revolutions*, the British archaeologist Clive Gamble suggests that as the modern mind developed, archaeologists find more standardization and size reduction in cultural remains. Researchers also see more artifacts enter the archaeological record since the accumulation of material in the form of caching or storage suggests an increased sense of place and memory in the human mind. This is linked to the concept of habitus, which refers to the repeated action of everyday routines, or habits. In this sense, the body serves as an extension of the mind and material culture as an extension of the body. The link between the two allows researchers to interpret physical archaeological remains with reference to much more abstract concepts, including culture and society.

One of the best ways to study the concepts of identity and personal adornment is to go straight to the source: human burials. When people are buried with grave goods, these goods can serve as clues about their lives and roles in society as individuals. Some of the best evidence comes in the form of jewelry—beads, to be exact. When did people first begin to decide that shells would look better on their own bodies than in the sand? The answer might be about 100,000 years ago. At the Mount Carmel cave site of Skhūl in present-day Israel, two shells that once belonged to *Nassarius gibbosulus* were found to have been deliberately perforated. Another decorative shell from the same species, argued to be just as old, comes from the cave site of Oued Djebbana in Algeria. It, too, was punctured by someone using a sharp object, probably a flint tool.

Although Skhūl is several kilometers from the coast, Oued Djebbana would have been nearly 200 kilometers away at the time the shell was deposited. These are small whelks that would not have been the type of thing one would eat. Therefore, they were likely purposefully collected and brought back to the cave for another reason, which remains unclear. The important thing is there are two early examples where deliberate modification of an item with no obvious utilitarian function is seen.

The site of Blombos Cave in South Africa has yielded more than 40 beads from the same genus but a different species of snail, *Nassarius kraussianus*. These are common in estuarine environments, which would have existed

nearby, within about 20 kilometers of the cave. These specimens date to between 75,000 and 80,000 years ago. The beads were found in clusters, suggesting that they were strung on something and perhaps worn. They also showed signs of having been colored red using iron-rich clay. This is significant because Blombos is also famous for yielding early evidence of a modified mineral pigment: ochre. Likewise, 13 perforated *Nassarius* shells dating to about the same time frame were found at the cave site of Taforalt in Morocco and show signs of having been suspended as beads. They, too, are covered in ochre. Thus, archaeologists can comfortably call these objects beads and consider what it means that humans were creating such decorative items at this early date.

All told, about 166 *Nassarius* beads dating from the Paleolithic period between approximately 100,000 and 10,000 years ago have been recovered from Africa and Southwest Asia. The Israeli archaeologist Daniella Bar-Yosef Mayer suggests that the significance of this choice is that the two species of the genus *Nassarius* used in bead making are both smooth, round, lightweight, and durable. This makes them stand out as aesthetically pleasing compared to other similar-sized shells that would have been readily available. Thus, people were likely selecting them purposefully for conspicuous adornment.

Beads were also formed from bone and ivory. However, this does not occur until later in time, after 50,000 years ago, coinciding with the development of art in the archaeological record. These beads are again being associated with red ochre. For example, the site of Hohle Fels in southwestern Germany has yielded carved ivory beads from between 35,000 and 43,000 years ago, stained with hematite. Many of these beads are oblong in shape, with two perforations on either side. Some are also incised.

Researchers used several high-tech methods to understand the beads' creation process. First, they applied SEM coupled with energy-dispersive spectroscopy to show—at the microscopic level, with high resolution—how the residue adhered to the beads. This confirmed that the beads had first been carved and the ochre applied afterward. Raman spectroscopy, which identifies molecular structure, was then used to establish the mineral composition of the red color. This was the hematite. Finally, x-ray diffraction was applied to the sediment

surrounding the finds to see what kinds of minerals were present. After all, it's conceivable that across thousands of years, hematite in the dirt could have made its way onto the buried beads.

Researchers got the answer they were hoping for: There was no naturally occurring iron in the cave dirt. Thus, our ancestors had painstakingly carved the ivory beads and then applied the ochre powder to each one individually. Ochre has a gritty consistency. Thus, it's possible that it might have been used to add a shiny luster to the beads. It's also possible that the beads were sewn onto clothing colored with ochre since archaeologists find traces of ochre even on the insides of the perforations. However, ochre could have been applied more than once and for more than one reason.

Clothing

It's remarkable to consider how important clothing was to the proliferation of our species. Wearing clothing allows us to spend more time in elements that we would not otherwise be able to tolerate. It's quite likely that clothing of some kind helped facilitate human dispersal out of Africa, even at its earliest stages. How can archaeologists know this? The DNA of a parasite, lice, helps shed light on this question. Unlike other furry animals, which tend to have one species of lice all over their bodies, humans have three different types of lice that can live on ours: head lice, pubic lice, and body lice. As for head and body lice, DNA shows the two species diverged around 170,000 years ago and possibly as early as 200,000. That was right around the same time the earliest specimens of *Homo sapiens* emerged from the fossil record.

There's good evidence for skin working more than 100,000 years ago at the archaeological site of Neumark-Nord in Germany. Neanderthals there soaked hides in tannin, a binding agent that turns untreated skins to leather. Archaeologists know this because they were able to analyze tiny scraps of organic material—oak bark—stuck to a hafted stone point. It was probably part of a tool handle that got wet while someone scraped and worked the animal skin. There aren't any bone needles this old. However, it's likely that the skins were pierced with a sharp implement and, in this way, held together with other strips of leather. In fact, there is specific tooth wear on some

Neanderthal skeletons. This suggests that they used their teeth as tools. This might have included holding hides in their teeth as they worked to make them pliable for wear.

Unfortunately, this amazing capability—the creation and wearing of clothes—is somewhat dismissed. After all, it was cold in many places where Neanderthals lived, and they would have needed clothing to survive. One theoretical model suggests that despite the Neanderthals' other physical adaptations, such as large nasal passages and broad chests, they would have needed to cover about 80% of their bodies to stay warm enough. Still, this shouldn't detract from indications that they were sophisticated enough to make clothing and, quite possibly, cared about what they looked like. They also used beads made from various materials and probably wore feathers.

There is some tantalizing early evidence for unnecessary modification of plant fibers, which could have been woven into fabric. This falls within the time frame for the emergence and elaboration of symbolic thought in the human species. Researchers at Dzudzuana Cave in Georgia have identified and radiocarbon-dated spun plant fibers (most likely wild flax) more than 34,000 years old. These pieces of flax were highly fragmented and degraded due to their age. They were discovered as sediment was being collected for pollen analysis. This type of analysis requires dissolving much of the sediment and then mounting the resulting particles, suspended in a liquid, onto a microscope slide.

Under a high-powered microscope, researchers discovered there was more than just pollen preserved at the site. Plant fragments were also discovered, some of which had once been twisted, suggesting their use in sewing or weaving. Even more remarkable was the fact that the plant fibers had been dyed. There would have been no functional need to dye the fibers. Thus, the fact people took the trouble to do so opens another window into the importance of self-expression or perhaps group expression.

The only other evidence for the existence of fabric this early comes from the Czech Republic site of Dolní Věstonice, which is also famous for the world's earliest ceramics. These date to about 28,000 years ago. Some pieces show imprints left by fabric that has long since rotted away. This demonstrates that fabric weaving existed at this early date and in more than one location.

Weaving requires all manner of complexity. If Paleolithic people were carrying out such complicated tasks, there should be some evidence for it in the material record.

Circular bone discs called rondelles have been found at many Paleolithic sites across Eurasia. They are round, flat, circular pieces of bone. Some are incised or decorated in some way. They are generally between two and four centimeters in diameter and have a single hole pierced through the middle. An obvious explanation would be that they are buttons, implying both a utilitarian and decorative function. The bone pieces might also have been attached to clothes for purely aesthetic purposes. That said, it's also been argued that they were spindle whorls: weights that fibers were strung onto for weaving thread or fabric. Spindle whorls do emerge as their own class of artifact when people begin living in villages later in time. If people were wearing clothing during the Paleolithic period, it makes sense that we would also see earlier precursors made of bone.

Still other researchers suggest the rondelles are children's toys: thaumatropes. A thaumatrope is a disk with a picture on each side, attached to two pieces of string. When the strings are pulled, the two pictures appear to blend into one. Given the highly decorative nature of some of these ancient bone pieces, it's possible they were used this way. There's also no reason why these items couldn't have been used in different ways at different points in time.

Tattoos

What are the earliest roots of tattooing? The most direct evidence is found on mummified human remains. For example, the Siberian Ice Maiden, discovered in the Russian steppe, was laid to rest in a type of burial mound known as a kurgan. In 1993, a team led by the Russian archaeologist Natalia Polosmak discovered her elaborate grave along with the remains of three horses and other valuable grave goods. Further study—and the conclusion that she was likely debilitated at a young age by aggressive breast cancer—suggested that she was likely seen as a shaman. She had several elaborate tattoos on her fingers and shoulder, including swirling patterns and an elaborate deerlike creature. She is one of the earliest direct examples of tattooing, having lived about 2,500 years ago.

Ötzi, the "Iceman," found frozen high in the Italian Alps back in 1991, is today considered the earliest direct example of a tattooed individual. His naturally mummified body is covered with more than 60 simple tattoos, consisting of dots and lines that appear to have been strategically placed for healing. They are found around his lower back, ankles, and other joints. Otzi lived about 5,300 years ago, when people in Europe were beginning to practice agriculture. His tattoo artist used carbonized material—basically soot—to create the markings.

The earliest indirect evidence for tattooing as a practice comes from ancient figurative art. The Löwenmensch of Hohlenstein-Stadel cave in Germany dates back 35,000 years. This figurine has a series of parallel lines on its left shoulder. Indeed, these are what Ötzi's tattoos look like. In addition, a carved female figurine from Hohle Fels, also in Germany and dating to 40,000 years old, has lines purposefully incised down along both arms and across the torso. These examples are both argued as representing tattoos.

Other indirect evidence for tattooing comes from the La Grotte du Mas d'Azil cave site in France, where the makings of a tattoo kit were discovered. It included hundreds of fine bone needles and a substantial amount of ochre pigment that was in various processing stages. A deer hip socket would have served as a pigment reservoir. Other bone implements might have been used as a spatula and palette. The kit dates to about 12,000 years ago.

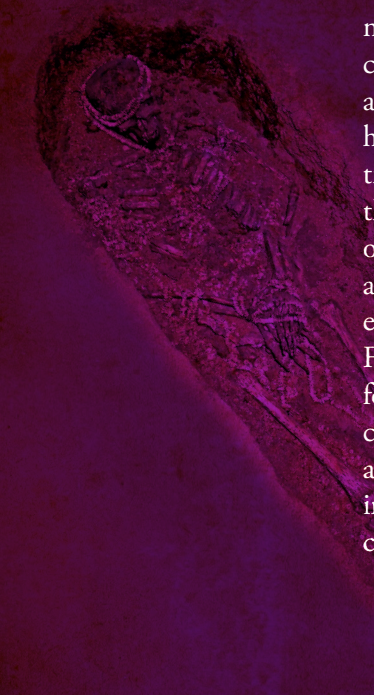
Another way archaeologists have tried to understand the practice of ancient tattooing is through experimental archaeology. Tools are recreated using the same techniques that would have been employed long ago. They are then used in various ways and analyzed to determine the traces that different types of applications leave behind. One novel study used bones from white-tailed deer to create fine-pointed tattoo needles based on methods of the Iroquois, who were historically known to use them. Researchers used the needles to tattoo pig skin, which is similar in thickness to ours. Afterward, the needles were examined under a microscope to reveal diagnostic smoothing and shine occurring as a result of this specific use. The marks were argued to be distinct from other microscopic markers left by activities such as sewing or piercing.

Reading

Bar-Yosef Mayer, Daniella E. "*Nassarius* Shells: Preferred Beads of the Palaeolithic." *Quaternary International* 390 (December 2015): 79–84. https://doi.org/10.1016/j.quaint.2015.05.042.

Gamble, Clive. *Origins and Revolutions: Human Identity in Earliest Prehistory*. Illustrated ed. New York: Cambridge University Press, 2007.

11
DEATH AND BURIAL IN THE PREHISTORIC WORLD



More than 4,000 religions exist today, and many of them are concerned with how to conduct one's life in reference to what happens after death. In this lecture, you will see how human treatment of the dead evolved over time. When did people first start to bury their dead and begin to realize the meaning of death? Different burial practices tell archaeologists how humans coped with their environment and about their social structures. From the earliest deliberate burials to evidence for cremation, exhumation, and perhaps ritual cannibalism, you can think of these practices as offering insights into how our ancestors interacted with those who died, and how such customs have changed through time.

Burying the Dead (or Not)

Burial was not originally the preferred choice for processing human remains. Paleolithic people were frequently on the move. The first cemeteries appeared only after the beginnings of sedentism: the practice of living in one place year-round. If you were part of a highly mobile society, you might want to keep your loved ones close, perhaps even bringing them or objects such as talismans with you.

For the whole Upper Paleolithic period—50,000 years ago to about 10,000 years ago—archaeologists have discovered fewer than 150 human burials. Moreover, hominin remains are relatively rare throughout the archaeological record, and evidence of deliberate burial before 50,000 years ago is contested. Did species other than us bury their dead?

The famous cave site of Sima de los Huesos in Spain, dating to some 430,000 years ago, contains the remains of about 28 individuals whom researchers now know to have been the ancestors of Neanderthals. Some archaeologists believe that the deceased found there were deliberately disposed of by their companions over an extended period of time. Moreover, the Rising Star Cave in South Africa was home to the human species *Homo naledi* between 330,000 and 230,000 years ago. The remains of 15 individuals have been identified there. They were deposited over the course of millennia. No grave goods have been recovered, nor are there any other animal remains that would suggest a carnivore den. This leads some to argue that the evidence indicates deliberate deposition by groupmates.

Perhaps easier to accept as some of the earliest evidence for deliberate burial are the remains of Neanderthals at Shanidar Cave in Iraq. These date back 45,000 to 50,000 years and were first excavated in the 1950s. It took more than half a century—and newer, more methodical excavations—for the argument to be settled. The net result is that it does seem that Neanderthals deliberately buried their dead at this site. Still, Paleolithic burials are the exception, not the rule. It might have been that burial was reserved for individuals who were somehow different. A disproportionate number seem to have had physical disabilities or were children and infants.

Notable Burials

Early in 2021, headlines splashed the discovery of the earliest known human burial in Africa: that of a young child nicknamed Mtoto (meaning "child" in Swahili), who was no more than 2.5 to 3 years old and died about 78,000 years ago. A team lead by Spanish researcher María Martinón-Torres found the burial during excavations at the Panga ya Saidi cave in Kenya. Excavators identified a small pit by observing the different colors of the sediment used to fill the hole. It seemed clear from the outset that the pit had been dug for the child's burial. The shallow grave contained tightly clustered bones. Excavators encased the bones in plaster before painstakingly exposing and analyzing them in laboratory conditions. The highly precise technique used to reveal the bones, accompanied by microscopic analysis of the sediment particles surrounding the remains, enabled researchers to state unequivocally that the child had been deliberately buried and decomposed in situ.

At Sunghir, Russia, around 34,000 years ago, people living near modern-day Moscow buried two boys, a 10-year-old and a 12-year-old, in an elaborate manner. The remains were laid head to head, covered in red ochre, and accompanied by mammoth tusk spears, pierced antlers, fox teeth, bracelets, pins, carvings, pendants, and thousands of ivory beads. Detailed paleopathological analysis showed that both boys had debilitating health conditions: The 10-year-old had abnormally short, bowed thigh bones, thought to possibly be the result of a congenital condition. The 12-year-old's pathologies were more subtle, but from an analysis of his muscle attachments, it appeared that he likely had been bedridden. His teeth, which jutted out from his mouth to an anomalous degree, were so lightly worn that he might have been fed soft, prepared foods. The remains of both children exhibited linear enamel hypoplasia, which is an early childhood disruption in the formation of the tooth enamel, caused by poor nutrition or even starvation.

At the Dolní Věstonice archaeological site in the Czech Republic, there's an unusual triple burial, dating to about 30,000 years ago. Three young individuals, about 18 to 20 years old, lay side by side, their skulls covered in ochre, accompanied by pierced deer canine teeth and ivory beads. The individual in the middle had short, bowed legs and arms, a curved spine, and linear enamel hypoplasia. This led to the diagnosis of a disease that would

have had other effects on the individual's appearance, potentially including alopecia, cataracts, and scaly skin. However, his companions did not display any sign of sharing the disorder.

One other triple burial from the Paleolithic period has been discovered to date, this one at the Barma Grande site at Grimaldi, Italy. These remains were found in 1892 and partially damaged during World War II. The skeletons were covered in red ochre, along with pierced deer canine teeth, shell beads, carved ivory pendants, and long flint blades. The flint came from the mountain of Lure in southern France, about 200 kilometers away. Mammoth ivory would also have been rare in this region. Based on recent genetic analysis, two of the adolescents were identified as female, potentially sisters, while the third was male and possibly also related. His upper arms were significantly different in size; the right was much larger than the left.

Although evidence of triple burials is rare, double burials such as the one at Sunghir have been found more often than you might expect. Varying interpretations are proposed. The burial at Sunghir appears completely undisturbed, suggesting that the two children were buried simultaneously. Other burials are less clear. It's possible that some graves were reopened several months—or even a couple of years—later without disturbing the extant remains. Alternatively, some double burials might represent the deaths of two individuals at the same time.

Another possible explanation is the rite of human sacrifice. Many of the graves include artifacts that would have been extremely valuable, whether because they were transported from afar, were made from precious material, or were labor intensive to produce. In some cases, the sacrifice might have occurred after the natural death of one individual who was then thought to have required a companion in death. For example, one burial at a 5,000-year-old Bronze Age site in Turkey, Başur Höyük, is reminiscent of that at Sunghir. Two children were lavishly entombed with bronze spears, beaded vests, and other precious materials. Outside the grave, an additional nine individuals were laid to rest, apparently having been killed for solely that purpose. The bioarchaeologist Vincenzo Formicola says that the frequency of multiple burials, as well as the number of young individuals found in them and the mismatched sexes of those interred together, is an intriguing pattern in the Paleolithic.

Alternatives to Burial

There is scant evidence of cremation among our ancient relatives. The earliest known cremation—of a female who lived about 40,000 years ago—was found at Lake Mungo in New South Wales, Australia. Another site at Vlasac, Serbia, shows evidence of multiple burial practices, among them cremation, about 9,500 years ago, often in pits that appear to have been reused over time. Around 9,000 years ago, at the Beisamoun site in Israel, one individual was found to have been seated and burned in a pit. However, the 30,000-year gap in the cremation record between Australia on the one hand and Serbia and Israel on the other hand is mystifying. What were people doing in between?

In each of these three examples, the cremated remains were also buried. However, if, across millennia and miles, people were more typically cremated above ground, such as on a pyre, and the remains spread or scattered, they would have never entered the archaeological record at all.

Cremation is not the only alternative to burial. Evidence exists later in the record, closer to 10,000 years ago, for deliberate disarticulation and manipulation of human remains. The purpose might have been to keep part of someone with you as you moved from place to place. Thus, bodies might have been processed just after death, left out to decompose and become skeletons, or buried and dug back up.

Moreover, cannibalism has probably been with us from day one. The Bodo cranium—a famous 600,000-year-old fossil skull recognized as belonging to a direct human ancestor, *Homo bodoensis*—has cut marks laterally along the maxilla, suggesting its jaw and surrounding flesh were removed. It stands as the earliest evidence of postmortem modification in our lineage. Moreover, one of the earliest known specimens of *Homo sapiens*, dating to 160,000 years ago at the site of Herto in Ethiopia, shows cut marks and polishing on a child's skull, suggesting it was de-fleshed and kept before being buried. There is evidence for modification of human remains and consumption at more than one Neanderthal site, spanning from Krapina in Croatia 130,000 years ago to El Sidrón in Spain 50,000 years ago.

At Gough's Cave in the United Kingdom, cut marks on multiple individuals who died around 15,000 years ago show how the eyes, lips, cheeks, and tongue were removed shortly after death—before the calvaria, or skullcap, was turned into a drinking vessel. Alongside these finds, an engraved human forearm has marks that show the skin was first filleted off and the bone gnawed—by other humans—prior to being decorated, suggesting a ritual importance to the process of consumption.

Early Cemeteries

After the end of the last ice age, the number of burials increased in the archaeological record, and the earliest examples appeared of what could be considered cemeteries. For instance, at the Taforalt (or Grotte des Pigeons) cave in Morocco, the remains of at least 34 individuals have been recovered from about 15,000 years ago. It's been hailed as the earliest cemetery in the world.

The evidence includes primary and secondary inhumation. In primary inhumation, skeletons are completely articulated, suggesting an individual was buried soon after death. Secondary inhumation includes disarticulated bones, some of which have signs of cut marks from de-fleshing and which might have been used in ritual practices, as suggested by the presence of ochre. Sometimes, earlier burials were disturbed by later ones, with certain bones removed, suggesting reuse of the burial area over time.

The early date of this North African cemetery is notable because this is when things began to warm up after the end of the last glacial maximum. In Europe, it was a climate period known as the Bølling-Allerød interstadial. In Morocco, this was probably reflected by wetter conditions and more abundant food sources. Thus, the establishment of a burial ground potentially reflects increased sedentism and a deeper attachment to a single place than previously existed.

Evidence for another early cemetery, from about 9,000 years ago, appears at the Gross Fredenwalde cave site in Germany. This was early in the Holocene period, when something approximating modern-day climate conditions emerged. The cultural period known as the Mesolithic was flourishing in Europe. Agricultural practices were beginning to develop further south. People were becoming less mobile, utilizing smaller ranges of land with abundant natural resources. This appears to be what was happening in

the Serbian region of the Iron Gate along the Danube River, where people hunted, fished, and lived in villages, eventually burying their dead under house floors.

In the Near East, at the heart of agricultural development, the link between sedentism and increased burial practices is also apparent. The Natufian culture in Israel began burying their dead in organized cemeteries. More than 400 burials have been recorded in this region and cultural period. For example, the Hilazon Tachtit cave contains the remains of 28 individuals who died about 12,000 years ago. One of these was a 45-year-old woman who stood 4 feet, 9 inches tall, with spinal and pelvic deformities. More than 50 complete tortoise shells were found in the grave and are proposed to have been part of the funerary feast. Other animal parts placed in the grave include the wing of a golden eagle. Also found was a single foot belonging to an adult human. The grave goods additionally include a basalt bowl and a bone tool. The woman's contemporaries appear to have bestowed special significance on her life and afterlife and to have desired proper passage for her in death with a variety of items imbued with spiritual meaning.

Reading

Formicola, Vincenzo. "From the Sunghir Children to the Romito Dwarf: Aspects of the Upper Paleolithic Funerary Landscape." *Current Anthropology* 48, no. (2007): 446–453. https://doi.org/10.1086/517592.

Grosman, Leore, Natalie D. Munro, and Anna Belfer-Cohen. "A 12,000-Year-Old Shaman Burial from the Southern Levant (Israel)." *Proceedings of the National Academy of Sciences* 105, no. 46 (2008): 17665–17669. https://doi.org/10.1073/pnas.0806030105.

Martinón-Torres, María, Francesco d'Errico, Elena Santos, Ana Álvaro Gallo, Noel Amano, William Archer, Simon J. Armitage, et al. "Earliest Known Human Burial in Africa." *Nature* 593, no. 7857 (2021): 95–100. https://doi.org/10.1038/s41586-021-03457-8.

12
FEAST OR FAMINE? THE PALEOLITHIC DIET

Before the domestication of plants and animals, humans obtained food by hunting, gathering, and fishing. As you will find in this lecture, the human diet was, in many cases, varied and plentiful. Over the last several decades, zooarchaeology has emerged as an important research area in its own right. By applying both theory and method, archaeologists can reconstruct entire ancient economies. The reconstruction of ancient diets goes hand in hand with the subfield of archaeobotany, or paleoethnobotany, which is the study of plant remains from archaeological sites.

Early Hominin Diets

Plants most likely dominated the diets of our earliest hominin ancestors. These plants included leafy forage, energy-rich tubers, and sugary fruits. However, it was arguably eating substantial quantities of meat that started to make a difference in the development of our brains early in our evolutionary tree. This was probably facilitated by the occasional use of fire for cooking by the time of *Homo erectus* 1.8 million years ago.

The Smithsonian Institution paleoanthropologist Briana Pobiner concluded, after reviewing the available evidence for hominin diets prior to *Homo erectus*, that meat was not the main nutrition source for our apelike ancestors. When they did eat meat, the selection was probably varied. Across more than 1.5 million years, between the earliest cut-marked bone, from Dikika, Ethiopia, 3.4 million years ago, and the appearance of *Homo erectus* 1.8 million years ago, the record consists of only 32 known cut-marked bone fragments. These come from four African sites.

The scant evidence of meat eating prior to *Homo erectus* includes cut marks that indicate the carcass was processed by disarticulating the skeleton, filleting the meat, and sometimes removing the tongue. It might be concluded that butchery behavior was not common between 3.4 and 1.8 million years ago and that meat eating was the exception rather than the rule. Thus, what was the purpose of the earliest stone tools, which appear between 3.3 and 2.6 million years ago? The edges of some stone tools from 2 million years ago appear likely—based on microscopic wear—to have been used to process plant tissues. Thus, not only were we consuming plants but we were also beginning to modify and prepare plant foods alongside meat.

What Can Bones Tell Researchers?

How well do animal bones reflect what people ate? Since bones are already overrepresented in the archaeological record relative to plant material, researchers tend to overemphasize the importance of meat in our ancestors' diets. However, meat was probably more important than nourishment from plants, at least from about 1.8 million years ago until grains began to be domesticated around 12,000 years ago.

Zooarchaeologists are trained to identify the fragments of bone that come out of an archaeological site. After the bones are excavated, washed, and dried, they are sorted into two piles. One pile consists of bones that should be identifiable; the others are not. The difference is usually based on their size and whether there are any distinguishing features. Then, researchers need to determine what bone it is. Once that assessment has been made, an analyst can make species determinations and further observations about cut marks or burning. In contrast, the pile of unidentified bones is counted, weighed, put in a bag, and set aside or even discarded. This doesn't necessarily present a problem. If, out of 10,000 bone fragments, 50% can be identified, you should have plenty of material to work with. However, what if you could identify only 30%, as is often the case in Paleolithic caves? What if certain factors led to higher fragmentation of certain bones, creating a bias in what you were able to identify?

This is what researchers found while working in the 40,000-year-old Mousterian Neanderthal layers at the site of Fumane Cave in Italy. Enter the science of proteomics: the study of proteins. Fumane is an important site for understanding Neanderthal behavior. Finds there include painted stones, ornamental objects, and evidence for the use of bird feathers, alongside the typical finds of stone tools, hearths, and animal bones. However, out of nearly 37,000 bone fragments, only about 1,100 have been positively identified as belonging to hunted prey, such as elk. To gain further insight into what kinds of animals Neanderthals consumed, researchers randomly selected about 700 unidentifiable bone fragments for zooarchaeology by mass spectrometry analysis (ZooMS). DNA and proteins can be used as molecular fingerprints. Protein analysis is cheaper than analyzing ancient DNA, and it can be performed under poorer preservation conditions.

DNA tells our body which amino acids to produce, and amino acids are linked by peptide bonds to form a chain: polypeptides. This is the basic structure of a protein. The weights of these peptide chains vary. To measure this weight, bone collagen, or the protein portion of bone, is first extracted in the laboratory and then broken down into its components using the enzyme trypsin. These polypeptides are then analyzed, and the resulting masses are compared to a database that contains values for known samples. A human, a bird, and a fish will all be different. In this way, the "molecular fingerprint" can be matched. The bone can be identified with the correct taxon.

At Fumane Cave, the relative importance of deer and ibex in Neanderthal diet was overestimated based on visual identification of the bones alone. As a result of ZooMS analysis, the representation of wild cattle increased nearly sixfold, from 7% to 41% of the assemblage. Why had the dietary importance of cattle previously been so hard to identify? The bone fragments chosen for ZooMS analysis came from the shaft portion of limb bones, many of which showed evidence of having been deliberately pounded and shattered. Thus, perhaps archaeologists shouldn't be so quick to discard that pile of "unidentifiable" bone fragments in the future.

Marrow and Bone Grease

Pounding would have given access to the marrow inside the bones. It seems likely the Neanderthals preferred the marrow of cattle as opposed to that of deer, probably because there was more of it. Fat is nutritionally important and provides plenty of calories, which our evolving brains and active bodies desperately needed. It is stored directly underneath an animal's skin and may vary in amount depending on the season. Skeletal fat sources include marrow stored in the central cavity of long bones and grease found at the ends of the bone. The amount of an animal's skeletal fat is more consistent than that of its body fat throughout the year.

Marrow extraction requires breaking bones open when they are fresh. Researchers are usually able to identify this in the archaeological record when they see spiral fractures or percussion marks repeatedly occurring on the shaft portion of marrow-rich bones. Marrow extraction has sometimes been interpreted as a sign of dietary stress since it indicates an intensification of resource use. However, this practice could also have been part of dietary preference, consumed by a certain demographic or during certain seasons. Neanderthals living in the throes of the ice age at Fumane would have wanted to glean as many calories as possible from their prey.

Bone grease production is harder to identify. The ends of the bones must be shattered and boiled at a constant temperature, sometimes for relatively long periods, requiring vigilance. This also requires a container for boiling in, water, and fuel for the fire. This practice has been observed ethnographically, but its inception remains controversial. The best candidate so far is the Portuguese Paleolithic site of Vale Boi. *Homo sapiens* who lived in the region

25,000 years ago hunted elk alongside horse, ibex, wild boar, aurochs, and wild ass. Equal proportions of the animal bones found at the site are from fetal or infant remains. This suggests that humans purposely targeted pregnant animals or those with young fawns and foals during the spring months. People also supplemented their diet with rabbits and limpets.

Australian zooarchaeologist Tiina Manne observed that at the site of Vale Boi, the limb bones of larger animals had been intensively smashed, including the spongy, grease-rich ends. The breakage evidence as well as fire-cracked rock and stone anvils at the site suggested that grease rendering was occurring there as early as 25,000 years ago, making it one of the earliest examples of grease production in Europe. Most animal remains recovered from archaeological sites dating to this time—at the height of the last glaciation in Europe, about 20,000 years ago—are large-bodied ungulates, or hooved animals. Hunters usually focused their efforts on one species only, depending on the latitude: reindeer, elk, aurochs, or even woolly mammoth and rhinoceros.

It might have taken a human much effort to bring down an elk, but specialized targeting of a single species can be argued as efficient. The calories from these large-bodied animals would provide the greatest return on the energy invested to hunt them once they were encountered. This reasoning is called optimal foraging theory, often used as a starting point for the interpretation of past diets. Not accounted for in the theory are such variables as making traps, prior knowledge of where to find a herd, and other food sources, including plants possibly harvested by the elderly and children.

Preagricultural subsistence studies talk about economy. If you didn't eat, you died, hence the reliance today on optimal foraging theory. However, there is also some evidence for "paleo cuisine." A good example of this comes from Neustadt, Germany, dating to around 6,000 years ago. People in the region had begun to adopt pottery from further south but were still hunting and gathering for dinner. Biomolecular analysis of fatty residues on a pottery shard at Neustadt yielded evidence that the pot had once contained fish and deer meat. Microscopic analysis revealed another ingredient: the seeds of the garlic mustard plant. Garlic mustard is pungent and spicy in flavor but of little nutritional value. The only other documented use of spices in Europe and Southwest Asia comes from slightly later agriculturalist sites, making this the earliest confirmed instance in a hunting and gathering population.

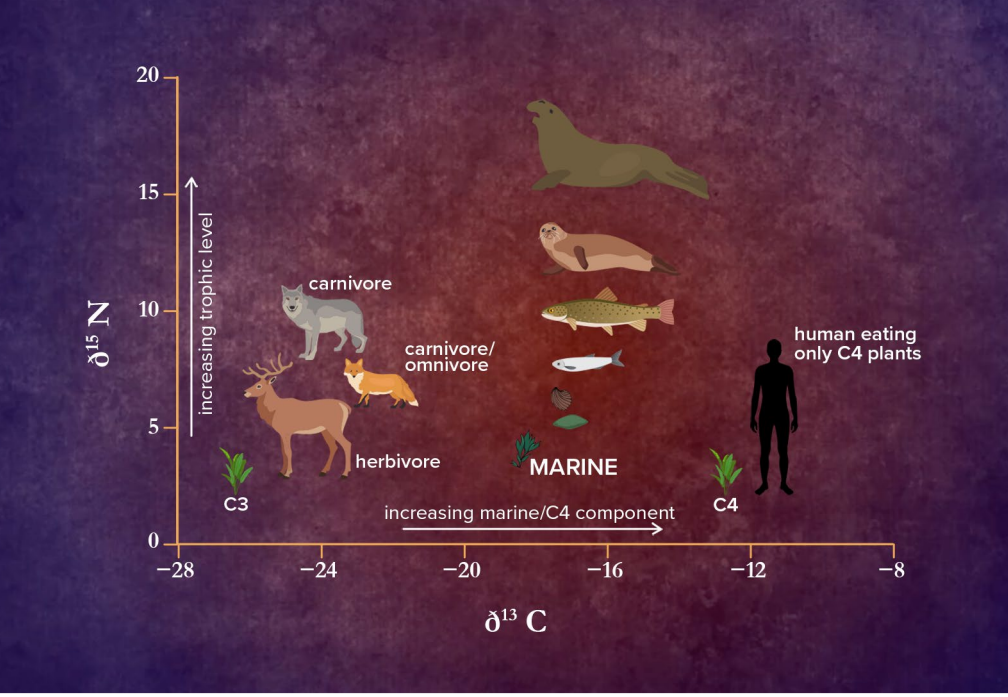
The standard procedure for recovering macroscopic plant remains is called flotation. With this method, some volume of excavated sediment—perhaps 5% to 10% of a given layer—is reserved. In the case of special contexts, such as a hearth, all excavated sediment should be floated. A flotation tank is filled with water and equipped with a pump. Sieves with a mesh size ranging from 1 millimeter at the top level down to 0.5 millimeters at the bottom level are stacked and submerged. Sediment is slowly poured in as the pump circulates the water. As the sediment dissolves, some material floats, and some sinks. The heavy fraction, or the portion that sinks, usually contains small pebbles along with larger seeds, tiny snail shells, and the bones of microvertebrates. However, archaeobotanists are looking at what floats: small seeds and seed fragments that otherwise would have been lost. This material is gathered in a fine mesh, bundled, and dried before being analyzed.

Stable Isotope Analysis

Stable isotope analysis of human remains, i.e., measuring the ratios of carbon and nitrogen isotopes in bones, is yet another way to synthesize various dietary inputs and provide a more well-rounded picture of what people ate in the past. With this technique, archaeologists can evaluate what types of plants people ate, how much meat they ate, whether they consumed fish, and whether the fish were marine or freshwater.

Carbon atoms exist in two stable forms: carbon-12 and carbon-13. Carbon-12 has one less neutron than carbon-13, making it infinitesimally lighter. It's also more abundant in the atmosphere. When plants carry out photosynthesis, taking in carbon dioxide, they prefer this lighter isotope of carbon. This is more pronounced in wheat and most green leafy vegetables and less pronounced in grasses such as corn and sugarcane. An animal or person who is eating more—or less—of these types of plants will plot somewhere between the two.

Likewise, there are two stable isotopes of nitrogen. Organisms preferentially retain the heavier isotope of nitrogen-15 and excrete more nitrogen-14 via urine. Moving up the food chain, each organism becomes more enriched in nitrogen-15 relative to the lighter isotope nitrogen-14. An herbivore such as a cow will have a relatively low ratio of nitrogen-15 to nitrogen-14 since it eats only plants. A carnivore will have a ratio that's two to three times higher. Humans, as omnivores, tend to fall somewhere in between. Fish tend to have



ratios even higher than terrestrial carnivores. Thus, when people eat more fish, their nitrogen-15 ratio is also higher. Archaeologists use this principle to detect the consumption of marine fish as well as to differentiate freshwater fish, which produce a more negative carbon-13 ratio than marine fish do.

This method was used at Tianyuan Cave, near Beijing, China, to establish the earliest known date for human consumption of freshwater fish. The isotopic ratios were locked in the bones of one man who had lived there 39,000 to 42,000 years ago, making him one of the earliest modern humans to be found in eastern Asia. The stable isotope analysis revealed that even at this early date, people were fishing as well as hunting and gathering.

Reading

Buckley, Michael. "Zooarchaeology by Mass Spectrometry (ZooMS) Collagen Fingerprinting for the Species Identification of Archaeological Bone Fragments." In

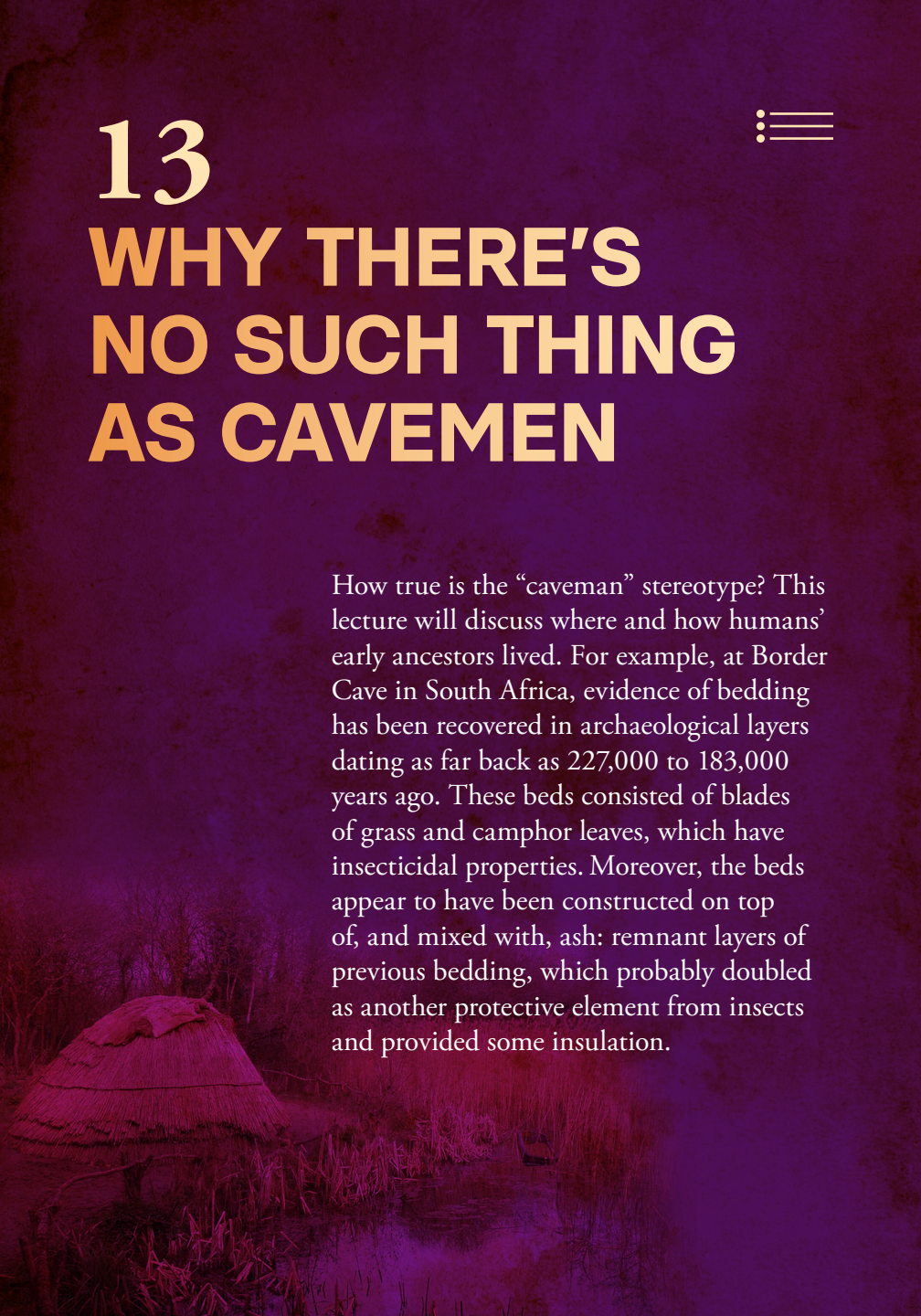
Zooarchaeology in Practice: Case Studies in Methodology and Interpretation in Archaeofaunal Analysis, edited by Christina M. Giovas and Michelle J. LeFebvre, 227–247. Switzerland: Springer, Cham, 2018. https://doi.org/10.1007/978-3-319-64763-0_12.

Makarewicz, Cheryl A., and Judith Sealy. "Dietary Reconstruction, Mobility, and the Analysis of Ancient Skeletal Tissues: Expanding the Prospects of Stable Isotope Research in Archaeology." *Journal of Archaeological Science* 56 (April 2015): 146–158. https://doi.org/10.1016/j.jas.2015.02.035.

Russell, Nerissa. *Social Zooarchaeology: Humans and Animals in Prehistory*. New York: Cambridge University Press, 2011.

13
WHY THERE'S NO SUCH THING AS CAVEMEN

How true is the "caveman" stereotype? This lecture will discuss where and how humans' early ancestors lived. For example, at Border Cave in South Africa, evidence of bedding has been recovered in archaeological layers dating as far back as 227,000 to 183,000 years ago. These beds consisted of blades of grass and camphor leaves, which have insecticidal properties. Moreover, the beds appear to have been constructed on top of, and mixed with, ash: remnant layers of previous bedding, which probably doubled as another protective element from insects and provided some insulation.



Early Bedding

Early bedding has been identified through various sophisticated methods, including soil micromorphology and phytolith analysis. Phytoliths are tiny, microscopic silica-based particles left behind by the decay of plants. Think of them as the fossils of individual plant cells. The silica forms different shapes depending on whether it's located in the leaf or stem. An expert can generally identify a phytolith as coming from a blade of grass versus the leaf of a tree, though this isn't true for all plants. Moreover, phytoliths can tell researchers whether plant material was burned based on whether the fossilized cells appear clear or dark under the microscope.

A team led by South African archaeologist Lyn Wadley found that bed making occurred around 77,000 years ago, at Sibudu Cave in South Africa. The beds at Sibudu included remnants of sedges, rushes, grasses, and camphor bush. The team used phytolith and micromorphology analysis. They also performed an experiment in which they constructed beds out of dried sedges, burned and compressed the beds, and then repeated the process before burying their creation. Later, they excavated and analyzed the remains to compare them with the original archaeological material. The phytolith remains and resulting soil micromorphology were similar to those found in the archaeological sample.

Geoarchaeologists concentrate on the geological aspects of archaeology. One of the more specialized approaches is micromorphological analysis. Stratigraphic sections, found in the exposed vertical surface of an excavation trench that shows the layers of sediment as they were originally deposited, are sampled by removing rectangular blocks that preserve the layers' integrity. Normally, researchers target an area that is visibly of interest, such as ash from a fire. Once the block has been removed, it's taken to a lab, where it's impregnated with resin and left to cure for some time as the resin dries. Then, several slabs are cut into thin sections, which are polished and mounted for microscopy.

Under the microscope, researchers can see fine layers of site formation. Moreover, the arrangement of particles can tell them about things such as trampling and redeposition. In the case of the beds at Sibudu and Border Caves, researchers saw evidence of routine burning, the ash having been

trampled down, and fresh beds having been made. Lithics were also recovered in the bed areas, leading archaeologists to suggest that they were likely seating areas as well.

Early Structures

Caves consist of three main parts: the entrance, a twilight zone, and a dark zone. Most archaeological evidence of human activity in and around caves is at their entrance. Sometimes, researchers find cave art and human remains in the twilight or dark zones, but it's likely that these areas were off-limits for regular use. They might have even had sacred connotations. As groups used the entrance area of a cave, activities probably were also taking place outside. These might not be as well preserved as contexts inside the cave. This bias is seen in the overall archaeological record. It's far more likely that the shelter caves provided to people also protected what was left behind. In contrast, open-air sites might not have left traces of human activity.

What is the earliest evidence for built structures? This, too, comes mostly from caves. At the cave site of Haua Fteah in Libya, a posthole in a layer dating to between 30,000 and 40,000 years ago attests to deliberate construction. Postholes occur from a hole being dug (a "cut") to place a piece of wood (the post) into the ground. The earth is then stabilized with "fill" back around the wood. The wood eventually leaves a ring of ash, if burned, or organic material, if left to rot. So far, the earliest evidence for postholes dates to 100,000 years ago. Three postholes were found at the Zambian site of the Mumbwa caves. Their location seemed to have been for a wall, interpreted as a windbreak, protecting a semicircular deposition of bone, lithics, and ash.

Some argue that the lack of evidence for structures at open-air sites means that people didn't bother to build any shelter at all. However, ethnoarchaeology might help bridge the gap between what archaeologists expect to find at an ephemeral camp and what they do find. The Greek archaeologist Nena Galanidou reviewed the use of space by modern foragers at caves and rock shelters in different environments. Galanidou found that people use space in different ways—with separate activity areas, refuse disposal areas, and hearths—but that these patterns are related more to the cultural background of a group and the way people relate to the space than to any physical constraints of the space.

It may be that the occurrence of fire and the existence of hearths are better proxies for identifying human occupation. The earliest documented occurrence of human-controlled fire could have been as early as 1.5 million years ago. Some of the earliest evidence of the use of fire is from Africa, when *Homo erectus* roamed the land. However, it is inconclusive as to the extent that it was routinely used and whether humans created it as opposed to taking advantage of existing fires, such as those caused by lightning strikes.

Some of the best evidence for human-controlled fire comes from Wonderwerk Cave in South Africa, reaching back to 1 million years ago. Contemporary analysis applying micromorphology and a technique called FTIR shows that plant material and animal bones were once burned there. Outside of Africa, the Gesher Benot Ya'aqov site in Israel yields related evidence from as early as 790,000 years ago that flint tools were burnt to harden them. Not until about 400,000 years ago does the evidence seem to support routine control and use of fire, represented by examples of burnt material and ash layers.

Some of the best early evidence for the repeated and deliberate use of hearths in Europe comes from the Bolomor Cave site in Spain. Fourteen hearths, each made in a roughly circular shape on the ground, were analyzed macro- and microscopically and found to date back 228,000 years, with an error range of about 50,000 years. Researchers dated snail shells in the archaeological layer containing the hearths. They used amino acid racemization. It works like this: Our DNA tells our bodies which amino acids to produce. These combine to form proteins. The molecular structure of amino acids can exist in one of two possible forms, L and D, which are mirror images of one another. In living organisms, amino acids exist—for the most part—in their L form. Once an individual dies, the amino acids in the body begin to shift from L to D but not all at the same time. Researchers measure the ratio of L to D forms to estimate how long it's been since death.

One problem is that the decay rate here can be influenced by various external and internal factors, including the acidity of the surrounding sediment, humidity, and temperature. In this example, the snails in the layer with fire might have been dead for quite a while before the layer was buried but not for more than 50,000 years, which encompasses the range of error for this date.

Early Settlements

When does the evidence for hearths and homes start to flourish? It's not until later in the Upper Paleolithic period—around 15,000 years ago—that evidence for more significant built structures appears. The Mezhyrich site in Ukraine is notable because it yielded one of the best examples of early musical instruments: a mammoth skull painted with ochre and other bones apparently used to beat it like a drum. The site is also remarkable because these mammoth bones were also used to build houses.

In 1965, a local farmer discovered the lower portion of a mammoth jaw, a mandible, and reported his find. Subsequent excavation revealed four large circular dwellings, the largest measuring 8 meters in diameter. It was entirely constructed from mammoth bones. In at least one of the structures, mandibles were used to create the foundational first layer, with flatter bones, such as the scapula, used higher up in the structure. At the time these houses were built 15,000 years ago, the world was in the throes of the end of the last ice age. This feat of early engineering is all the more impressive considering that each structure used about 20 tons of bone and the remains of an estimated 95 mammoths.

This site is also important for what it implies about the overall settlement pattern. Here, the world's earliest map was inscribed on a piece of ivory. It represents a schematic of the local area at the confluence of two tributaries of the Dnieper River. Other mammoth bone sites were also found along this river valley, situated on old terraces with strategic views overlooking what were likely fertile hunting grounds below.

Yet another example of an early built settlement comes from the Mesolithic site of Lepenski Vir in Serbia, along the Iron Gate gorge of the Danube River. Not until well after the world began to warm did Lepenski Vir coalesce—about 9,500 years ago. It was first discovered in 1960 and began to be excavated in 1965. Over about five years, amazing finds emerged at the site, including stone-lined hearths and trapezoidal structures with hard lime-plaster floors, which were interpreted as houses and shrines. It was thought that this site represented an early advanced agricultural population.

The zooarchaeologist Sándor Bökönyi published a paper in *Science* claiming that the site was an example of local animal domestication, occurring independently from what was happening in the Near East. Early radiocarbon dates seemed to support the argument. Advancements in radiocarbon dating technology—particularly the advent of accelerator mass spectrometry, which allows for more precise dates—enabled researchers to return to the question of the dates for Lepenski Vir in the late 1990s and early 2000s. Animal bones and human remains from the site were reevaluated. The dates did not agree with each other. Humans appeared to have lived there earlier in time than some of the animals from the same layers. What would cause this discrepancy? Researchers carried out stable isotope analysis on the human and animal remains and found that these people, in addition to hunting and gathering, ate plenty of fish, which had caused a problem for the radiocarbon dating.

As the Danube flowed across ancient limestone, old carbon-14 sequestered in the rock dissolved and entered the tissues of living fish alongside the carbon-14 atoms of the time. People ate these fish, ingesting old and new carbon. The stable isotope analysis revealed this, making it necessary to calibrate the freshwater reservoir effect by calculating the offset between fish-eating humans and non-fish-eating animals. Ultimately, the researchers concluded that the site was a few thousand years more recent than originally argued and not a unique instance of the early Neolithic period in Europe. The earliest layers at the site were reassigned to the Mesolithic period, prior to farming. Still, these Mesolithic layers contain intriguing evidence for lined hearths and the emergence of built structures prior to the arrival of domestic animals from further south.

One way archaeologists try to reconstruct the nature and extent of human settlement patterns through time is by mapping and modeling with radiocarbon dates. However, the radiocarbon date record is, for the most part, only as good as the excavated sites. Thus, blank spots on the map might represent not a lack of settlement but instead a lack of research. Also, many radiocarbon dates generated before the advent of accelerator mass spectrometer instrumentation provided erroneously broad date ranges, artificially lengthening estimated periods of occupation. Other problems arise when considering material that was dated while people still thought it was okay to smoke cigarettes during an excavation, introducing contamination from younger carbon.

Reading

Borić, Dušan, Thomas Higham, Emanuela Cristiani, Vesna Dimitrijević, Olaf Nehlich, Seren Griffiths, Craig Alexander, et al. 2018. "High-Resolution AMS Dating of Architecture, Boulder Artworks and the Transition to Farming at Lepenski Vir." *Scientific Reports* 8, no. 1 (2011): 14221. https://doi.org/10.1038/s41598-018-31884-7.

Pilaar Birch, Suzanne E., and Marc Vander Linden. "A Long Hard Road … Reviewing the Evidence for Environmental Change and Population History in the Eastern Adriatic and Western Balkans during the Late Pleistocene and Early Holocene." *Quaternary International* 465 (January 2018): 177–191. https://doi.org/10.1016/j.quaint.2016.12.035.

Wadley, Lyn, Christine Sievers, Marion Bamford, Paul Goldberg, Francesco Berna, and Christopher Miller. "Middle Stone Age Bedding Construction and Settlement Patterns at Sibudu, South Africa." *Science* 334, no. 6061 (2011): 1388–1391. https://doi.org/10.1126/science.1213317.

14
EARLY TECHNOLOGY: AXES, HARPOONS, AND HOOKS

Technology played a significant role in human development. Human ancestors forming hand axes from stone almost 3 million years ago paved the way hundreds of thousands of years later for more efficient and elaborate blades made from materials such as volcanic glass. Changes in tool form and function and an explosion in varieties of technology are among the foremost markers of the arrival of the modern mind. New tool forms such as blades appeared by 50,000 years ago. They helped make hunting and food preparation more efficient, giving humans greater control over their environment. As you will learn in this lecture, there is now evidence for even more complex technology employed by our human ancestors, including the use of poison and glue more than 30,000 years ago.

Technological Innovation and Classification

During the Upper Paleolithic period, beginning 40,000 to 50,000 years ago and lasting until about 12,000 years ago, technological complexity proliferated. Innovations included new raw materials, such as bone and antler, and the use of exotic stones recovered far from their original source. There were also composite tools such as the atlatl, or spear-thrower, which increased the efficiency of hunting by leaps and bounds. New stone-flaking techniques also emerged, and blades entered the archaeological record. These innovations led to an overall increase in efficiency over previous lithic technology. Some new tools, such as needles, hint at the development of sewn clothing. Additionally, 23,000-year-old fishhooks made from shells, such as those recovered from Sakitari Cave in Japan, are evidence of fishing.

The new opportunities afforded by such technological adaptations were wide-ranging. However, change was not always progressive. Some innovations probably represented specific adaptations to a particular time and place. Subsequently, some of these tool types then disappeared from the record, only to emerge later on somewhere else. This does not necessarily indicate cultural stagnation. Instead, it shows that the human mind could produce such a tool long before it entered our behavioral repertoire as standard.

As with all technology, the longer a form or function exists, the more varieties proliferate. Some researchers argue that the occurrence of distinctive styles in different regions across the Old World—sometimes within close proximity—is indicative of regional cultures and traditions. Stylistic changes and improvements also occur more frequently moving forward in time. However, the cultures archaeologists have identified based on stone tool types might have little or no relation to how ancient peoples organized and understood themselves. Archaeologists tend to subdivide the long span of the Paleolithic into subperiods, based on stone tool traditions. Such categories are generally useful because they refer to a specific time range and illustrate something about the material culture found at a site.

The first blades and bladelets began to appear in Europe's archaeological record during the Aurignacian period, which spans about 45,000 to 29,000 years ago. Modern humans first appeared in Africa close to 200,000 years ago and likely made their way across Asia and into Australia by around 65,000. However, there is no evidence for their entry into Europe until about 45,000 years ago. The Aurignacian is therefore the first stone tool industry in Europe associated with modern humans.

The French paleontologist Édouard Lartet was the first to document the fine flint and bone tools at the Aurignac Cave site in southern France. He also found abundant fossils of animals that occupied Europe during the last ice age, such as cave bears. The comingling of tools and bones proved that humans interacted and lived alongside the animals. In the mid-1800s, this was quite the novel discovery. Lartet advocated for subdividing the Paleolithic period into categories corresponding to the most abundant fossil species of their time. His classification didn't hold up, but it provided a basis for a later stone tool chronology, beginning with the Aurignacian, as developed by French archaeologists Gabriel de Mortillet and Henri Breuil.

Most 19th- and early-20th-century archaeologists thought of stone tool traditions and the chronology being described as unilinear stages along a cultural evolution timeline. Archaeologists still use the terms today, but they are meant to be more descriptive and fluid. Most European archaeological sites from 17,000 to 11,000 years ago are considered to be Magdalenian (named after the French site of La Madeleine). Here, detailed composite tools emerge. There are abundant harpoons and denticulated microliths—essentially, small, sharp stone chips that would have been set into wood and

used for serrated cutting. Other regional lithic chronologies toward the end of the Magdalenian period have been identified, coinciding with the end of the last ice age, including the Azilian in Spain and France, the Federmesser in Germany, and the Creswellian in the British Isles. Generally, these signal the end of the Paleolithic period and the transition to the Mesolithic.

Tool Refinement

The Mesolithic period across Europe encompassed widespread changes in subsistence, settlement patterns, and technology. It is characterized by the ubiquity of microliths, including such forms as trapezes, triangles, lunates, burins, bladelets, and points. All were probably hafted into wood to create saws, serrated knives, harpoons, and arrows.

Early on, our ancestors learned that by bashing one rock against another, they could break off sharp edges that could be used for a variety of purposes. Later, they realized they could use a more rounded river cobble as the hammerstone and certain types of rocks, such as chert or obsidian, to create a more refined tool. They could shape and prepare the core stone before hitting off a flake to gain more surface area for cutting. They could also retouch the edge to make it sharper.

During the Upper Paleolithic period, new methods emerged for making the finer blades and bladelets of this time. In soft-hammer percussion, instead of using a hard cobblestone to directly strike the core piece of rock from which the tool will be made, a softer implement is used. It might be antler, bone, or wood. This creates a thinner and flatter chip that can still be quite large. Pressure flaking is a related technique using soft hammers. Instead of striking the surface, pressure is applied, either directly or indirectly, to produce fine flakes that can be further retouched. A stone tool might first be struck using a hard hammer, refined with a soft hammer, and then retouched with pressure flaking.

Where did people get the right materials, and how far did they have to travel, to produce early stone tools? Researchers often think of water as the most essential variable in choosing where to live and food as a close second. A source for obtaining raw material for tool manufacture was probably also high on the list. Early in the history of archaeology, researchers paid attention to local geology to discern where most tools came from. However, certain tools

did not correspond to anything reasonably close by. Thus, archaeologists reasoned that our early ancestors probably traveled long distances or traded with others to obtain certain artifacts.

During the second half of the 20th century, advances in mass spectrometry and geochemical analysis allowed archaeologists to further investigate how far lithic sources might have ranged. X-ray fluorescence (XRF) allows researchers to analyze the elemental composition of artifacts by bombarding an object with x-rays and gamma rays, causing it to emit its own radiation in response. This fluorescence can be measured and used to generate a wavelength that tells them how much of each element is contained in a certain rock. The full spectrum of peaks forms a fingerprint unique to the formation of that rock. For example, this might result from a single volcanic eruption millions of years ago, as in obsidian. Using XRF, archaeological scientists can evaluate how many different lithic sources people used and how far they had to travel to get to them.

The layers of the Ksar Akil site in Lebanon stretch back to the Middle Paleolithic period, which is beyond the reaches of radiocarbon dating. The site has allegedly yielded more than 2 million lithic fragments alongside Neanderthal and anatomically modern human remains. Many of the lithic fragments were considered waste and discarded during the site's initial excavation in the 1930s. However, a single obsidian artifact—a burin—was found in layers dating to between 37,000 and 41,000 years old and analyzed using XRF.

Archaeologists Ellery Frahm and Christian Tryon showed that the obsidian used to create the burin came from Turkey's volcanic mountain region of Göllü Dağ. This identification was based on the obsidian's chemical signature. The Ksar Akil site is 485 kilometers away. Traversing this route would have involved both traveling on foot and crossing water. The shortest distance over land only is even further: 695 kilometers. Obsidian artifacts from this period have also been found at sites such as Shanidar Cave in Iraq and the Yabroud rock shelter in Syria. This suggests that the long-distance transport of resources such as obsidian potentially occurred as part of a connected social network in this region.

Early Poisons and Glues

At the Border Cave site, archaeologists found a suite of organic materials that provide some insight into human ingenuity as far back as 44,000 years ago. The recoveries included bone arrowheads similar in form to those used by the indigenous San people of South Africa in the modern era. A modified wooden implement of interest was also preserved at Border Cave. The stick had been stripped of bark and notched, similar in form to poison applicators used by the San people today. These notches hold a poison paste applied to the tips of arrowheads. Could the stick from 24,000 years ago have also been used for such a purpose?

Researchers used a technique called residue analysis to determine this. It involved extracting lipids trapped in the pores of the wood. Once the lipid portion was isolated, the sample was run through a gas chromatograph, which identified the individual chemical components of the compound. In this example, the wooden implement was shown to be a poison applicator that contained ricinoleic acid—the poison ricin. It occurs in castor beans and is one of the most dangerous naturally occurring poisons. Thus, it appears that at least 24,000 years ago, people were aware of its killing power and used it.

Less clear is the purpose of a lump of indented organic material found at the excavation site. It had apparently been bound by plant material and twine that had long since rotted away, leaving only imprints behind. It was dated at 34,000 years old. Researchers used gas chromatography to analyze this material as well. It turned out to be a mixture of beeswax, protein (possibly egg, used as a binder), and plant resin from the poisonous pencil plant, *Euphorbia tirucalli*, which can cause temporary blindness. It can also be used medicinally.

Sibudu Cave, about 400 kilometers south of Border Cave, provides other intriguing evidence of organic preservation. Residue analysis coupled with SEM has shown that microscopic remains on the edge of a stone flake found there were composed of ochre and casein. The protein casein is found only in milk (in this case, from wild cattle). Generally, milk isn't thought of as being something used or exploited by humans until after the domestication of herd animals, closer to 10,000 years ago. However, this milk is five times older than the earliest dairy cow. Moreover, the stone tool comes from a layer

dating to 49,000 years ago. Thus, a lactating female cow is thought to have been killed and its milk used as a binder to create an ochre paint applied to the weapon. Could animals have been targeted for their milk as a resource?

There is evidence for the world's earliest glue at this site, too: Two stone tools from contexts dating to between 65,000 and 38,000 years before present had residues that contained resin from a conifer tree. An early glue was also identified at the South African site of Diepkloof from 56,000 years ago. It seems logical that people would have needed an adhesive to help keep spearheads and arrowheads attached to the rest of the weapon.

Reading

d'Errico, Francesco, Lucinda Backwell, Paola Villa, Ilaria Degano, Jeannette J. Lucejko, Marion K. Bamford, Thomas F. G. Higham, Maria Perla Colombini, and Peter B. Beaumont. "Early Evidence of San Material Culture Represented by Organic Artifacts from Border Cave, South Africa." *Proceedings of the National Academy of Sciences* 109, no. 33 (2012): 13214–13219. https://doi.org/10.1073/pnas.1204213109.

Frahm, Ellery, and Christian A. Tryon. "Origin of an Early Upper Palaeolithic Obsidian Burin at Ksar Akil (Lebanon): Evidence of Increased Connectivity Ahead of the Levantine Aurignacian?" *Journal of Archaeological Science: Reports* 28 (December 2019): 102060. https://doi.org/10.1016/j.jasrep.2019.102060.

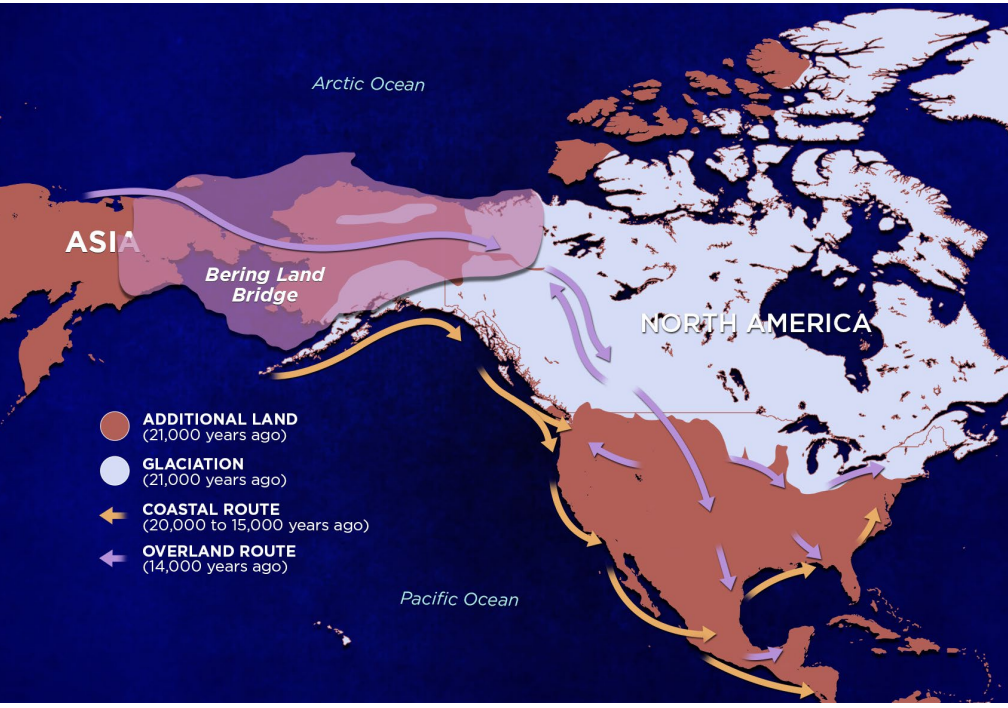
Villa, Paola, Sylvain Soriano, Tsenka Tsanova, Ilaria Degano, Thomas F. G. Higham, Francesco d'Errico, Lucinda Backwell, Jeannette J. Lucejko, Maria Perla Colombini, and Peter B. Beaumont. "Border Cave and the Beginning of the Later Stone Age in South Africa." *Proceedings of the National Academy of Sciences* 109, no. 33 (2012): 13208–13213. https://doi.org/10.1073/pnas.1202629109.

15
COMING TO THE AMERICAS 20,000-PLUS YEARS AGO

As the last ice age reached its peak around 25,000 years ago, *Homo sapiens* was on the move in the far north, from the Eurasian continent into the Americas. At the time, so much water was locked up in ice that global sea levels were about 120 meters lower than today. This exposed entirely different landmasses than can be seen now, including Sunda and Doggerland. Beringia, between modern-day Russia and Canada, constituted what is sometimes referred to as the Bering Land Bridge. It encompassed more than 620,000 square kilometers and is how people first entered the North American continent. However, the timing has been a subject of continuing debate, as you will see in this lecture.

The Beringian Standstill Theory

Archaeologists think that modern humans were first leaving Africa, moving across Eurasia, and arriving in Australia between about 70,000 and 60,000 years ago. Though a brief land bridge existed at this time, it's generally accepted that humans did not cross Beringia then and that a seaway reopened between 60,000 and 30,000 years ago. It was not until between 30,000 and 11,000 years ago that the land bridge existed once again. It seems logical that this must have been when humans crossed over from Siberia into the North American Arctic. However, much of the North American continent was covered by two different ice sheets: the Laurentide and the Cordilleran.



Despite this, due to atmospheric circulation patterns—and moisture from the northern Pacific Ocean—Beringia was warmer and wetter than the rest of the Arctic region and was not covered in ice. The land was covered with steppe vegetation. It supported mammoths, saiga antelope, caribou, and horses. People were theoretically able to live here.

In 2017, researchers published radiocarbon dates from Bluefish Caves in the northern Yukon. There were 15 bones with cut marks on them made by humans using stone tools to obtain the meat. Of these, two (a horse jaw and a caribou pelvis) established the earliest evidence of human presence in North America yet: between 23,000 and 24,000 years ago. Five additional directly dated, cut-marked bones attest that the site was used from about that time until 12,000 years ago.

This finding supports the Beringian standstill theory, which is that people arrived early on in the northernmost reaches of North America but temporarily stayed put because of the ice sheets. The overland route south would have opened only after around 13,000 years ago. Environmental DNA in buried sediment suggests the passageway could not have supported life until about 12,600 years ago. After that point, people moved southward.

The Clovis First Theory

For a long time, the commonly accepted ingress date was around 11,500 years ago—right at the start of the Holocene epoch. In turn, the earliest archaeological sites in North America were named after the fluted projectiles first excavated at Blackwater Draw, outside Clovis, New Mexico, and referred to as Clovis sites. However, no Clovis-type stone tools dated to before the existence of the ice-free corridor. That nicely suited proponents of the Clovis first theory.

One issue that arises time and again when synthesizing radiocarbon dates from multiple sites is ensuring that the dates are properly calibrated. The instrument used in radiocarbon dating is an accelerator mass spectrometer. It counts the atoms of carbon-14 and carbon-12 in any given sample. As carbon-14 decays by one-half every 5,730 years, the age of an archaeological sample can be calculated by comparing its ratio of carbon-14 to carbon-12 to the ratio of the present-day atmosphere. However, some archaeological material was originally measured when radiocarbon dating technology was less precise and some of the material was less than ideal for testing.

Complicating things, the atmospheric carbon ratio fluctuates depending on a variety of factors, such as solar flares. For instance, the amount of radiocarbon in the atmosphere literally skyrocketed in the mid-20th century after the detonation of hundreds of nuclear bombs. Thus, a ratio corresponding to the year 1950 is used to calculate radiocarbon ages. Tree rings have been used to establish atmospheric carbon ratios going back thousands of years, contributing to the radiocarbon calibration curve. The curve allows researchers to convert the radiocarbon years to calendar years.

The original Clovis stone tools that were discovered in the 1920s came from an excavation layer that was later dated to 11,300 radiocarbon years before present. However, the calibrated age is somewhat older, ranging from 13,200 to 12,900 calendar years old. During most of the second half of the 20th century, North American archaeologists were divided between those who believed in Clovis first, the idea that no humans inhabited the Americas prior to those who created the Clovis-type stone tools, and those who did not support this hypothesis. The ice-free corridor south of Beringia became the linchpin in the debate.

Clovis first proponents argued that it wasn't physically possible for humans to have arrived in North America any earlier. However, considering the calibrated calendar age of the Clovis stone tools themselves (13,200 to 12,900 years ago) as compared to when experts say the ice-free passage would have been survivable (12,600 years ago), Clovis first doesn't add up. Thus, how early could people have arrived in the Americas pre-Clovis, and what evidence is there for pre-Clovis sites?

Pre-Clovis Sites

Perhaps the most iconic of the pre-Clovis sites is near a small town outside Pittsburgh, Pennsylvania. In 1973, the property owner, Albert Miller, who had found some artifacts there, was able to convince researchers from the University of Pittsburgh to search for additional artifacts. Three years of scientific excavation yielded well-preserved plant and animal remains, stone tools, and ceramics. One find in particular put Meadowcroft on the map: a stone projectile point that did not fit the Clovis profile. It was named a Miller point, and it was argued that this and other stone tools at Meadowcroft predated Clovis.

Archaeologist James Adovasio, who led the excavations, sent off material from these layers to be radiocarbon-dated. When the dates came back, they put the earliest human occupation at 16,000 years ago—quite a bit earlier than the dates for Clovis. Adovasio also dated archaeologically sterile layers (as old as 19,000 years old) to model the timing of earliest human occupation at Meadowcroft. He argued that even the most conservative interpretation of the data would support human occupation at Meadowcroft no later than 12,000 years ago. Thus, even this interpretation suggested that people made it 2,000 miles east of Beringia only a few hundred years after the ice-free corridor opened.

However, another discovery—the Cerutti Mastodon site in Southern California—blew that date out of the water. Proponents claim that it provides evidence for the peopling of North America as far back as 120,000 years ago. The site was discovered during the construction of a Southern California freeway berm in the early 1990s. A partial skeleton of a mastodon was unearthed along with what proponents say are five cobble-type stone tools. The dates may be correct. However, it's hard to believe the purported tools are more than plain rolled river stones. Percussion marks on the mastodon bone are also unconvincing.

Another fringe theory is the so-called Solutrean solution. It holds that *Homo sapiens* in Europe during the Solutrean period 20,000 years ago crossed the Atlantic Ocean via boat and settled in eastern North America before spreading westward. The argument is based primarily on a few cosmetic similarities between Solutrean and Clovis stone tools. Solutrean hypothesis proponents point to the Meadowcroft site—and another in Virginia, known as Cactus Hill—to support their theory. No aspect of this conjecture has stood up to scrutiny.

Still, the early dates for Meadowcroft appear to be legitimate. With the refinement of radiocarbon chronologies and the discovery of additional archaeological sites in the late 20th and early 21st centuries, the evidence was beginning to indicate that people made it across North America well before the corridor south of Beringia was ice-free.

Seafaring

As a frame of reference, consider what happened in Australia. The Sahul landmass was never attached to mainland Asia throughout the whole of human existence. Yet, people first arrived in Australia around 65,000 years

ago. That should have been physically impossible, but they had boats. They were able to populate an entire continent soon after arrival. If it is accepted that humans were seafaring as early as 65,000 years ago and exploiting coastal resources by at least 40,000 years ago, why shouldn't they have been able to make the journey down North America's Pacific Coast by water some 25,000 years ago? Thousands of ice age islands teeming with life would have provided ample resources as people moved south from Beringia along the coast.

This line of thinking makes the recent find of 33 human footprints at White Sands National Park in New Mexico all the more valid. The footprints date to between 21,000 and 23,000 years ago and were discovered in situ. They were preserved due to the unique environmental conditions in the area. Soft mud on a seasonal lake bed recorded the prints, and the mud later hardened to preserve them. Seeds of a small aquatic plant called spiral ditchgrass were also preserved at the site. This allowed researchers to radiocarbon-date the human tracks. Uranium-thorium analysis of gypsum in the surrounding sand also lent credence to this early date for human footprints.

Another notable find at White Sands was the discovery of an extinct giant ground sloth's trackway. This kind of sloth went extinct about 11,000 years ago. Other human footprints—though later in time than the earliest footprints—appear alongside the trackway, indicating that humans and sloths were in the same place at the same time. The cause of the demise of ice age animals is a matter of debate. Was it the fundamental shift in the environment during the end of the last ice age, or was it overhunting by humans?

Clovis first fit a theory of humans targeting large-bodied herbivores and causing a trophic cascade that drove rapid extinction shortly after their arrival. However, if humans were in North America more than 20,000 years ago, at the height of the ice age, what would that suggest about our impact on native fauna? Overhunting might still have had an impact on extinction but a more gradual one. The best physical evidence for occupation of Beringia comes from Bluefish Caves in the Yukon 24,000 years ago. As there is also evidence suggesting that people lived more than 2,600 miles to the south in New Mexico 1,000 or 2,000 years later, either they traveled extremely quickly or the Beringia dates need to be pushed back further.

The Monte Verde archaeological site in Chile is the oldest confirmed human settlement in South America—some 14,000 years ago, according to radiocarbon dating. A small group of perhaps no more than 20 to 30 people lived there and used a 20-foot-long tentlike structure for shelter, based on posthole evidence. Archaeobotanical analysis of plant remains from cooking hearths there indicates the presence of 45 different plant species harvested near the site. However, there was also evidence for 9 species of seaweed from the Pacific Ocean some 30 miles away, suggesting some sort of connection to the sea.

Indigenous Remains

There are essentially two ways to address the interrelated questions about the timing of arrival and dispersal of the first Americans: genetic analysis of skeletons from the early sites and genetic analysis of modern, living indigenous people. To date, few human remains have been recovered from early archaeological sites in the Americas. None of the earliest sites—Bluefish Caves, White Sands, Meadowcroft, or Monte Verde—yielded human remains. Moreover, the Native American Graves and Repatriation Act of 1990 protects the remains and associated artifacts of indigenous North Americans who might be linked to any existing tribe in the present day.

The law was central to a conflict over the remains of one of North America's oldest human skeletons, known as Kennewick Man, or the Ancient One. In 1996, two college students noticed a skull eroding out of the banks of the Columbia River in Washington state, on ceded Yakima land. They notified authorities, who properly excavated the skeleton of a middle-aged male. Radiocarbon dates showed that the man had died much earlier than suspected: about 9,000 years ago. An ancient arrowhead known as a Cascade point was embedded in his hip.

Multiple local tribes claimed ancestral affiliations to the remains under the Native American Graves and Repatriation Act. Ultimately, five tribes, including the Yakima, won the right to rebury the Ancient One's remains in 2017. However, first, scientists were granted the right to study the bones. They extracted DNA that showed that he was descended from lineages present exclusively in North America but related to the indigenous Ainu people of Japan. This suggested that his ancestors worked their way from the Pacific coast of Asia north to Beringia and then traversed along the land

bridge's shoreline, continuing in an arc south along the margins of the Pacific Northwest coast into what is now the continental US. His ancestors likely arrived close to 15,000 years ago. This supports mounting evidence that the peopling of the Americas was the result of multiple migrations over multiple routes over many thousands of years.

The oldest human remains found to date in North America are those of a baby boy identified as Anzick-1 who died some 12,600 years ago. He was coated with red ochre and buried with more than 100 Clovis-style tools on land ancestral to the Apsáalooke or Crow people. The remains were discovered in 1968 on the Anzick family farm in Montana, when the geneticist and cancer researcher Sarah Anzick was a child. In 2010, she collaborated with the Danish evolutionary geneticist Eske Willerslev. They found that Anzick-1 had descended from populations originating in Siberia but was most closely related to indigenous populations in Central and South America. In 2014, through collaboration with Crow tribal member Shane Doyle, the body of the child was reburied in an intertribal ceremony.

Reading

Nash, Stephen E., and Chip Colwell. "NAGPRA at 30: The Effects of Repatriation." *Annual Review of Anthropology* 49, no. 1 (2020): 225–239. https://doi.org/10.1146/annurev-anthro-010220-075435.

Owsley, Douglas W., and Richard L. Jantz, eds. *Kennewick Man: The Scientific Investigation of an Ancient American Skeleton*. College Station: Texas A&M University Press, 2014.

Raff, Jennifer. *Origin: A Genetic History of the Americas*. New York: Twelve, 2022.

Sandburn, Josh. "How the FBI Discovered a Real-Life Indiana Jones in, of All Places, Rural Indiana." *Vanity Fair*, October 19, 2021. https://www.vanityfair.com/style/2021/10/how-the-fbi-discovered-a-real-life-indiana-jones-in-indiana.

16
LIVING DANGEROUSLY AS THE LAST ICE AGE ENDED

The vast sheets of ice that once enveloped Earth's northern and southern poles and capped mountain ranges around the world began to melt by about 15,000 years ago. By this point, *Homo sapiens* had made it onto every continent except Antarctica. The planet was warming, sea levels rising, and landscapes changing. These new environmental conditions, and humans' adaptations to them, would set the stage for the later development and adoption of agriculture around the world. This lecture will discuss what caused the end of the last ice age and how archaeologists know exactly what happened across such vast distances of time and space.

Obliquity, Precession, and Eccentricity

The Pleistocene, which immediately precedes our current epoch of the Holocene, stretched from 2.6 million years ago to 11,700 years ago. Throughout the Pleistocene's long duration, Earth and its inhabitants experienced multiple glacial periods. These were interspersed with interstadials, where the ice began to recede before the climate cooled again. Warm interglacials also punctuated each ice age. These lasted thousands of years, though they themselves were briefly interrupted by stadials, which were not cold enough to be considered glacials.

Humans currently live in an interglacial. Based on orbital forcing, Earth should be heading into another ice age beginning a few thousand years from now. However, with atmospheric carbon dioxide levels rising to about 415 parts per million, double that of historical levels over the past several hundred years, we're headed toward climate conditions comparable to when australopithecines walked the earth 4 million years ago. Although Earth's atmosphere has been significantly altered by human activity in recent times, there are also several factors that influence the planet's climate over which we have no control. Solar radiation, which is the amount of light and heat that reaches Earth's surface, also known as insolation, has a significant impact on our climate.

Due to Earth's curvature, the poles receive less insolation per square kilometer than elsewhere on the planet's surface, while the equator receives the most insolation. As Earth orbits the sun, the tilt of its axis, or obliquity, remains the same, and this affects insolation. For instance, when the Northern Hemisphere is tilted toward the sun, it's summer for the Northern Hemisphere and winter for the Southern Hemisphere. Right now, Earth's obliquity is relatively stable at 23.5 degrees. However, this angle changes slightly in a recurring cycle across a 41,000-year period, traveling between a maximum of 24.5 degrees and a minimum of approximately 22 degrees. Earth was at its maximum tilt during the Pleistocene-Holocene transition. Summers then were much warmer than winters. That helped to bring us out of the ice age as more ice melted each spring.

Likewise, Earth's wobble as it spins on its axis, or its precession, also influences the magnitude of the seasons. When Earth is farthest from the sun amid its yearly orbit, i.e., at its aphelion, its precession can either strengthen or weaken seasonality, making summers warmer and winters colder. Precession shifts every 21,000 years. The Northern Hemisphere currently experiences summer at aphelion. However, during the last ice age, the Northern Hemisphere would have experienced winter at aphelion, and its precession would have made those winters more severe. The combination of long, extremely cold winters and cool summers helped create conditions for the era's sustained growth of polar ice sheets and mountain glaciers.

Distance from the sun is also a factor in seasonality. Thus, it bears mentioning that Earth's orbit—because it follows an elliptical path—also plays a role in the planet's glacial cycles. Sometimes, Earth is farther away from the sun during its northern winters, and sometimes, it is closer. The shape of Earth's orbit, or its eccentricity, follows a 100,000-year cycle.

These three cycles—obliquity, precession, and eccentricity—are collectively known as Milankovitch cycles, after the Serbian mathematician Milutin Milankovitch. During the early 20th century, Milankovitch theorized the existence of these cycles to explain the ice ages. In the 1970s, the marine oxygen isotope record showed that cyclical variation in Earth's ice volume and temperature corresponded with Milankovitch's calculations. The record has since been further supplemented with ice cores drilled in Greenland and Antarctica, providing additional evidence for the turbulent—and sometimes extreme—shifts in Earth's past climate. After the peak of the last ice age, summers became warmer, gradually melting the ice that had encapsulated the land for so long. The change in timing, duration, and average temperature of the seasons was central to this process.

The Bølling-Allerød Interstadial

Beginning around 15,000 years ago, the Bølling-Allerød interstadial was defined by an increased variety of temperate plant species and the expansion of deciduous forest across the Northern Hemisphere. This disturbed long-term ecological relationships between plants, animals, and people. The dry, cold plains of the tundra, previously populated by large animal herds,

were now replaced by shrubland and forest that made it logistically more difficult to hunt and obtain prey. Several species became functionally extinct, including giant elk (*Megaloceros*).

As the forests spread, they caused further warming to occur. This was due to albedo, which is the amount of solar radiation reflected by surfaces depending on their color. The dark surface of forested land absorbed more radiation than it reflected, lowering Earth's overall albedo and contributing to postglacial warming. As the ice began to build and the glaciers expanded, the white surface of the glaciers and tundra reflected even more sunlight, cooling the earth again. Then, the glaciers began to melt due to seasonality shifts caused by orbital forcing. As vegetation expanded, the growth of dark green forest helped to retain even more solar energy, further warming the earth.

These relationships are known as positive feedback loops: Deviations from the original state of the system are amplified, leading to new and modified relationships. For this to happen, a threshold often needs to be surpassed. In this case, the combination of warmer summers and increased albedo likely caused a tipping point, bringing Earth out of the last ice age. The average global temperature moved from 4.3°C colder than the 20th-century average to almost 1°C warmer, peaking about 8,000 years ago during the Holocene Climatic Optimum.

The Bølling-Allerød warming was punctuated by three century-scale cooling events. These events were possibly caused by changes in atmospheric circulation patterns as the ice melted in the North Atlantic. Even so, such cooling was minor compared to the abrupt cold snap of the Younger Dryas. This 1,000-year cool period occurred at the end of the Pleistocene and lasted from about 12,900 to 11,600 years ago.

The Younger Dryas

During the Younger Dryas, temperatures returned to near-glacial conditions, averaging in some areas about 5°C to 8°C below present in the summer and 10°C to 16°C below present in the winter. This was probably something of an idiosyncratic event that primarily affected the Northern Hemisphere, most likely caused by cold glacial meltwater from Lake Agassiz in Canada flowing into the Atlantic Ocean, disrupting atmospheric circulation patterns.

After the Younger Dryas, rapid sea level rise resumed. This occurred during the brief Preboreal phase of favorable climatic conditions, beginning 11,600 years ago, which also marks the formal start of the Holocene epoch. Sea level rise and more favorable climate conditions were then interrupted about 11,300 years ago by yet another short-lived period of cooling called the Preboreal oscillation. This lasted until about 11,000 years before present, when warmer conditions resumed.

The Boreal phase of the Holocene—11,000 to 9,000 years ago—is generally characterized by a shift to temperate climate. This is when the emergence and proliferation of early agriculture occurred. These conditions were close to modern ones, with warmer temperatures and distinct seasonal patterns. Deciduous and mixed forests proliferated throughout Europe. One of the most distinctive characteristics of this period is a continued rapid rise of sea levels, with global coastlines remaining dynamic until about 8,000 years ago. Archaeologists know less about the climate dynamics of the Southern Hemisphere, but it's likely that precipitation there was more affected than average temperatures and that previously arid regions would have become wetter.

The Marine Oxygen Isotope Curve and Cores

To determine what happened at the global level, the scientific community relies on a few key sources thought to represent global averages. For instance, the marine oxygen isotope curve was created by analyzing the stable oxygen isotopes from shells of foraminifera. These tiny shells are composed of calcium carbonate, which is formed of calcium, carbon, and oxygen. As they build their shells, the foraminifera incorporate the oxygen from the seawater around them. This is important because oxygen occurs in three forms, called isotopes, each with a slightly different molecular weight. Oxygen isotope ratios in water—the ratios of heavy to light oxygen—are affected by temperature and salinity. Glaciers at their utmost extent consisted of isotopically lighter H_2O. This created a denser, more saline ocean, which was enriched in the heavier isotopes that produce a more positive isotope ratio.

The oxygen isotope value of the ocean today is the standard against which all oxygen isotopes are measured; it has a ratio of 0. When glacial ice was at its maximum extent, the ratio was 1.5. When researchers analyze the isotopes of

the foraminifera shells, they see fluctuating values, reflecting the glacial and interglacial cycles across hundreds of thousands of years. This means that Milankovitch was right.

To obtain ancient foraminifera shells, archaeologists rely on cores, which are cylindrical samples of sediment recovered with special drills from the ocean floor or ice. They even analyze ancient air bubbles that formed when water froze. The Greenland ice cores help interpret what happened in the Northern Hemisphere. Antarctica tells researchers about the Southern Hemisphere, and the marine sediment cores reveal overall global changes. Ice core records from mountain glaciers offer insights at the continental scale.

Scientists can also use the muddy sediment from the bottoms of lakes. Lake Baikal in Siberia is the largest and deepest lake in the world. Sediment cores there have produced one of the longest continental-based paleoenvironmental records, reaching back more than 250,000 years. As each layer of mud originally settled into place, the remains of living organisms became embedded within it. This can tell researchers something about the conditions of the lake and its catchment.

From these layers, scientists can recover pollen from ancient plants; the fossils of single-celled algae known as diatoms; millimeter-sized "seed shrimp" called ostracods; and the head capsules of larval-stage, nonbiting midges. Each

proxy is responsive to different environmental pressures. Analyzing them can tell archaeologists about what was happening in their habitats when they were living organisms. Other measurements, such as the sediment's magnetic susceptibility and resistivity—meaning the degree to which it is attracted or repelled by a magnetic field—and its chemical composition, can also inform paleoenvironmental reconstructions.

Based on lake core records, researchers know that the Amazon rainforest did not yet exist during the last ice age. However, as the world warmed, forest began to develop in patches. The Younger Dryas cooling period produced about a 2°C drop in temperature in the area, likely causing the fledgling forest to contract. Then, forest cover expanded rapidly following the Younger Dryas around 11,000 years ago. That formed the basis for the abundant rainforest known today.

Reading

Lowe, J. J., S. O. Rasmussen, S. Björck, W. Z. Hoek, J. P. Steffensen, M. J. C. Walker, and Z. C. Yu. "Synchronisation of Palaeoenvironmental Events in the North Atlantic Region during the Last Termination: A Revised Protocol Recommended by the INTIMATE Group." *Quaternary Science Reviews* 27, no. 1–2 (2008): 6–17. https://doi.org/10.1016/j.quascirev.2007.09.016.

Norris, S. L., D. Garcia-Castellanos, J. D. Jansen, P. A. Carling, M. Margold, R. J. Woywitka, and D. G. Froese. "Catastrophic Drainage from the Northwestern Outlet of Glacial Lake Agassiz during the Younger Dryas." *Geophysical Research Letters* 48, no. 15 (2021): e2021GL093919. https://doi.org/10.1029/2021GL093919.

Rasmussen, S. O., K. K. Andersen, A. M. Svensson, J. P. Steffensen, B. M. Vinther, H. B. Clausen, M.-L. Siggaard-Andersen, et al. "A New Greenland Ice Core Chronology for the Last Glacial Termination." *Journal of Geophysical Research: Atmospheres* 111, no. D6 (2006). https://doi.org/10.1029/2005JD006079.

17
BREWING BEER AND BAKING BREAD IN THE LEVANT

About 15,000 years ago, people began to settle down and adopt certain aspects of sedentary agricultural lifestyles in the eastern Mediterranean area of present-day Lebanon, Syria, Iraq, Jordan, Israel, and Palestine. Today, this preagricultural period in the Levant is viewed as a phenomenon in its own right. The Natufian people who personified the late Epipaleolithic archaeological culture of the Levant collected grains that one day would become the cornerstone domestic crops of wheat and barley. Although the Natufians were principally foragers who hunted wild animals, they also kept domestic dogs and began to settle in small communities. This lecture covers whether these adaptations were the result of environmental stress or indications of plenty.

The Kebaran

Glaciation had little direct effect on the living environments of the Levant and Southwest Asia, which had mostly been cool and arid during the peak of the last ice age, lasting from about 30,000 to 20,000 years ago. As postglacial temperatures warmed and sea levels rose, this region flourished. The climate phase at the end of the Pleistocene epoch is known as the Bølling-Allerød. It lasted from about 15,000 to 13,000 years ago, in the middle of the Epipaleolithic archaeological period, which followed the Upper Paleolithic in the Levant and Southwest Asia. In the Near East, the tail end of the Epipaleolithic blurs into the Neolithic period, a time marked by the development of agricultural lifestyles.

The Epipaleolithic in the Levant can be divided into subperiods, each associated with distinctive stone tool industries: early (about 20,000 to 15,000 years ago), with Kebaran tools; middle (15,000 to 13,000 years ago), with Geometric Kebaran tools; and late (13,000 to 10,000 years ago), with the Natufian culture. However, the boundaries and definitions of these time periods blur around the edges. At some sites, the Natufian has been defined as early as 15,000 years ago, with new research and radiocarbon dates advancing understanding of this dynamic period.

Kebara Cave on Mount Carmel in what is now Israel is one site that archaeologists turn to again and again to gain insight into humanity's past. It was initially excavated in 1929 by British archaeologist Dorothy Garrod. Between 1929 and 1934, Garrod and her team completed 12 excavations in the area, including the famed sites of Tabun, El Wad, Skhūl, Shuqba, and Kebara Cave. Garrod defined the chronology of the region and coined the terms *Kebaran* and *Natufian*.

Kebara is perhaps most famous for its Neanderthal skeletal remains, several of which appear to have been intentionally buried. However, a new culture associated exclusively with *Homo sapiens* emerged in the layers dating to between about 20,000 and 14,500 years ago. Excavators unearthed tiny stone blades that had been retouched along one side to create a sharp edge, known as backed bladelets. These microliths were once affixed to wooden handles to create composite tools. During the more recent Geometric Kebaran period, the shapes of the tools changed. Geometric microliths were formed in the

shapes of trapeze, triangle, and lunate flakes and then hafted into saws and projectiles, such as harpoons and spears. In addition, the use of a bow and arrow at this time is suggested by the existence of small stone points.

Other regional sites also fall into the Kebaran cultural category. In fact, archaeologists start to see an increase in temporary settlements at some open-air sites in the region. These were likely camps, occupied part of the year as people moved seasonally, in small bands of about 25 to 50 people, seeking abundant food and other resources. The Ein Gev I site in Jordan is one of the few Kebaran sites that does demonstrate evidence of structures in the form of round huts that were partially sunk into the ground.

It's argued that some of the earliest indications of human record keeping were found at one of these open-air campsites, Ein Qashish South, in Israel. The evidence is in the form of three engraved limestone plaquettes that depict a bird, crosshatching, and a ladder. These symbols could have had something to do with keeping time or tracking the seasons. The engravings are from the Kebaran and Geometric Kebaran periods at the site. They suggest long-term cultural continuity in the region—on the order of millennia. Other evidence includes the fact that people living in the area consumed the same wild grains

that Natufians would later begin to cultivate. To process this wild wheat and barley, people turned again to limestone to create the mortars and pestles that are hallmarks of later Neolithic technology.

Relatively few human remains have been recovered from this period. One notable exception, dating to the earliest Kebaran, comes from the well-preserved site of Ohalo II. It's an extremely robust skeleton, with well-developed muscle attachments, of a tall male from the southwest shore of the Sea of Galilee. The features of this skeleton also appear in later populations dating to the Natufian, again suggesting continuity in this region between the end of the Paleolithic and the Neolithic.

The Natufian

When entering the Natufian, a shift occurs. This term, *Natufian*, describes not only a time period and a lithic industry but also the people who lived during it. In 1928, Garrod excavated Shuqba Cave on the margins of the Wadi en-Natuf. The stone tool assemblage was dominated by lunates, which are tiny, crescent-shaped geometric microliths. These had previously been documented in the European Mesolithic but never before encountered in the Near East. Thus, Garrod was the first to relate the Epipaleolithic and the Natufian in the Levant to the Mesolithic in Europe. She went on to excavate other sites in the area and found several more with Natufian layers.

As the Natufian period spans from as early as 15,000 years ago to as late as about 9,500 years ago, it includes the postglacial warming of the Bølling-Allerød and the rapid cooling of the Younger Dryas period from 12,900 to 11,600 years ago, which was likely a time of extreme aridity in the Near East. Subsequently, amid the warmer and wetter climate conditions of the early Holocene, Natufians were able to take advantage of a seasonal abundance of resources, collecting wild wheat and barley, legumes, almonds, and pistachios. Microliths were inserted into curved wooden handles to create sickles for cutting down tall grasses. The Natufians also hunted wild game and waterfowl, and they used fishhooks and harpoons made from animal bones to catch freshwater fish.

The Natufians used limestone quite a bit. In addition to figurative art representing humans and animals, they also produced ground-stone tools for processing grain. Evidence of the first bread comes from the site of Shubayqa 1 in the Black Desert of Jordan. In a layer dating to 14,400 years ago, well before evidence of grain domestication, 24 charred breadcrumbs were recovered from a hearth and painstakingly analyzed using SEM. The analysis revealed the texture of the ancient bread. The grain used to make it was winnowed, sieved, and milled to tiny particles under 2 millimeters in diameter. Based on the microscopic structure, it could have included wheat, rye, millet, oat, and possibly barley. The bread also contained the powdered root of the clubrush, or cattail. The original ingredients were mixed with water and baked on hot stones to produce the world's earliest flatbreads.

The Natufians also determined how to make beer. There is now evidence of early brewing at Raqefet Cave in Israel some 13,000 years ago. About 100 stone mortars up to 2 feet deep were carved into the cave floor and apparently used for food processing and storage. Stanford University archaeologist Li Liu employed a combination of residue analysis, microbotanical analysis, and use-wear to find evidence of wheat- and barley-based alcohol production at the site. The ancient brewery was situated among about 30 graves, some of them lined with ancient flowers and others containing animal bones: remains from funerary feasts. Some mortars carved into the bedrock there were directly associated with burials.

People began to settle down during the Natufian period, and that meant keeping their dead nearby. In life, they dug down into the earth to form the foundations of circular huts, the bottoms of which were lined with stone, with a hearth in the middle. Saws were used to cut down surrounding reeds and brush for the rest of the hut structure, which itself was supported with large posts. This is what is seen at the 'Ain Mallaha, or Eynan, site in Israel. It provides the earliest evidence of sedentary village life, predating agriculture. The people at 'Ain Mallaha lived on the shores of an ancient lake and stayed there year-round, in as many as 50 huts. This suggests a relatively sizable population.

During the initial occupation of 'Ain Mallaha, some huts measured up to 7 meters in diameter. Over time, the huts became smaller, by about half. When people living at 'Ain Mallaha died, they remained in place. Houses apparently

were seen as so important that their inhabitants were buried under the floor. A body was usually laid to rest in a flexed position (with its legs bent), adorned with shell or bone beads.

Another important finding was that many skeletons had dental caries, or cavities. This indicates that a high proportion of their diet consisted of grain. Several later burials showed the occurrence of a strange custom: the removal of the front teeth, or top incisors. This practice of dental avulsion was apparently also practiced at several other sites in the region, including Kebara Cave, and much further west in North Africa.

The Palegawra Cave

In Iraq and Iran, archaeologists are beginning to piece together more of the Epipaleolithic story. One example is the Palegawra cave site in the piedmont of the Zagros Mountains of Iraq, which was first dug in the early 1950s. It was excavated again in 2016 and 2017, by which time methodological approaches had advanced considerably. Radiocarbon dates from the later excavations reveal that the so-called Zarzian cultural period—previously thought to be equivalent to the Natufian further west—stretches back as far as the Kebaran, about 19,000 years ago.

Small groups likely used the Palegawra cave complex as a seasonal encampment across a period of about 6,000 years. They stayed for a few months at a time while hunting midsize to large herbivores and smaller animals. In addition, the rich riparian habitat nearby provided human inhabitants there with harvests of legumes, tubers, grasses, almonds, and pistachios.

There's little evidence that the open-air sites in Iraq's Zagros Mountains might have been used more intensively, even year-round, throughout the Epipaleolithic period. One possible exception is Zawi Chemi Shanidar, a village site outside Shanidar Cave. However, it currently lacks definitive radiocarbon dates.

Reading

Asouti, Eleni, Douglas Baird, Ceren Kabukcu, Kate Swinson, Louise Martin, Aroa García-Suárez, Emma Jenkins, and Kamal Rasheed. "The Zagros Epipalaeolithic Revisited: New Excavations and 14C Dates from Palegawra Cave in Iraqi Kurdistan." *PLOS ONE* 15, no. 9 (2020): e0239564. https://doi.org/10.1371/journal.pone.0239564.

Smith, Pamela Jane. "Dorothy Garrod, First Woman Professor at Cambridge." *Antiquity* 74, no. 283 (2000): 131–136. https://doi.org/10.1017/S0003598X00066230.

Yaroshevich, Alla, Ofer Bar-Yosef, Elisabeta Boaretto, Valentina Caracuta, Noam Greenbaum, Naomi Porat, and Joel Roskin. "A Unique Assemblage of Engraved Plaquettes from Ein Qashish South, Jezreel Valley, Israel: Figurative and Non-Figurative Symbols of Late Pleistocene Hunters-Gatherers in the Levant." *PLOS ONE* 11, no. 8 (2016): e0160687. https://doi.org/10.1371/journal.pone.0160687.

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THE HUNTER-GATHERERS BEGIN TO SETTLE DOWN

The glaciers began to melt following the peak of the ice age around 20,000 years ago. Over the next few thousand years, the landscape became extremely dynamic. Large river systems drained into the sea. Animal herds had to relocate to survive. People took refuge on the Iberian and Italian Peninsulas and in the southern Balkans. With the beginning of the Holocene epoch 11,700 years ago, people began to move back into the northernmost reaches of Europe. This coincided with the archaeological period of the Mesolithic, which occurred between the Paleolithic, with highly mobile hunter-gatherers, and the Neolithic, with sedentary agriculturalists. Thus, as you will see in this lecture, the Mesolithic was a transitional period characterized by varying degrees of mobility, dietary change, and the presence of versatile microlithic stone tools.

Cultures of the Mesolithic

Much of Europe was a patchwork of sites and cultures during the Mesolithic. The Maglemosian culture of the early Mesolithic stretched across much of northwestern Europe (from about 11,000 to 9,000 years ago). The Mesolithic archaeological site of Star Carr in North Yorkshire, Britain, attests to the existence of hunter-gatherers who used the site in spring and summer. They built wooden huts and platforms and created ornate masks from the skulls and antlers of elk stags.

While hunter-gatherers were resettling the British Isles 11,000 years ago and early agriculturalists were domesticating plants and animals in the Near East, the northern reaches of Europe and Scandinavia were not yet free of ice. The Mesolithic period in Scandinavia therefore began some 2,000 years later than elsewhere in Europe, around 9,000 years ago, and lasted until the Neolithic arrived about 4,000 years ago. During the 20th century, discoveries dredged from the bottom of the North Sea revealed well-preserved remnants of a people who had lived in Doggerland, which connected the British Isles to the European continent. Discoveries included the distinctive late Mesolithic Ertebølle culture, in which people were known for hunting, gathering, fishing, and using pottery by about 7,000 years ago.

In contrast, the Mesolithic age began much earlier to the south—along the margins of the Mediterranean—where the landscape remained largely habitable. Named after the French site of Mas-d'Azil, the Azilian tool tradition of southern France and northern Spain dates from about 12,000 to 10,000 years ago. These tools include short blades, double-pointed blades, clawlike scrapers, and flat harpoons made from antler bone.

Even further south, the site of Franchthi Cave in Greece was used almost continuously from the end of the last ice age in the late Pleistocene right through the Holocene. Backed by limestone hills and looking out onto a coastal plain, the environment around the cave evolved substantially from 15,000 to 9,000 years ago, as the sea level rose in the immediate vicinity. This created marsh and shrubland where previously there had been open plains.

The Broad Spectrum Revolution

At Franchthi Cave, by the early Holocene around 11,000 years ago, there was a shift in local wildlife (and the local diet) from wild ass and aurochs, which preferred more open environments, to species such as elk and wild boar, which prefer woods. Smaller game also began to enter the diet. Plant remains from this time include wild lentils, pistachios, and almonds. By about 10,000 years ago, human inhabitants at Franchthi Cave began to fish for deepwater species, based on bones found at the site. The appearance of seafood was likely the result of a decrease in terrestrial prey as sea levels rose.

The human exploitation of multiple food sources was part of a "Broad Spectrum Revolution" in diet that laid the groundwork for what would be another revolution: agriculture. There was a shift away from the targeted hunting of large-body ungulate species that had dominated the diet during the late Upper Paleolithic. As the world began to warm and vegetation changed, people turned to new dietary options instead of following their food across the landscape. Large ungulates remained part of the diet but no longer contributed 80% to 90% of the animal bones excavated in a given layer.

The increased dietary breadth of human populations at this time has often been cited as an adaptation to scarcity. Moreover, there were notable decreases in efficiency as people expanded their palate. It theoretically takes more effort to capture fast, small game (e.g., a hare) than slow, small game (e.g., a tortoise). Both provide fewer calories than elk, which might cost more energy to hunt but yield more in return. Still, the ability of our ancient relatives to plan, use traps, divide labor, and consider the utility of their prey in providing not only calories but also goods should not be underestimated. Tortoise shells were valued as containers, and hare bones were used in tool manufacture.

Snails are one low-cost food item that seemed to flourish as part of the Broad Spectrum Revolution in the Mesolithic. At least 30 archaeological sites from the late Pleistocene and early Holocene periods have yielded abundant deposits of snail shells. Some argue that the snails occurred naturally and represent remains accumulated over hundreds of years. Wetter conditions probably meant that the snail population size also increased. However, most snails found in archaeological contexts are large enough to eat. In a naturally

occurring population, you might expect to see more variation in shell size. Moreover, many specimens show signs of having been cracked open and burnt, suggesting they were, indeed, a food item.

In the North African Maghreb, five different species of snail are commonly found at archaeological sites and associated with other food remains, such as aurochs. It's been suggested that snails might have been the earliest domesticated animals. Sea snails, mussels, clams, and cockles also appear at various Mesolithic archaeological sites. Massive mounds of discarded seashells are a distinctive Mesolithic archaeological feature along the margins of the Atlantic coast.

Generally speaking, however, evidence of fishing in the archaeological record is quite slim. Fishnets were made from organic materials that did not preserve, and weights for the nets were probably usually undiagnostic stones. Moreover, fish bones are few and far between at archaeological sites. Prior to more contemporary scientific methods of excavation, they were often missed because of their small size.

Nugljanska Cave

By about 9,500 years ago, hunter-gatherer-fishers were beginning to live in open-air settlements along the Iron Gate gorge of the Danube River, taking advantage of the abundant local resources. In Serbia, at Lepenski Vir, people built trapezoidal structures to live in and plastered their floors with a hardened mixture of clay, ash, and dung. They buried the dead under their floors and made microlithic stone tools. However, they did not practice agriculture until it arrived from the south a few thousand years later.

The Mesolithic Iron Gate region was a somewhat isolated area. In the rest of the Balkans, most Mesolithic sites tend to be cave sites located along the Adriatic coast, such as Nugljanska Cave, at the head of the Adriatic Sea in Istria, Croatia. Located in the uplands of the Ćićarija Mountains, it represents one of the earliest examples of people returning to higher elevations after deglaciation nearly 15,000 years ago.

As the glaciers receded further north, people appear to have used Nugljanska Cave as an outpost for monitoring migratory elk during certain times of the year. Then came the Younger Dryas period, a temporary return to glacial conditions, between 12,900 and 11,600 years ago. There was a notable gap in occupation of Nugljanska Cave and many other sites in the region during this period. No one came back for 3,000 years. When people finally did return about 9,400 years ago, they used the site as a residential base camp. They employed microlithic stone tools to hunt a broad spectrum of prey, including elk, ibex, and wild boar. They might have also consumed land snails. The appearance of marine shells suggests they also traveled west to meet the rising sea.

Marine Resources

To help answer the question of how much seafood Mesolithic people ate, researchers can analyze stable isotope values locked in human bone. Someone who eats fish will have noticeably higher nitrogen-stable isotope ratios than someone who does not. However, someone who eats plenty of meat will also have higher values than a vegetarian. How do researchers tell them apart? Carbon ratios (of carbon-13 to carbon-12) will also be more positive in someone who eats plenty of marine fish and more negative in someone who doesn't.

One example comes from a rare Mesolithic burial that was recently published by a team of researchers led by American archaeologist Jamie Hodgkins. A baby girl was buried in the cave of Arma Veirana in Liguria, Italy, about 10,000 years ago. Her grave was adorned with ornamental *Columbella* shells, some of which appeared to have been sewn into a garment. This study gained traction because of the care and personhood ascribed to such a young infant. Researchers carried out stable isotope analysis on the remains. The results show that her mother was consuming primarily terrestrial protein—despite the cave being located approximately 10 miles from the coast. This is similar to what is seen at Mesolithic sites along the Adriatic coast.

For years, debate has raged as to the nature of the transition from the Mesolithic period to the Neolithic in Europe. Isotope analysis of human remains from the Mesolithic and Neolithic in Europe reveals that there was a stark contrast in diet between the two periods. Mesolithic human remains

generally have positive isotopic ratios, reinforcing the interpretation of a marine-inclusive diet. However, by 6,000 years ago, Neolithic human remains indicate that their diet was heavily terrestrial.

Reading

Asouti, Eleni, Maria Ntinou, and Ceren Kabukcu. "The Impact of Environmental Change on Palaeolithic and Mesolithic Plant Use and the Transition to Agriculture at Franchthi Cave, Greece." *PLOS ONE* 13, no. 11 (2018): e0207805. https://doi.org/10.1371/journal.pone.0207805.

Hodgkins, Jamie, Caley M. Orr, Claudine Gravel-Miguel, Julien Riel-Salvatore, Christopher E. Miller, Luca Bondioli, Alessia Nava, et al. "An Infant Burial from Arma Veirana in Northwestern Italy Provides Insights into Funerary Practices and Female Personhood in Early Mesolithic Europe." *Scientific Reports* 11, no. 1 (2021): 23735. https://doi.org/10.1038/s41598-021-02804-z.

Pilaar Birch, Suzanne E., and Preston Miracle. "Subsistence Continuity, Change, and Environmental Adaptation at the Site of Nugljanska, Istria, Croatia." *Environmental Archaeology* 20, no. 1 (2015): 30–40. https://doi.org/10.1179/1749631414Y.0000000051.

Zeder, Melinda A. "The Broad Spectrum Revolution at 40: Resource Diversity, Intensification, and an Alternative to Optimal Foraging Explanations." *Journal of Anthropological Archaeology* 31, no. 3 (2012): 241–264. https://doi.org/10.1016/j.jaa.2012.03.003.

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SECRETS OF CAVE ART, CERAMICS, AND CATTLE

During the Epipaleolithic and Mesolithic, recent additions to the archaeological record suggest that people were making bread and brewing beer with wild grains before domestic grains existed. Moreover, hunter-gatherers were using pottery and living in year-round settlements. These findings reveal more nuanced lifeways during this period than were previously known. As you will see in this lecture, the narrative about life in North Africa has shifted as well. There is now evidence of microlithic tool technology and the use of marine resources during this time. Moreover, it seems that pottery might have originated earlier in North Africa than anywhere else.

Haua Fteah

Along the Mediterranean coast of North Africa, the Haua Fteah cave site in the Cyrenaica region of Libya dominates both the landscape and the archaeological narrative. It contains archaeological deposits some 14 meters deep. More recent excavations reveal that humans first lived there close to 150,000 years ago, not long after *Homo sapiens* emerged in eastern Africa. The long time span means that the cave contains archaeological materials from the Middle Paleolithic period right through ancient Rome.

As a starting point, it contains archaeological evidence of a stone tool technology known as the Dabban from throughout the late Upper Paleolithic period, 40,000 to 15,000 years ago. After that time, from about 15,000 to 10,000 years ago, researchers see the emergence of a different type of technology, known as the Iberomaurusian. During the Iberomaurusian in North Africa, microliths came to dominate the assemblage, specifically bladelets produced using a microburin technique. This is a mode of production in which small blades are notched and snapped off from a larger stone blade, leaving a discarded waste product known as a burin. Evidence of a broad-spectrum diet of mammals, intertidal mollusks, and land snails was also found in the Iberomaurusian layers at Haua Fteah, signifying a shift from an earlier focus on bovines.

Other Iberomaurusian sites have been found in Morocco, Algeria, and Tunisia, pushing back the starting date for this period to about 22,000 years before present, lasting until about 10,000 years ago. This timing coincides with the duration of the Epipaleolithic in the Levant and Near East. The microlithic stone tools and broad-spectrum diet of the North African Iberomaurusian were also distinctive features of the Kebaran and Natufian phases of the Epipaleolithic in the Levant. This contemporaneity suggests that they may have been somehow connected despite their geographic distance.

Dental Evulsion

The human skeletal record also supports population and cultural exchanges between western North Africa and the Levant throughout this period. The people who lived in the Maghreb during this time practiced dental evulsion, which is the deliberate removal of a healthy tooth. The earliest example of this practice comes from the Taza archaeological site in Morocco. A skull belonging to a small female shows that her two front teeth were deliberately removed while she was still alive. Based on radiocarbon dates, she lived anywhere between 22,000 and 15,000 years ago.

Additional sites show that this practice was quite widespread. Almost every one of the 46 skulls discovered at one of the world's earliest known cemeteries—in the cave of Taforalt (or Grotte des Pigeons), Morocco—had at least one of the top front incisors removed and frequently both. The discoveries at Taforalt date to between 12,000 and 15,000 years ago. Likewise, at the Afalou cemetery in Algeria, which is thought to be about 13,000 years old, all but one of the skulls had at least one tooth removed.

Was this an individual rite of passage that took place at puberty? If so, why did some individuals have only one tooth pulled instead of two? The dental anthropologists Isabelle De Groote at Ghent University in Belgium and Louise Humphrey of the Natural History Museum in London say that based on signs of healing in the tooth sockets, there is no evidence to support the teeth having been pulled prior to puberty. Moreover, there does not appear to be a pattern as to whether pairs of teeth were removed simultaneously or months apart. No gender-related patterns emerged among men and women either.

Regardless, it appears to have been a common practice in North Africa between 15,000 and 10,000 years ago. However, it also occurred in the Levant between about 13,000 and 11,500 years ago, during the Late Natufian, at various sites, including Nahal Oren. It also appears to have spread to the Sahara by about 9,500. The archaeological evidence suggests there was likely significant population exchange between these regions during the late Pleistocene epoch. Genetic analysis has supported this argument. However, whereas the defining characteristics of the Neolithic cultural period—plant and animal domestication and the production of ground-stone tools and ceramics—began in the Levant nearly 12,000 years ago, it seems that these elements did not coalesce in North Africa until closer to 6,000 years ago.

The Capsian

Chronologically, the time period between the Iberomaurusian and the Neolithic in North Africa is known as the Capsian. It spanned from about 9,500 years ago to about 5,000 years ago. During this time, humans began to occupy small open-air sites on a seasonal basis along the Mediterranean coast of North Africa. During the Capsian period in North Africa, as during the Mesolithic in Europe, people began to adopt certain elements of the Neolithic lifestyle well before the accepted temporal onset of the Neolithic cultural period. During the Capsian at Haua Fteah, for example, microliths co-occur with pottery between 10,000 and 7,000 years ago.

The climate of northern Africa would have been much wetter then than it is today. In fact, from about the time of deglaciation around 15,000 years ago, the precession of Earth's axis affected the latitude and strength of the yearly monsoon season in North Africa. This occurred from about 11,000 to 5,000 years ago and is known as the African Humid Period, or Green Sahara.

Today, the Sahara is the largest hot desert in the world, known for its staggeringly hostile terrain. However, during the African Humid Period, it would have been a much more habitable mosaic of tropical savannah and grassland, dotted with numerous lakes. Today, a growing number of archaeological sites throughout the Sahara provide additional evidence that more favorable climatic conditions for humans once characterized the region.

The Cave of Swimmers, which is found in a valley of the Gilf el-Kebir plateau in the Libyan desert, features ancient wall paintings on the face of a rock shelter known as Wadi Sura I. These paintings are believed to be between 8,000 and 10,000 years old. They depict several human figures, some with arms and legs spread, as if floating or swimming. Perhaps even more impressive is the nearby rock shelter Wadi Sura II, or the Cave of Beasts. About 8,000 figures and impressions are displayed here, including close to 900 human hand stencils. About a dozen of them are incredibly tiny. Initially, these hand stencils were interpreted as having been made by newborn infants. However, a subsequent study demonstrated that the hands of a modern infant were too large to be used in them. Instead, it's now believed that the people at Wadi Sura II stenciled the paw of a reptile—likely the forelimb of a monitor lizard found in the region, known as a varan.

Early African Ceramics

Evidence for the earliest ceramics in Africa—dating to more than 11,400 years ago—has been found in Mali's Ounjougou region located in the Ravin de la Mouche. This site does not represent a place where people lived. Instead, a high-energy river system once flowed through it, depositing coarse sand and gravel atop redeposited archaeological material. Three fire-hardened pieces of ceramic recovered there, along with nearly 500 stone tools, were buried naturally at least 11,400 years ago, according to radiocarbon dates.

The recovered tools include small bifaces. The authors of a supporting study attest that the artifacts found at Ravin de la Mouche do not appear to be waterworn, suggesting they were transported only a short distance. One of the ceramic pieces is curved, as if from a bowl. The other two are negligible in size. Small-grain grasses flourished across the lush Sahel at this time. From this scant evidence, the authors hypothesize that the ceramics were perhaps used to boil these wild grains.

The adjacent site of Ravin du Hibou, also in Ounjougou, has yielded seven highly fragmented ceramic shards tempered with quartz. Two of the shards display decorative impressions and are dated to at least 10,000 years old. Taken together, these two discoveries suggest that there was an early, independent origin of ceramic technology in this region. Various other

archaeological sites in the Sahara have yielded microlithic stone tools, rock art, and ceramics dating to between 11,600 and 5,000 years ago, though evidence for ceramic production remains elusive.

Possible Bovine Domestication

Some archaeologists claim that they have found evidence of domestic cattle. Numerous ancient rock art sites across the central Sahara attest to the importance of cattle in this part of the world. Bovines appear repeatedly in the art, with some of them showing the act of milking. However, secure dates for the art are unavailable. The earliest evidence of dairying in Africa comes from the rock shelter of Takarkori in southwest Libya. Here, potsherds dating to between 7,200 and 5,800 years ago were analyzed using gas chromatography to detect lipids absorbed into the microscopic pores of the ceramic material when it was used to store milk thousands of years ago. If people were milking cattle by about 7,000 years ago, the animals were likely domesticated even earlier.

A monograph from excavations in 1979 and 1980 at the Bir Kiseiba site in southern Egypt was titled "Cattle-Keepers of the Eastern Sahara." The site is interpreted as a seasonal encampment area that dates to between 10,000 and 6,700 years ago. About 20 fragmented bones from a large bovid were recovered there, leading excavators to argue that the people at Bir Kiseiba were herding cows. However, the remains of ground squirrels, hare, gazelle, and even elephants were found at the site along with the bovid bones. The cattle bones were too fragmentary to be analyzed based on their shape. However, a later study suggests that they are more likely *Bos primigenius*—i.e., aurochs—based on their size and some limited mitochondrial DNA evidence. There is no proof that they were tame.

Reading

Dunne, Julie, Richard P. Evershed, Mélanie Salque, Lucy Cramp, Silvia Bruni, Kathleen Ryan, Stefano Biagetti, and Savino di Lernia. "First Dairying in Green Saharan Africa in the Fifth Millennium BC." *Nature* 486, no. 7403 (2012): 390–394. https://doi.org/10.1038/nature11186.

Honoré, Emmanuelle, Thameur Rakza, Brigitte Senut, Philippe Deruelle, and Emmanuelle Pouydebat. "First Identification of Non-Human Stencil Hands at Wadi Sūra II (Egypt): A Morphometric Study for New Insights into Rock Art Symbolism." *Journal of Archaeological Science: Reports* 6 (April 2016): 242–247. https://doi.org/10.1016/j.jasrep.2016.02.014.

Huysecom, E., M. Rasse, L. Lespez, K. Neumann, A. Fahmy, A. Ballouche, S. Ozainne, M. Maggetti, Ch. Tribolo, and S. Soriano. "The Emergence of Pottery in Africa during the Tenth Millennium Cal BC: New Evidence from Ounjougou (Mali)." *Antiquity* 83, no. 322 (2009): 905–917. https://doi.org/10.1017/S0003598X00099245.

Williams, Martin. *When the Sahara Was Green: How Our Greatest Desert Came to Be*. Princeton, NJ: Princeton University Press, 2021.

20 WAS AGRICULTURE A REVOLUTION OR AN ACCIDENT?

Agriculture has historically been framed as a revolution. However, its emergence was the result of thousands of years of process. After the end of the last ice age, changes in global climate and environmental conditions made possible an evolution in the way humans obtained food. Humanity had long survived by adapting to diverse environments, but no adaptation was like the development of agriculture. It changed people's relationship with the natural world for millennia to come. This lecture will show how the transformation spanned the first steps of domestication of plants and animals to later, full-blown agricultural economies.

The Path to Sedentism

The concept of agriculture itself became tied up in the advent of ground-stone tool technology, the development of pottery, and the appearance of sedentism during the Neolithic period. Archaeologists refer to this combination as the Neolithic package. Ground-stone tools include such implements as axes and adzes that can be used to clear land or hoe. Creating these tools was more labor-intensive than knapping a hand axe or blade. To start, a hammerstone was used to peck away at the edges of the stone to create an initial shape. Then, the edge would be polished and sharpened by grinding it against another rock or using some combination of grit, sand, and water.

Likewise, mortars and pestles were used to grind the grain that was produced in early fields. A round rock and flat surface could be used in combination to produce the desired effect. To store the grain and cook it, people needed containers of varying sizes. From the early to late Neolithic, the number and diversity of ceramic vessels increased exponentially. Pots could be created by coiling the clay like a rope, forming it inside an existing basket, or molding it via a combination of wooden paddles and hands. The clay might be tempered with crushed seashells, plant material, gravel, or sand. It was then dried and fired in open-air hearths at temperatures of around 600°F.

After you'd cleared the land, grown the grain, and manufactured your ground-stone tools and ceramics, you might not want to pick up and move again. Your dwellings would become more permanent. With improved nutrition, your reproductive rate would begin to increase. Settlements would become larger, and the demand for resources would grow.

In the last few decades, new evidence about the emergence of agricultural lifestyles makes clear that the phenomenon of domestication was occurring independently around the world, with or without the accompanying Neolithic cultural definition. As a result, one might ask whether the concept of the Neolithic—and indeed, an agricultural or Neolithic revolution—is useful at all anymore. Many archaeologists have even stopped using the term *revolution*.

To Label or Not to Label

Today, even if researchers know that the concept of a Neolithic revolution is wrong—i.e., that there are exceptions to it and that it was a process millennia in the making—they are still somehow bound to it. Therefore, pre-Neolithic archaeological layers at some sites in the Levant and Near East are even referred to as Pre-Pottery Neolithic A, B, and C. In other words, the layers are defined by what is not present: fired clay vessels. However, other elements of the Neolithic package are found at these sites, including communities of 50 to 100 people who settled in semisubterranean huts; cultivated wheat, barley, and lentils; and husbanded livestock. Moreover, polished and ground-stone tools were the dominant technology, though blades and bladelets still appeared.

The Pre-Pottery Neolithic designation grew out of the dogma of a three-age system: the Stone Age, the Bronze Age, and the Iron Age, as coined originally by Christian Jürgensen Thomsen, a Danish antiquarian who was head of the National Museum of Denmark. Later, the British nobleman and scientist John Lubbock subdivided the Stone Age into the Paleolithic, Mesolithic, and Neolithic. These periods became further segmented. In addition to the Pre-Pottery Neolithic A, B, and C, there is the early, middle, and late Neolithic. Some sites even have what is known as the E ("end") Neolithic. It's sometimes followed by a Copper Age or Chalcolithic, which is thought to be a transitional period between the Neolithic and the Bronze Age. However, in reality, most things exist on continuums, including human subsistence and economies.

Researchers need labels to categorize these long-term processes. However, by adhering to these labels, archaeologists risk overlooking the astonishing variety of lifeways in existence throughout the human past worldwide. Some of these lifestyles extended into the modern era and even the present day.

What Did Agriculture Look Like Worldwide?

Sedentary agriculturalist production is but one of many strategies in the human repertoire of survival. However, it has gained inordinate representation historically and archaeologically, as agriculturalists came to colonize the

globe. Beginning around 12,000 years ago, people living in the Fertile Crescent—today's Iraq and surrounding areas—domesticated emmer and einkorn wheat, barley, cotton, chickpeas, and fig trees, along with sheep, goats, cattle, and pigs.

Less talked about is what the dawn of agriculture looked like across the rest of the world during the first half of the Holocene epoch, from about 11,000 to 5,000 years ago. In present-day China, for instance, there is evidence during this time for domestication of the chicken and crops such as rice, foxtail and broomcorn millet, the bottle gourd, water chestnut, and burdock. The Neolithic Dadiwan culture existed across central China's Gansu and Shaanxi provinces from about 8,000 to 5,000 years ago. The remains of domestic dogs and pigs and domesticated millet were recovered from the Dadiwan archaeological site in Gansu, as were wild deer, which humans likely still hunted for food. Geochemical analysis of the dog bones indicates the dogs ate the same millet that people did, likely in the form of meal scraps.

The Dadiwan site became the namesake of the Dadiwan culture, which is distinguished by cord-marked ceramics. These distinctive vessels are formed by pressing wood paddles wrapped in cords across the outside of a clay pot

or bowl to create thin walls, producing a lightweight container. This method results in a distinctive pattern on the pot or bowl itself. Though Dadiwan represents the early Neolithic in China, the earliest evidence for ground-stone tools in China is much older yet. Sites from as early as 23,000 years ago—roughly contemporaneous with the earliest Epipaleolithic in the Levant—have yielded grinding stones that would have been used to process wild cereals.

The highlands of Papua New Guinea have emerged as another independent center of early plant domestication. Geomorphology was used to reconstruct deforestation and erosion rates in the Papua New Guinea highlands. The results of this research were used to argue that people were clearing the land and cultivating crops there as early as 7,000 years ago. To grow sugarcane, bananas, and taro root, people dug pits and drainage ditches and constructed levees and circular mounds. However, other aspects of the traditional Neolithic package do not appear in Papua New Guinea until much later. For example, there is limited evidence for sedentism there at this time. The earliest dates for postholes thought to be associated with a permanent structure are from about 4,000 years ago. Moreover, pottery and pigs did not arrive from Polynesia until about 3,000 years ago.

What about the Americas? People in parts of South America domesticated various crops beginning at least 10,000 years ago. In the Zaña Valley of Peru, there is evidence of permanent settlements—small, stone-lined circular structures——between 10,000 and 7,000 years old. By about 8,000 years ago, agricultural cultivation included maize, potatoes, beans, cassava, cotton, and the bottle gourd. As early as about 6,000 years ago, llamas, alpacas, and guinea pigs were domesticated in Peru. However, several South American sites yielding evidence of domestic crop production are rock shelters and small open-air sites. Additionally, despite these early dates for domesticated crops, there's no accompanying pottery associated with the origins of agriculture.

In Central America, in a cave in the Mexican state of Oaxaca, there is evidence of the independent domestication of maize, squash, arrowroot, and beans. By measuring the stalks of plant remains at Guilá Naquitz, researchers could trace the increased sizes that accompanied the domestication process. Animal bones there included deer, rabbits, and a variety of birds. No domestic animals or ceramics were found, however. In North America, some domesticated

staple crops included sunflower, squash, goosefoot, and sumpweed or marsh elder. Physical archaeological evidence and genetics place the timing of the domestication of these crops at between 4,000 and 3,000 years ago.

In Africa, the question of plant domestication and Neolithic cultural development remains to be further investigated. DNA analysis suggests that domestic cattle originated in the Near East and bred with wild aurochs in the Sahel around 6,000 years ago, complicating their genetic profile. The presence of pottery and ground-stone tools coincides with this timing, suggesting that Neolithic culture was imported into the sub-Saharan region. However, many people of the Sahel also lacked the Neolithic attribute of sedentism. Instead, they practiced mobile pastoralism.

Some pottery has been found to predate the arrival of the cattle in the region, with evidence for independent development in Mali stretching back as early as 11,000 years ago. This is potentially related to the consumption of wild grains. Here, again, the story is complicated. The antiquity of the relationship between people and wild grains can be evaluated using multiple lines of evidence, including ancient dental calculus, or plaque. A recent study applied this technique to show that some people living along the Danube in the central Balkans were intensively processing and consuming wild grains as early as 11,500 years ago—thousands of years before agriculture arrived in the region.

Reading

Jones, Martin, Harriet Hunt, Emma Lightfoot, Diane Lister, Xinyi Liu, and Giedre Motuzaite-Matuzeviciute. "Food Globalization in Prehistory." *World Archaeology* 43, no. 4 (2011): 665–675. https://doi.org/10.1080/00438243.2011.624764.

Marston, John M. "Archaeological Approaches to Agricultural Economies." *Journal of Archaeological Research* 29, no. 3 (2021): 327–385. https://doi.org/10.1007/s10814-020-09150-0.

Piperno, Dolores R. "The Origins of Plant Cultivation and Domestication in the New World Tropics: Patterns, Process, and New Developments." *Current Anthropology* 52, no. S4 (2011): S453–S470. https://doi.org/10.1086/659998.

Zeder, Melinda A. "The Origins of Agriculture in the Near East." *Current Anthropology* 52, no. S4 (2011): S221–S235. https://doi.org/10.1086/659307.

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