Human evolution and migrations

Early stone tools spread more widely (January 2019)

The rift systems of Ethiopia, Kenya and Tanzania, and the limestone caverns near Johannesburg, South Africa have a long history of intensive archaeological study, rewarded by many finds of hominin skeletal remains and artifacts over the last century. Each region lays claim to be the birthplace of humans, that in South Africa being grandiloquently dubbed 'The Cradle of Humankind'. Of course, the realistic chances of making discoveries and careers draws scientists and funds back to these regions again and again: a kind of self-fulfilling prophesy fueled by the old miners' adage, 'to find elephants you must go to elephant country'. The key site for the earliest stone tools was for a long time Tanzania's Olduvai Gorge, thanks to finds of deliberately shaped choppers, hammer stones and sharp edges from about 2 Ma ago in close association with remains of *Homo habilis* by the Leakeys. Termed 'Oldowan', signs of this industry emerged from 2.6 Ma sediments in the Afar Depression of Ethiopia in 2010, but with no sign of who had made them. By 2015 the cachet of 'first tools' moved to Lomekwi on the shore of Lake Turkana in Kenya, dated to 3.3 Ma but again with no evidence for a maker. In fact the oldest evidence for the *use* of tools emerged with the 2010 controversial discovery at Dikika in Afar of 3.4 Ma old bones that carry cut marks, but no sign of tools nor whoever had used them. However remains of *Australopithecus afarensis* occur only a few kilometres away.

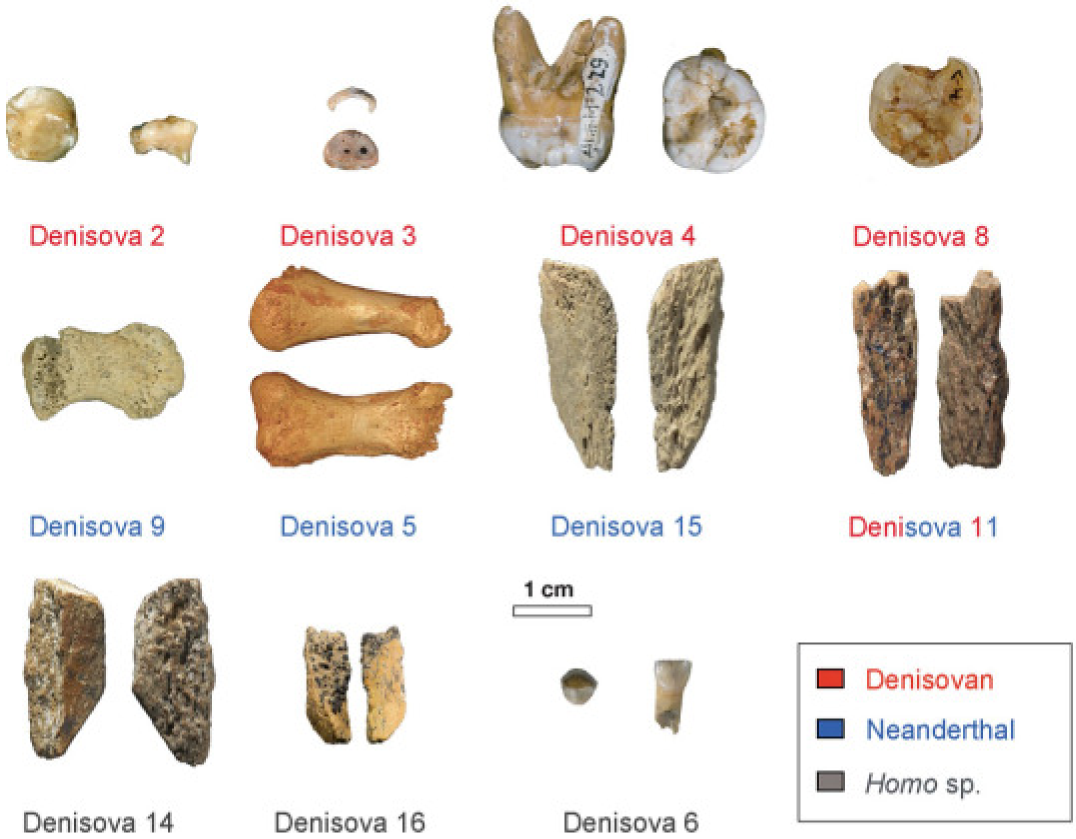
Excavations outside the East African Rift System and South Africa are still few and far between, especially from before 1 Ma. The High Plateaus of eastern Algeria include one ancient site, near Ain Hanech, which yielded 1.8 Ma Oldowan stone artifacts as long ago as 1992. A nearby site at Ain Boucherit takes the North African record back to 2.4 Ma with both Oldowan tools and cut-marked bones of horse and antelope (Sahnouni, M. and 12 others 2018. 1.9-million- and 2.4-million-year-old artifacts and stone tool–cutmarked bones of from Ain Boucherit, Algeria. *Science*, v. **362**, p. 1297-1301; DOI: 10.1126/science.aau0008). Tool makers had clearly diffused across what is now the Sahara Desert by that time. Given the distance between the Lomekwi and Dikika sites in East Africa that is hardly a surprise, provided climatic conditions were favourable. Michel Brunet's discovery in 3.3 Ma old sediments of an australopithecine (*Au. bahrelghazali*) in central Chad demonstrates that early hominins were quite capable of spreading across the African continent. Yet, to wean palaeoanthropologists and their sponsors from hitherto fruitful, 'elephant' areas to a more 'blue skies' approach is likely to be difficult. There are plenty of sedimentary basins in Africa that preserve Miocene to Recent sediments that may yet turn up fossils and artifacts that take the science of human origins and peregrinations further and possibly in unexpected taxonomic directions

Related article: Gibbons, A. 2018. Strongest evidence of early humans butchering animals discovered in North Africa. *Science* News online; doi:10.1126/science.aaw2245.

***A stratigraphic timeline for the Denisova Cave* (February 2019)**

Denisova Cave was named to commemorate an 18th century hermit called Denis, who used it as his refuge. The culmination of more than four decades of excavation, which followed the discovery there of Mousterian and Levallois tools there, has been the explosion onto the palaeoanthropological scene of Denisovan genomics, beginning in 2010 with sequenced DNA from a child's finger bone. The same layer yielded Neanderthal DNA from a toe bone in 2013. Another layer yielded similar evidence in 2018 of an individual who had a Neanderthal father and a Denisovan mother. Application of the new technique of peptide mass fingerprinting, or zooarchaeology by mass spectrometry (ZooMS), to small, unidentifiable bone fragments from the cave sediments revealed further signs of Denisovan occupation and the first trace of anatomically modern humans (AMH). So far the tally is 4 Denisovans (two female children and two adult males), a Neanderthal woman and the astonishing hybrid. Analyses of the sediments themselves showed traces of both Neanderthal and Denisovan mtDNA from deeper in the stratigraphy than levels in which human fossils had been found, but which contained artefacts. The discovery of the first Denisovan DNA revealed that AMH migrants from Africa who reached the West Pacific islands about 65 ka ago carried fragments of that genome. As well as hybridising with Neanderthals some of the people who left Africa had interbred with Denisovans sufficiently often for genetic traces to have survived. Yet, until now, the ages of the analysed samples from the cave remained unknown.

That is no surprise for two reasons: cave sediments are complex, having been reworked over millennia to scramble their true stratigraphy; most of the organic remains defied ^{14}C dating, being older than its maximum limit of determination. However, using alternative approaches has resulted in two papers in the latest issue of *Nature*. The first reports results from two methods that rely on the luminescence of grains of quartz and feldspar when stimulated, which measures the time since they were last exposed to light (Jacobs, Z. and 10 others 2019. Timing of archaic hominin occupation of Denisova Cave in southern Siberia. *Nature*, v. **565**, p. 594-599; DOI: 0.1038/s41586-018-0843-2). Over 280 thousand grains in 103 sediment samples from different depths and various parts of the cave system have yielded a range of ages from 300 to 20 ka that span 3 glacial-interglacial cycles except for a few gaps, giving rough estimates of the timing of hominin occupation shown by fossils and soil layers that contain DNA. The youngest evidence for Denisovans is shown to be roughly 50 ka; a time when AMH was present elsewhere in Siberia. They lived at a time halfway between the 130 ka interglacial and the last glacial maximum. Two Neanderthals, a Denisovan and the hybrid occupied the site during the 130 ka interglacial. Soils from the previous warm episode from 250 to 200 ka contain both Neanderthal and Denisovan DNA traces. The oldest occupancy, marked by the presence of a Denisovan bone sample, was 300 ka ago, once again midway between an interglacial and a glacial maximum.



All the hominin remains found in Denisova Cave: Note the common scale. (Credit: Douka et al. 2019; extended data Figure 1)

The second paper (Douka, K. and 21 others 2019. Age estimates for hominin fossils and the onset of the Upper Palaeolithic at Denisova Cave. *Nature*, v. **565**, p. 640–644; DOI: 10.1038/s41586-018-0870-z) focused on direct dating of the hominin fossils themselves – and thus their DNA content, important in trying to piece together timings of genetic mixing. In the absence of radiocarbon dates from the bones themselves because of most specimens' >50 ka ages, except in the case of the youngest whose ^{14}C age is at the 50 ka limit. They resorted to a hybrid technique based on a means of modelling fossils' ages from differences in mtDNA between the specimens and that in the youngest hominin, which, luckily, was dateable by radiocarbon means. Weighted by dating of the actual sediments that contain them, the differences should become greater for successively older fossils because of random mutations: a variant of the 'molecular clock' approach. It's complicated and depends on assuming that mitochondrial mutation rate was the same as that in modern humans. Unsurprisingly the results are imprecise, but sufficient to match the hominin fossil occurrences with different environmental conditions

Pollen grains and vertebrate fossils from various levels in the cave system demonstrate the wide climatic and ecological conditions in which the various hominins lived. The warmest episodes supported broad-leafed forest, offering maximum resources for hominin survival. Those between interglacial and full glacial conditions were much less benign, with alternating dry and wet cold conditions that supported open steppe ecosystems. The oldest Denisovan occupation was at the close of a period of moderately warm and humid conditions that supported mixed conifer and broad-leafed trees that gave way to reduced tree cover.

As well as the presence of stone tools sporadically through the sedimentary sequence, in the youngest levels there are bone rings and pendants made from deer teeth; clearly ornamental items. Did the late Denisovans make them or do they signify anatomically modern human activity? Radiocarbon ages do not give a concrete answer, one of the pendants is about 45 ka old with an error that puts it just within the range of age variation of the oldest Denisovan fossil. No AMH remains have been found in Denisova Cave, but remains of a modern human male have been found at Ust'-Ishim, in NW Siberia. At 45 ka, he represents the earliest arrival of AMH in northern Asia. So it may have been members of this new population that left ornaments in Denisova, but, for the moment, artistic Denisovans are a possibility.

Further deployment of rapid screening for hominin bone fragments using the ZooMS method and analyses for traces of DNA in soils is likely to expand the geographic and time ranges of Denisovans and other close human relatives. Denisova Cave formed in Silurian limestones of the Altai Range, and there are other caves in those hills …

Related article: Dennel, R. 2019. Dating of hominin discoveries at Denisova. *Nature*, v. **565**, p. 571-572; DOI: 10.1038/d41586-019-00264-0)

'Hobbits' found in the Philippines **(May 2019)**

Topography of the Philippines, showing location of the Kalinga site. Palest blue sea may have been above sea level only during extreme glacial maxima. (credit: Wikipedia)

The earliest signs that hominins had colonised the island of Luzon in the Philippines took the form of crude stone tools found around half a century ago. Re-excavation of one of the sites uncovered yet more tools buried in a river-channel deposit, along with remains of a butchered rhinoceros dated at around 700 ka by two methods (see Clear signs of a hominin presence on the Philippines at around 700 ka May 2018). The primitive nature of the tools and their age suggested that Asian *Homo erectus* had managed to reach the Philippine archipelago, despite it being separated from larger islands by deep water. Even during large falls in sea level (up to 130 m) during glacial periods that exposed Sundaland, which linked the larger islands of Indonesia to mainland Eurasia, at best only a narrow stretch of sea (~20 km) connected the Philippines to the wider world. For most of the time since the earliest known colonisation any hominins on the islands would have been cut off from other populations.

The first hominin fossil found by archaeologists in 2007 was a 67 ka old toe bone (metatarsal) in cave sediments from Northern Luzon. It was undoubtedly from *Homo*, but which species was unclear. More recent excavations added a mere 12 fossil fragments, probably from three individuals; 7 teeth, 4 adult finger- and toe bones and part of the femur of a juvenile (Détroit, F. and 8 others 2019. A new species of *Homo* from the Late Pleistocene of the Philippines. *Nature*, v. **568**, p. 181–186; DOI: 10.1038/s41586-019-1067-9). The finger bones, being curved, are unlike those of modern humans and *H. erectus*. The teeth are even more different; for instance the premolars show two or three roots – ours have but one – and their unusually tiny molars only a single root. The combined features are sufficiently distinct to suggest a separate species (*H. luzonensis*). The small teeth may indicate that the adults may have been even smaller that the 'Hobbits' of Flores and anatomically different.

Like *H. floresiensis*, as a result of isolation the new human species probably evolved to become small, possibly from very few original *H. erectus* colonisers. But an even stranger possibility is suggested by their curved toe and finger bones. They may have been habitual climbers as much as walkers – unlike us and *H. erectus*. Could that indicate that their ancestors left Africa already distinct from the rest of Late Pleistocene humans? That is also a hypothesis for the origins of *H. floresiensis*, remains of whom are more complete. Similarly, the Philippine hominins pose the issue of how their progenitors managed to get to the archipelago: deliberately by boat or being carried there clinging in desperation to vegetation torn-up by tsunamis and transported seawards by the back-wash.

Denisovan on top of the world **(May 2019)**

Who the Denisovans were is almost completely bound up with their DNA. Until 2019 their only tangible remains were from a single Siberian cave and amounted to a finger bone, a toe bone three molars and fragment of limb bone. Yet they provided DNA from four individuals who lived in Denis the Hermit's cave from 30 to more than 100 thousand years ago. The analyses revealed that the Denisovans, like the Neanderthals, left their genetic mark in modern people who live outside of Africa, specifically native people of Melanesia and Australia. Remarkably, one of them revealed that a 90 ka female Denisovan was the offspring of a Denisovan father and a Neanderthal mother whose DNA suggested that she may have come from the far-off Balkans. Living, native Tibetans, whose DNA has been analysed, share a gene (*EPAS1*) with Denisovans, which regulates the body's production of haemoglobin and enables Tibetans and Nepalese Sherpas to thrive at extremely high altitudes (see The earliest humans in Tibet).

The Baishiya Karst Cave in eastern Tibet, with Buddhist prayer flags (credit: Dongju Zhang, Lanzhou University)

Part of a hominin lower jaw unearthed by a Buddhist monk in 1980 from a cave on the Tibetan Plateau, at a height of 3280 m, found its way by a circuitous route to the Max Planck Institute for Evolutionary Anthropology in Leipzig in 2016. It carries two very large molars comparable in size with those found at the Denisova Cave, and which peculiarly have three roots rather than the four in the jaws of non-Asian, living humans. East Asians commonly show this trait. This and other aspects of the fossil teeth resemble those of some uncategorised early hominin fossils from China. Dating of speleothem calcium carbonate with which the jaw is encrusted suggests that the fossil dates back to at least 160 thousand years ago, around the oldest date recovered from Denisova Cave; during the glacial period before the last one. So the individual was able to survive winter conditions worse than those experienced today on the Tibetan Plateau. Further excavation in the cave found numerous stone artefacts and cut-marked animal bones (Chen, F. and 18 others 2019. A late Middle Pleistocene Denisovan mandible from the Tibetan Plateau. *Nature*, v. **569,** published online; DOI: 10.1038/s41586-019-1139-x).

Unfortunately the Tibetan Jaw did not yield DNA capable of being sequenced, so the issues of inheritance of the 'high-altitude' gene and wider relatedness of the individual could not be checked. However, one of the teeth did contain preserved protein that can be analysed in an analogous way to DNA, but with less revealing detail. The results were sufficient to demonstrate that the mandible was consistent with a hominin population closely related to the Denisovans of the Siberian cave.

No doubt a path has already been beaten to the Tibetan cave, in the hope of further hominin material. To me the resemblance of the Tibetan fossil jaw to other hominin finds in China, including those from Xuchang, summarised here, is exciting. None of them have been subject to modern biological analysis. Perhaps the 'real Denisovan' will emerge from them.

See also: Mysterious ancient human found on the 'roof of the world' (*National Geographic magazine*); Major discovery suggests Denisovans lived in Tibet 160,000 years ago (*New Scientist*); Finally, a Denisovan specimen from somewhere beyond Denisova Cave (*Ars Technica*)

Neanderthal demographics and their extinction **(June 2019)**

About 39 thousand years ago all sign of the presence of Neanderthal bands in their extensive range across western Eurasia disappears. Their demise occurred during a period of relative warmth (Marine-Isotope Stage-3) following a cold period at its worst around 65 ka (MIS-4). They had previously thrived since their first appearance in Eurasia at about 250 ka, surviving at least two full glacial cycles. Their demise occurred around 5 thousand years after they were joined in western Eurasia by anatomically modern humans (AMH). During their long period of habitation they had adapted well to a range of climatic zones from woodland to tundra. During their overlap both groups shared much the same food resources, dominated by large herbivores whose numbers burgeoned during the warm period, with the difference that Neanderthals seemed to have depended on ranges centred on fixed sites of habitation while AMH maintained a nomadic lifestyle. Having shared a common African ancestry about 400 thousand years ago, DNA studies have revealed that the two populations interbred regularly, probably in the earlier period of overlap in west Asia from around 120 thousand years ago and possibly in Europe too after 44 ka. Considering their previous tenacity, how the Neanderthals met their end is something of a mystery. It may have been a result of competition for resources with AMH, which could be countered by the increase in food resources. Maybe physical conflict was involved, or perhaps disease imported with AMH from warmer climes. Genetic absorption through interbreeding of a small population with a larger one of AMH is a possibility, although DNA evidence is lacking. An inability to adapt to climate change contradicts the Neanderthals long record and their disappearance during MIS-3. Previous population estimates of changing Neanderthal populations in the Iberian Peninsula (see Fig. 2 in Roberts, M.F. & Bricher, S.E 2018. Modeling the disappearance of the Neanderthals using principles of population dynamics and ecology. *Journal of Archaeological Science*, v. **100**, p.16-31; DOI: 10.1016/j.jas.2018.09.012) show decline from about 70,000 to 20,000 before MIS-4, then recovery to about 40,000 before the arrival of AMH at 44 ka followed by a decline to extinction thereafter. Roberts and Bricher developed a model for investigating demographics from archaeological evidence that is neutral as regards any particular hypothesis for Neanderthal extinction.

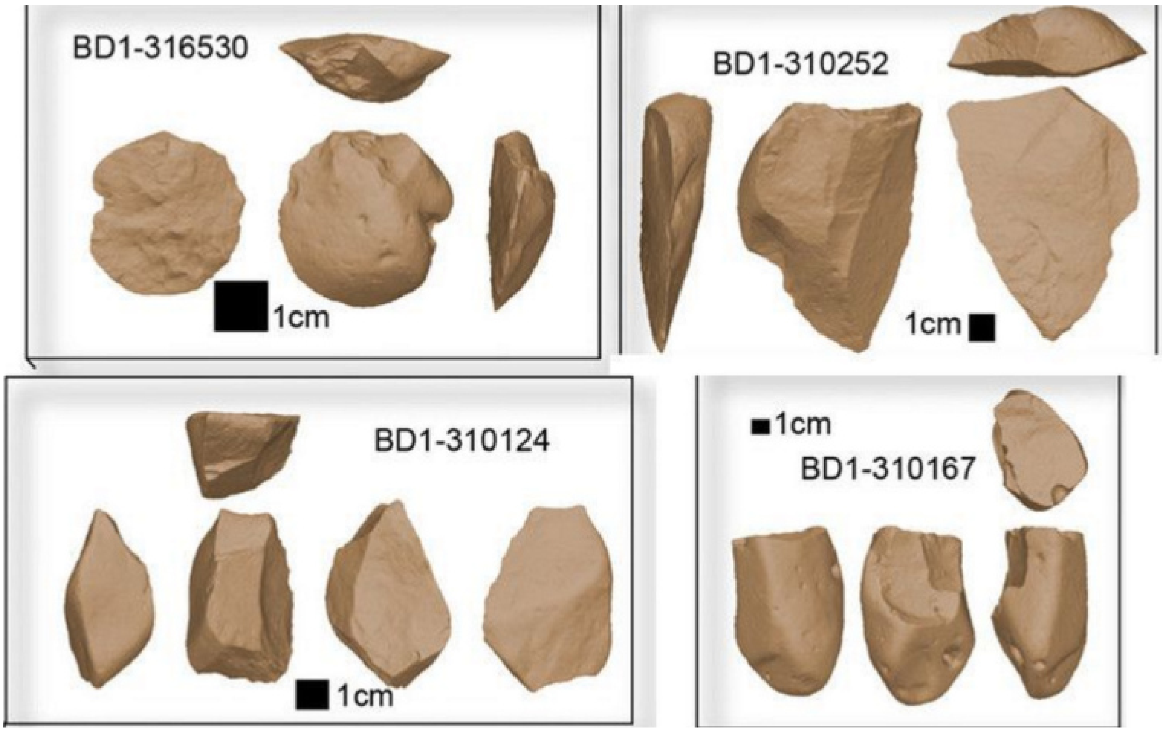
Artistic reconstruction of Neanderthal family group (credit: Nikola Solic, Reuters)

Attempting to take modelling further, another research consortium from France has focussed on the demographic changes needed to draw Neanderthals to extinction (Degioanni, A. *et al*. 2019. Living on the edge: Was demographic weakness the cause of Neanderthal demise? *PLOS One*, v. **14** e0216742; DOI: 10.1371/journal.pone.0216742). It is based on studies of living hunter-gatherer groups and those from the recent past. Survival of individuals in such groups is strongly age-dependent, i.e. low survival among juveniles, high among individuals in their prime and decreasing among the elderly. Fertility also varies among females, increasing from post-pubescence to ages between 21 to 30 years. In groups that practice sexual pairing between individuals from different communities (exogamy) migration from one to another is necessary to avoid inbreeding. The modellers assumed that only individuals from 16 to 18 years old migrated in this way. They found that a small decrease (~8%) in the fertility rate of younger females (<20 years) having a child for the first time could produce the decreasing trend in Neanderthal populations during the 5,000 year period of sharing resources with AMH populations. This would have culminated in the extinction of the Neanderthals, irrespective of the fertility rates of older, pre-menopausal females. So what could trigger such a change from a primiparous (first pregnancy) fertility rate that gave stable or growing population to one that ended so badly? The authors make no suggestion, eschewing the 'why' for the 'how'. All they suggest is that the decrease in Neanderthals, which would have benefited AMH settlement in the vacated areas, could have occurred without any need for some catastrophic event, such as disease, slaughter or climate change. Any of these causes would probably have resulted in more rapid extinction. However, the lead author, Anna Degioanni from Aix Marseille Université, when interviewed by *The Independent* newspaper said. 'First-time pregnancies, especially in young females (less than 20 years old), are on average more at risk than second and other pregnancies… a slight decrease in food may explain a reduction in fertility, especially among first-time mothers'.

One of the key features of Neanderthals is that they were probably sedentary with widely spaced communities across their huge range. So exogamy would have been more difficult for them than it would have been for nomadic groups. Genetic evidence from a few Neanderthals suggests that inbreeding was an issue. Had it been widespread among Neanderthals – risky to infer from such scanty information – that may also account for decreased primiparous fertility and also survival of newborns.

Related article: Neanderthals may have died out because of infertility, new model suggests. (*The Independent*)

Multiple invention of stone tools **(June 2019)**



Various 2.6 Ma old Oldowan stone tools from Ledi-Geraru, Ethiopia (credit: Braun et al., 2019)

Steadily, the record of stone tools has progressed further back in time as archaeological surveys have expanded, especially in East Africa (Stone tools go even further back, May 2015). The earliest known tools – now termed Lomekwian – are 3.3 million years old, from deposits in north-western Kenya, as are cut-marked bone fragments from Ethiopia's Afar region. There is no direct link to their makers, but at least six species of*Australopithecus* occupied Africa during the Middle Pliocene. Similarly, there are various options for who made Oldowan tools in the period between 2.6 and 2.0 Ma, the only known direct association being with *Homo habilis* in 2.0 Ma old sediments from Tanzania's Olduvai Gorge; the type locality for the Oldowan.

The shapes of stone tools and the manufacturing techniques required to make them and other artefacts, are among the best, if not the only, means of assessing the cognitive abilities of their makers. A new, detailed study of the shapes of 327 Oldowan tools from a 2.6 Ma old site in Afar, Ethiopia has revealed a major shift in hominin working methods (Braun, D.R. and 17 others 2019. Earliest known Oldowan artefacts at >2.58 Ma from Ledi-

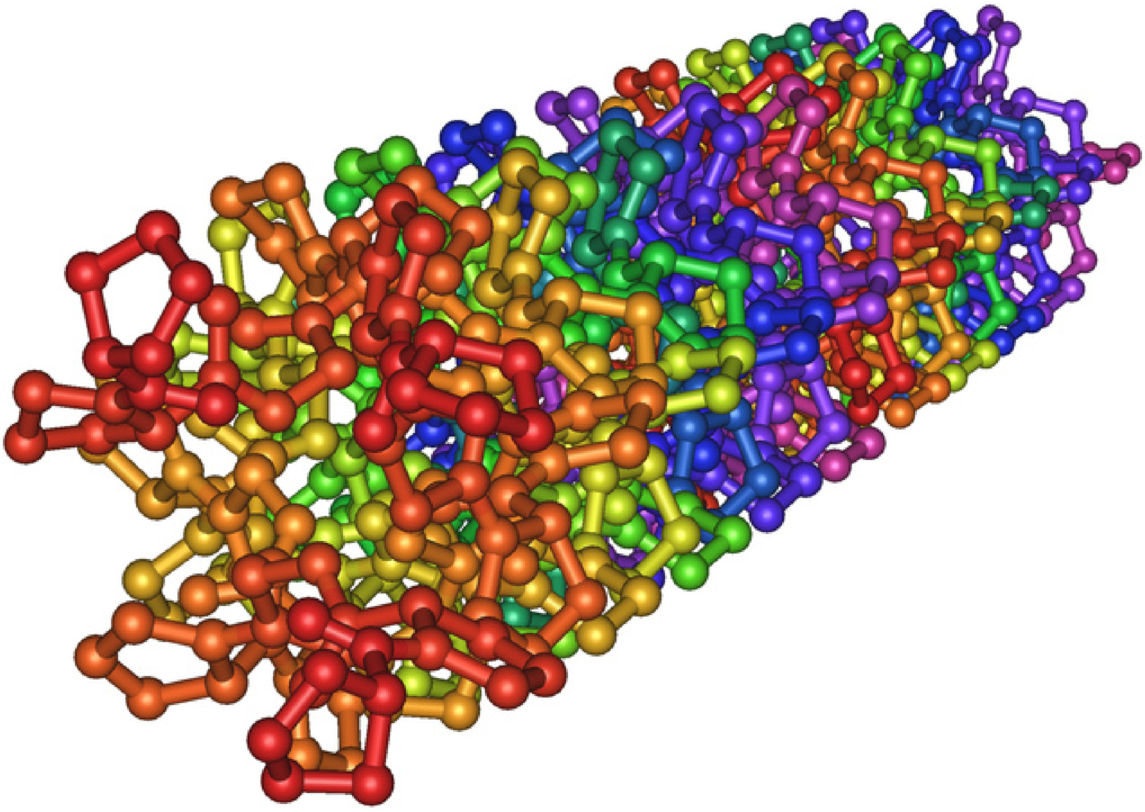
Geraru, Ethiopia, highlight early technological diversity. *Proceedings of the National Academy*, v. **116**, p. 11712-11717; DOI: 10.1073/pnas.1820177116). The sharp-edged tools were made by more complex methods than the Lomekwian. Analysis suggests that they were probably made by striking two lumps of rock together, i.e. by a deliberate two-handed technique. On the other hand, Lomekwian tools derived simply by repeatedly bashing one rock against a hard surface, not much different from the way some living primates make rudimentary tools. But the morphology of the Ledi-Geraru tools also falls into several distinct types, each suggesting systematic removal of only 2 or 3 flakes to make a sharp edge. The variations in technique suggest that several different groups with different traditions used the once lake-side site.

Ledi-Geraru lies about 5 km from another site dated about 200 ka earlier than the tools, which yielded a hominin jawbone, likely to be from the earliest known member of the genus *Homo*. A key feature that suggested a human affinity is the nature of the teeth that differ markedly from those of contemporary and earlier australopithecines. It appears that the tools are of early human manufacture. The ecosystem suggested by bones of other animals, such as antelope and giraffe was probably open grassland – a more difficult environment for hominin subsistence. The time of the Lomekwian tools was one of significantly denser vegetation, with more opportunities for gathering plant foods. Perhaps this environmental shift was instrumental in driving hominins to increased scavenging of meat, the selection pressure acting on culture to demand tools sharp enough to remove meat from the prey of other animals quickly, and on physiology and cognitive power to achieve that.

See also: Solly, M. 2019. Humans may have been crafting stone tools for 2.6 million years (*Smithsonian Magazine*)

Ancient proteins: keys to early human evolution? **(July 2019)**

A jawbone discovered in a Tibetan cave turned out to be that of a Denisovan who had lived and died there about 160,000 years ago (see: *Denisovan on top of the world*; 6 May, 2019). That discovery owed nothing to ancient DNA, because the fossil proved to contain none that could be sequenced. But the dentine in one of two molar teeth embedded in the partial jaw did yield protein. The teeth are extremely large and have three roots, rather than the four more common in modern, non-Asian humans, as are Denisovan teeth from in the Siberian Denisova Cave. Fortunately, those teeth also yielded proteins. In an analogous way to the genomic sequencing of nucleotides (adenine, thymine, guanine and cytosine) in DNA, the sequence of amino acids from which proteins are built can also be analysed. Such a proteomic sequence can be compared with others in a similar manner to genetic sequences in DNA. The Tibetan and Siberian dentine proteins are statistically almost the same.



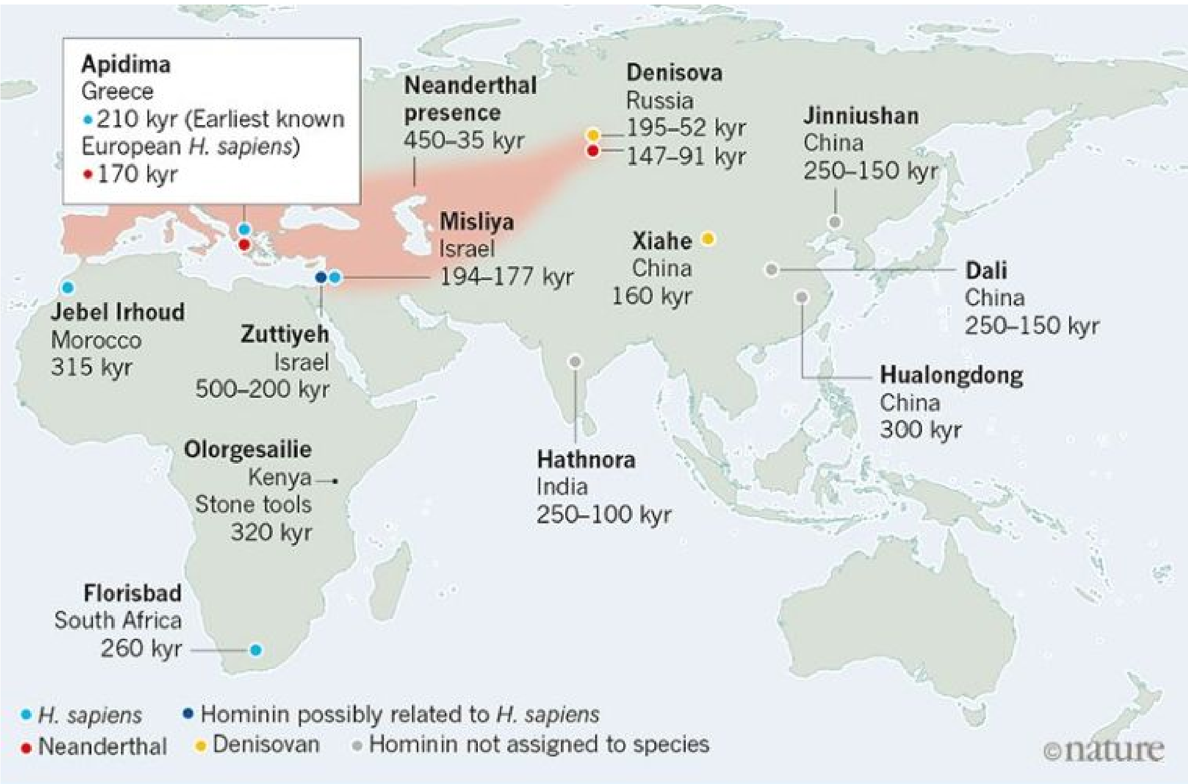
Triple helix structure of collagen, colour-coded to represent different amino acids (credit: Wikipedia)

At present the most ancient human DNA that has been recovered – from an early Neanderthal in the Sima de los Huesos in Spain – is 430,000 years old (see:Mitochondrial DNA from 400 thousand year old humans; December 2013). Yet it is proving difficult to go beyond that time, even in the cool climates that slow down the degradation of DNA. The oldest known genome of any animal is that of mtDNA from a 560–780 thousand year old horse, a leg bone of which was extracted from permafrost in the Yukon Territory, Canada. The technologies on which sequencing of ancient DNA depends may advance, but, until then, tracing the human evolutionary journey back beyond Neanderthals and Denisovans seems dependent on proteomic approaches (Warren, M. 2019. Move over, DNA: ancient proteins are starting to reveal humanity's history. *Nature*, v. **570**, p. 433-436; DOI: 10.1038/d41586-019-01986-x). Are the earlier *Homo heidelbergensis* and *H. erectus* within reach?

It seems that they may be, as might even earlier hominins. The 1.8 Ma Dmanisi site in Georgia, now famous for fossils of the earliest humans known to have left Africa, also yielded an extinct rhinoceros (*Stephanorhinus*). Proteins have been extracted from it, which show that *Stephanorhinus* was closely related to the later woolly rhinoceros (*Coelodonta antiquitatis*). Collagen protein sequences from a 3.4 Ma camel preserved in the Arctic and even from a Tanzanian 3.8 Ma ostrich egg shell show the huge potential of ancient proteomics. Most exciting is that last example, not only because it extends the potential age range to that of *Australopithecus afarensis* but into tropical regions where DNA is at its most fragile. Matthew Warren points out potential difficulties, such as the limit of a few thousand amino acids in protein sequences compared with 3 million variants in DNA, and the fact that the most commonly found fossil proteins – collagens – may have evolved very little. On the positive side, proteins have been detected in a 195 Ma old fossil dinosaur. But some earlier reports of intact dinosaur proteins have been questioned recently (Saitta, E.T. *et al*. 2019.Cretaceous dinosaur bone contains recent organic material and provides an environment conducive to microbial communities. eLife, **8**:e46205; DOI: 10.7554/eLife.46205)

Out of Africa: The earliest modern human to leave **(July 2019)**

The 2017 discovery in Morocco of fossilised, anatomically modern humans (AMH) dated at 286 ka (see: Origin of anatomically modern humans, June 2017) pushed back the origin of our species by at least 100 ka. Indeed, the same site yielded flint tools around 315 ka old. Aside from indicating our antiquity, the Jebel Irhoud discovery expanded the time span during which AMH might have wandered into Eurasia, as a whole variety of earlier hominins had managed since about 1.8 Ma ago. Sure enough, the widely accepted earliest modern human migrants from Skhul and Qafzeh caves in Israel (90 to 120 ka) were superseded in 2018 by AMH fossils at Misliya Cave, also in Israel, in association with 177 ka stone artefacts (see Earliest departure of modern humans from Africa, January 2018). Such early dates helped make more sense of very old ages for unaccompanied stone tools in the Arabian Peninsula as tracers for early migration routes. Unlike today, Arabia was a fertile place during a series of monsoon-related cycles extending back to about 160 ka (see: Arabia : staging post for human migrations? September 2014; Wet spells in Arabia and human migration, March 2015). The 'record' has now shifted to Greece.



Key ages of early H. sapiens, Neanderthals (range shown in pink) and Denisovans (credit: Delson, 2019; Fig. 1)

Fossil human remains unearthed decades ago often undergo revised assessment as more precise dating methods and anatomical ideas become available. Such is the case for two partial human skulls found in the Apidima Cave complex of southern Greece during the late 1970s. Now, using the uranium-series method, one has been dated at 170 ka, the other being at least 210 ka old (Harvati, K. and 11 others 2019. Apidima Cave fossils provide earliest evidence of Homo sapiens in Eurasia. *Nature, v.* ***571*** online; DOI: 10.1038/s41586-019-1376-z). These are well within the age range of European Neanderthals. Indeed, the younger one does have the characteristic Neanderthal brow ridges and elongated shape. Albeit damaged, the older skull is more rounded and lacks the Neanderthals' 'bun'-like bulge at the back; it is an early member of *Homo sapiens*. In fact 170 ka older than any other early European AMH, and a clear contemporary of the long-lived Neanderthal population of Eurasia; in fact the age relations could indicate that Neanderthals replaced these early AMH migrants.

Given suitable climatic conditions in the Levant and Arabia, those areas are the closest to Africa to which they are linked by an 'easy', overland route. To reach Greece is not only a longer haul from the Red Sea isthmus but involves the significant barrier of the Dardanelles strait, or it requires navigation across the Mediterranean Sea. Such is the 'specky' occurrence of hominin fossils in both space and time that a new geographic outlier such as Apidima doesn't help much in understanding how migration happened. Until – and if – DNA can be extracted it is impossible to tell if AMH-Neanderthal hybridisation occurred at such an early date and if the 210 ka population in Greece vanished without a trace or left a sign in the genomics of living humans. Yet, both time and place being so unexpected, the discovery raises optimism of further discoveries to come

See also: Delson, E. 2019. An early modern human outside Africa. *Nature, v.* ***571***online; DOI: 10.1038/d41586-019-02075-9

Humans gorged on giant mole rats during Ethiopian glaciation **(August 2019)**

Until recently it was believed that humans only adapted to life at high elevations, such as those of the Tibetan Plateau, during the Holocene. Then it turned out that the DNA of modern Tibetans contains a mutated gene (EPAS1) that boosts haemoglobin production that underpins their comfortably living at above 4000 m. In quick succession it was discovered that: modern humans were living in Tibet as early as 30 to 40 ka; the same gene was found in Denisovan DNA; and then a jawbone of that earlier human emerged from a Tibetan cave. It has been estimated that ancestral Tibetans inherited the DNA segment from Denisovans at around 40 ka. The ancestral African homeland of our genus *Homo* has large highland tracts that rise above 4000 m, most notably Mount Kilimanjaro (5895 m, Tanzania), Mount Kenya (5199 m Kenya) and Mount Stanley (5109 m, Rwenzori, Uganda). Those three retain glaciers, albeit small ones. But during the last glacial maximum permanent ice fields also capped highland areas in Morocco, Ethiopia and South Africa. Today there are permanent or seasonal habitations above 4000 m in all these African settings because of warmer conditions, but DNA analyses of the inhabitants have yet to be tested for the EPAS1 genetic mutation.

Glacial erratic in the Bale Mountains National Park, Ethiopia (credit: James Steamer)

Understandably, research into the former glaciation of highland areas in tropical Africa is a hot topic. One of the largest areas of glacial till and moraine in Africa lies on the >4000 m high Sanetti Plateau in the Bale Mountains of south-eastern Ethiopia. These mountains are the dissected remnants of a Miocene shield volcano and host a rich ecosystem; in fact the largest reserve of Afro-alpine flora and fauna. Like many mountains in tropical Africa, Bale helps rising moist air to condense as mists. The resulting rich ecology makes such mountain systems high-elevation 'oases' surrounded by semi-arid to arid savannah and desert. Because this was likely to have been equally true during the more arid conditions of the last glacial period areas such as Bale may have been refuges for humans during those times, despite the risk of altitude sickness (hypoxia). Archaeologist Götz Ossendorf of the University of Cologne, together with a large team from Germany, France, Ethiopia, Switzerland the USA, set out to test this hypothesis (Ossendorf, G. and 21 others 2019. Middle Stone Age foragers resided in high elevations of the glaciated Bale Mountains, Ethiopia. *Science*, v. **365**, p. 583–587; DOI: 10.1126/science.aaw8942).

Their main target was to excavate a rock shelter at around 3500 m, but outcrops of volcanic glass (obsidian) at 4200 m had clearly attracted human interest as they are scattered with flaked tools and debitage from their manufacture. The upper sediment layers in the rock shelter yielded ashes, charcoal, a few pottery shards and a glass bead, together with evidence for herbivore droppings. Dates fall in the last 800 years; hardly surprising as the Bale Plateau is seasonally visited by local herders who use rock shelters as corrals for livestock. The lower levels, however, contain artefacts of the Middle Stone Age (MSA); the African terminology roughly equivalent to the Upper Palaeolithic in Eurasia. The MSA layer also contain coprolites, some of hyena in its upper parts but also massive amounts likely to be human that extend to the base of the cave sediments. Dated at 47 to 31 ka, the sediments bracket the age of maximum glacier extent.

Alert giant mole rat in Ethiopia's Bale Mountains (credit: M. Watson)

The lower cave sediments contain abundant animal bones and signs of several hearths. Some of the bones show signs of cooking from burn marks. Although several prey species occur, more than 90% of the bones are those of giant mole rats (*Tachyoryctes macrocephalus*). It is not difficult to conclude that the human population's meat consumption was almost entirely of roasted mole rat. That is not surprising because the thin soils of the Bale Mountains support at least 29 mole rats per hectare, each adult weighing around a kilogram. Like the guinea pig (*Cavia porcellus*), which forms a major source of protein for people living today in the high Andes of Peru and Bolivia – an estimated 65 million being eaten annually by Peruvians, mole rats are extremely easy to catch; an attractive proposition for consumers surviving under the stress of hypoxia. They also reproduce at a phenomenal rate. Today, Andean people domesticate guinea pigs for the table. Until other sites of human habitation during the Bale 'ice age' are discovered, whether the MSA people lived permanently at high elevation or migrated there seasonally to gorge on mole rats cannot be resolved.

Symbolic art made by Denisovans (?) **(August 2019)**

The deep soil by a permanent spring in a vegetable allotment on the edge of the small town of Lingjing near Xuchang City in Henan Province, China has provided a wealth of stone artefacts and bone fragments to a depth of 10 m (*see Denisovan(?) remains in the garden, March 2017). Optically stimulated lumin*escence (OSL) dating of mineral grains shows that the last time that the deepest soils were exposed to sunlight was between 78 to 123 ka. Long before the first arrival of anatomically modern humans (AMH) in China the site had been much as it is today, a human habitation site. Among the bones were fragments of the crania from five human individuals, perhaps either *Homo erectus* descended from the earliest arrivals in China or more recent Denisovans closely related to the Neanderthals of western Eurasia. Reconstruction of the two most complete crania hinted at the second possibility by resemblance to Neanderthal anatomy yet the complete lack of evidence that Neanderthals travelled so far to the east.

Top: lines etched through ochre veneer on a rib bone from Lingjing, China; bottom: hashed lines carved on a faceted block of hematite from Blombos Cave (Credit: Li et al 2019; Fig. 3 and Chris Henshilwood)

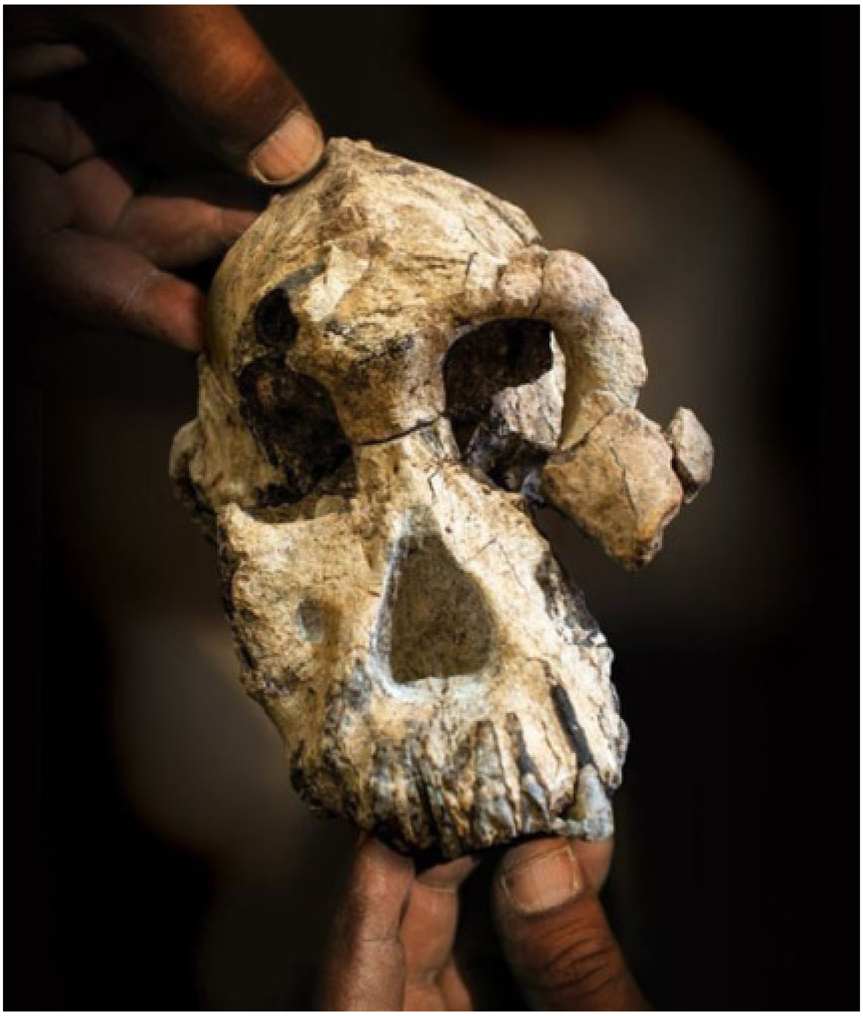
So far there have been no reports of DNA from these enigmatic fossils, but some of the bones from the deepest layers show etched, roughly parallel lines (Li, Z *et al*. 2019.Engraved bones from the archaic hominin site of Lingjing, Henan Province. *Antiquity*, v. **370**, p. 886-900; DOI: 10.15184/aqy.2019.81). Analysis shows that they were deliberately made after the bones had been defleshed: the fragments have thin veneers of red ochre through which the deep scratches reveal white bone. They are not cut marks, but the scratches on previously reddened bone suggest some form of design. This is by no means the earliest symbolic art, for shells associated with Eugene Dubois's ~500 ka old '*Pithecanthropus' (Homo) erectus* remains from Trinil, Java are similarly engraved (see Art from half a million years ago. December 2014). Yet the Lingjing engravings predate the oldest know symbolic art from the Blombos Cave of South Africa that was produced by AMH who lived in about 75 ka ago. Neanderthal artistic ability has shown up at many sites (see Human evolution and migrations, March 2011; May 2016; February 2018)

An ability to express mental concepts of some kind in a durable way now seems to have characterised at least four human species over the last half-million years.

See also: Schuster, R. 2019. Prehistoric Art or Doodle? 110,000-year-old Engraved Bones Create New Mystery (*Haaretz*, 31 July 2019); Denisovan(?) remains in a Chinese garden (Earth-logs, March 2017)

Australopithecus anamensis; a face to fit the name **(August 2019)**

Ethiopian palaeoanthropologist Yohannes Haile-Selassie of the Cleveland Museum of Natural History, Ohio, USA has been involved in the search for early human ancestors in the Awash Valley of the Afar Depression in Ethiopia since 1990. The Middle Awash Project, founded by his mentor Tim White, has been enormously successful over the years. That is because most members from the top down are persistent, inured to heat and sharp sighted. Haile-Selassie is a case in point. In 2016 near a place called Miro Dora, he and a local worker independently spotted two parts of what turned out to be a near-complete cranium of an australopithecine (*Au. anamensis*) (Haile-Selassie, Y. *et al*. 2019. A 3.8-million-year-old hominin cranium from Woranso-Mille, Ethiopia. *Nature*, v. **572**, published online; DOI: 10.1038/s41586-019-1513-8). When it was dated at about 3.8 Ma, using the $^{40}Ar/^{39}Ar$ method and magnetic reversal stratigraphy (Saylor, B.Z. and 13 others 2019. Age and context of mid-Pliocene hominin cranium from Woranso-Mille, Ethiopia. *Nature*, v. **572**, published online; DOI: 10.1038/s41586-019-1514-7), his find caused quite a stir.



The near-complete cranium of an Au. anamensis found in the Afar Depression of NE Ethiopia. Note the lateral fflattening caused by sedimentary burial. (Credit: Cleveland Museum of Natural History)

Fragmentary hominin fossils, including a complete lower jaw, found near Lake Turkana, Kenya in 1994 were sufficiently different from other, known australopithecines to warrant their recognition as a new species, *Australopithecus anamensis*. Seeming more ape-like than the famous 'Lucy' fossil *Au. afarensis* and also older – 3.9 to 4.2 Ma compared with 3.0 to 3.8 Ma for Lucy's species – *Au. anamensis* has long been regarded as a possible ancestor of *afarensis*, or even a more primitive member if the same species. The new, almost perfect cranium – except for some distortion during burial – is of an hominin that cohabited the Afar Depression with *Au. afarensis*, for as long as 100 ka, and is sufficiently different to retain its species status. Because many palaeoanthropologists consider *Au. afarensis* to be early in the evolutionary line that lead to humans, the new find seems to throw a spanner in this linear hypothesis. However, there is another possibility that may resolve the issue.

During the Pliocene, Afar was a very diverse place with many volcanoes, lava flows and minor rift systems. It is possible that geographic complexity separated and isolated small groups allowing them to diverge genetically, in the manner of island faunas. *Australopithecus afarensis* may have arisen from such isolation, going on to outcompete its 'parent' species *Au. anamensis* whose numbers progressively dwindled. Nevertheless, the emerging diversity of coexisting hominin populations in the Pliocene seriously challenges linear evolutionary hypotheses aimed at understanding the origin of our own genus (see Taking stock of hominid evolution February 2002 and Hominid evolution: a line or a bush? May 2006).

See also: Video of the discovery and summary of subsequent research; Barras, C. 2019. Rare 3.8-million-year-old skull recasts origins of iconic 'Lucy' fossil.*Nature*, v. **572**; DOI: 10.1038/d41586-019-02573-w; Spoor, F. 2019. Elusive cranium of early hominin found. *Nature*, v. **572**, p. ; DOI: 10.1038/d41586-019-02520-9

***Life with the Neanderthals* (September 2019)**

From Robinson Crusoe's discovery of Friday's footprint on his desert island to Mary Leakey's unearthing of a 3.6 Ma old trackway left by two adults and a juvenile of the hominin species *Australopithecus afarensis* at Laetoli in Tanzania, such tangible signs of another related creature have fostered an eerie thrill in whoever witnesses them. Other ancient examples have turned up, such as the signs of mud trampled by 800 ka humans (*H. antecessor?*) at Happisburgh, Norfolk, UK (see Traces of the most ancient Britons, February 2014). From a purely scientific standpoint, footprints provide key evidence of foot anatomy, gait, travel speed, height, weight, and the number of individuals who contributed to a trackway.

At Le Rozel on the Cherbourg Peninsula in Normandy, France – about 30 km west of the D-Day landing site at Utah beach – Yves Roupin, an amateur archaeologist, discovered a footprint on the foreshore in the 1960s close to the base of a thick sequence of late-Pleistocene dune sediments exposed below a rocky cliff. Fifty years later, rapid onset of wind and tidal erosion threatened to destroy the site, so excavations and scientific analysis began. This involved excavation of thick overburden on an annual basis to expose as much as possible of what turned out to be five footprint-bearing horizons (about 90 m^2).

The Le Rozel excavation, with weighted plastic sheets to protect the site from erosion between visits (credit: Dominique Cliquet)

More and more prints emerged, each photographed and modelled in 3-D, with the best being preserved as casts using a flexible material, similar to that used by dentists (Duveau, J. eyt al. 2019. The composition of a Neandertal social group revealed by the hominin footprints at Le Rozel (Normandy, France). *Proceedings of the National Academy of Sciences*. 9 September 2019; DOI: 10.1073/pnas.1901789116). At the end of the excavation hundreds of prints had been found and recorded. They had been preserved in wet sand, probably deposited in an interdune pond. Luminescence dating of sand grains revealed that the footprints were produced around 80 ka ago, 35 ka before Europe was occupied by anatomically modern humans. Scattered around the site are numerous fossils of butchered prey animals, together with stone tools typical of Neanderthal technology.

Such a large number of footprints presented a unique opportunity to analyse the social structure of the Neanderthal group that produced them, for they came in many different sizes. During the very short period in which they were produced and buried by wind-blown sand, an estimated 10 to 13 individuals had crossed and re-crossed the site – there may have been more individuals who didn't happen to cross the wet patch But the evidence suggests that children and adolescents, one of whom may have been as young as 2 years, predominated. Two or three with the biggest feet were probably adults as tall as 1.9 metres – about 20 cm taller that the average for modern human males. That is surprising for Neanderthals who are widely believed to have been more stocky. The fact that footprints occur in 5 horizons suggests that the band, or perhaps family, found the site to be good for occupation. Wider hypotheses are a little shaky. Did Neanderthals have large families? Does the predominance of children and adolescents indicate that they died young? But perhaps children stayed close to habitations with just a few 'minders', while other adults went off hunting and foraging. Were the kids playing?

***Tracing hominin evolution further back* (November 2019)**

The earliest hominin known from Africa is *Sahelanthropus tchadensis,* announced in 2002 by Michel Brunet and his team working in 7 Ma old Miocene sediments deposited by the predecessor to Lake Chad in the central Sahara Desert. Only cranial bones were present. From the rear the skull and cranial capacity resembled what might have been regarded as an early relative of chimpanzees. But its face and teeth look very like those of an australopithecine. Sadly, the foramen magnum – where the cranium is attached to the spine – was not well preserved, and leg bones were missing. The position of the first is a clue to posture; forward of the base of the skull would suggest an habitual upright posture, towards the rear being characteristic of knuckle walkers. Some authorities, including Brunet, believe *Sahelanthropus* may have been upright, but others strongly contest that. The angle of the neck-and-head ball joint of the femur (thigh bone), where the leg is attached to a socket on the pelvis to form the hip joint is a clue to both posture and gait. The earliest clear sign of an upright, bipedal gait is the femur of a fossil primate from Africa – about a million years younger than *Sahelanthropus*, found in the Tugen Hills of Kenya. *Orrorin tugenensis* was described from 20 bone fragments, making up: a bit of the other femur, three hand bones; a fragment of the upper arm (humerus); seven teeth; part of the left and right side of a lower jawbone (mandible). Apart from the femur that retains a neck and head and signifies an upright gait, only the teeth offer substantial clues. *Orrorin* has a dentition similar to humans, apart from ape-like canines but significantly smaller in size – all known hominins lack the large canines, relative to other teeth. Despite being almost 2 Ma older than *Ardipithecus ramidus*, the first clearly bipedal hominin, *Orrorin* is more similar to humans than both it and *Australopithecus afarensis*, Lucy's species.

Near-complete skeleton of Oreopithecus bambolii from Italy (credit: Wikipedia Commons)

DNA differences suggest that human evolution split from that of chimpanzees about 12 Ma ago. Yet the earlier Miocene stratigraphy of Africa has yet to provide a shred of evidence for earlier members of either lineage or a plausible last common ancestor of both. In 1872, a year after publication of Charles Darwin's *The Descent of Man* parts of an extinct primate were found in Miocene sediments in Tuscany and Sardinia, Italy. In 1950 an almost complete skeleton was unearthed and named *Oreopithecus bambolii*(see *Hominin evolution becoming a thicket*, January 2013). Despite dozens of specimens having been found in different localities, the creature was largely ignored in subsequent debate about human origins, until 1990 when it was discovered that not only could *Oreopithecus* walk on two legs, albeit differently from humans, it had relatively small canine teeth and its hands were like those of hominins, capable of a precision grip. Dated at 7 to 9 Ma, it may lie further back on the descent path of hominins; but it lived in Europe not Africa. Now the plot has thickened, for another primate has emerged from a clay pit in Bavaria, Germany (Böhme, M. and 8 others 2019. A new Miocene ape and locomotion in the ancestor of great apes and humans. *Nature*, online publication; DOI: 10.1038/s41586-019-1731-0).

Bones from 4 Danuvius guggenmosi *individuals. Note the diminutive sizes compared with living apes (Credit: Christoph Jäckle)*

Danuvius guggenmosi lived 11.6 Ma ago and its fossilised remains represent four individuals. Both femurs and a tibea (lower leg), together with the upper arm bones are preserved. The femurs and vertebrae strongly suggest that *Danuvius* could walk on two legs, indeed the vertebral shapes indicate that it had a flexible spine; essential for balance by supporting the weight of the torso over the pelvis. It also had long arms, pointing to its likely hanging in and brachiating through tree canopies. Maybe it had the benefit of two possible lifestyles; arboreal and terrestrial. Its discoverers do not go that far, suggesting that it probably lived entirely in trees using both forms of locomotion in 'extended limb clambering'. It may not have been alone, another younger European primate found in the Miocene of Hungary, *Rudapithecus hungaricus*, may also have had similar clambering abilities, as might have *Oreopithecus*.

There is sure to be a great deal of head scratching among palaeoanthropologists, now that three species of Miocene primate seem – for the moment – to possess 'prototype specifications' for early entrants on the evolutionary path to definite hominins. Questions to be asked are 'If so, how did any of them cross the geographic barrier to Africa; i.e. the Mediterranean Sea?', 'Did the knuckle-walking chimps evolve from a bipedal common ancestor shared with hominins?, 'Did bipedalism arise several times?'. The first may not have been as difficult as it might seem (see *Africa Europe exchange of faunas in the Late Miocene*, July 2013). The Betic Seaway that once separated Iberia from NW Africa, in a similar manner to the modern Straits of Gibraltar, closed during the Miocene after a 'mild' tectonic collision that threw up the Betic Cordillera of Southern Spain. Between 5.6 and 5.3 Ma there was a brief 'window of opportunity' for the crossing, that ended with one of the most dramtic events in the Cenozoic Era; the Zanclean Flood, when the Atlantic burst through what is now the Straits of Gibraltar cataclysmically to refill the Mediterranean .

See also: Barras, C. 2019. Ancient ape offers clues to evolution of two-legged walking.*Nature*, v. **575**, online; Kivell, T.L. 2019. Fossil ape hints at how walking on two feet evolved. *Nature*, v. **575**, online; DOI: 10.1038/d41586-019-03347-0

Early human migrations in southern Africa **(November 2019)**

Comparing the DNA profiles of living people who are indigenous to different parts of the world has achieved a lot as regards tracing the migrations of their ancestors and amalgamations between and separations from different genetic groups along the way. Most such analyses have centred on alleles in DNA from mitochondria (maternal) and Y chromosomes (paternal), and depend on the assumption that rates of mutation (specifically those that have neither negative nor positive outcomes) in both remain constant over tens of thousand years and genetic intermixing through reproduction. Both provide plausible hypotheses of where migrations began, the approximate route that they took and the timing of both departures from and arrival at different locations en route. Most studies have focused on the 'Out of Africa' migration, which began, according to the latest data, around 80 ka ago. Arrival times at various locations differ considerably, from around 60 ka for the indigenous populations of Australia and New Guinea, roughly 40 ka for Europe and ~12 ka for the Americas. Yet an often overlooked factor is that not all migrating groups have descendants that are alive today. For instance, remains of anatomically modern humans (AMH)have been found in sediments in the Levant as old as 177 ka (see: *Earliest departure of modern humans from Africa*, January 2018), and between 170 to 210 ka in southern Greece (See: *Out of Africa: The earliest modern human to leave*). Neither have yielded ancient DNA, yet nor are their arrival times compatible with the 'route mapping' provided by genetic studies of living people. Such groups became extinct and left no traceable descendants, and there were probably many more awaiting discovery. Maybe these mysteries will be penetrated by DNA from the ancient bones, should that prove possible.

The recorded history of AMH within Africa began around 286 to 315 ka in Morocco (see: *Origin of anatomically modern humans*, June 2017) and their evolutionary development may have spanned much of the continent, judging by previously discovered fossils in Ethiopia and South Africa that are older than 200 ka. Again, ancient DNA has not been extracted from the oldest fossils; nor is that likely to be possible because the double helix breaks down quickly in hot and humid climates. Genetic data from living Africans are growing quickly. An additional 198 African mtDNA genomes reported recently have pushed up the total available for analysis, the bulk of them being from eastern and southern Africa (Chan, E.K.F. and 11 others 2019. [Human origins in a southern African palaeo-wetland and first migrations](). *Nature*, v. **575**, p. 185-189; DOI: 10.1038/s41586-019-1714-1). The study focuses on data from the KhoeSan ethnic group, restricted to areas south of the Zambezi River, who speak a language with distinctive click consonants. Some KhoeSan still practice a hunter-gatherer lifestyle. Previous genetic studies showed the KhoeSan to differ markedly from other inhabitants of southern Africa, and they are widely regarded as having inhabited the area for far longer than any other groups. A sign of this emerges from their mtDNA in a genetic lineage signified as L0. Comparing KhoeSan mtDNA with the wider genetic database allowed the researchers to plot a 'family tree'. Measures of the degree of difference between samples push back the origin of L0 and the KhoeSan themselves to roughly 200 ka.

The Okavango Delta today during the wet season (Credit: Wikimedia Commons)

It turns out that the LO lineage has several variants, whose geographic distributions allow the approximate place of origin for the lineage and directions of later migration from it to be mapped. It seems that LO was originally indigenous to the modern Okavango Delta and Makgadikgadi salt flats of Botswana. People carrying the original (L0k) variant are estimated to have remained in the broad area for about 70 thousand years. During that time it was all lush, low-lying wetland around a huge, now vanished lake. The hydrology of the area was dramatically split by regional tectonic activity at around 60 ka. The lake simply evaporated to form the salt pan of the Makgadikgadi, leaving only the seasonal Okavango Delta as a destination for flood water. People carrying Lok stayed in the original homeland whereas other shifted. Migration routes to the northeast and towards the southwest and south are crudely mapped by the distribution of the other L0 variants among modern populations.

They followed ‘green corridors’ between 130 and 110 ka, the collapse of the ecosystem leaving a small group of the founding population isolated from its descendants.

The paper claims that the former Botswana wetlands were the cradle of the first modern humans. Perhaps in southern Africa, but other, older AMH remains found far off and perhaps undiscovered elsewhere are more likely. But that can only be reconciled with the KhoeSan study by ancient DNA from fossils. Criticism of the sweeping claims in the paper has already been voiced, on these grounds and the study’s lack of data on paternal DNA or whole genomes from the sampled population.

See also: Gibbons, A. 2019. Experts question study claiming to pinpoint birthplace of all humans. *Science* (online); DOI: 10.1126/science.aba0155

Why did anatomically modern humans replace Neanderthals? **(December 2019)**

Extinction of the Neanderthals has long been attributed to pressure on resources following the first influx into Europe by AMH bands and perhaps different uses of the available resources by the two groups. One often quoted piece of evidence comes from the outermost layer in the teeth of deer. Most ruminants continually replace tooth enamel to make up for wear, winter additions being darker than those during summer. Incidentally, the resulting layering gives away their age, as in, ‘Never look a gift horse in the mouth’! Deer teeth associated with Neanderthal sites show that they were killed throughout the year. Those around AMH camps are either summer or winter kills. The implication is that AMH were highly mobile, whereas Neanderthals had fixed hunting ranges whose resources would have been depleted by passing AMH bands. That is as may be, but another possibility has received more convincing support.

Neanderthal populations across their range from Gibraltar to western Siberia were extremely low and band sizes seem to have been small, even before AMH made their appearance. This may have been critical in their demise, based on considerations that arise from attempts to conserve threatened species today (Vaesen, K. *et al*. 2019. Inbreeding, Allee effects and stochasticity might be sufficient to account for Neanderthal extinction. *PLoS One*, v. **14**, article e0225117; DOI: 10.1371/journal.pone.0225117). The smaller and more isolated groups are, the more likely they are to resort to inbreeding in the absence of close-by potential mates. There is evidence from Neanderthal DNA that such endogamy was practised. Long-term interbreeding between genetic relatives among living human groups is known to result in decreased fitness as deleterious traits accumulate. On top of that, very low population density makes finding mates, closely related or not, difficult (the Allee effect). A result of that is akin to the modern tendency of young people born in remote areas to leave, so that local population falls and becomes more elderly. The remaining elders face difficulties in assembling hunting and foraging parties; i.e. keeping the community going. Many Neanderthal skeletons show signs of extremely hard, repetitive physical effort and senescence; e.g. loss of teeth and evidence of having to be cared for by others. Both factors in small communities are exacerbated by fluctuating birth and death rates and changed gender ratios more than are those with larger numbers; i.e. random events have a far greater overall effect (stochasticity). Krist Vaesen and colleagues from the Netherlands use two modern demographic techniques that encapsulate these tendencies to model Neanderthal populations over 10,000 years.

By themselves, none of the likely factors should have driven Neanderthals into extinction. But in combination they may well have done so, even if modern humans hadn't arrived around 40 ka. Completely external events, such as epidemics or sudden climate change, would have made little difference. Indeed the very isolation of Neanderthal bands over their vast geographic range would have shielded them from infection, and they had been able to survive almost half a million years of repeated climate crises. If their numbers were always small that begs the question of how they survived for so long. The authors suggest that they ran out of luck, in the sense that, finally, their precariousness came up against a rare blend of environmental fluctuations that 'stacked the odds' against them. It is possible that interactions, involving neither competition nor hostility, with small numbers of AMH migrants may have tipped the balance. A possibility not mentioned in the paper, perhaps because it is speculation rather than modelling, is social fusion of the two groups and interbreeding. Perhaps the Neanderthals disappeared because of hybridisation through choice of new kinds of mate. Some closely-related modern species are under threat for that very reason. Although individual living non-African humans carry little more than 3% of Neanderthal genetic material it has been estimated that a very large proportion of the Neanderthal genome is distributed mainly in the population of Eurasia. For that to have happened suggests that interbreeding was habitual and perhaps a popular option

See also: Sample, I. 2019. Bad luck may have caused Neanderthals' extinction – study. (*Guardian* 27 November 2019)

Chewing gum and the genetics of an ancient human (December 2019)

The sequencing of DNA has advanced to such a degree of precision and accuracy that minute traces of tissue, hair, saliva, sweat, semen and other bodily solids and fluids found at crime scenes are able to point to whomever was present. That is, provided that those persons' DNA is known either from samples taken from suspects or resides in police records. In the case of individuals unknown to the authorities, archived DNA sequences from members of almost all ethnic groups can be used to 'profile' those present at a crime. Likely skin and hair pigmentation, and even eye colour, emerge from segments that contain the genes responsible.

One of the oddest demonstrations of the efficacy of DNA sequencing from minute samples used a wad of chewed birch resin. Such gums are still chewed widely for a number of reasons: to stave off thirst or hunger; to benefit from antiseptic compounds in the resin and to soften a useful gluing material – resin derived by heating birch bark is a particularly good natural adhesive . Today we are most familiar with chicle resin from Central America, the base for most commercial chewing gum, but a whole range of such mastics are chewed on every inhabited continent, birch gum still being used by Native North Americans: it happens to be quite sweet. The chewed wad in this case was from a Neolithic site at Syltholm on the Baltic coast of southern Denmark (Jensen, T.Z.T. and 21 others 2019. A 5700 year-old human genome and oral microbiome from chewed birch pitch. *Nature Communications* v. **10**, Article 5520; DOI: 10.1038/s41467-019-13549-9). The sample contained enough ancient human DNA to reconstruct a full genome, and also yielded fragments from a recent meal – duck with hazelnuts – and from several oral bacteria and viruses, including a herpes variety that is a cause of glandular fever. The sample also shows that the carrier did not have the gene associated with lactase persistence that allows adults to digest milk.

An artist's impression of the gum-chewing young woman from southern Denmark (credit: Tom Bjorklund)

The chewer was female and had both dark skin and hair, together with blue eyes; similar to a Mesolithic male found in a cave in Cheddar Gorge in SW England whose petrous ear bone yielded DNA. By no means all fossil human bones still carry enough DNA for full sequencing, and are in any case rare. Chewed resin is commonly found in archaeological excavations and its potential awaits wider exploitation, particularly as much older wads have been found. Specifically, the Danish woman's DNA reveals that she did not carry any ancestry from European Neolithic farmers whose DNA is well known from numerous burials. It was previously thought that farmers migrating westward from Anatolia in modern Turkey either replaced or absorbed the earlier Europeans. By 5700 years ago farming communities were widespread in western Europe, having arrived almost two thousand years earlier. The blue-eyed, dark Danish woman was probably a member of a surviving group of earlier hunter gatherers who followed the retreat of glacial conditions northwards at the end of the Younger Dryas ice re-advance about 11,500 years ago. The Syltholm site seems to have been occupied for hundreds of generations. Clearly, the community had not evolved pale skin since its arrival, as suggested by a once popular theory that dark skin at high latitudes is unable to produce sufficient vitamin-D for good health. That notion has been superseded by knowledge that diets rich in meat, nuts and fungi provide sufficient vitamin-D. Pale skins may have evolved more recently as people came to rely on a diet dominated by cereals that are a poor source of vitamin-D.