Human evolution and migrations

Assorted developments in palaeoanthropology (*January 2011*)

The notion that Neanderthals were dim and brutish compared with us continues to be undermined, but although their brain capacity was as large and in some cases distinctly larger than that of fully modern humans, its shape was significantly different; longer towards the rear than our more rounded brain. Studies of a Neanderthal baby and three children reveal that just after birth the Neanderthal brain was virtually identical to that of fully modern babies, i.e. elongate, but remains so in childhood through to maturity, whereas modern children's brains develop towards the roundness of adults. Consequently, there must have been differences in the parts of the brain from which aspects of behaviour stem: Neanderthals almost certainly behaved differently from us both in childhood and as adults (Harvati, K. *et al*. 2010. Evolution of middle-late Pleistocene human cranio-facial form: a 3-D approach. *Journal of Human Evolution*, v. **59**, p. 445-464. **See also:** Gibbons, A. 2010. Neandertal brain growth shows a head start for moderns. *Science*, v. **330**, p. 900-901).

The now widely accepted hypothesis that modern humans did not begin to leave Africa to colonise Eurasia until about 60 ka may be under threat from reports of what seem to be fully modern human remains in China dated to ~105 ka (Liu, W. *et al*. 2010. Human remains from Zhirendong, South China, and modern human emergence in East Asia. *Proceedings of the National Academy of the US*, v. **107**, p. 19201-19206). The dating appears to be sound, being based on the uranium-series (^{230}Th) method applied to flowstone that rests on top of the sedimentary layer containing the remains in Zhirendong cave. The precipitated calcite layer completely sealed in the fossils as soon as it began to form about 105 ka ago, indicating that they are older still. Whether or not the remains are of fully modern humans is uncertain. Had they been found in Europe there would be little doubt about their affinities, the only other contemporary hominins being the Neanderthals. The problem in South China is that it was inhabited by *H. erectus* and the finds may be from 'late' members of that archaic species which arrived more than a million years earlier than fully modern humans. Judging by the DNA evidence for three interfertile hominin genetic groups cohabiting Eurasia, there is a host of possibilities for the Zhirendong fossils. One line of evidence that does not rule out that they are fully modern is the occurrence of stone tools more advanced than used by Asian *H. erectus* beneath the 74 ka Toba volcanic ash in India. It seems inevitable that these remains will be tried for DNA sequencing

See also: Dennell, R. 2010. Early *Homo sapiens* in China. *Nature*, v. **468**, 512-513

It is well accepted that as with all forms of life the twists and turns in hominin evolution was surely tuned by changes in their environments. But that is not just linked to the immediate milieu of individuals: environments change on all scales up to that of the entire planet and reflect physical as well as biological processes. The largest scales are generally assumed to be the province of climate change, yet animals also occupy a landscape subject to geophysical forces such as tectonics and erosion. Geoffrey Bailey and Geoffrey King of the University of York, UK and the Institute de Physique du Globe in Paris, France have championed the view that water supplies and topography, for example, are just as influential over hominin evolution as interspecies competition and changing vegetation patterns for almost two decades. They have now put their ideas to rigorous tests (Bailey,

G.N.& King, G.C., 2010. Dynamic landscapes and human dispersal patterns: Tectonics, coastlines, and the reconstruction of human habitats. *Quaternary Science Reviews* doi:10.1016/j.quascirev.2010.06.019). This fascinating and well illustrated paper correlates known hominin sites in Africa with variations in topography and its roughness, derived from global elevation data from the Shuttle Radar Topography Mission (SRTM), active seismicity, Neogene uplift and volcanicity.

Afar Depression: a cradle of human evolution (Credit: Wikipedia)

They concentrate on the rich palaeoanthropological pickings of the Afar Depression and the Sterkfontein area of South Africa, applying their ideas and findings to the eastern coast of the Red Sea at the recently discovered Palaeolithic site of Harat Al Birk south of Jeddah, and the Red Sea islands that would have been connected to either side of the Red Sea during the last glacial maximum because of a 130 m lower sea level. This application is vital for directing searches for new site that relate to the pathways out of Africa for early modern humans. Though a largely empirical study, it forms a link between human evolution and geological and landscape change that is not yet widely grasped and linked to climate studies.

See also: Marshall, M. 2010. Human evolution was shaped by plate tectonics. *New Scientist*, v. **208** (2786), p. 8-9; DOI: 10.1016/S0262-4079(10)62787-X.

Human migration: latest news (*March 2011*)

A widely accepted view of the departure from Africa of anatomically modern humans to colonise the rest of the habitable world is that it involved them crossing the Straits of Bab el Mandab in the southern Red Sea. Following coastlines around Arabia would then lead to the rest of Eurasia. That crossing would have become possible when sea level had fallen by more than 80m to expose much of the shelf between southern Eritrea and Yemen; a level

that was reached during a stadial event from 60 to 70 ka as climate cooled erratically to reach the last glacial maximum. That hypothesis focused archaeologists on the narrow coastal fringe of Arabia in the search for remnants of human occupation. Indeed there have been discoveries of Palaeolithic stone tools in caves and rock shelters in southern and central Oman, and lately in the United Arab Emirates close to the Straits of Hormuz at the outlet of the Persian Gulf (Armitage, S.J. *et al*. 2011. The southern route 'out of Africa': evidence for an early expansion of modern humans into Arabia. *Science*, v. **331**, p. 453-456; DOI: 10.1126/science). The trouble is that optically stimulated luminescence (OSL) dating of the UAE site (Jebel Faya) yielded ages of around 125, 95 and 40 ka for the tool-bearing layers; during the last (Eemian) interglacial, the early cooling in the succeeding glacial epoch and just before the last glacial maximum, respectively. For the two oldest ages sea level would have been high and the Bab el Mandab as wide as it is nowadays.

Armitage *et al*. focus on the stone tool kits at the site, finding them substantially different from any known Palaeolithic artefacts. The oldest tools are about the same age as those found at sites in the Levant (occupations at ~120 and 80 ka), but unlike them. The best match is with coeval tools from E and NE Africa. Accepting that view could point to a much earlier migration from Africa than currently accepted: probably during the previous glacial maximum (130-140 ka) as proposed by Armitage *et al*., when crossing the Red Sea would have been even easier because sea level had by then fallen 120 m. Alternatively, the anatomically modern human sites of the Levant may represent 'waypoints' along a northerly exodus. That has some geographic support as the narrow Nile flood plain would have provided continuous subsistence for gatherer hunters moving along it throughout even the most arid times. Yet before the hyperarid, and probably impassable desert would have separated the Levant from the Tigris Euphrates plains *en route* eastwards. Yet there is no evidence, other than their morphology, that the Jebel Faya tools were made by modern humans; skeletal remains are yet to be found and the tools could have been made by more archaic humans from a much earlier diaspora. Until tangible evidence of their association with anatomically modern humans emerges from Jebel Faya or other old Arabian sites, Neanderthals or, quite conceivably, *H. erectus* remain candidates. Perhaps, however, Jebel Faya presents a sign of a soon-to-come shift in ideas about human migration.

Morocco at the opposite side of the African continent also hosts a potentially revolutionizing discovery at the Grotte des Contrabandiers on the Atlantic coast (Balter, M. 2011. Was North Africa the launch pad for modern human migrations? *Science*, v. **331**, p. 20-23; DOI: 10.1126/science.331.6013.20). The cave revealed 108 ka remains of an 8 year-old child. Like other human fossils in Morocco and across North Africa, the child has much larger teeth than other contemporary Africans; a trait shared with some of the earliest anatomically modern human fossils outside the continent, including those found in the Levant. Merely following the Mediterranean coast would have brought migrants of this group into the Levant. Indeed there are old sites all along the Maghreb shore and in the Saharan interior that yield tool kits similar to those of the Grotte des Contrabandiers, which interestingly include triangular blades that may have been arrowheads or spear points. This surprisingly advanced culture, which also contains shell ornaments, has yielded ages up to 145ka. More archaic human remains on the Atlantic coast date to 160 ka suggest that modern-human occupation of North Africa may have been almost as prolonged as that of Ethiopia.

So, there are now modern humans in two groups that are candidates for populating the rest of the world: those of NE Africa (Nile to Levant and/or via Bab el Mandab to Yemen) and those of North Africa. Using records of past sea level and climate there is scope for hypothesizing multiple migrations, for which there is, as yet, no tangible evidence. Early migrants entered unknown territories, so they did not set out purposively to colonise them. But provided there were navigable and survivable routes simple diffusion could take people far and wide in radiometrically brief periods (order of 1-5 ka) as they followed similarly migrating prey species. As regards sea-level, it was low enough for the Bab el Mandab crossing (and that of the Straits of Hormuz) to be feasible during several stadials of the 240-130 ka glacial, and seashore resources would have sustained migrants hugging the coast during the aridity that accompanies low global mean surface temperatures. The desert stretching from northern Syria to Aqaba on the Red Sea, is passable now during periods of high rainfall, as it would have been during the Eemian interglacial. Yet there is every reason to believe it would have become far more arid in colder global climates; a major barrier to migration.

That humans reached India before crossing the Bab el Mandab was probably not feasible because of high sea level, as suggested from stone tools that occur below a 74 ka volcanic ash layer in Andhra Pradesh, India. The tools lie above sediments with a 77 ka date, and have Middle Palaeolithic characteristics, although that alone does not necessarily signify that they were made by modern humans. If they were then that suggests a route from the Levant eastwards. The search is on for anatomically human remains in Arabia and also in India, although whether they have been preserved in the acid tropical soils of southern India is less likely than in more arid regions.

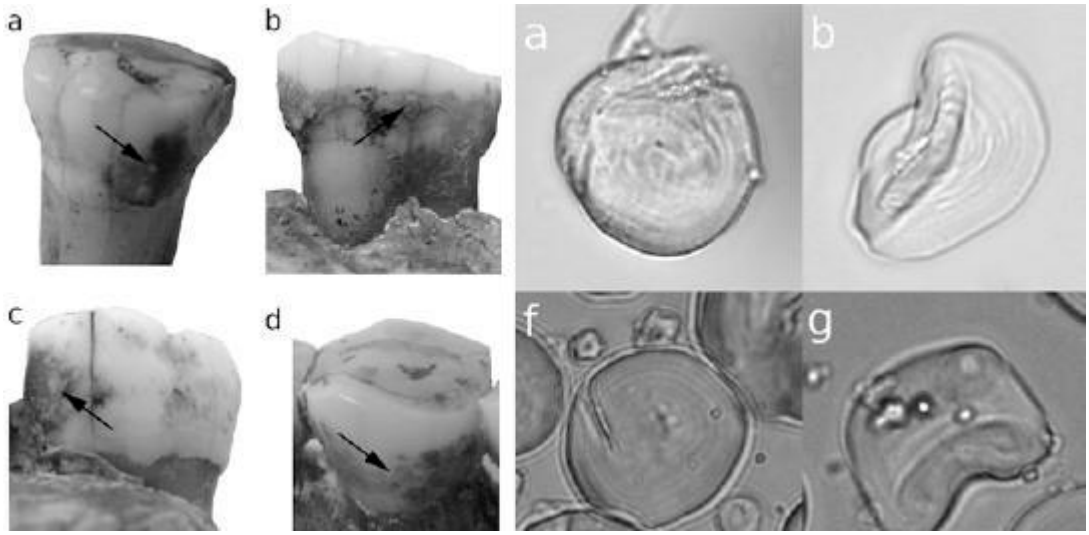
See also: Petraglia, M.D. 2011. Trailblazers across Arabia. *Nature*, v. **470**, p. 50-51; DOI: 10.1038/470050a. Callaway, E. 2011. Early human migration written in stone tools. *Nature News online*; DOI: 10.1038/news.2011.55. 125,000 Year Old Hand Axes From Jebel Faya, UAE

Neanderthals: diet, gait and ornamentation (*March 2011*)

Neanderthal sites known in Europe and the Levant (Credit: Wikipedia)

Anyone who has followed British TV series featuring the survival specialist Ray Mears will be well aware of the wealth of wild foods available from plants even in cold climes: Mears is

famous for persuading his camera crews to try what he eats when 'out bush'. Surviving gatherer-hunters, such as the native people of Australia, have encyclopaedic knowledge of what is edible and how to find plant victuals, and we can surmise that such skills date back to the earliest hominins. Neanderthals have been widely regarded as being exclusive meat eaters – the Innuit of Greenland can subsist on a meat- and fish-only diet, showing that it is a perfectly wholesome strategy – but new evidence reveals that they also ate a wide variety of vegetables, and cooked them. Neanderthals suffered from plaque (calculus) and that dental biofilm preserves traces of their diet (Henry, A. G. *et al*. 2010. Microfossils in calculus demonstrate consumption of plants and cooked foods in Neanderthal diets (Shanidar III, Iraq; Spy I and II, Belgium). *Proceedings of the National Academy of Sciences*, v. **108** (2), p. 486-491; DOI: 10.1073/pnas.1016868108). Teeth from the famous Neanderthal sites of Shanidar in Iraq and Spy in Belgium had substantial plaque deposits. The authors found a wide variety of starch grains and silica-bearing hard parts that are characteristic of a wide range of plants (phytoliths) embedded in the plaques. Food plants included grasses, such as wild barley and sorghum; starchy roots, such as water lily; date palm, and a wide variety of starch grains and phytoliths that proved difficult to link to specific plants. Clearly, Neanderthals were not exclusively hunters of large and small game. The exclusively hunting hypothesis arose from analysis of fossilized fecal matter preserved with Neanderthal remains in occupation sites dating to the onset of frigid conditions in Europe, and in any case only shows what their producer's last few meals contained. We can expect a closer look at teeth of other hominins from now on, as mineralized plaque is almost as indestructible as teeth themselves.



Left – Neanderthal molars with plaque (arrowed); Right – recovered starch grains of grass seeds. (Credit: Henry *et al*. 2010)

Neanderthals definitely did hunt, and evidence is that they were able regularly to bring down enormous beasts such as elephants and rhinoceroses. The question is, did they have to chase their prey animals so that they weakened through heat exhaustion before the kill, as in the case of the San hunters of SW Africa? To do that they would have had to be endurance runners. Comparing their ankle bones with those of modern humans suggests they were not very athletic in this way. (Raichlen, S.A. *et al*. 2011. Calcaneus length determines running economy: Implications for endurance running performance in modern humans and Neandertals. *Journal of Human Evolution*, v. **60**, p. 299-308; DOI:

10.1016/j.jhevol.2010.11.002). Running well and keeping it up over long distances depends to a large extent on the efficiency of the Achilles tendon, the largest in the whole body. It literally puts a 'spring in the step' and couples muscle power to the role of feet in running. The calcaneus bone in the ankle provides leverage from the elastic storage of power in the Achilles, so its length is a guide to running efficiency. Neanderthals had a longer calcaneus than modern humans and probably had to spend considerably more muscular energy in keeping up with prey; they would have tired more quickly. The authors put this down to an evolutionary adaptation in cold climes to the lesser chance of prey animals succumbing to heat exhaustion. That would also perhaps explain evidence from other parts of Neanderthal skeletons for severe injuries, probably caused during hunting. They probably used ambush techniques and close-quarters stabbing with spears; a very risky strategy with unexhausted big game.

Interestingly, a newly discovered foot bone of *Australopithecus afarensis* (Ward, C.V. *et al*. 2011. Complete fourth metatarsal and arches in the foot of Australopithecus afarensis. *Science*, v. **331**, p. 750-753; DOI: 10.1126/science.1201463) shows that, like us, it had arches whereas modern apes do not. This seems to settle a lengthy debate about how australopithecines walked – they are long acknowledged to have been at least partly bipedal. The 4th metatarsal is crucial: in apes its shape gives the flexibility needed to negotiate and grip branches, whilst in *Homo sp*. it endows the foot with the rigidity and stability to balance, absorb shock and use the toes efficiently in walking. This is pretty fundamental stuff *en route* to 'proper' humans, yet skull morphology dominates discussion of hominin anatomical relationships: the earliest tools (~3.4 Ma; see Another big surprise September 2010) are a million years older than the earliest human, *H. habilis*. But they overlap in age with and occur in the same area as *Australopithecus afarensis.* So, should these beings actually be renamed *H. afarensis?*

Tantalising glimpses suggesting that Neanderthals were not brutes, such as possible shell jewellery, use of pigments and scattering of flowers at burials, has been accumulating for years. The latest has been unearthed from a cave in the north of Italy, in association with Levallois tools that are distinctive of Neanderthals (Peresani, M. *et al*. 2011. Late Neandertals and the intentional removal of feathers as evidenced from bird bone taphonomy at Fumane Cave 44 ky B.P., Italy. *Proceedings of the National Academy of Sciences*, DOI: 10.1073/pnas.1016212108). Wing bones of vultures, eagles, owls, crows and various other birds show grooves and scratches suggesting that the long flight feathers had been carefully removed: there isn't much meat on a wing. Since fletched arrows are believed not to have been invented until much later times, it seems pretty certain that the feathers were aimed at personal adornment, or even clothing. The evidence is very convincing and so helps confirm earlier suspicions of feather-use from wing bones found at a variety of Neanderthal sites. Some hollow bird bones are also suspected of having been used as whistles. Given the recent genetic evidence of their sexual interaction with anatomically modern humans, gradual build-up of signs of a rich cultural life make the Neanderthals significantly more attractive than the famous view of geneticist Steve Jones in 1994 that 'If you met an unwashed Cro Magnon dressed in a business suit on the Underground, you would probably change seats. If you met a similarly garbed Neanderthal, you would undoubtedly change trains'.

Early bi-face tools from South India (*May 2011*)

An icon of palaeoanthropology, the bi-face or Acheulean 'hand axe' was invented in Africa, presumably by *H. ergaster,* about 1.6 Ma ago. Apart from in the Middle East, where it first occurs around 1.4 Ma, elsewhere it was a late arrival in the artefact record. Human colonisation of Asia began as early as 1.8 Ma ago, so those early arrivals could not have brought the later Acheulean technology but used less elegant tools similar to the Oldowan edged pebbles. Although occupied by *H. erectus* until as recently as ~20 ka, those Asians are believed not to have managed the bi-face breakthrough, indeed its absence has suggested to some that the erects evolved from the very earliest immigrants into Asia. It has been widely accepted that abundant bi-face tools in India date from about 500 ka ago, presumed to have been brought by *H. heidelbergensis* migrants. An object lesson in the way that new techniques rather than new archaeological sites can dramatically change such long-held notions has emerged from excavations at Attirampakkam about 30 km NW of Chennai (Madras) in South India (Pappu, S. *et al*. 2011. Early Pleistocene presence of Acheulean hominins in South India. *Science*, v. **331**, p. 1596-1599; DOI: 10.1126/science.1200183). This was the site where Palaeolithic tools first came to light in the sub-continent in 1863. The Indo-French research team used cosmogenic-isotope dating and magnetostratigraphy to estimate when the tools were buried. They discovered a much earlier age than expected, between 1.0 to 1.5 Ma. That throws into question the assumption of younger ages in general for the technology in India, but more important, suggests that there may have been an eastward wave of migration from Africa shortly after the invention of bi-face tools. A flurry of re-evaluation of the somewhat confusing Asian record of early humans seems on the cards.

See also: Dennell, R. 2011. Earlier Acheulian arrival in South Asia. *Science*, v. **331**, p. 1532-1533; DOI: 10.1126/science.1203806.

Clovis first hypothesis refuted (*May 2011*)

For decades palaeoanthropologists studying the Americas were dominated by a single idea; that nobody entered the continents before those people who used the elegant fluted spear blades first found near Clovis, New Mexico in the 1930s. These were eventually dated at a maximum age of around 13 ka before the present. One reason for accepting the Clovis people as the first Americans, apart from the lack of conclusive evidence for any earlier occupation, was the fact that glaciers blocked the overland route from the Bering land bridge of the last Ice age until about 13 ka. But migration may have been possible along the Pacific coast as far back as 30 ka if people crossed the Beringia flatlands exposed by fallen sea-level. There have been suggestions of pre-Clovis sites, but none have carried the weight of evidence to shift the majority from their position. This now has to change because of very high-quality evidence from a site in Texas (Waters, M.R.and 12 others 2011. The Buttermilk Creek complex and the origins of Clovis at the Debra L. Friedkin site, Texas. *Science*, v. **331**, p. 1599-1603; DOI: 10.1126/science.1201855). The site in question is in sediments that lie beneath those containing Clovis style tools. In fact it has yielded more than 15 thousand items that are well made, but bear little comparison with the iconic Clovis tools. Almost 50 optically stimulated luminescence (based on time of burial after exposure to sunlight) dates show a clear increase in age with depth in the excavations, some reaching back as far as 33 ka. The authors favour a conservative approach and restrict their estimated ages to those

artefacts found in a well defined stratigraphic horizon, which span the range 13.2 to 15.5 ka. The Clovis-first case seems likely to be closed, but a new phase in North America aimed at pushing back the time of first human colonising will undoubtedly begin now.

Strontium isotopes and australopithecine habits (*July 2011*)

The eating habits and places of habitation can be derived from isotopic analyses of the teeth of modern humans found by archaeologists. The methods enabled scientists to work out where 'Ötzi the Iceman' hailed from. Strontium isotopes show it was most likely to have been the South Tyrol province of Italy. Isotopes of nitrogen and carbon show that he was predominantly vegetarian; i.e. he was neither a hunter, nor an especially privileged member of Tyrolean Chalcolithic society.

The same methods offer insights into the life styles of far earlier hominins and has recently been used on teeth of australopithecines (*Australopithecus africanus* and *Paranthropus robustus*) found in the famous Sterkfontein and Swartkrans caves South Africa (Copeland, S.R. *et al*. 2011. Strontium isotope evidence for landscape use by early hominins. *Nature*, v. **474**, p. 76-78; DOI: 10.1038/nature10149). The caves formed in Precambrian dolomites and it was expected that all the teeth would show signs that the individuals from whose jaws they were collected lived their entire lives in the small tract of dolomites (~30 km^2) surrounding the caves. For large individuals that was indeed the case, but teeth from smaller fossils show $^{87}Sr/^{86}Sr$ ratios that are significantly different from those characteristic of local rocks and soils. That suggests the smaller individuals came from further afield than the restricted tract of carbonate strata. Although pelvic remains are normally the best guide to the sex of primate fossils, they are less frequently found than those of crania and dentition. Size variations of adults in a primate species, however, may indicate sexual dimorphism – larger males than females – and this is well-accepted for australopithecines. The inference is that for both species males had small home ranges on the dolomites, or that they preferred that tract. Yet females had dispersed from their parental groups and moved into the area.

Most living primates do not show this kind of sexual dispersion pattern, termed male philopatry, but it is common among modern humans, chimpanzees and bonobos. In the case of the australopithecines that were being studied, both were diminutive creatures living in open savannah with risks of predation from a range of large carnivores. Perhaps the bands living in the dolomite area had better refuges in caves than those elsewhere and therefore able to attract females, rather than male philopatry being dominant among all australopithecines. There are comparable numbers of associated fossils elsewhere, such as the *Au. afarensis* at the site where 'Lucy' was found in the Ethiopian Afar depression, whose teeth have not been subject to detailed strontium-isotope analysis.

Arctic Neanderthals

The last Neanderthals known to have been alive were close to the southernmost limit of Europe, in caves on the Rock of Gibraltar at about 24 ka, shortly before the last glacial maximum. Their remains have been found in a >6000 km west-east zone at temperate latitudes, south of 50°N, which extended from western Europe to the Denisova cave in the Altai republic of Russia (50°N, 87°E). This suggests that they subsisted in deciduous

woodland and temperate steppe, diffusing southwards as conditions cooled during 2 or 3 past glacial periods. Consequently, sites at higher northern latitudes that preserve only cultural remains – Palaeolithic tools – have hitherto been regarded as signs of fully modern human occupation; it takes considerable skill to distinguish Neanderthal from early modern human artefacts, which are very similar during the time of overlapping occupation (~40-30 ka). A site in northern Siberia at Byzovaya in the Polar Urals, close to the Arctic Circle, is a case in point. A French, Norwegian and Russian team of archaeologists re-examined the site (Slimak, L. *et al*. 2011. Late Mousterian persistence near the Arctic Circle. *Science*, v. **332**, p. 841-845; DOI: 10.1126/science.1203866) and dated it to between 31-34 ka. They also analysed a suite of stone tools, finding that they are directly comparable with Mousterian (Middle Palaeolithic) implements from western Europe rather than products of modern human's industry of similar antiquity. At that time high-latitude climate was well on its way to frigid, dry conditions (there were no substantial continental ice sheets in northern Russia). The animal remains found at the site were dominated by those of mammoth, with minor proportions of other cold-steppe large mammals, such as woolly rhino, musk ox, horse and bear.

The Byzovaya site (red) near the Scandinavian ice sheet. (Credit: Slimak *et al*. 2011; Fig. 1)

A notable feature of the results is that they suggest that Neanderthals, or others people with a Mousterian culture, were occupying this bleak terrain at roughly the same time as modern humans, who left considerably richer suites of artefacts, including tools, ornaments and figurines carved from bone and ivory, but were after more or less the same prey species. Both groups clearly were able to cope with and thrive on the harsh conditions, until recently only within the scope of highly specialised cultures such as the Innuit and original Siberian peoples. The dating shows that whoever produced and used the Mousterian tools not only shared the terrane with modern humans, but lingered until well after the

previously accepted time (~37 ka) of the Neanderthals' demise except for a few refuges in the Iberian Peninsula and Balkans. Despite the occupation of northern Siberia by different cultural groups, until their bones are found who they were is not certain. Denisova Cave showed that Neanderthals and the genetically different Denisovans co-occupied temperate central Siberia (see *Other rich hominin pickings* May 2010) so there are currently two options.

Homes for hominin evolution (*September 2011*)

In his *The Part Played by Labour in the Transition from Ape to Man* (1876), encouraged by Darwin's *The Descent of Man* (1871**),** Friedrich Engels suggested that the road to modern humans began with walking on two legs, thereby freeing the hands for work and tool making. His hypothesis has been central to discussion of human evolution for more than a century. The 'descent from the trees' that bipedalism signifies has long been supposed to stem from the replacement of tropical forests in East Africa by open woodland or savannah, but evidence to support that environmental change has been difficult to glean from the fossil record since the Late Miocene. Even in terrestrial sediments plant remains are rare, so that much has rested on animal fossils in relation to the habitats of their living descendants: opinion is divided.

There is a round-about means of resolving this central issue: using the carbon-isotope record in fossil soils that depends on the fractionating effects of broadly different kinds of plants that once grew in the soils and the signature of that fractionation in carbonate nodules that formed in the soils. The $\delta^{13}C$ value (the difference between the $^{13}C/^{12}C$ ratio of a sample and that of a carbon-rich standard) found in C4 plants (many grasses) ranges from -16 to -10 ‰, whereas that in C3 plants (including almost all trees) it is much more depleted in the heavier ^{13}C isotope (-33 to -24‰). Exchange of carbon between living and dead organic matter, and carbonates that are precipitated from soil waters through the intermediary of gases in the soil should leave a $\delta^{13}C$ signature in the carbonates that reflects the overall proportions of different photosynthetic plant groups living while the soil formed. The approach was developed in the early 1990s by Thure Cerling and Jay Quade of the US universities of Utah and Arizona respectively.

After a long gestation period, involving calibration using soils from different modern ecosystems, it has been applied painstakingly to palaeosols in which hominin remains have turned-up (Cerling, T.E. and 9 others 2011. Woody cover and hominin environments in the past 6 million years. *Nature*, v. **476**, p. 51-56; DOI: 10.1038/nature10306). All the famous hominin sites from the Awash and Omo Valleys of Ethiopia and around Lake Turkana in Kenya, figure in this important study, in which the authors devise a proxy for 'palaeo-shade' based on their carbonate $\delta^{13}C$ data from 76 modern tropical soils: a good 'straight-line' plot of $\delta^{13}C$ against the fraction of woody cover at the different calibration sites. Applying the proxy to their 1300 samples of palaeosols they show convincingly that since about 6 Ma tree cover rarely rose above 40% in the homelands of all the East African hominins. From the times of *Ardepithecus ramidus* (~4 Ma) at Aramis in Ethiopia, through those of 'Selam' and 'Lucy', the 2.5 Ma first stone tools at Gona, the times when Africa was dominated by *Homo erectus*(1.8 to 1 Ma) to perhaps the first signs of modern human cranial remains around 1 Ma, all hominins strolled through open, grassy environments. One can imagine pleasured nods from the shades of Darwin and Engels now their prescience has finally been confirmed.

First bi-face tools and *Homo erectus* (*November 2011*)

The elegant pear-shaped, double edged tool, known as the Acheulean 'hand-axe' is an icon for the distant past of humans. It appears in the record as a sharp contrast to the crude cutting tools made of broken and sharpened pebbles, known generally as Oldowan, which around 2.5 Ma marked the appearance of some hominin species with the wit to exploit the inorganic world and begin manufacture. There can be little doubt that the visualisation of a useful shape within a formless block of stone and the dexterity to realise it as a tool marked a major change in human cognitive ability. Oddly, there is no agreement on what the bi-face axe was for. Even odder is the frequent discovery of pristine examples that seem never to have been used. It has long been accepted that the originator was *Homo erectus* living in Africa around 1.5 to 1.6 Ma ago. It also seems likely that the first migrants out of Africa were *H. erectus* at around 1.7 to 1.8 Ma, who reached Europe and Asia, surviving in SE Asia until perhaps as recently as 20 ka. Yet the earliest émigrés seem not to have carried the bi-face technology with them (see: *Early bi-face tools from South India* above); an absence from the record that has been taken to indicate that they left before its invention. That assumption is no longer as sound as it was formerly.

Modelled Nariokotome adolescent male *Homo erectus* (Credit: Science Photo Library)

The shores of Lake Turkana in NW Kenya have provided rich pickings for ancient tools, both Oldowan and more rarely Acheulean, and at Nariokotome was found an almost complete skeleton of a young male *H. erectus*. Some of the most prolific sites for tools are around Nachukui in a thick sequence of terrestrial and lacustrine sediments that span the period 2.3 to 1.6 Ma. Volcanoclastic sediments that are dateable by radiometric means are few and far between, but the base of the sequence, 100 m below the stratigraphically oldest bi-face tool-bearing horizon, is a tuff with an Ar-Ar age of 2.33 Ma, with another 20 m below aged 1.87 Ma. A team of French and US archaeologists (Lepre, C.J *et al*. 2011. An earlier origin for

the Acheulian. *Nature*, v. 477, p. 82-85; DOI: 10.1038/nature10372) used systematic measurements of magnetic polarity through the intervening sediments to match this magneto-stratigraphy with the global record of flips in the geomagnetic field, famed for its use in unravelling plate tectonics through magnetic 'stripes' above the ocean floor. The match is extremely good, and the Acheulean occurrence is a mere 5 m above the end of the Olduvai subchron. Plotting radiometric and magneto-stratigraphic datums against sediment depth gives a calibration that suggests an age for the tools of 1.76 Ma.

Fortuitously, this age coincides with the earliest evidence for out-of-Africa human migration (see *First out of Africa?* November 2003). So why did the early travellers not equip themselves with this literally 'cutting-edge' technology? The answer may lie at Nachukui, in the close association of sites bearing bi-face tools and those devoid of them. The technology was not universally used; indeed, some may have been 'imported' from the originators (but not shared). Another possibility is that the archaeological record marks two species, one with and the other without bi-face tools. Also, Lake Turkana is far distant from points at which people could have made the crossing to Europe and Asia; the diffusion of the new may not have reached that far. Easily as important is the near coincidence of the date with that of the earliest known African *H. erectus* remains. Their emergence, involving an increased cranial capacity, seems to have coincided with new ways of using that potential. Whatever use the bi-face tools had, they and the brain that made them conferred such an advantage that there was little evolution in both humans and their technology for more than a million years until *H. heidelburgensis* appeared; revolutionary change followed by prolonged biological, social and intellectual conservatism.

Another candidate for earliest, direct human ancestor (*October 2011*)

In May 2010 (*Other rich hominin pickings*) I commented on a new find from the famous fossil-rich caves of north-eastern South Africa; a new hominin species called *Australopithecus sediba*. At least one of them fell into a deathtrap cavern, died and remained unchewed without bones being spread far and wide. Inevitably, near-complete skeletons of individual hominins are soon pored over by dozens of specialists in human evolution, as they were for the much older *Ardepithecus ramidus* found in sediments of Ethiopia's Afar Depression (see *Early hominin takes over Science magazine* November 2009 issue). Now there are two near-complete, well-preserved skeletons of *Au. Sediba* and the palaeoanthropological world is agog. Dating to about 1.98 Ma the specimens coincide in time with the far less impressive remains of *H habilis* from Tanzania and their associated rudimentary stone tools. The first hint (just a fragment of upper jaw) of any remains that might be tagged '*Homo*' dates to 2.3 Ma and is from Ethiopia, as are the first undoubted stone tools going back as far as 2.5 Ma, though lacking association with a maker.

Five consecutive papers on *Au. Sediba* occupy 22 pages in the 9 September 2011 issue of *Science* and make for startling reading. The first concerns the shape of its brain case, and therefore crudely its brain, discerned by tomographic X-ray scanning (Carlson, K.J. *et al.* 2011. The endocast of MH1, *Australopithecus sediba*. *Science*, v. **333**, p. 1402-1407; DOI: 10.1126/science.1203922). It isn't any bigger than that of other members of the genus but shows 'some foreshadowing of the human frontal lobes' and other shifts from the basic ape model that the authors imply are en route to human features. The next considers the two pelvis regions (Kibii, J.M. *et al*. 2011. A partial pelvis of *Australopithecus sediba*. *Science*, v.

333, p. 1407-1411; DOI: 10.1126/science.1202521); again australopithecine-like in the small size of the birth canal but with a hint of the S-shape of humans. Most astonishingly well-preserved are the fragile bones of a complete hand (Kivell, T.L. *et al*. 2011. *Australopithecus sediba* hand demonstrates mosaic evolution of locomotor and manipulative abilities. *Science*, v. **333**, p. 1411-1417; DOI: 10.1126/science.1202625), which convincingly shows the long thumb and short fingers (for a primate) that characterise *Homo* and are essential for a precision grip and making things. Actually, the thumb is longer relative to fingers (60%) than in humans (54%), but Lucy's (*Au. afarensis*) was a closer match. No tools that such a hand might have created and wielded were found with the fossils.

Palm and dorsal views of the right hand Of *Au. sediba*. (Credit: Kivell *et al*. 2011; Fig. 1)

Then there is the foot (Zipfel, B. *et al*. 2011. The foot and ankle of *Australopithecus sediba*. *Science*, v. **333**, p. 1417-1420; DOI: 10.1126/science.1202703), which, again, mixes human and australopithecine features, giving 'a unique form of bipedality and some degree of arboreality'. The fifth paper (Pickering, R. *et al*. 2011. *Australopithecus sediba* at 1.977 Ma and implications for the origins of the genus *Homo.* *Science*, v. **333**, p. 1417-1420; DOI: 10.1126/science.1203697) is as remarkable for the precision of U-Pb dating of speleothem (cave carbonates), which at 1.977±0.002 Ma far exceeds the workhorse Ar-Ar method used for most other hominins, as it is for the absolute age that precedes that of undisputed remains of humans.

In short, for *Australopithecus sediba* there is an embarrassment of riches unmatched until those of the 1.6 Ma old *H. erectus* ('Turkana Boy') found at Nariokotome in NW Kenya. To some extent this throws a flock of peregrines in among the palaeoanthropology pigeons, as an account of a meeting earlier in 2011, at which the bones were grandstanded, shows (Gibbons, A. 2011. Skeletons present an exquisite paleo-puzzle. *Science*, v. **333**, p. 1370; DOI: 10.1126/science.333.6048.1370). Naturally, the authors are making the most of their material especially, it seems, its finder Lee Berger of the University of Witwatersrand, South Africa, the last author in all the papers. Comparisons with more australopithecine remains were said to be needed. The soon-to-be-famous hand has been said to be essentially like

others from the same genus. While the remains of the creature's pelvis could imply that its evolution was more driven by a need for efficient upright walking than to birth big-headed babies, the ankle shows a primitive trait that would have forced *Australopithecus sediba* to walk strangely as the heel bone is small and angled unlike that in human feet, which is broad and flat. But all the species's features are combined in two near-immaculate individuals, whereas for the rest of its contemporaries, predecessor and near successors in time speculation is based on fragments of several individuals, none more so than in the case of the earliest agreed human, near-contemporaneous *H. habilis*, which barely stands up to taxonomic scrutiny (Gibbons, A. 2011. Who was *Homo habilis* – and was it really *Homo*? *Science*, v. **332**, p. 1370-1371; DOI: 10.1126/science.332.6036.1370). Some would say that it was only the associated stone tools that assigned 'Handy Man' to more elevated status than slightly large-headed australopithecine. The fact is; stone tools were around since 2.5 Ma, at least in Ethiopia, and this newly found being *could* have handled them and even made them given its palpable dexterity. Finding skeletons together with tools is almost as rare as hens with teeth...

Snippets on human evolution (*November 2011*)

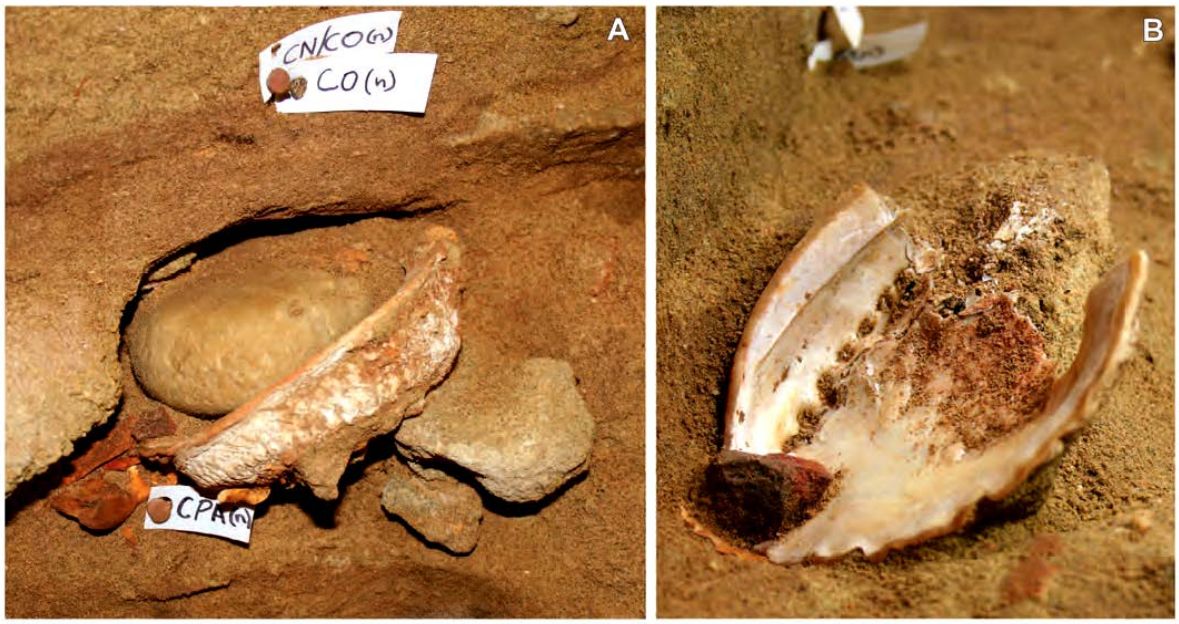
The news that most humans outside of Africa carry fragments of DNA that match with those of Neanderthals and the mysterious Denisovan archaic humans (see *Yes, it seems that they did...* and Other rich hominin pickings May 2010) has entered into popular culture; or soon will have! Similar dalliances with 'archaic'humans seem also to have occurred among those anatomically modern humans who remained in Africa (Hammer, M.F. *et al*. 2011. Genetic evidence for archaic admixture in Africa. *Proceedings of the National Academy of Sciences*, v. **108**, p. 15123-15128; DOI: 10.1073/pnas.1109300108). The DNA of three groups in West Africa who maintain a hunter-gatherer lifestyles show non-protein coding regions that differ from the modern African norm. This suggests mating with an entirely separate and unknown group of hominins – probably archaic forms of humans – that produced fertile offspring, probably around 35 thousand years ago. Yet there is evidence that these were beings who split from the ancestors of anatomically modern humans at around 700 ka. The find spurred re-evaluation of bones with a mix of archaic and modern features that were discovered in a Nigerian cave in the 1960s (Harvati, K. *et al.* 2011. The Later Stone Age Calvaria from Iwo Eleru, Nigeria: Morphology and Chronology. *PLoS ONE*, v. **6**: e24024; DOI: 10.1371/journal.pone.0024024). The study confirms that the skulls are outside the fully modern human range, but display a close similarity with Neanderthal and *H. erectus*. The big surprise is that U-Th dating suggests they are quite recent, around 16 ka. The stage seems set for nor only a burst of exploration for human remains of less antiquity than early hominins but a 'paradigm shift' in our view of what constitutes a human species.

See also: Gibbons, A. 2011, African data bolster new view of modern human origins. *Science*, v. **334**, p. 167; DOI: 10.1126/science.334.6053.167.

Another interesting link with archaic humans who had the closest of relationships with some of our ancestors is that their union may have bolstered the resistance of migrants from Africa to Eurasian pathogens (Abi-Rached, L. and 22 others 2011. The shaping of modern human immune systems by multiregional admixture with archaic humans. *Science*, v. **334**, p. 89-94; 10.1126/science.1209202). The focus was on the human leucocyte antigen (HLA) group that is a vital part of our immune system in the form of 'killer cells'. Part of modern

Eurasian DNA that codes for the group (HLA-B*73 allele) appears in the Neanderthal and Denisovan genomes; indeed more than half the HLA alleles of modern Eurasians may have originated in this way, and have also been introduced into Africans subsequently.

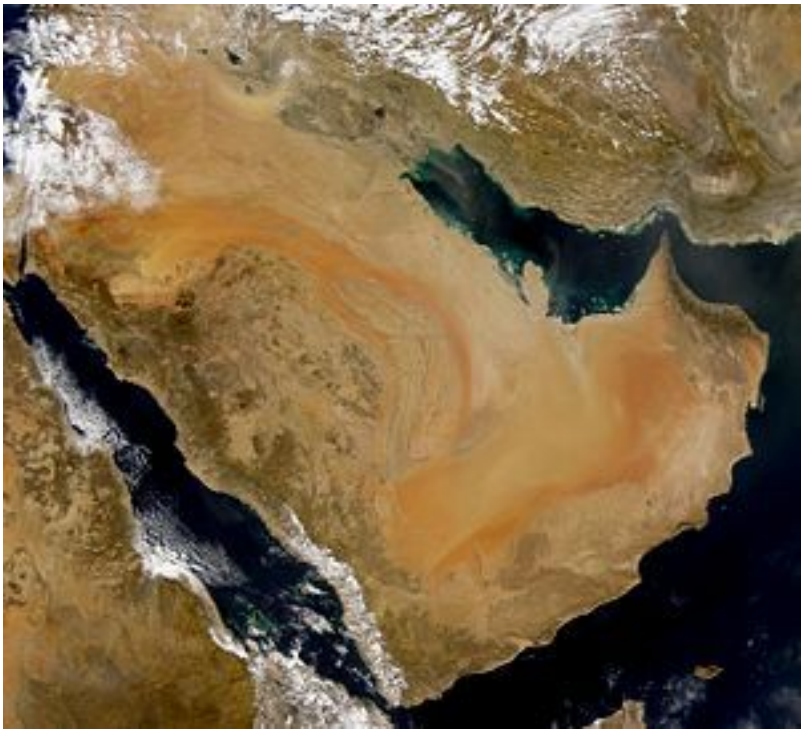
Also from the front line of genomic research into human origins, DNA sequenced from a lock of hair given to an Edwardian anthropologist by a native Australian turns out to have an extreme antiquity compared with that of other Eurasian people descended from African migrants (Rasmussen, M. and 57 others. An aboriginal Australian genome reveals separate human dispersals into Asia. *Science*, v. **334**, p. 94-98; DOI: 10.1126/science.1211177). The unique aspects of the Australian genome signify separation of a group of individuals from the main African population around 62-75 thousand years ago; significantly earlier than and different from 'run of the mill' migrants from whom modern Asians arose at between 25 to 38 ka. There is little doubt that native Australians are descended from the pioneers who first diffused from Africa either by crossing the Straits of Bab el Mandab or taking another route and they moved more speedily across southern Asia than other waves made possible by climate change and sea-level falls following the Eemian interglacial of 133-115 ka.



Ochre-processing tools as they were found in Blombos Cave (Credit: G. Moéll Pedersen)

Despite the lingering Eurocentrist view that somehow fully modern human consciousness sprang into being at the time the famous French and Spanish cave art was painted, around 30 ka, increasing evidence points to an African origin for a sense of aesthetics and the ability to express it. The latest is the discovery of a 100 ka 'paint box' in a South African coastal cave (Henshilwood, C.S. *et al.* 2011. A 100,000-year-old ochre-processing workshop at Blombos Cave, South Africa. *Science*, v. **334**, p. 219-223; DOI: 10.1126/science.1211535). The material consists of two large abalone shells containing traces of red and orange ochre, together with a hammer stone and grinder with adhering ochre, and fat-rich bones which ground-up would have produced a binder for the ochre. No art occurs in the cave and it might be supposed that the pigments were intended for face- or body adornment.

Water sources and early migration from Africa (*November 2011*)



The Arabian Peninsula today

I reported a puzzle in *Human migration: latest news* (above) relating to evidence for modern human occupation of Arabia on the southern shore of the Persian Gulf during the last Eemian interglacial at 125 and 95 ka. At that time sea level would have been as it is now, discouraging any attempt to cross the Red Sea via the Straits of Bab el Mandab; a widely suggested short-cut from East Africa to the rest of the world. Around 125 ka modern humans were making a living from coastal resources in Eritrea, leaving abundant stone tools in shoreline deposits at the head of the Gulf of Zula, and in the Sodmein Cave on Egypt's Red Sea coast. They had also reached the famous Qafzeh and Skhul caves of Mount Carmel in today's Israel around 100 thousand years ago. A route out of Africa through the Levant has not been widely favoured and the humans of Qafzeh and Skhul have been suggested to have reached a geographic cul-de-sac with no eastward exit because of the aridity of the Arabian Peninsula. Yet once in the Levant they could have skirted the desert interior by following the east coast of the Red Sea, and 'strandloped', as Jonathan Kingdon has dubbed following the coastline. But continuous access to fresh water would still have been essential.

The shores of the Red Sea preserve many examples of uplifted coral reefs, indeed signs of human presence in Eritrea occur in such a terrace. Being extremely porous, reef terraces are potential aquifers and a sign that they may have sourced freshwater springs is the conversion of the intricate coral skeletons from one form of calcium carbonate to another; original aragonite changes to calcite in the presence of fresh water, a complete replacement being estimated to take a thousand years of continual contact with fresh water. This change allowed Boaz Lazar and Mordechai Stein of the Hebrew University of Jerusalem and the Geological Survey of Israel to check for the presence of freshwater coastal springs in the past (Lazar, B. & Stein, M. 2011. Freshwater on the route of hominins out of Africa revealed by U-Th in Red Sea corals. *Geology*, v. **39**, p. 1067-1070; 10.1130/G32257.1). Their test site was a series of uplifted reefs near Aqaba on the Red Sea coast of Jordan. The authors

determined variations in the $^{230}Th/^{238}U$ ratio in the reefs relative to that of $^{234}U/^{238}U$ and showed open-system addition of ^{230}Th and ^{234}U during the aragonite to calcite recrystallization, that results in an isotopic compositional trend charting the timing of any alteration. Thus, the original age of reef terraces can be backtracked, revealing at Aqaba successively higher terraces formed recently and at 120, 142 and 190 ka. The oldest of the terraces seems to have been flooded with fresh water at the start of the Eemian interglacial (~140 ka), and may have been a source of springs that would have served the earliest human travellers well. It remains to use Lazar and Stein's approach at other reef terraces along the postulated northern exit route for the earliest modern human emigrants from Africa and, more important, to find traces of their passage.

Added 21 December 2011. The likely route for leaving Africa got a push towards the Bab el Mandab with publication of evidence for a greener south Arabia at several times in the late Pleistocene (Rosenberg, T.M. and 8 others 2011. Humid periods in southern Arabia: Windows of opportunity for modern human dispersal. *Geology*, v. **39**, p. 1115-1118; DOI: 10.1130/G32281.1). On the eastern edge of the now hyper-arid Rub al Khali are a series of former lakes with thin sediments. When first discovered they yielded radiocarbon ages of fossil molluscs of around 40 to 20 and 10.5 to 6 ka. However recent dating using optically stimulated luminescence (OSL) of the dune sands between which occur lacustrine muds and silts suggest that the lakes were water-filled for lengthy periods before those ages – radiocarbon dating can be reset to younger ages by precipitation of carbonates on older fossils. The OSL results show wet periods around 80, 100 and 125 ka, suggesting that around these times the Intertropical Convergence Zone was pulled northwards so taking seasonal monsoon rains well into the Arabian Peninsula. They tie in nicely with a variety of other parameters, including the timing of lowstands of the Red Sea. This created episodes a few thousand years long that would have been conducive to humans living there and passing through en route to Asia around eastern Arabia and perhaps to the Levant up the west side of the sub-continent. Potential occupancy was shut off by long arid periods, which might have allowed only pulses of migration. Had such episodic diffusion occurred it might have left a record in human DNA that ongoing and planned population genetic research may reveal.

More hominin updates (*December 2011*)

A new approach to ^{14}C dating at the Oxford Radiocarbon Accelerator Unit at the University of Oxford UK, combined with detailed analysis of human teeth to distinguish fully modern human remains from those of Neanderthals has pushed back the date and pace of migration into Europe by people whose tools define the Aurignacian and Italian Uluzzian technologies. These are the earliest modern-human cultures found in Europe, but some of the tools are similar to those produced by Neanderthals (Châtelperronian culture), raising the possibility of transfer of technologies between the two groups. So, without confirmation from human remains of the anatomical affinities the would be doubts about using tools of these kinds to signify the presence at a site of full modern humans. Teeth found decades ago at caves in SW England and southern Italy prove, on detailed comparative study, to be from 'moderns' (Higham, T. And 12 others 2011. The earliest evidence for anatomically modern humans in northwestern Europe. *Nature*, v. 479, p. 521-524; DOI: 10.1038/nature10484. Benazzi, S. And 13 others 2011. Early dispersal of modern humans in Europe and implications for Neanderthal behaviour. *Nature*, v. 479, p. 525-528; DOI: 10.1038/nature10617).The new

carbon-isotope method efficiently eliminates chemical contamination of material by post-fossilisation processes which tends to increase the measured age of samples. The two studies produced exciting results: dates of occupation between 42-43 and 43-45 ka from SW England and southern Italy respectively. Together with results from other sites throughout central and southern Europe, the discovery shows that widespread colonisation was accomplished in three to five thousand years by migrants probably from the Levant, who may have travelled along three routes fanning out from the Bosporus in modern Turkey: along the Danube; along the Adriatic coast; from southern Greece to the 'heel' of Italy.

In early 2011 a group of archaeologists led by Simon Armitage of the University of Birmingham, UK reported stone tools from a cave in the United Arab Emirates for which they derived possible ages of 125, 95 and 40 ka (see *Human migration* above). The older dates were coeval with anatomically modern humans in the Levant, but the tools themselves showed features that could not be matched decisively with those from any other sites, including those in the Levant, though they most closely resembled collections from East and NE Africa. Armitage and colleagues suggested that the people who occupied the UAE cave had crossed the Red Sea at the time of the glacial maximum around 130 ka, at a time of unprecedented low sea level. A recent paper adds considerable weight to this idea (Rose, J.I. and 9 others 2011. The Nubian Complex of Dhofar, Oman: An African Middle Stone Age Industry in Southern Arabia. PLOSone; DOI: 10.1371/journal.pone.0028239). Jeffrey Rose, also of the University of Birmingham, and colleagues from Ukraine, US, UK, Germany, the Czech Republic and Australia excavated site in Dhofar southern Oman, much closer to the Straits of Bab el Mandab than the UAE. Chert tools found in the area are of the Levallois type, specifically resembling closely those found widely in the Nile Valley of southern Egypt and northern Sudan, and in the Afar Depression of Ethiopia, in deposits dated between 128 to 74 ka. The Omani tools yielded an optically stimulated luminescence age of about 106 ka. This nicely confirms that Africans had moved far beyond the confines of their home continent by the last interglacial episode, with the route to South Asia open to them along the shores of the Persian Gulf and Indian Ocean. However, the route that they had taken could equally have been around the head of the Red Sea as across the Bab el Mandab.