

Human evolution and migrations

Hominid evolution: a line or a bush? (May 2006)

From the late 19th century it has been clear that two species of our genus *Homo* inhabited Europe and the Middle East: modern humans and Neanderthals. Recent partial sequences of Neanderthal genetic material, compared with the human genome, confirm that the two did not interbreed; at least, no trace of Neanderthal genetics remains in that of modern humans. The discovery in Indonesia that fully modern immigrants occupied the same territory as *Homo erectus* from 70 to 20 thousand years ago adds more weight to the hypothesis of multiple occupancy of the world by different kinds of humans until recent times. The astonishing discovery in 2003 of the remains of tiny hominids (*Homo floresiensis*) on Flores whose occupancy lasted from at least 840 ka to as recent as 12 ka (see [The little people of Flores, Indonesia](#), November 2004) confirms mixed occupancy late in hominid evolution. That includes several different representatives of *Homo* – *habilis*, *ergaster* and *erectus* – and also paranthropoids in Africa around 2 Ma years ago. As regards *Homo*, this cohabitation, especially that in Africa, supports two hypotheses: that our lineage was bush-like and involved separate extinctions and sudden appearances of new species (cladogenesis), or that the great variability in physiognomy (polymorphy) of modern humans extended back for a considerable time. The second is the view of Jonathan Kingdon, who believes insufficient hominid fossils have been collected to rule out polymorphism among tool-using and tool-creating beings. The idea of a single lineage since the first appearance of bipedal apes that led unerringly through gradual changes to modern humans (phyletic evolution) has been largely discarded. For at least part of the 6-7 Ma hominid record, that abandonment of phyletic evolution may have to be reconsidered, following a report of remarkably productive excavations in the Awash Valley of NE Ethiopia (White, T.D. and 21 others 2006. [Asa Issie, Aramis and the origin of Australopithecus](#). *Nature*, v. **440**, p. 883-889; DOI: 10.1038/nature04629).

The Middle Awash is the single most productive area for hominid remains and other fossils that help establish changes in their environment. That is so because of consistent collecting for more than two decades by a multinational team, co-led by Ethiopian and US palaeoanthropologists, from a sequence of flood plain sediments over 1 km thick, liberally interlayered with dateable volcanic horizons. Its middle parts record three species, *Ardepithecus ramidus*, *Australopithecus anamensis* and *Australopithecus afarensis* (of which 'Lucy' was a member), in an age range from 4.42 to 3.88 Ma. White and the other members of the team have unearthed 30 new fossils of all three species, but, so far, no examples of more than one in a particular thickness of sediments. Of course, 'absence of evidence is not evidence of absence', but this massive addition to the Pliocene hominid record is a challenge to the prevailing hypothesis of cladogenesis – Steven J. Gould's idea of punctuated equilibrium, in which species arise by sudden appearance of new characteristics from earlier ancestors. Its test is whether or not ancestral species co-exist with new species for a time. In the Middle Awash, it seems that they do not, even though the critical 300 m of sediments represents only 200 thousand years.

The three species, and their predecessor *Ardepithecus ramidus kadabba* (5.5-5.8 Ma), show variations in their teeth, with *Ar. r. kadabba* and *Ar. ramidus* sharing some similarities, and

Au. anamensis and *Au. afarensis* others. The shift between the two sets of common dentition can be explained by either gradual changes in a single lineage over about 2.5 to 3.0 Ma, or a sudden speciation event, perhaps around 4.5 Ma. The lack of overlap favours the first hypothesis. Complicating factors are rife, however, for there may have been migrations (*Ar. Ramidus* is known from far to the south in Kenya), and yet more evidence will undoubtedly be found from the vast amount of sediment of this age in the Afar Depression.

See also: Dalton, R. 2006. Feel it in your bones. *Nature*, v. **440**, p. 1100-1101; DOI: [10.1038/4401100a](https://doi.org/10.1038/4401100a).

Palaeodentistry (May 2006)

Those of a nervous disposition perhaps should not read this item.

A 7500 to 9000 year-old Neolithic graveyard in Pakistan has yielded remains of about 300 people who cultivated wheat, barley and cotton, and herded cattle. There is nothing remarkable in that, except that nine individuals have teeth that have clearly been drilled neatly (Coppa, A. et al. 2006. [Early Neolithic tradition of dentistry](https://doi.org/10.1038/440755a). *Nature*, v. **440**, p. 755-756; DOI: 10.1038/440755a). The holes are between 1-3 mm in diameter and up to 3.5 mm deep, and would have exposed sensitive parts of the tooth. In excavations of the nearby village of Merhgarh are found tiny flint drill heads associated with beads of various ornamental materials. The drills are of the same size as the tooth holes. Quite probably, miniature bow-drills tipped with flint would have been used by Neolithic dentists for at least 1500 years – there is no evidence for tooth drilling from younger cemeteries in the area, despite abundant evidence of dental decay. Experiments show that such drills would take less than a minute to produce the neat holes, probably wielded by jewellers rather than dentists.

Asian *Homo erectus* skilled in tool making (May 2006)

The 1.8 Ma emigrants from Africa who first populated the Far East have not been regarded as having been especially inventive. While their 'cousins' in Africa developed the aesthetically stunning bi-face axe about 1.6 to 1.4 Ma ago (the first instance of visualising a finished object within a rough piece of raw material), *H. erectus* in East Asia is associated with the most primitive stone tools made by simply breaking flinty stones. That seemed to have been the extent of their stone-using skills up to their final demise about 20 thousand years ago – not a lot of progress in 1.8 million years. A report in March at the Indo-Pacific Prehistory Association Congress (Manila) of yet to be published work by Harry Widiyanto of Indonesia's National centre of Archaeology may force a revision of this less than charitable view of early Asians (Stone, R. 2006. [Java Man's first tools](https://doi.org/10.1126/science.312.5772.361). *Science*, v. **312**, p. 361; DOI: 10.1126/science.312.5772.361). In the Solo district of Java, made famous by Renée Dubois who found the first fossils of *H. erectus* there, a wealth of finely worked flake tools has been discovered in sediments that are about 1.6 Ma old. Most are small and made from blood-red to beige, translucent chalcedony. It seems that necessity was the mother of invention in this case, because suitable materials for sharp tools are very scarce in Java.

Implications of a mismatch between hominin genes and bones (June 2006)

Finds in Kenya, Ethiopia and Chad during the first few years of the 21st century suggest that bipedal hominins, perhaps on the human clade, emerged as long ago as 7 Ma. Even using the previously accepted molecular-clock age for separation of chimpanzees and hominins, this is dangerously close to the time of the last common ancestor of both (5-10 Ma). Results from comparison of more detailed chimp and human genomics (Paterson, N. *et al.* 2006. [Genetic evidence for complex speciation of humans and chimpanzees](#). *Nature*, DOI: 10.1038/nature04789. See also [Discussion and Reply](#)) throw up a bewildering series of possibilities. On Patterson *et al.*'s reckoning, our descent split from that of our nearest relatives no more than 6.3 Ma ago and perhaps as recently as 5.4 Ma, implying an overlap between tangible evidence and that based on DNA. Of even greater concern is the fact that human and chimp X-chromosomes are more similar than the rest, and seem to have diverged even later. One way in which this greater similarity could have arisen is if natural selection had been operating more strongly on X-chromosome genes, which studies of other related species show to have stemmed from hybridisation. Genes found on X-chromosomes that make hybrids less fertile can create strong selection pressures on this chromosome. An explanation that takes into account the young date of apparent splitting and strong selection operating on X-chromosomes is that the actual speciation(s) did take place before the time when the oldest hominin fossils were preserved, but that there was common interbreeding between the two closely related lines.

Understandably, palaeoanthropologists and geneticists are arguing heatedly, but failing to recognise the great differences between fossils and extant genetic evidence: each is bound to tell a different part of the story. Yet another is the ecology connected to either lineage, the end point being a regional separation into creatures of forest and open savannah, separated by considerable distances in Africa – basically west and east of the East African Rift system. Before that climatic and vegetation-cover schism what would there have been to stop a great many branchings from either lineage of very closely related animals? The rarity of fossils from either may leave the true relationships early in the history of both clades completely impenetrable. One thing is for sure, although chimps and humans today do make close friendships, that is as far as it goes...

See also: Holmes, B. 2006. Did humans and chimps once merge?. *New Scientist*, v. **190** 20 May 2006, p. 14. Pennisi, E. 2006. Genomes throw kinks in timing of chimp-human split. *Science*, v. **312**, p. 985-986; DOI: 10.1126/science.312.5776.985a.

Hobbit matters (June 2006)

Debate about the significance of the tiny hominid fossils from the Indonesian island of Flores (*H. floresiensis*) continues to escalate. The remains are sufficiently complete for analysis of other things than size and morphology of skull and brain. It seems that the shoulder structure is different from that of modern humans, but more similar to that of full-sized *H. erectus* (see Culotta, E. 2006. [How the hobbit shrugged: tiny hominid's story takes a new turn](#). *Science*, v. **312**, p. 983-984). In ourselves, when standing straight, our inner elbows face slightly forwards so that we can work with both hands in front of the body. The necessary twist in the humerus is somewhat less in *H. floresiensis*, and by itself that would inhibit being able to make tools. However, the shoulder bones of the fossil articulate differently with the hobbit humerus so that a hunched posture would allow intricate work,

but not an overarm throwing action. Much the same features characterise the well-preserved upper bodies of *H. erectus* fossils from Africa and Georgia. Incidentally, like J.R.R Tolkien's fictional Hobbit, *H. floresiensis* also had disproportionately large feet.

It seems inescapable that *H. floresiensis* did make tools. As well as the 90-12 ka artefacts found in the Liang Bua cave with the hominid remains, which some have reckoned to be too complex for the small people to have made the, large numbers of similarly sophisticated stone tools have been found at other sites in Flores. These occur with similar prey species, but not hominid remains, from as long ago as 800 ka; a time at which only *H. erectus* was present in the Indonesian archipelago (Brumm, A. *et al.* 2006. [Early stone technology on Flores and its implications for Homo floresiensis](#). *Nature*. v. **441**, p. 624-628; DOI: 10.1038/nature04618).

The minute size of *H. floresiensis*, with a brain capacity of a mere 400 cm³, continues to cause some researchers to doubt that the fossils – in fact 9 sets of remains from Liang Bua – were other than congenitally deformed modern humans: microcephalics. In a [comment on the brain of H. floresiensis](#), anatomist Robert Martin and colleagues of the Chicago Field Museum of Natural History used scaling factors of other dwarfed mammals from island faunas to model the body versus brain size to be expected for similarly dwarfed hominids that might arise from isolated *H. erectus*. He calculated that the 400 cm³ brain of *H. floresiensis* should be associated with a creature with around 11 kg body mass: about the size of small monkey. But that conflicts with the fact that the famous skull shows no signs of other deformities associated with microcephaly (See Culotta, 2006).

Out of Africa and back again? (August 2006)

Humans left Africa with a meagre tool kit at a remarkably early date, possibly around 1.9 Ma from finds of primitive stone tools in Pakistan and Central China, and certainly before 1.7 Ma in the case of the now celebrated human remains at Dmanisi in Georgia and in Java. Around 1.7 Ma sites with evidence for human occupation extend from southern to north-western Africa and over 2/3 of the width of southern Eurasia. Despite the increased chances of preservation in later times, such a wide-ranging expansion seems not to have recurred until the fully modern human diaspora from Africa that began around 70 to 100 ka. Fossil evidence suggests that descendants of these earliest known migrants thrived until as recently as 20 ka in south-east Asia, and perhaps longer, if tiny *Homo floresiensis* prove to be other than symptomatic of congenital dwarfism. They represent a puzzle, and absence of evidence has deterred palaeoanthropologists from sticking out their necks, until a recent review of possibilities (Dennell, R. & Roebroeks, W. 2005. [An Asian perspective on early human dispersal from Africa](#). *Nature*, v. **438**, p. 1099-1104; DOI: 10.1038/nature04259).

For a long time all human remains dated between 1 and 1.9 Ma were ascribed to *H. erectus*, whose type specimen hails from Java, not Africa. Anatomical re-evaluation of specimens from Africa, notably the famous, 1.6 Ma old Turkana Boy from Kenya, shows that they are sufficiently different from Eugène Dubois's Javan *H. erectus* type specimen to warrant a different species name – 'Action Man' or *H. ergaster*. The Dmanisi humans have close affinities, but are older. Therein lies one puzzle: apart from the much more primitive (and rare) *H. habilis* of east Africa, there is no obvious African candidate as an ancestor for *H. ergaster* there. Dennell and Roebroeks speculate that they migrated back to Africa after

evolving there from some unknown earlier species. Another puzzle centres on the tools carried by the early migrants from Africa.

Simple chopper and rough flake tools first appear in north-east Ethiopia at 2.6 Ma, but with no clear sign of who made them. The first discovery of the earliest known tool kit was at Olduvai Gorge in Tanzania – hence their name, Oldowan. They are associated with remains of the earliest known human species *H. habilis*, but date only to 1.8 Ma. Since Oldowan tool use is now known to have extended over a huge range of Africa and Eurasia at that time, the original emigrants must have carried the culture with them sometime after its first appearance in Ethiopia at 2.6 Ma. The emblematic artefact of '*H. erectus*' is the beautiful pear-shaped biface axe, yet it first appeared at 1.5 Ma in Africa, and did not make an appearance outside the continent until about 700 ka. It never made it to east Asia until carried there by fully modern humans: it was an African invention. Oddly, these highly crafted tools are often found with little sign of wear, and indeed opinion about what they were for is divided.

The great problem in palaeoanthropology is absence of fossils, which is hardly surprising. Dennell and Roebroeks comment that most Late Pliocene to Early Pleistocene terrestrial faunas are nearly always of large, robust animals, and even they are uncommon. The ravages of erosion and transportation also make it difficult to date finds of stone tools, as they may have been mixed with younger dateable materials. With confidence, they rely on the old adage (not well liked by the Popperian school of scientific methodology) that, 'Absence of evidence is not evidence of absence', and also that the earliest evidence for a new migrant is bound to be younger than its first presence. They look to the palaeoecological record of the period, which suggests a vast extent of open savannah covering much of Africa and southern Asia in the period when the climatic effects of glacial-interglacial cycles had not gripped low latitudes to create the desert barriers of later Pleistocene times. For species adapted to savannah life there was little to prevent their very wide migration, indeed simple diffusion would have moved them across the entire savannah range. Once thought to be confined to the East African Rift, australopithecines have turned up as far afield as modern Chad, 2500 km away, and as long ago as 3.5 Ma. If such diminutive creatures with no tools could diffuse so far, then what might have been the geographic limitation to the earliest tool users? Moreover, diffusion has no direction in the area that presents its possibility: movement could have been back and forth. An intriguing point made by Dennell and Roebroeks is that climatic instability first appeared around 2.6 Ma in Central China, so any emigrants moving north would have been subject to greater evolutionary-selective pressures for longer. *Homo ergaster* might have evolved in Asia and returned to Africa in the face of worsening conditions. This approach raises as many plausible hypotheses as a stick can be poked at, and should re-vitalise palaeoanthropological research outside Africa as a means of testing them.

Dee also: Kohn, M. 2006. [Made in Savannahstan](#). *New Scientist*, v. **191** (1 July 2006 issue), p. 34-39.

'Peace' (Selam) disturbed (October 2006)

The Afar Depression of Ethiopia, especially the middle reaches of the Awash River, has become world renowned as the cradle for early humanity. After the revolutionising discovery in 1974 in the Hadar area of the 3.3 Ma old *Australopithecus afarensis* remains

that became known as 'Lucy', other finds – *Ardepithecus*, *Orrorin* and *Sahelanthropus* hit the headlines, pushing back the age of possible human ancestors to almost 7 Ma. None of these had Lucy's degree of preservation, and the vital issue for the origin of humanity – bipedalism – could only be addressed by scanty evidence about the position of attachment of the cranium to the spine. Much else had to be inferred from teeth and facial shape, and odd bits of long limb bones. Lucy and remains of other *A. afarensis* individuals that rain progressively washes from the badlands of Hadar provide an embarrassment of riches by comparison. There is little doubt that could walk upright, but a question that has lingered is whether or not it also clambered habitually in trees. The other missing information is the vital one of development, for one big difference between apes and us is the grossly extended infancy of modern humans during which the attributes of consciousness, language and much else that is unique arise. To get a grip on developmental issues demands near-complete juvenile remains. The oldest infant fossils that come close are those of a Neanderthal child from 100 ka ago. A dramatic paper (Alemseged, Z. *et al.* 2006. [A juvenile early hominin skeleton from Dikika, Ethiopia](#). *Nature*, v. **443**, p. 296-301; DOI: 10.1038/nature05047) brings the spotlight back to Middle Awash and to *A. afarensis*.

The drama has been long in the making. Zeresenay Alemseged, an Ethiopian working in Germany, made the initial find in 2000, collecting more material and painstakingly exposing bones from their sandstone matrix, grain by grain, over the last 5 years. The skull and dentition are complete, and bar the pelvis, lower spine and some limb bones, so is the rest of the skeleton. Morphology points unerringly to *A. afarensis*, and the stratigraphic position is the same as that entombing 'Lucy'. Even without the inferences that can be drawn from it, preservation of a complete body is a near-miracle that ranks with that of the 'Turkana Boy' (*H. ergaster*) and 'Lucy'. The entombing sediments are those of a small stream, which discharged to a large lake that occupied parts of the Middle Awash area during the Pliocene, so that the body was quickly enclosed in fine sands, possibly after the child was washed away in a flash flood. The jaws contain adult teeth waiting to erupt and, by comparison with chimpanzees, they suggest an age at death of about three years, although comparison with human children would probably give an older estimate. The shape of the adult teeth is similar to those of female, so the infant is a 'she'. Much more work needs to be done on 'Selam' (Peace in Amharic), but that reported so far bears strongly on the issue of bipedalism. The shoulder blades and semi-circular canals of the ear, on which balance depends, are ape-like, and a finger bone is curved like that of a chimpanzee. 'Selam' was equipped for climbing, but she has leg and foot bones with more human affinities, which would enable upright walking as well. Being a near-complete individual, 'Selam' can be compared with whole adult *A. afarensis* specimens, notably 'Lucy', and with modern apes and humans, to assess the crucial issue of development that should throw light on just how close the species was to a transition to the human species that arose about a million years later.

Interestingly, the same issue of *Nature* includes a mini-biography of the Tunisian-born geologist Maurice Taib. He was the first to work on the terrestrial Pliocene sediments of the middle reaches of the Awash River, thereby opening to road to palaeoanthropological fame for the likes of Don Johanson, Tim White and two generations of Ethiopian scientists, whom Taib played a major role in training and encouraging (Dalton, R. 2006. [The history man](#). *Nature*, v. **443**, p. 268-269; doi:10.1038/443268a).

See also: Wood, B. 2006. [A precious little bundle](#). *Nature*, v. **443**, p. 278-281. Wynn, J.G. *et al.* 2006. [Geological and palaeontological context of a Pliocene juvenile hominin at Dikika](#), Ethiopia. *Nature*, v. **443**, p. 332-336; doi:10.1038/nature05048.

Drying East Africa (October 2006)

The 7 Ma recorded history of humans and their hominin ancestors was almost exclusively East African, until early members of the genus *Homo* began to migrate in pulses after about 1.8 Ma. Exodus from Africa on several occasions has been linked with climate change or the opening of routes by falls in sea level during periods of massive ice accumulation at high northern latitudes. Likewise, the evolutionary adoption of a bipedal gait by formerly forest-dwelling apes was probably driven by climate change that saw the spread of more open savannah ecosystems. Records from fossil assemblages in river and lake-bed sediments of East Africa, and from pollen in nearby sea-floor sediments do show a reduction in woodland cover and a spread of grasslands since the Upper Miocene (6 to 8 Ma) – the period of hominin adaptive radiation. Most workers on African climate change in the Neogene attribute the shift to cooling, either through a fall in atmospheric CO₂ or the onset of Northern Hemisphere glaciation. Yet East Africa has its own engine for climate and ecosystem change: the formation of the great Rift system and the uplift associated with it. While recognised as a climatic influence tectonics in the region has been downplayed by comparison with global shifts. That is surprising, since in the last 20 Ma, and perhaps more recently, what was an area of low relief has been transformed while rift shoulders rose to more than 3 km, from Eritrea in the north to Malawi 6000 km to the south.

Before rifting began, flood volcanism poured out a basaltic veneer in the late Eocene to mid-Oligocene, to achieve a thickness of more than 2 km in Ethiopia. Rather than creating high ground the flood basalts, being denser than continental crust, probably caused subsidence that roughly maintained low surface elevations. The achieved their present high elevations in the Ethiopian Plateau no earlier than the late Miocene. Large plateaux deflect low altitude winds and seem certain to have influenced climate on a regional scale, as did the Tibetan Plateau. The timing and pace of East African uplift remains poorly constrained, partly because geological evidence shows highly episodic tectonics, with periods of seeming quiescence between episodes of extensive and profound faulting and uplift, and partly because many of the rocks involved are sparsely dated. Yet the present topography and geological infrastructure are sufficiently well known that modelling any morphological influence on climate is possible. By considering several plausible tectonic scenarios, a team of French palaeoclimatologists have modelled the possibilities (Sepulchre, P. *et al.* 2006. [Tectonic uplift and eastern Africa aridification](#). *Science*, v. **313**, p. 1419-1423; DOI: 10.1126/science.1129158). Their models show that uplift may have shifted atmospheric circulation drastically to establish the strong seasonality that dominates the region nowadays. Applying their results to likely ecosystems results in a pattern of decreased tree-cover.

While convincing, Sepulchre and colleagues' work demands more precise timing for the establishment of sufficient tectonic topography. Nevertheless, it shows that events, arguably beginning at the core-mantle boundary, that triggered East Africa's dominant tectonic influence, the Afar plume, probably conditioned our own eventual emergence.

A lot closer in time is an analysis of climate change in the Eastern Sahara desert since the end of the Younger Dryas (<12 ka) that devotees of the 'English Patient' will find revealing (Kuper, K. & Kröpelin, S. 2006. Climate-controlled Holocene occupation in the Sahara: motor of Africa's evolution. *Science*, v. **313**, p. 803-807; DOI: 10.1126/science.1130989). Being based on 150 archaeological excavations, the account of sudden humidity after 8.5 ka and then slow aridification since 5.3 ka is persuasive background to the rise of the pharaonic kingdoms of the Nile once nomadic Saharan pastoralism slowly became impossible.

Asian migrations reviewed (October 2006)

Sometime between 100 and 60 ka, fully modern humans found their way from Africa to the Far East and beyond. The timing and the issue of how many migrations were involved are topics in turmoil, now that genetic analyses help trace linkages among modern people. That was semi-popularised by Steven Oppenheimer's *The Peopling of the World* (2003, Constable, London), which remains the genetically based 'straw man' of human migrations. Like Oppenheimer, Paul Mellars also of the Dept of Archaeology at Cambridge University, argues for single exodus and rapid eastward dispersal, but leaves open the route either via the Straits of Bab el Mandab or through Mesopotamia (Mellars, P. 2006. Going East: new genetic and archaeological perspectives on the modern human colonization of Eurasia. *Science*, v. **313**, p. 796-800; DOI: 10.1126/science.1128402). While genetic lines of descent are a most powerful tool, any conclusions need confirmation through 'hard' evidence from excavations, and both Arabia and the India subcontinent are irritatingly blank in that regard. However, there are a few coastal sites that whet the appetite. As Jonathan Kingdon first suggested, in *Self-made Man and His Undoing* (1993, Simon and Schuster, London), the most likely routes for migrants would have been along the shoreline. 'Strandlopers' would have had easy pickings from littoral food sources, even during periods of aridity related to global cold spells. But there is the problem: with sea levels well below the present ones, most truly ancient sites will now be hidden below the sea. As regards the route taken, much depends on what the Nile valley has to offer archaeologically, for that is the natural way to the eastern Mediterranean and access to the Arab Gulf either across Syria or skirting the mountains of Kurdistan. The route across the Red Sea already has excellent support by the discovery by the Gulf of Zula in Eritrea of abundant evidence for habitation by 'strandlopers' around 100 ka.

Confused by radiocarbon ages? Hopefully, not anymore (October 2006)

When we come to the near past, signifying time that has elapsed becomes unclear. Most christians divide the last four thousand years into AD and BC (with some confusion as to whether the division is at 1 or 0 AD), yet muslims place their starting year differently, and so might many other faiths, if they so chose. The adoption of 'Before the Common Era' and 'the Common Era' (BCE and CE, which are the same as BC and AD) really doesn't help politically, being based on a now obvious fact: that the dominantly christian US and EU dominate the planet. The only foolproof way to judge elapsed time in years is to have some continual and irrefutably annual events to count. Now, it is not always convenient to use the annual growth rings in a collection of enormous logs of a variety of ages to tell time, and the same goes for snow layers in polar ice caps and layered stalagmites. Using the decay of radioactive ¹⁴C in preserved carbon-containing materials revolutionised archaeology and the

science of recent climate change. But it has a snag, for ^{14}C , unlike many other geochronometers, is continually being formed, by cosmic ray bombardment of nitrogen in the upper atmosphere. Cosmic ray flux is not constant, so the proportion of ^{14}C to stable carbon was different at any time in the past.

Until recently nobody knew how that proportion had varied. Radiocarbon ages have to be calibrated in some way, so that they record events in a truly absolute time-frame. Without calibration, even the most precise age determinations give a warped view of history (see [Rationalising radiocarbon dating](#) February 2004). For instance, the date when the Younger Dryas glacial pulse began was a thousand calendar years before its calibrated ^{14}C age. Despite heroic efforts to establish a link between radiocarbon ages and the true passage of years from long annual records in dateable materials, calibration gaps in the ~50 ka period achievable by using the quite short half-life of ^{14}C have caused a problem. Many published and even some new dates are given without calibration, while others are in 'years before present (BP)', i.e. before the start of above-ground atomic bomb tests in 1950, which uniformly contaminated all later atmospheric carbon with ^{14}C produced by nuclear transformation. The confusion should soon be resolved as the effort to match productivity of ^{14}C to real time nears completion (Balter, M. 2006. [Radiocarbon dating's final frontier](#). *Science*, v. **313**, p. 1560-1563; DOI: 10.1126/science.313.5793.1560). But some workers are impatient to give real ages using calibration curves for difficult periods, which have not yet been verified and are controversial. An interesting case relates to the possible overlap period, roughly around 35 to 30 ka ago, between fully modern humans and Neanderthals in Europe. That awkward era may soon be clarified with the unearthing of monstrous logs from New Zealand swamps, which may contain annual rings back to the 50 ka limit.

Neanderthal genome on the cards (*December 2006*)

That fragments of DNA from Neanderthal bones can somehow be spliced together is an astonishing development. There are two methods that have linked tens of thousands to a million base pairs (Noonan, J.P. and 10 others 2006. [Sequencing and analysis of Neanderthal genomic DNA](#). *Science*, v. **314**, p. 1113-1118; DOI: 10.1126/science.1131412. Green, R.E and 10 others 2006. [Analysis of one million base pairs of Neanderthal DNA](#). *Nature*, v. **444**, p. 330-336; DOI: 10.1038/nature05336). At one three thousandth of the human genome, that still leaves a lot of work to complete the Neanderthal genome, but advances in the methodologies may yield a draft version within two years.

A big hurdle to clear is getting fossil material that is not contaminated with modern human DNA, many of the available specimens having been collected before modern forensic precautions were developed. Luckily, a 38 ka bone from Croatia contains only 5% contamination from modern sources Another is damage caused by chemical degradation after burial. Nonetheless, interesting results are already emerging. The molecular clock technique indicates a divergence between ancestral populations that led to fully modern humans and Neanderthals about half a million years ago, long before signs of moderns appear in the fossil record at around 200 ka. The intriguing question about whether or not moderns and Neanderthals successfully interbred to pass on genes that were favoured by natural selection may also be answered. Earlier work on Neanderthal DNA fragments seemed definitively to rule out significant genetic exchange, but current studies are finding genes that may have entered the modern human genome in such a way. Candidates have to

be shown to have appeared in modern humans during the 10 to 15 ka period of possible contact in Europe after about 40 ka.

See also: Lambert, D.M & Millar, C.D. 2006. Ancient genomics is born. *Nature*, v.444, p. 275-276; DOI: 10.1038/444275a. Pennisi, E. 2006. The dawn of Stone Age genomics. *Science*, v. 314, p. 1068-1071; DOI: 10.1126/science.314.5802.1068

The diet of robust australopithecines (December 2006)

After the invention of stone tools in East Africa 2.5 Ma ago, the tool makers – species of *Homo* – shared the savannah plains with other hominids that were very different. Until around 1 Ma ago australopithecines were our ancestors' cohabitants, but ones designated as 'robust' by virtue of their much larger teeth and thick skulls with a bony crest on top to anchor large chewing muscles. While early humans have long been known to have a broad diet that included meat, from the morphology of their teeth and the wear patterns on them, robust australopithecines, such as *Paranthropus*, were thought to be specialised consumers of tough vegetable matter.



Cranium of *Paranthropus robustus* (Credit: *Science*)

A means of roughly establishing an animal's diet uses the relative proportions of ^{13}C and ^{12}C in their fossil remains. Differences in the $^{13}\text{C}/^{12}\text{C}$ ratio arise from plants at the base of the food chain. Grasses using the C_4 photosynthetic pathway have distinctly higher values of the ratio than the bulk of broad-leaved herbs, shrubs and trees. Carbon incorporated into fossilised hard parts retains the ratio inherited either from a vegetable diet or by eating other animals with a grazing or browsing life style. The approach has proved very useful in recognising extinct grazing and browsing herbivores and the preferred meat on which carnivores dined. However, analyses have depended on drilling into teeth and the owners of rare hominid fossils have been unwilling to expose them to damage. Tooth enamel has great potential because it exhibits 1- to 2-week growth layers that can reveal seasonal differences in diet. The new technique of laser-ablation mass spectrometry is almost non-destructive

and can chart these variations (Sponheimer, M. *et al.* 2006. [Isotopic evidence for dietary variability in the early hominin *Paranthropus robustus*](#). *Science*, v. **314**, p. 980-982; DOI: 10.1126/science.1133827). The first results show that *Paranthropus* had an annual diet in which the proportion of grasses and their seeds, and possibly the meat of grazing animals varied by as much as 40%. That suggests either a seasonal migration from open grassland to more wooded terrain or that *Paranthropus*'s robust dentition allowed them to get by with browsing tough shrubs and leaves during the dry season, as do modern gorillas. They were not as specialised as widely believed, which could explain their long survival despite competition with tool-using early humans.

See also: Ambrose, S.H. 2006. A tool for all seasons. *Science*, v. **314**, p. 930-931; DOI: 10.1126/science.1135741.

Back to Africa? (December 2006)

Comparison of mitochondrial DNA (mtDNA) sequences in living females from many populated regions first established that the ancestry of all modern humans lay in Africa sometime before about 150 ka. Refinement of the mtDNA method of establishing relatedness and the approximate time and place of mutations then went on to suggest that about 80 to 90 ka ago the first modern humans left Africa across the Strait of Bab el Mandab at the mouth of the Red Sea when sea level fell at the onset of the last Ice Age (an earlier migration around 100 ka into what is now the Middle East seems to have failed). All humans surviving elsewhere are descended from those African migrants; quite probably only a few hundred at most.

As the mtDNA method and that based on Y-chromosome DNA in males become more reliable and have been applied to more and more individuals the finer details of migrations become clearer, as summarised entertainingly by Stephen Oppenheimer in his book *Out of Eden* (Robinson: London, 2004). The latest development comes from a multinational team (Olivieri, A. and 14 others 2006. [The mtDNA legacy of the Levantine early Upper Palaeolithic in Africa](#). *Science*, v. **314**, p. 1767-1770; DOI: 10.1126/science.1135566). Two groups of females from North (Morocco and Egypt) and East Africa (Ethiopia, Somalia and Kenya) have mtDNA containing the genetic markers M1 and U6, which they share with females from the Middle East (the Levant) and southern Europe. Both markers arose from earlier ones that are found only outside of Africa. The most likely explanation is that their ancestors migrated back to Africa. That is not so surprising, but the date of the return, from the mtDNA 'molecular clock', certainly is. It was between 37 and 45 ka, around the same time as fully modern humans entered Europe as the Aurignacian culture. The time is around that (44-48 ka) of a prominent warming event shown by the Greenland ice cores. Cold and dry periods before that would have expanded the deserts of the Middle East, thereby creating a barrier to migrations from south-west Asia where the M and U mutations probably arose.