there a phased arrival of the Aurignacian in the west, consistent with a migration from elsewhere, and a correlated phased replacement or absorption of the Neanderthals?

- What internal morphological changes can be detected in the last Neanderthal and first modern populations which might reflect evolutionary change or gene flow between them (evidence of hybridization)?
- What behavioural changes can be detected in the late Middle and earliest Upper Palaeolithic archaeological records which might reflect changing adaptations, or interaction between Neanderthal and early modern groups, such as economic competition or acculturation?

Addressing these questions requires above all a better chronological framework for Europe between 30,000 and 50,000 years (30–50 kyr) BP. Part of this time span is beyond the present capabilities of radiocarbon dating, but the newly applied or newly developed dating techniques of uranium series, thermoluminescence (TL) and electron spin resonance (ESR) have the potential to date materials associated with human occupation during this critical period[6]. In the past two years, realization of that potential has grown with age estimates being obtained for five important Neanderthal hominids (Grotta Guattari, La Chapelle-aux-Saints, Le Moustier, Saint-Césaire and Banyolas)[1,7,8], as well as for some important archaeological sites. A picture is beginning to emerge of a complex and dynamic period of transition at the interface between the last Neanderthals and first modern humans in Europe.

In the Middle East, things are even more complicated. Although the technological transition from the Middle to the Upper Palaeolithic has been dated to about 45 kyr BP (some 5 kyr earlier than in Western Europe)[9], TL and ESR dating have supported other lines of evidence that anatomically modern humans were already present about 100 kyr ago[7,10] (see figure). There seems to be a period during which this area was occupied by both Neanderthals and early modern humans using indistinguishable Middle Palaeolithic technologies. Whether there was a contemporaneous coexistence or a migrational succession of these different hominids remains unknown.

The new technique of uranium-series dating with mass spectrometry has already achieved age estimates with errors of less than 1 per cent in the 100,000 years region when applied to corals[11]. Applications to secondary carbonates at hominid sites will, one hopes, provide results with similar precision. Thermoluminescence dating of burnt flint already seems to be at a stage where it is providing results with surprisingly small errors. ESR dating of tooth enamel is still fraught with the specific problem of uranium uptake which often prevents precise estimations[7]. Such has been the march of dating technology that we can expect the latter techniques to be further developed and their reliability enhanced by intercomparison with independent dating methods (such as radiocarbon and uranium series). With that, we should be able to arrive at a more accurate record of the dispersal of modern humans to all parts of the world and the transition from Middle to Upper Palaeolithic technologies.

But what of the Neanderthals? Despite talk of Palaeolithic genocide, it is now clear that their replacement by modern humans was not an overnight process, and the extent and manner of the interactions between Neanderthal and early modern populations could have taken different forms in different areas. Palaeoanthropologists are not agreed as to whether Neanderthals and early modern humans represented different species, but they were probably sufficiently closely related to allow hybridization. Mitochondrial DNA studies suggest that there is no trace of a genetic input from Neanderthal females in recent European samples[12]. This, however, is not the same as saying there was no hybridization, although interpreting the patchy fossil record of this period for 'hybrids' is very problematic. The archaeological data from industries such as the Châtelperronian in Western Europe and the Szeletian further east are more suggestive of population interactions[2,3], but these are replaced locally by industries firmly associated with modern humans.

The real fate of the Neanderthals may well have been gradual displacement to more marginal and less favourable environments, where their dwindling numbers would have suffered greater attrition from the vagaries of fluctuating climates and food supplies, as well as disease. The Neanderthals probably went out with a whimper, not a bang. □

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DAEDALUS

Tyre everlasting

The pneumatic rubber tyre is the crucial invention behind modern transport. Tyres are made in enormous quantities — and later discarded in enormous and intractable heaps. Daedalus now has a self-retreading tyre that will never wear out.

He points out that pneumatic tyres always leak. In the old days, you had to pump up your car's tyres every time you went for petrol. Rubber these days is much more retentive; but it too slowly leaks. Daedalus plans to make use of this effect.

Modern synthetic rubber is largely a polymer of the gas butadiene and the liquid styrene. If a tyre was pumped up with these fluids, they would gradually diffuse through the body of the tyre and escape from its surface. Now the oxygen of the air catalyses the polymerization of such compounds. So on reaching the outside of the tyre they should polymerize, and form new rubber exactly where you want it — on the tyre surface.

Even Daedalus didn't take the idea seriously at first. Oxygen is a very feeble polymerization catalyst. He imagined his novel tyre slowly acquiring a useless sticky surface of partially-polymerized rubber. But he then realized that as the monomers diffused out, oxygen would diffuse in, down an almost equally steep concentration gradient. The polymerization would therefore take place just beneath the surface of the tyre. Even if it took days or weeks, it should be complete long before wear had exposed that layer of rubber.

Even better, this cunning auto-retreading process is self-stabilizing. A rapidly-wearing tyre will get thinner, the monomers will diffuse out faster, and the rate of polymerization will increase. An unevenly worn area (from a serious skid, say) will likewise thicken faster than the rest of the periphery: the tyre will be self-balancing as well. Any actual leak would be rapidly sealed by outflowing monomer, making the new tyre puncture-proof too.

A lot of work will be needed to optimize this complex chemistry. But DREADCO's 'Grotyre' should then take over the market. Motorists and environmentalists will rejoice. Even the tyre industry should rapidly adapt to the change. Instead of selling tyres as such, it will sell the monomer fluid to filling stations, to put in their tyre-inflating compressors.

Grotyre technology will work on a small scale too. Running shoes with air-cushion inserts could also be pumped up with rubber monomers to counter their ever-thinning soles. But most running shoes are owned by fashion-dazed couch potatoes who seldom even amble. DREADCO's 'Grosoles' will be more useful on the boring, utilitarian shoes of people who really use their feet — housewives, salesmen and Jehovah's witnesses. David Jones