years ago, between the Middle Palaeolithic (Neanderthals) and Upper Palaeolithic (generally Cro-Magnons) in Eurasia. The Châtelperronian — which is characterized by a form of stone knife with a blunted diagonal edge, found for example at St Césaire — seems to be the only early Upper Palaeolithic industry that can definitely be associated with Neanderthals. But there are several other industries without associated fossil material.

Speculation about the effects that incoming Cro-Magnons might have had on Neanderthals in Europe depends on accurate dating of the archaeological cultures. Two schools of thought compete here. One holds that Neanderthals began the transition to 'modern' behaviour before Cro-Magnons arrived as, for instance, at Abric Romaní. The other is that the arrival of Cro-Magnons with behaviourally modern Aurignacian technology stimulated a similar development in Neanderthals. To tackle these issues, archaeologists will have to assess how much significance can be attached to constructs such as the Middle Palaeolithic, Aurignacian and Châtelperronian.

A better chronology of behavioural change and Neanderthal extinction is also required. At the moment, archaeological ^{14}C determinations often come up with a younger age for bones than for charcoal — this is because bones contain proportionately less carbon, and are more susceptible to contamination with younger ^{14}C . Where both bone and charcoal from the same level have been dated, some bone dates statistically match those on charcoal, but others are much younger and often make little stratigraphic sense. Most Châtelperronian dates are on bone samples, and so could either be about the right age or be underestimates — without comparable charcoal samples we cannot be certain. Resolving this issue will have a great influence on thinking about when and how Neanderthals achieved 'modern', Upper Palaeolithic behaviour.

The ^{14}C determinations also need to be corrected to account for variability in ^{14}C production. Intervals between ^{14}C dates will be expanded or contracted when we convert them to calendar years, and such changes can alter long-established views on the chronological pace and even the succession of human behavioural change. Cross-calibration curves are one answer, and it has become possible to calibrate dates against a curve ('CalPal³') derived from a marine core⁴ and lake sequence⁵ (B. Weninger, Köln Univ.; O. Jöris, Monrepos, Neuwied).

These curves are working models only, but several speakers in Liège described how they calibrated their ^{14}C determinations with CalPal. For instance, not only have Middle and Upper Palaeolithic ^{14}C dates from France and Iberia been corrected to

calendar years, but they have also been subdivided into dates for bone and charcoal (O. Jöris). The charcoal dates are consistently older than those for bone, and the pattern was even clearer after calibration. Such techniques will no doubt develop apace over the next few years, but these curves are complex and progress will not be straightforward. We can be sure, given the discrepancy between ^{14}C and calendar years of up to four millennia or so during the period 40,000–30,000 years ago, that many radiocarbon ages in the phase when the last Neanderthals and the first Cro-Magnons are assumed to have coexisted will be underestimates. But we cannot yet tell whether the upshot will be a longer or shorter inferred period of coexistence.

What of the future for these kinds of studies? More reliable chronologies are one item on the wish list. Another is identifying the makers — Neanderthal or Cro-Magnon — of some enigmatic European industries in the range 30,000–45,000 years ago, such as the Szeletian and the Bohunician. These industries are characterized by stone 'leaf-points', which are probably a form of projectile tip. They have previously been considered to be a central and eastern European analogue to the Châtelperronian — that is, a Neanderthal behavioural foray into the 'modern' world of the Upper Palaeolithic⁶. But in rethinking the transitional period we might in some cases consider the possibility that they are Cro-Magnon. A final wish is to be able to extract DNA from the earliest Cro-Magnons and compare it with the growing number of Neanderthal sequences. This has proved difficult so far, both because of preservation problems and because it will be far trickier to tell whether Cro-Magnon, as opposed to Neanderthal, DNA is contaminated with our own DNA.

Above all, both conferences showed that European prehistory cannot be studied in isolation — we will be better able to answer many questions about Neanderthals and Cro-Magnons when we have a comparably rich fossil and archaeological record from western Asia. ■

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Daedalus

The meaning of junk

The reading of the human genome has set Daedalus wondering what it all means. One puzzle is junk DNA, which is replicated down the generations as faithfully as useful DNA, but is useless or lethal if translated into protein. One theory is that it is a parasitic passenger. Daedalus thinks that nature is not so easily fooled; for him, junk DNA is a store of unused genes. He would like to think it might be a store laid in for the future. But more soberly, he agrees that it could be a relic, a cache of genes that came in handy in the past.

Human junk DNA should therefore tell us about the protohumans so vital to theory. How, for example, did our greatly extended childhood evolve? Presumably to accommodate the mighty human invention of 'unlearning' so many animal instincts: abandoning the fear, lust, rage and greed of animals and replacing them by the shrewd rational cunning of the true human. This evolution of new software is the hallmark of humanity, and should be written in our junk DNA, if only we can read it.

So DREADCO biochemists are studying the junk DNA revealed by the recent scanning of the human genome, looking for signs of the past. It should also throw up other markers — the development of the hand with its opposed thumb, or the foot and its bipedal gait, or the language instinct.

The DREADCO team are also looking for junk DNA laid down for future use. Even the most ardent believer in creative evolution must agree that most of this will have no value. In the same way, we need to store about a hundred times as much junk, or information, as we will ever use; we just don't know which 1% will be vital. But somewhere in among the junk the team hopes to read the things we should be preparing now: higher elasticity for the cardiovascular system, a better balance in women between pelvic shape and large brain size in babies, better-protected main joints, and a self-repairing brain.

But the biggest theoretical challenge is the 'panspermia' theory of Hoyle and Wickramasinghe. If indeed intelligent life is passed from one planet to the next by interstellar bacteria, those bacteria must carry in their junk DNA just the genes needed to develop such life. By contrast, mere earthly bacteria should have junk DNA reflecting their undistinguished past and unambitious future. Bacteria that colonize space will feel great evolutionary pressure to develop the ideal junk DNA for the job, very easy to spot.

David Jones