Zoology

Nose of moose


K. WARD/CORBIS

The distinctive size and shape of the moose's nose are a godsend for cartoonists. But to biologists this nose is no joke. Hence the investigations undertaken by Andrew B. Clifford and Lawrence M. Witmer (*J. Zool.* **262,** 339–360; 2004), "With a mind on the enigmatic function of the nose of moose".

The moose, *Alces alces*, is a member of the deer family, but its nasal apparatus is unlike that of any of its relatives. The apparatus overhangs the mouth, and the nostrils are large and laterally sited, as seen in this picture. The muzzle contains a long and complex nasal cavity, with a highly complicated muscle and cartilage system.

Using a variety of techniques, Clifford and Witmer undertook detailed anatomical studies of heads of moose that had been killed after being hit by vehicles, and of related species. Among the adaptive explanations they look at are that the nasal set-up enhances blood and brain cooling when escaping from predators, or that its mobile or tactile features improve the efficiency of feeding.

The authors' best bet, however, is that the curious design of the moose muzzle centres on the nostrils, and is primarily so that the nostrils can be closed when feeding under water. But, as they say, that conclusion is not watertight, and a further explanation — the ability to derive directional information from smell — remains plausible.

Tim Lincoln

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meteorites, we have recently learnt a lot about mineral grains in space by characterizing them remotely. For example, one of the most surprising findings of the Infrared Space Observatory mission was the great variety of types of star around which fine-grained silicates crystallize. It thus seemed certain that the young Solar System would also have contained interstellar silicate dust, as well as the other known grains, and there should be silicates from a variety of stellar environments in our meteorite collections.

Silicates make up the bulk of chondritic meteorites, however, so searching for the presolar variety requires a more subtle approach than for carbonaceous and oxide grains — akin to inspecting the haystack straw by straw. It requires both admirable patience and an ingenious analytical technique. Nagashima's group has developed a micro-imaging technique[3] that uses an ion microscope to detect different isotopes (such as those of oxygen — ^{16}O, ^{17}O and ^{18}O). In the images produced, any region of the meteorite that does not match isotopically the overall composition of the meteorite — and hence might be presolar in origin — shows up as a 'hotspot'. Nagashima *et al.*[1] have found hotspots *in situ* in the meteorites Acfer 094 and NWA 530: one micrometre-sized presolar grain made of the silicate olivine, plus five clusters of very fine-grained silicate that contain at least one presolar component.

This technique is remarkable in that it has managed to compete with the new-generation ion probe, the 'NanoSIMS', developed specifically for isotope-mapping over very small areas and hence perfect for the interstellar silicate search. In a parallel study, Nguyen and Zinner[4] have also reported presolar silicates in a sample of Acfer 094, captured in exquisite detail in NanoSIMS images. But these authors worked with a disaggregated sample of the meteorite: Nagashima and colleagues' detection has the advantage of being an *in situ* measurement.

The presolar silicates identified by Nagashima *et al.*[1] have a higher ratio of the oxygen isotope ^{17}O relative to the two other stable isotopes of oxygen, ^{16}O and ^{18}O, than does the bulk of the material in the Solar System. The silicon isotope composition of the grains is, however, close to normal. These nuclides formed inside stars and their isotopic abundances reflect the composition of the star, its size and its evolutionary stage; the grains that eventually took up these isotopes effectively bear a fingerprint that identifies the kind of star in which they evolved. The isotopic make-up of the presolar silicates suggests that they formed around red giants[1] — stars nearing the end of their lifetime and losing mass into space.

Nagashima *et al.* put the abundance of presolar silicates at between 3 and 30 parts per million, making them perhaps the most abundant type of presolar grain known (with the possible exception of diamonds). This abundance is very high for meteoritic presolar material, but it is about 100 times lower than that of the presolar silicates detected in interplanetary dust particles collected in the stratosphere[5]. The reason for the substantial difference in these values might be that the meteorites studied here originated in asteroids in the inner Solar System, whereas at least some interplanetary dust particles come from comets, which originate much farther from the Sun. Dust from the asteroidal regions might have experienced higher temperatures, at least intermittently, than dust farther out; or the presolar cloud might have been heterogeneous. Other presolar grains such as silicon carbide do not seem to be so depleted in meteorites, compared with their abundance in dust particles.

A comparative study of different meteorites should provide insight into how presolar grains were mixed and processed as the Solar System formed, and perhaps into the thermal profile of the early Solar System. If more silicate grains can be found, they should also help to answer the question of whether the inner Solar System once hosted presolar silicates that had formed in different astronomical environments. ■

Sara Russell is in the Department of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.
e-mail: sarr@nhm.ac.uk

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Palaeoanthropology

Neanderthal teeth lined up

Jay Kelley

A huge amount of biological information is preserved in the growth records of teeth. Tapping into those records provides a tantalizing look at how quickly Neanderthals grew up and reached maturity.

It is nearly 150 years since the existence of Neanderthals was first recognized, but debate about their relationship to modern humans remains as contentious as ever. Were they supplanted by modern humans or subsumed through interbreeding[1–4]? Information on Neanderthal growth[5], as well as genetic data[6,7], have recently been added to traditional studies of morphology in attempts to discern if we carry in ourselves any heritage of these immediate predecessors of modern humans in Europe. On page 936 of this issue[8], Ramirez Rozzi and Bermudez de Castro describe additional data on Neanderthal development that bear on their relationship not only to *Homo sapiens*, but to earlier European hominids as well.

The authors looked specifically at dental development. Teeth preserve their growth records, down to daily increments of deposition of the crown enamel and also the underlying dentine, from which the roots are formed. One curious occurrence in dental development is approximately weekly disturbances in deposition, which are preserved on the crown surface as a series of horizontal ridges known as perikymata (Fig. 1).

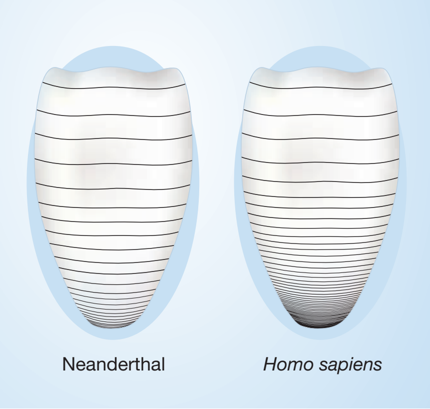

Figure 1 **Representations of the incisor surface of a Neanderthal (left) and Palaeolithic *Homo sapiens* (right). The horizontal ridges, or perikymata, are caused by brief, periodic disruptions in enamel deposition. Each of these successive ridges represents the developing enamel front at the time of the disruption as this front proceeds downwards from the tip of the cusp towards what will become the base of the crown. As the period of these disturbances is constant in any individual, they can be used to determine both the crown extension rate and the overall duration of tooth crown formation. Ramirez Rozzi and Bermudez de Castro[8] show that the less densely packed perikymata towards the base of Neanderthal incisors indicate that crown formation was more rapid, and the overall duration of crown formation shorter, than in *H. sapiens*.**

Ramirez Rozzi and Bermudez de Castro used the perikymata records from large numbers of anterior teeth (incisors and canines) to demonstrate significant differences in the rate and overall duration of crown growth between two Lower–Middle Pleistocene species of *Homo* (*H. antecessor* and *H. heidelbergensis*) and Late Pleistocene Neanderthals (*H. neanderthalensis*) on the one hand, and upper Palaeolithic–Mesolithic *H. sapiens* on the other. The two earlier Pleistocene species of *Homo*, which some researchers include in a single species, are from two localities in the Sierra de Atapuerca in Spain, respectively dated at roughly 800,000 and 500,000–400,000 years ago. The Neanderthal specimens come from numerous sites, with dates from about 130,000 to 28,000 years ago. The *H. sapiens* specimens, also from various sites, are between about 20,000 and 8,000 years old.

Tooth growth in *H. sapiens* is characterized by a dramatic slowing in the rate of crown extension after the formation of about the top half of the crown, indicated by the much closer spacing of the perikymata in the bottom half of the crown (Fig. 1). In contrast, Neanderthals share a more primitive pattern with *H. antecessor* and *H. heidelbergensis*, in which the slowing of enamel extension and crown formation are much less pronounced, indicating that the anterior dentition formed more quickly. Ramirez Rozzi and Bermudez de Castro argue that this indication of rapid dental development is further evidence, in addition to traditional morphological and the newer genetic and other developmental data, for placing Neanderthals and modern humans in separate species.

There are two compelling elements to this analysis. First is the large sample sizes, which are far larger than those in other, similar studies of fossil hominid dental development. Second is the remarkable consistency of the growth patterns despite the numbers of sites and the time spans represented in the Neanderthal and modern human samples. This is all the more significant given the potential sources of variation that might affect perikymata spacing, as Ramirez Rozzi and Bermudez de Castro point out.

The authors go on to make a number of more far-reaching claims. Based on their finding of rapid anterior-tooth crown formation in Neanderthals, they argue for more rapid growth as a whole and earlier attainment of adulthood, perhaps as early as 15 years of age, instead of approximately 18–20 years as in *H. sapiens*. This inference follows from another fascinating feature of dental development — that the overall period of development, and the timing of certain developmental events in particular, are strongly correlated with the pace at which an organism proceeds through its life stages, also known as its life history[9]. Thus, their conclusion that Neanderthals matured more rapidly than modern humans is not unreasonable. In fact, this has been suggested by others, but working without the advantage of the large samples amassed by Ramirez Rozzi and Bermudez de Castro.

Nevertheless, further studies of dental development are needed to test this conclusion. Because the correlation between dental development and the pace of life history is based on the timing of tooth eruption as opposed to crown formation, and therefore also involves root formation, it would be prudent to examine root development in Neanderthal teeth as well. The information on how rates of root formation vary across species, though scant, suggests that variation can be considerable[10,11].

Moreover, the strongest correlations between dental development and life history are those based on molar eruption, particularly the first molar. Ramirez Rozzi and Bermudez de Castro argue that because the sequence of tooth development is the same in Neanderthals and *H. sapiens*, the anterior teeth can serve as a reliable substitute for the molar teeth. This may well be the case. However, sequence and timing are not the same thing. For example, the sequence of tooth development and eruption is largely the same in most of the Old World monkeys and apes. But the relative timing between different teeth can vary greatly among species[12].

In a final exploration of the implications of their results, Ramirez Rozzi and Bermudez de Castro contrast the rapid dental growth and (inferred) early maturation of Neanderthals with their very large cranial capacity, which is greater, on average, than that of modern humans. To account for the apparently overly rapid maturation of Neanderthals given their large brains, and relying on life-history theory, Ramirez Rozzi and Bermudez de Castro suggest that rates of adult mortality in Neanderthals must have been very high. Again, this inference is at least plausible: among primates as a whole, dental development, life history and adult brain size are strongly correlated[9]. But variation and dissociation in these relationships are common if clusters of similarly sized species are analysed, and probably involve a host of species-specific factors. So it is not clear what to make of the particular expression of these relationships in Neanderthals — assuming they have been correctly portrayed — in contrast to modern humans.

As far as some of Ramirez Rozzi and Bermudez de Castro's conclusions are concerned, we will need more markers along the way to be fully confident that the trail of inference has reached the right destination. Nonetheless, these authors have opened up what should prove to be a fruitful line of research into both the relationships and the palaeobiology of Neanderthals. ■

Jay Kelley is at the College of Dentistry, University of Illinois at Chicago, Chicago, Illinois 60612, USA.
e-mail: jkelley@uic.edu

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