DIETS OF PREHISTORIC HUMANS — INVESTIGATED WITH STABLE ISOTOPES (^{13}C AND ^{15}N)

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Marine plants and animals have a higher content of the stable isotopes ^{13}C and ^{15}N than terrestrial plants and animals. These variations are passed down the natural food chains and, therefore, are also found in bone collagen from human beings who have subsisted either predominantly on marine food, or predominantly on terrestrial food (Tauber, 1981 a, 1981 b; Schoeninger, DeNiro, Tauber, 1983).

The differences in the content of stable isotopes may serve to elucidate some very central archaeological problems, such as 1) the subsistence patterns in prehistoric societies (which were the predominant food components in these societies?), 2) migration patterns (did people move between coastal places and inland places in order to utilize several ecological niches?), and 3) daily cooking habits (which food components were actually cooked in the earthen pots?). These are all long standing archaeological problems, especially within Stone Age archaeology.

The content of the two stable isotopes in various carbonaceous materials is measured as $\delta^{13}C$ values and $\delta^{15}N$ values, i.e. as per mille differences from the ^{13}C content of the PDB-standard and as per mille differences from the ^{15}N content of atmospheric nitrogen, respectively. Measured in this way, bone collagen from animals with known diets has given δ-values as indicated in Table 1. Similar δ-values have been obtained for bone collagen from human beings with a known reliance on either marine or terrestrial food.

All together 130 skeletons of humans, ranging in time from 10 000 B.P. and to the present, have been analysed for ^{13}C in order to investigate the development of food habits in prehistoris societies. The measurements have shown an apparent dominance of terrestrial food components in the Early Mesolithic (the Maglemose Culture), a strong dominance of marine food in the Late Mesolithic (the Ertebølle Culture), and a predominantly terrestrial diet from the beginning of the Neolithic and up to the present. The $\delta^{13}C$ values thus suggest a clear separation between a Hunter Stone Age (Maglemose Culture), a Fisher Stone Age (Ertebølle Culture), and a Farmer Stone Age (the Neolithic). The differences in diets between the Late Mesolithic and the Early Neo-

Table 1. Measured $\delta^{13}C$ and $\delta^{15}N$ values of bone collagen from terrestrial and marine animals with known diets.

	Terrestrial animals (n = 102)	Marine animals (n = 28)
$\delta^{13}C$ ‰	—23.0 to —17.4	—17.2 to —10.9
$\delta^{15}N$ ‰	+ 1.9 to +10.0	+11.1 to +22.9

lithic has been fully corroborated by the $\delta^{15}N$ values, which show the same pattern of marine and terrestrial food components. It may be noted that $\delta^{13}C$ and $\delta^{15}N$ values reflect not just the predominant food intake at a single dwelling place, but the overall, average food intake during an extended period of perhaps 5—10 years, during which the analysed bones were chemically build up.

The question of possible migrations between contemporaneous coastal and inland places in the Mesolithic could be unambiguously settled by means of ^{13}C or ^{15}N measurements, if skeletons of human beings from such contemporaneous sites were analysed. Due to the long time period reflected by the bones, interannual migrations would give similar $\delta^{13}C$ and $\delta^{15}N$ values of humans from coastal and inland places, whereas permanent settlements exclusively at the coast, or exclusively at inland sites, would give rise to a separation in $\delta^{13}C$ and $\delta^{15}N$ values similar to those indicated in Table 1 for marine and terrestrial animals.

So far bones of human beings from the Late Mesolithic in Denmark have only been recovered from coastal sites, but not from inland places. The question, therefore, cannot yet be decided. However, Nanna Noe Nygaard from the University of Copenhagen has suggested that the question of possible migrations may be solved by analysing bones of domesticated dogs from the two types of sites, because these animals live predominantly of the refuse from human meals. In two cases measurements of the ^{13}C content in bone collagen from humans and dogs from Late Mesolithic sites have substantiated this suggestion by showing similar $\delta^{13}C$ values corresponding to predominantly marine diets both for humans and dogs. Measurements of the ^{13}C content in domesticated dogs from Late Mesolithic inland sites, where no bones of humans are present, are very few, but so far they do not suggest interannual migration in the Late Mesolithic.

Finally, cooking habits may be elucidated by ^{13}C or ^{15}N measurements of the residues of food remains, which are sometimes preserved on the inside of the earthen pots. Measurements of $\delta^{13}C$ values of residues from 8 pots suggest that although diets were distinctly different in the Late Mesolithic and in the Early Neolithic, the components of the food that were actually cooked were rather similar, and in both periods were dominated by terrestrial food components. If the evidence provided by chemical investigations of the residues, as given by Birgit Arrhenius (this issue), is taken into consideration, it is suggested that the pots may preferentially have been used for cooking of roots and various types of vegetables, including grains in the Neolithic period.

Details of the measurements will be published elsewhere.

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