Evolutionary Medicine

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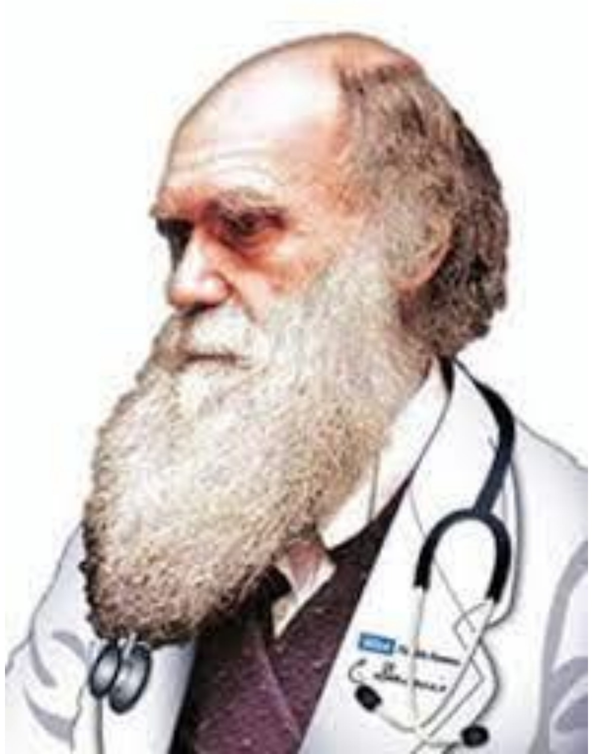


Isotopic reconstruction of ancient diet and health: implications for evolutionary medicine

Diet is personally and culturally important and helps us understand human physiology, metabolism and the evolution of these systems better.

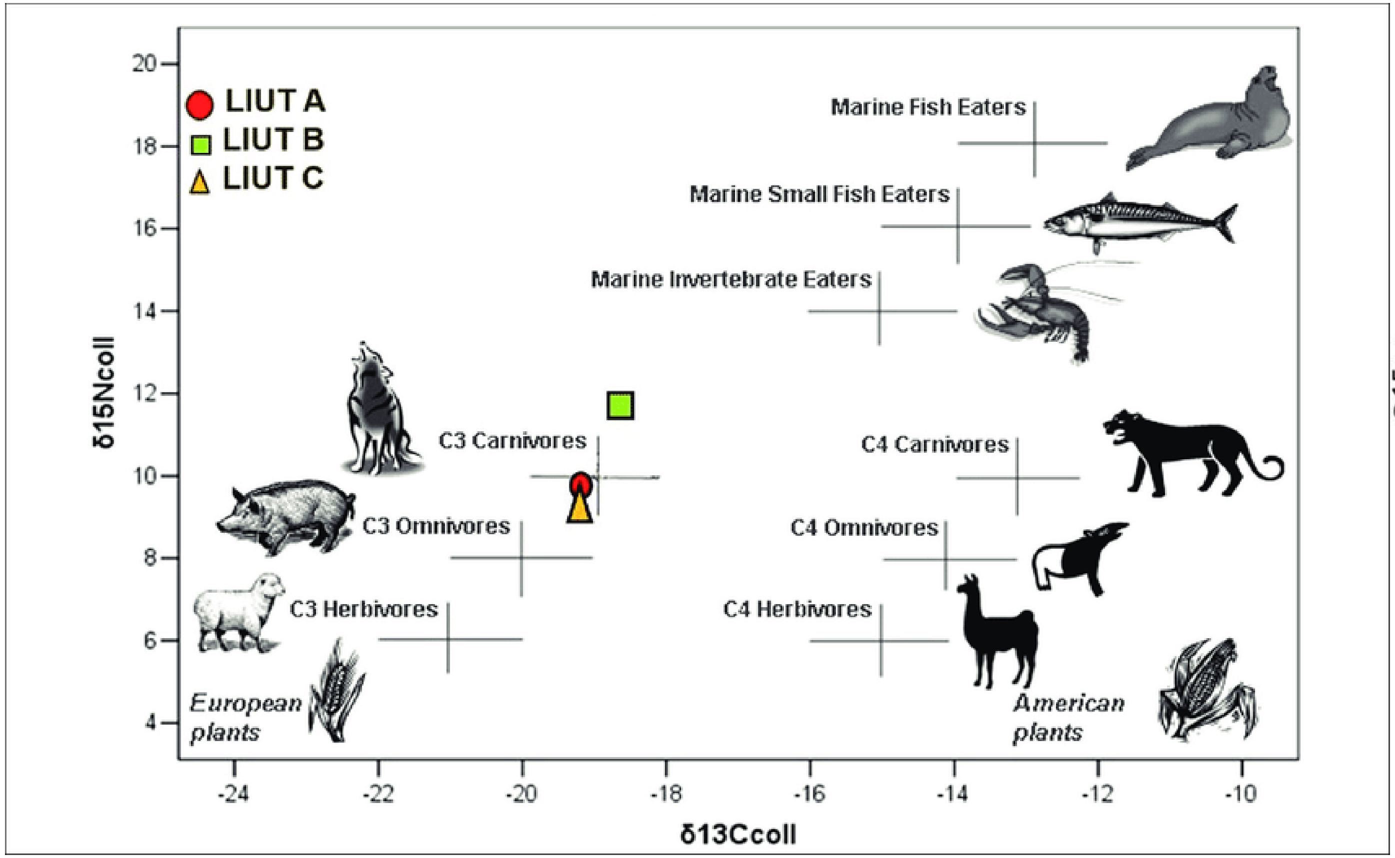
Understanding the diet and health of aour ancestor is directly relevant to modern public health and medicine.

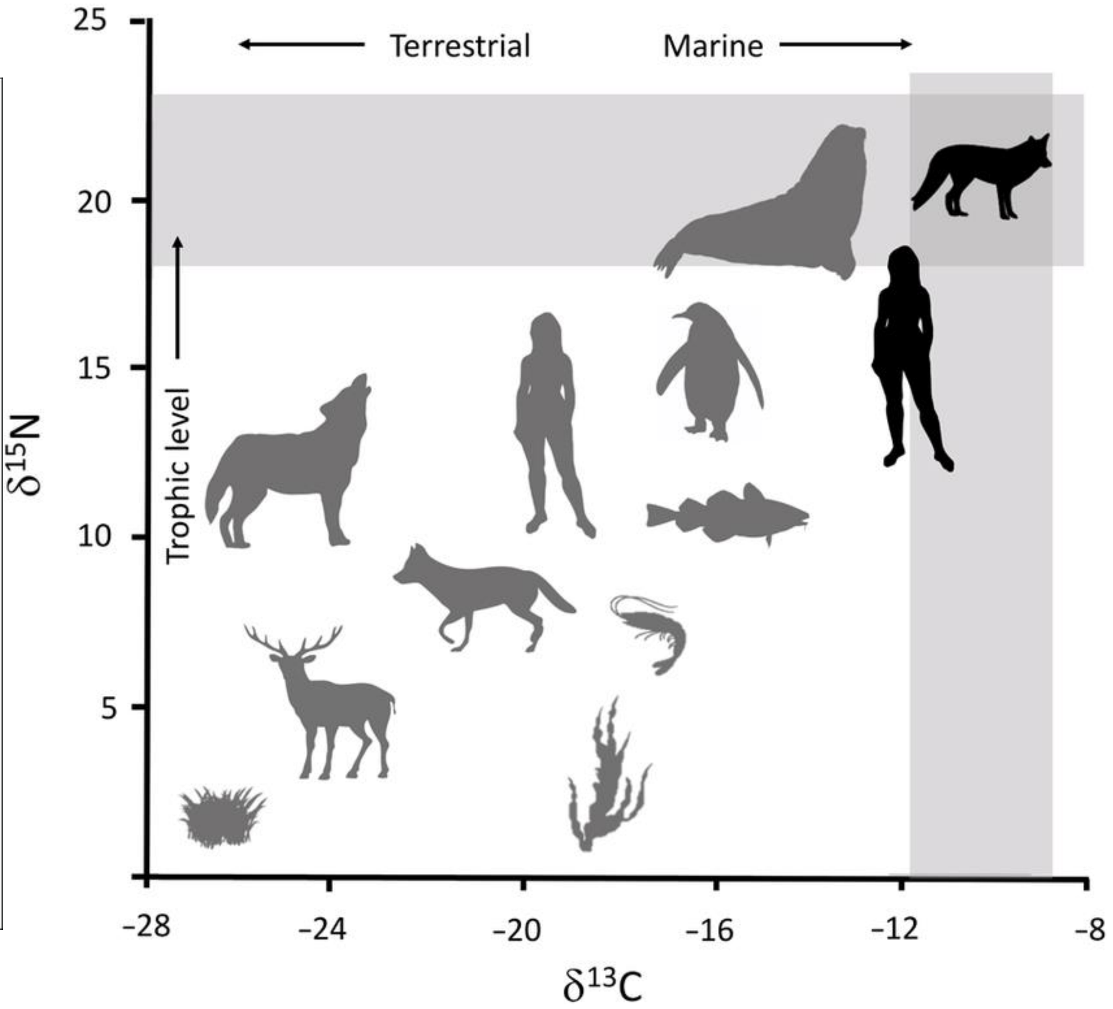
Stable isotope palaeodietary reconstruction and paleopathological data suggest a diversity of evolved human diets, and that dietary-induced health problem existed in the past.

Combining these data can help provide EM with the evolutionary perspective necessary for an improved undertstanding of diet-related condition like obesity and diabetes.

How stable isotope analysis reconstructs diet

Reconstructing the diets of ancient humans on the individual level relies on the analysis of isotopes cabon and nitrogen.

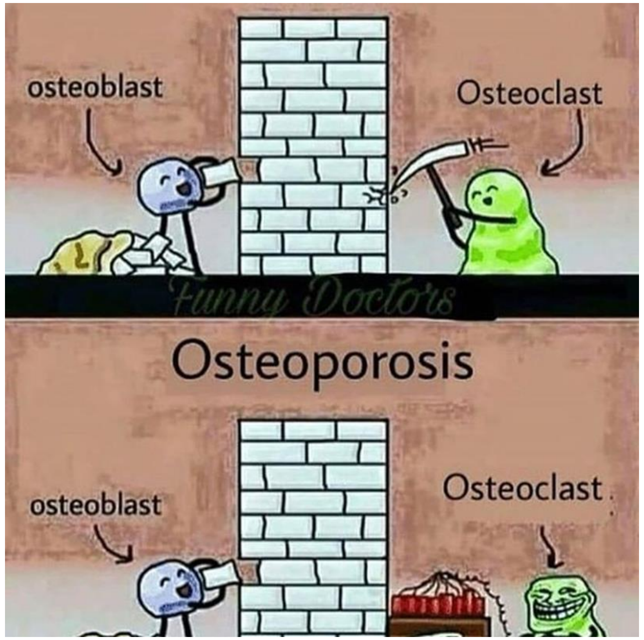


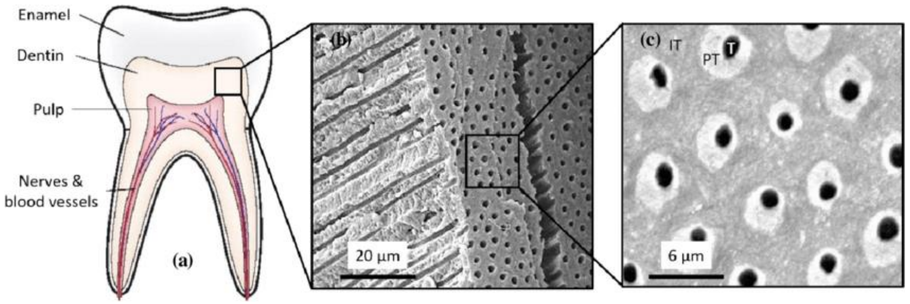


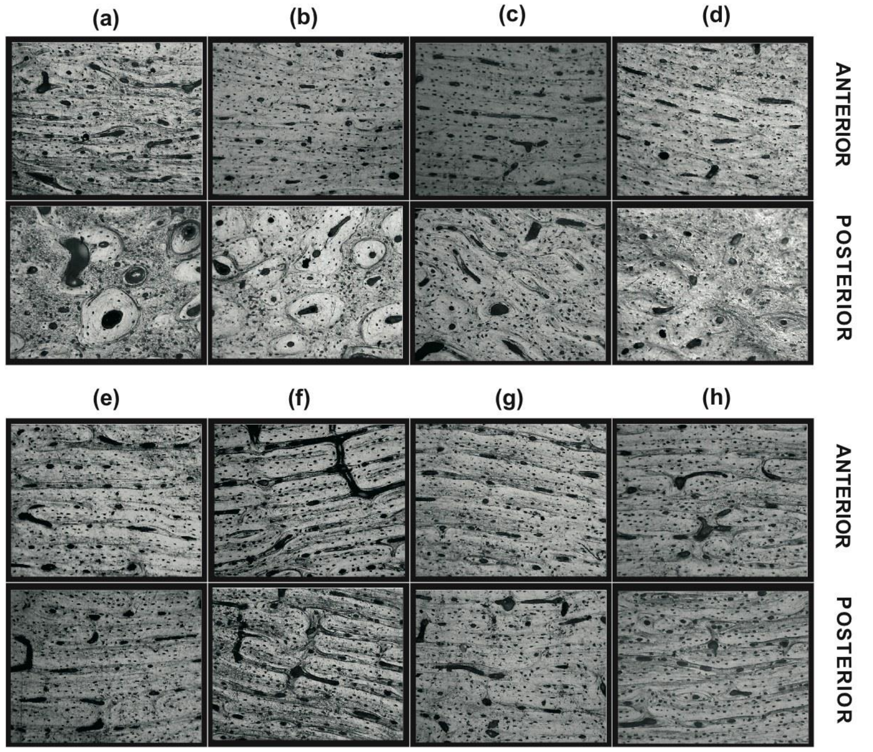
How stable isotope analysis reconstructs diet

Biological tissue are generated from the food and water consumed by individuals. Foods necessary for tissue synthesis vary in their stable isotope composition, including in the ratios of ^{13}C to ^{12}C and ^{15}N to ^{14}N. These elements are incoporated into tissues through internal fractionation or enrichment of one isotope relative to the other. Collagen-the primary organic component of bone, dentine and connective tissue-is synthesised primarily from dietary protein, and therefore contains stable isotopic signature reflective of a large component of individual protein budgets (see Ambrose and Norr, 1993, Schwarcz, 2000, etc.). Apatite, the inorganic component of bone and teeth, reflects the whole diet of an individual via its carbonate component (see White and Folkens, 2005).

Bone is formed via a proces of resorption and remodelling throughout an individual´s life, with tissue turnover occuring every 10-20 years, depending on the skeletal element.





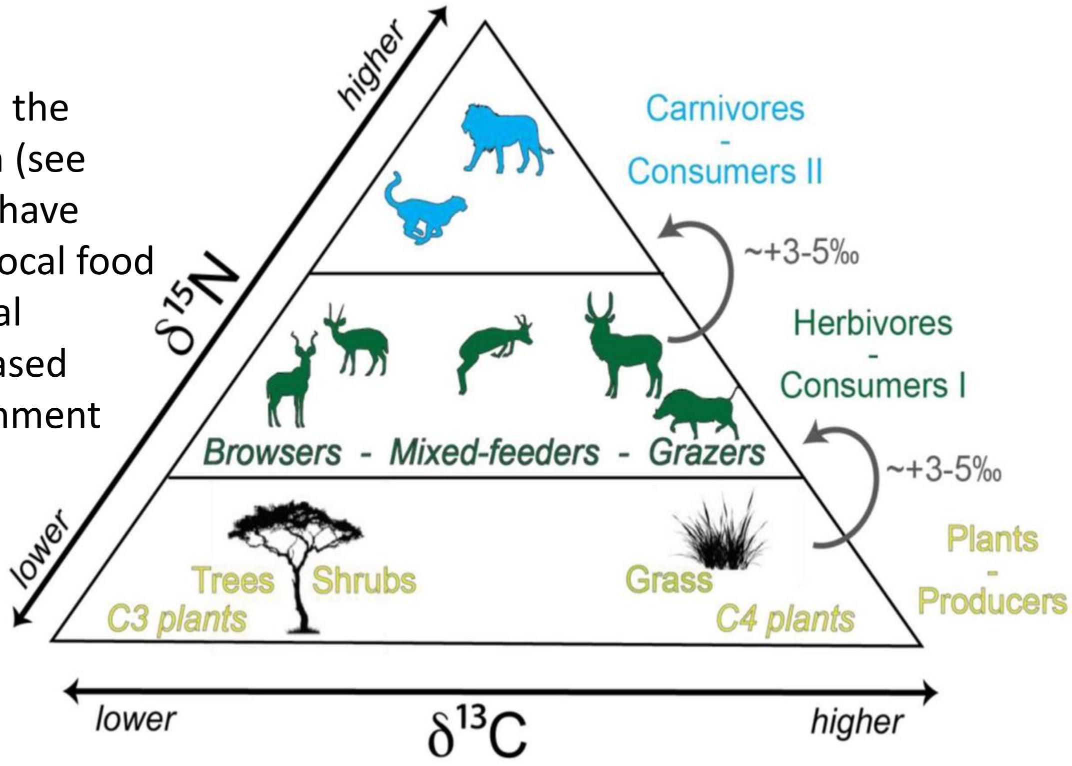


Optical micrographs showing variations in the microstructure along the length of the femur at sections (a) S1, (b) S2 to (h) S8 for anterior and posterior regions. The field width is 706 mm

How stable isotope analysis reconstructs diet

Consequently, stable isotope measures derived from bone reveal the dietary protein resorces consumed during the individual´s last decades of life (see Eerkens and Bartelink, 2013). Unlike bone, teeth do not experience tissue turnover and replacement; stable isotope ratios derived from either the collagen or apatite components of teeth reflect an individual´s diet during the period of development of specific tooth (see Hillson, 1986; White and Folkens, 2005).

Nitrogen isotope ratios, expressed as $\delta^{15}N$, display a trophic-level effect, wherein the collagen of a consumer will be enriched 2-4 ‰ over the source of dietary protein (see Schoeniger, 1985 or Schwarcz and Schoeniger, 1991). Different environment will have different isotopic starting points, which is why it is important to reconstruct the local food web or isoscape of the particular region of interest. In the food within a terrestrial environment, low $\delta^{15}N$ (usually 6-8 ‰) indicates consuption of primarily plant-based proteins, as is expected of a herbivore like a deer. Higher levels of nitrogen enrichment indicate incorporation of increased levels of animal-derived proteins see among omnivorous and carnivorous species.



Stable carbon isotopes in collagen weakly track trophic level but show a stronger correlation with the biological or ecological source of dietary protein. Stable carbon isotopes trach both marine versus terrestrial sources to the total protein budget and the dietary importance of C3 versus C4 plants (as maize, sorghum, and millet-it is important for archaeologist).

Stable isotopes, pathology, and health

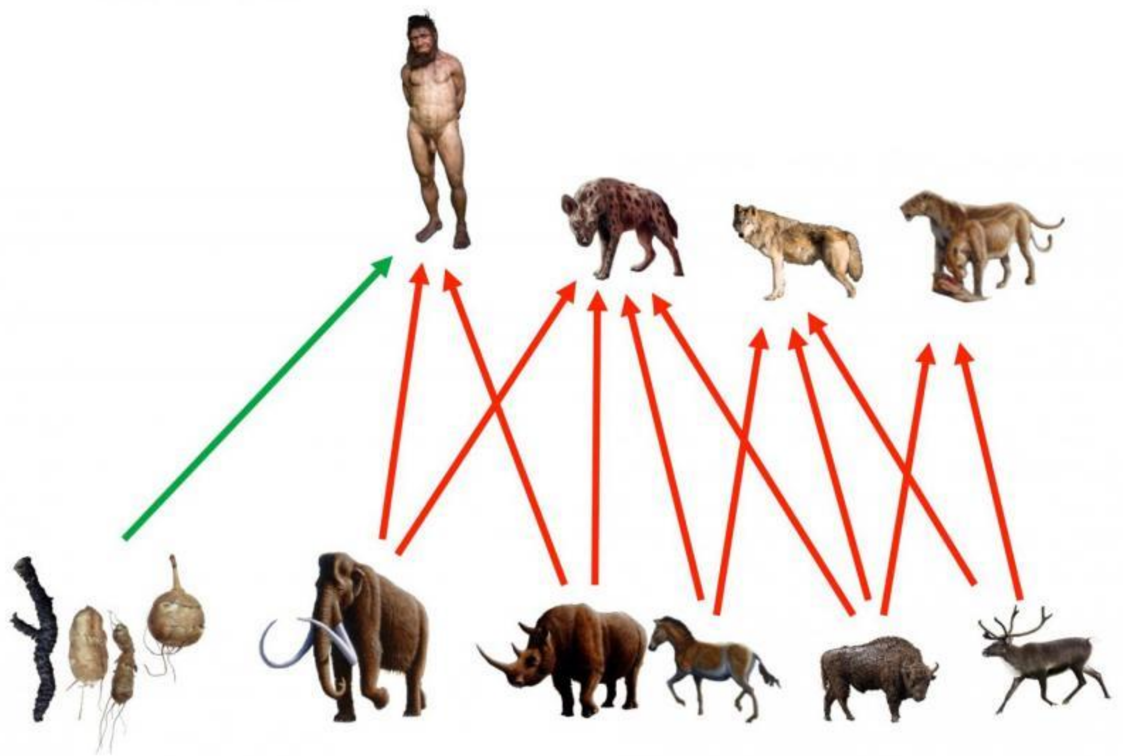
Stable isotope analysis has also been used to explore pathology in the past by looking for dietary differences that are correlated with disease (see D´Ortenzio et al., 2015; Fahy et al., 2017 etc.). This body of paleopathological research has two foci: a primary focus identifying correlation between the presence and severity of pathology and an individual´s diet to understand haw macro-ormicro-nutrient deficits may lead to ill health, and a second focus seeking to identify haw pathological condition might change isotopic signature in the tissue of an affected individual as a result of changes in metabolism (see Reitsema, 2013)

Hominin dietary ecology

The study of behavior and lifestyles of our hominin ancestors is an important area of anthropological study and isotopic data have been a major contributor to aunderstanding of their diets (see, Jaouen, 2018; Sponheimer et al., 2013 etc.)

Homo neanderthalensis

Homo neanderthalensis-diet



Hominin dietary ecology

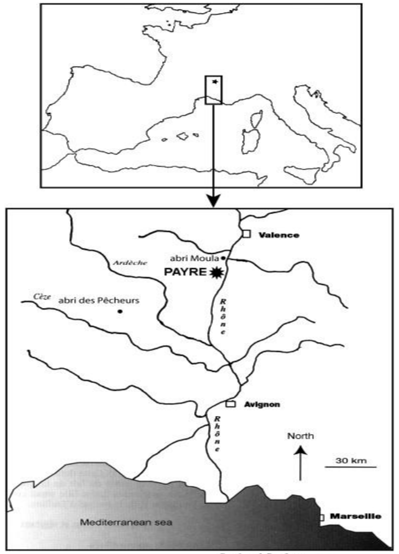
Understanding past dietary diversity between and within species is critical to understanding the evolution of human diet and its relationship to our environment and lifestyle (see Power et al., 2018 etc.). Isotopic analysis has been applied via both dietary reconstruction, and throught the palaeocological reconstruction of past enviroments. Direct comparison of diet and behaviour between species is strongest between *Homo neaderthalensis* and *Homo sapiens.* Diet it is cause of health disparities between modern *Homo sapiens* population and has been proposed as one of the key cultural differences between *Homo neanderthalensis* and *Homo sapiens* and a contributing factor to the better health and survivoship of *Homo sapiens* (see Melchionna et al., 2018; Villa and Roebroeks, 2014, etc.). This idea has persisted in popular consciousness despite clear evidence for dietary diversity and flexibility among Neanderthals, and Neanderthal-*H.sapiens* admixture.

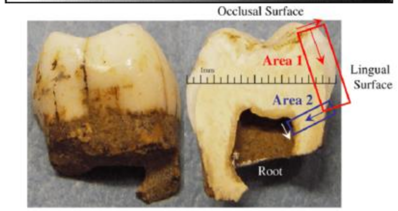
Hominin dietary ecology

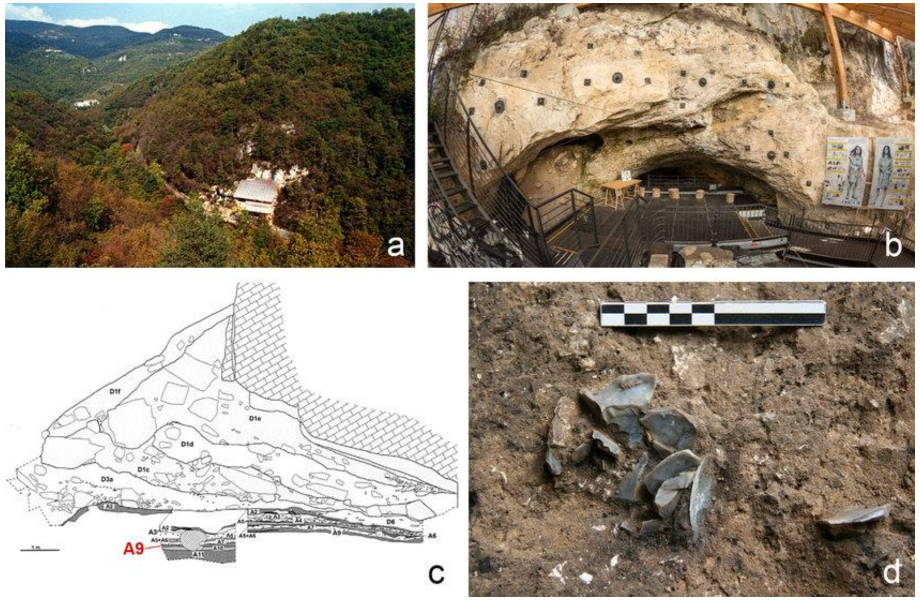
Neanderthals are thought to have exhibited higher rates of morbidity and infant mortality and lower total fertility rates compared to *H. sapiens* (see Hocket, 2012 etc.), which could be explained by a static, low-diversity diet. Low dietary diversity could also reduce the ability of Neanderthals adapt to a changing environment (see Power et al., 2018). The research showing variation in diet and health between Neanderthal communities is growing (see Power et al., 2018). Reconstruction of Neanderthal diet using zooarchaeological analysis showed seasonal exploitation of anaimals with a relianace on terrestrial hebivores (see Burke, 2000; Ready, 2013; Wood et al., 2012 atc.). The research was mainly focused on European neanderthal sites and indicated a large game-centred diet, with little to no evidence of other foods, even the consumption of small mammals. Tooal wear analysis and inicial residue analysis also indicated a reliance on hunting and butchering of animals (see Beier et al., 2018).

Hominin dietary ecology

Nitrogen stable isotope analysis of Nenaderthals confirmed the vision of meat-centred diet, with individuals having nitrogen signals higher than carnivores bones sampled at the same site (see Bocherens, 2009, Richard and Trinkaus, 2009). The isotope value were very similar in Neanderthals across their European geographical range regardless of ekology (open versus forested sites) and showed less variation within and between groups than was seen in *Homo sapiens* from the same period. If we asuume neandrthals had a metabolism similar to us, it seems impossible thah all of their nutritional requirements could be met without significant use of other plant and anaimal resource (see Hockett, 2012, Power et al., 2018). Analysis of Nenanderthals in the southern range of species (The Mediterranean and Middle East) does show evidence of broadering dietary niche over time. For example site such as Payre in France, Bolomor in Spain or Fumane cave in Italy have evidence small mammals and bird exploration, rather than strict focus on large game (see Blasco and Paris, 2009; Peresani et al., 2011)

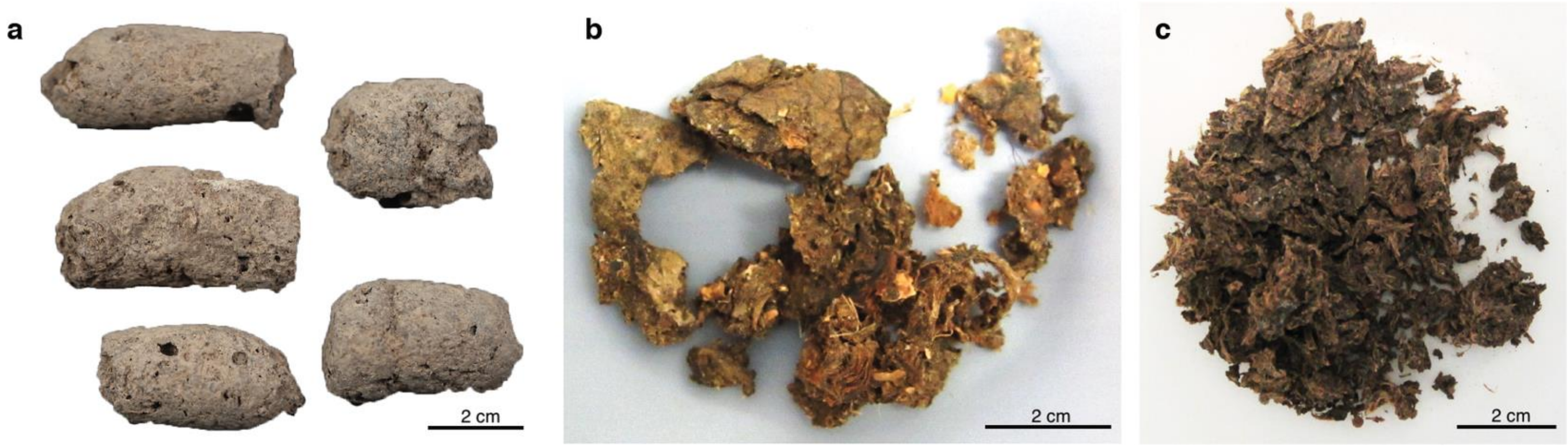


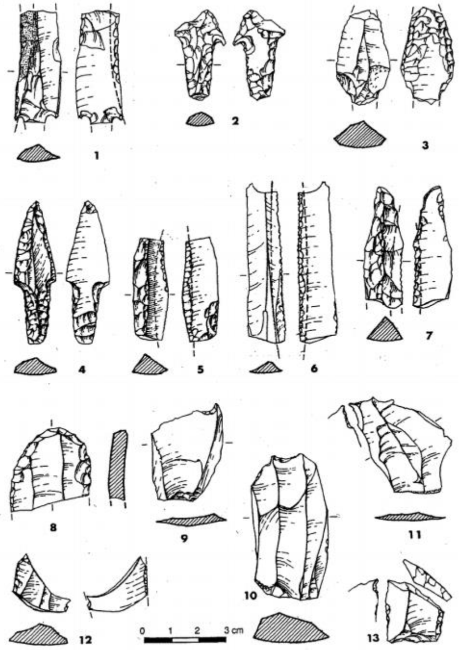


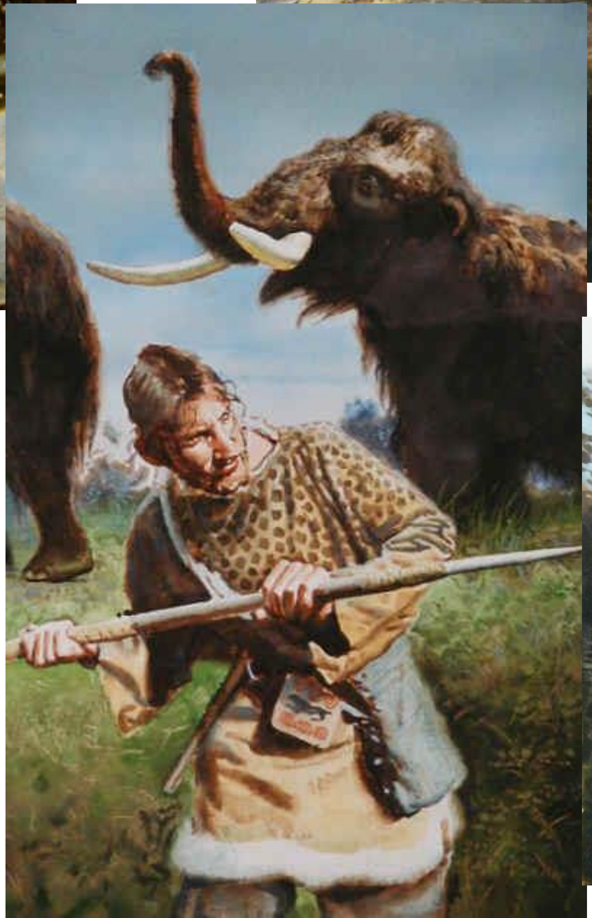


Hominin dietary ecology

Modern analysis of plant residues, coprolites and calculus have also provided evidence for a wide spectrum of starches and plants being eaten by later Neanderthals with local diet diversity (see Henry et al., 2014; Sistiaga, 2014). The complex behaviours of fishing and fish processing have also been identified throught lithic analysis at Payre (see Hardy and Moncel, 2011). The remains of processed and burned marine fish and moluscs were faound at Nenanderthals sites around the Mediterranean. We can see based on this data tha Neanderthals did eat local available foods and had some diversity in their diets, althought not as much as their *Homo sapiens* contemporaries. Stable nitrogen isotope analysis opf early modern humans shows a wide dietary variation between individuals and groups (see Richard at al., 2001). Diverse fauna and flora from these sites clearly indicate a diverse omnivorous diet reflective of local ekology and similar patterns we asociate with modern hunter-gatheres (see Richards and Trinkaus, 2009). These highly localised diets and ability to utilise new food sources likely played an important part in the global migration of our species. All this points to the readiness of our species, compared to the Neanderthals, to face the challenges of environmental changes and the ability to adapt to these changes.



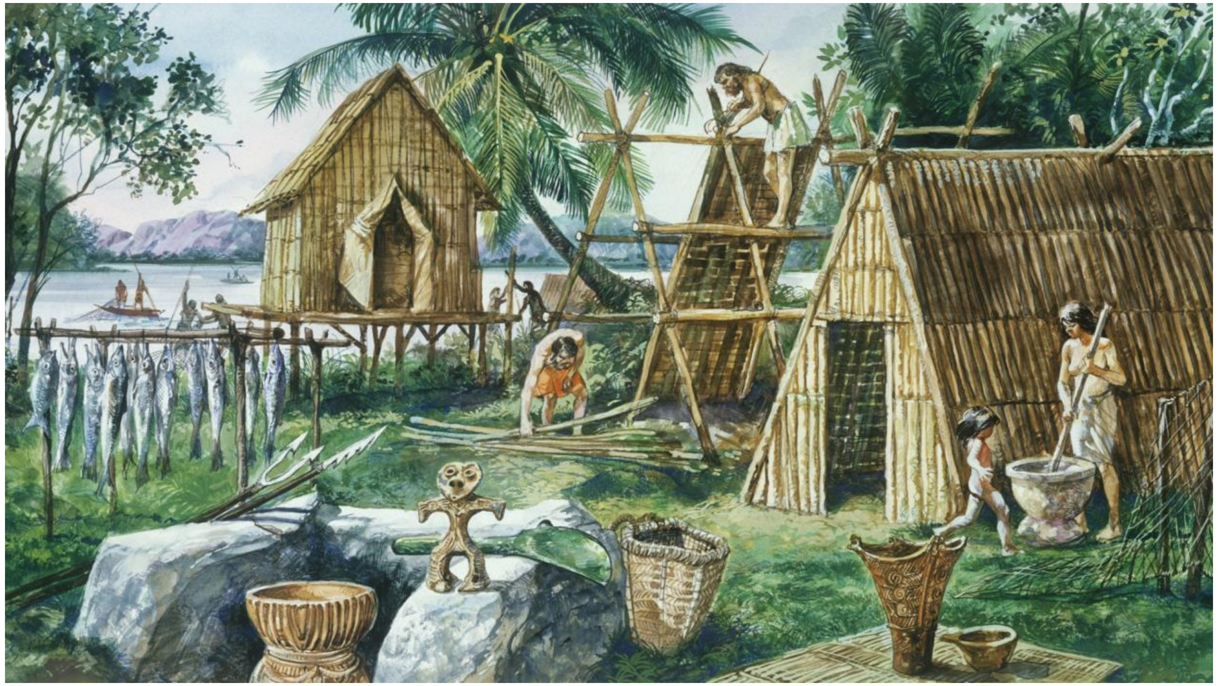


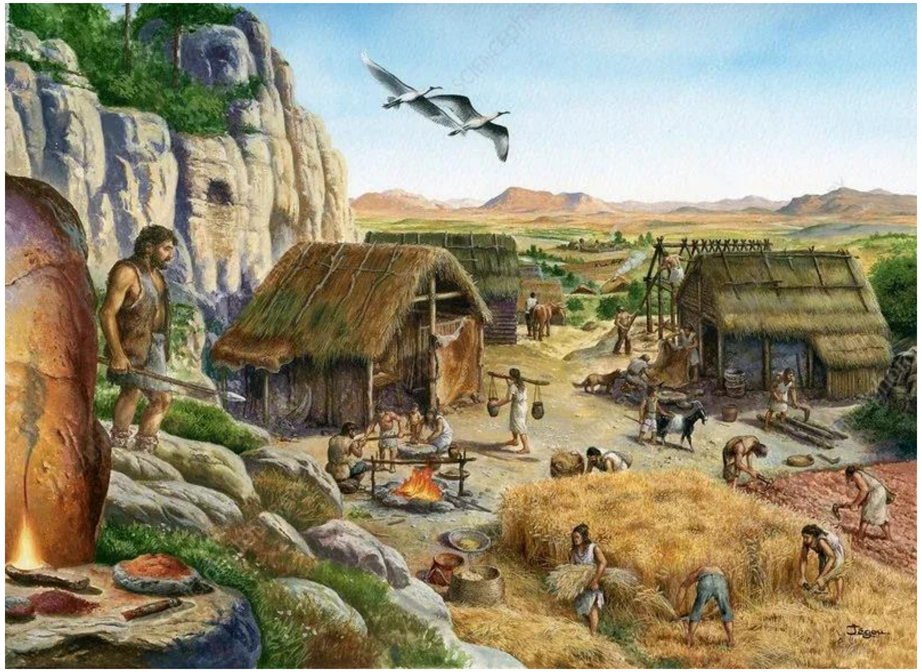


The so-called "mammoth hunters" were economically dependent on reindeer (already domesticated together with the dog, the dog helped guard reindeer herds) and small game (hares, foxes, white grouse, etc.), they were not dependent on mammoths, a mammoth was hunted 1-2 per/year , but the bones of mammoths are the most striking and they got their name from them (E. Štorch).They used everything from the reindeer, including the milk of the females.

Intensification and acriculture

The emergence of agriculture was linked to the expansion of our species and its need for food in the face of a growing population, and thus the domestication of animals and plants was considered important for our evolution. However, a contemporary study of contemporary hunter-gatherers has shown that this method is less labor intensive than agriculture and is much more successful. So the question arises why agriculture arose. Apparently, this is an adaptation to population growth and changing ecological conditions (see Bettinger, 2009, Kelly, 2007).





Intensification and acriculture

It turns out that the transition from a hunter-gatherer lifestyle to agriculture has had an adverse effect on our health (see Larsen, 1995). Agriculture has had an adverse effect on our dental health, tooth decay, tooth loss before death, child growth retardation, skeletal and dental pathology related to diet and physiological stress and degeneration (*cribra orbitalia*, porotic hyperostosis, osteoperiostitis, degenerative joint diseases and linear *enamel hypoplasias*). We note all this during the transition of hunter-gatherer cultures to agriculture (see Cohen and Crane-Kramer, 2005).

Intensification and acriculture

Infections and parasites related to animal domestication are increasing. Due to the increasing number and proximity of people and animals, the infection is transmitted from animals to people. The growth of these pathologies is not so much related to the diet, but rather to the poor hygienic conditions in which they live. These findings led to the rejection of everything connected with domestication, especially domesticated grain. This leads to the rejection of our diet and leaning towards extreme diets (paleo diet, keto diet, etc.). This leads to the rejection of our diet and leaning towards extreme diets (paleo diet, keto diet, etc.). Food sources that are beneficial to us both in terms of macro- and micronutrients are being rejected unnecessarily. Based on bioarchaeological analyses, we know that even agricultural societies used wild animal and plant species depending on environmental changes. They switched from one strategy to another according to the surrounding environment. This is also known in our country, when there are clear changes in the behavior of farmers and the transition from agriculture to hunting, depending on the climatic conditions. During periods of intense drought or precipitation, there is an increase in hunting or a transition to pastoralism (see Škrdla, Nývltová Fišáková et al., 2009).

Intensification and acriculture

Infant and early childhood diets

The time of breastfeeding, the time of giving complementary foods and the overall nutrition of children is influenced by both natural conditions and culture. For these findings in the past, isotope analyzes of single-rooted teeth and first stools are used, where eating habits from birth for the first 9 years are stored. Based on nitrogen isotopes, it was found through populations in the past that the period of breastfeeding and weaning was between 2-4 years. the earlier the weaning was, the worse the impact on the child's health. The period of complementary foods was the same as today between 4-6 months, when C3 plants and fish were given to children. Even after weaning, the children were fed mostly fish (see Greenwald 2017 etc.).

Isotopic application in evolution medicine

Isotopic analyzes can also be used in the current population. Hair samples can be analyzed, which will tell us how the given individual eats and whether his diet contains glucose syrup from corn (C4 plant), because it has a different composition of carbon isotopes. And thus find out the risks associated with this nutrition. Other food components can also be analyzed.

Thank you for your attention!