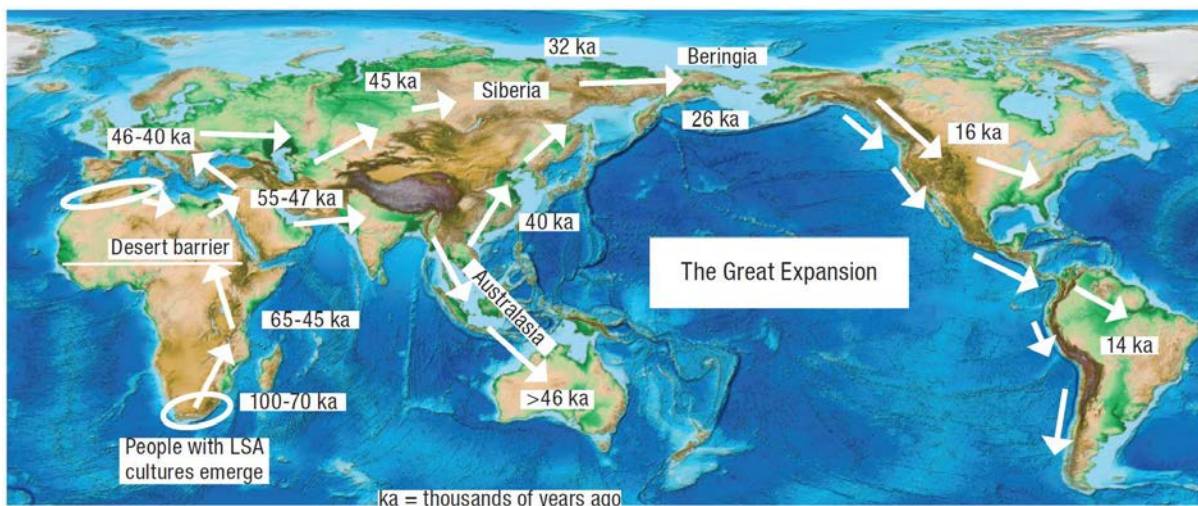


What happened to the Neanderthals?

Update #7 to *Human Origins: How diet, climate and landscape shaped us*

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We have long been fascinated by the Neanderthals and for good reason. All of us, outside of sub-Saharan Africa, are a bit Neanderthal. This is because we carry a small fraction of the Neanderthal genome acquired long ago when our ancestors left Africa. A relatively small group of our ancestors with cultures equivalent to modern-day hunter-gatherers left Africa around 60 to 50 thousand years ago. Upon leaving they rapidly multiplied and spread throughout Eurasia and then the Americas – a peopling of the world referred to as the ‘Great Expansion.’



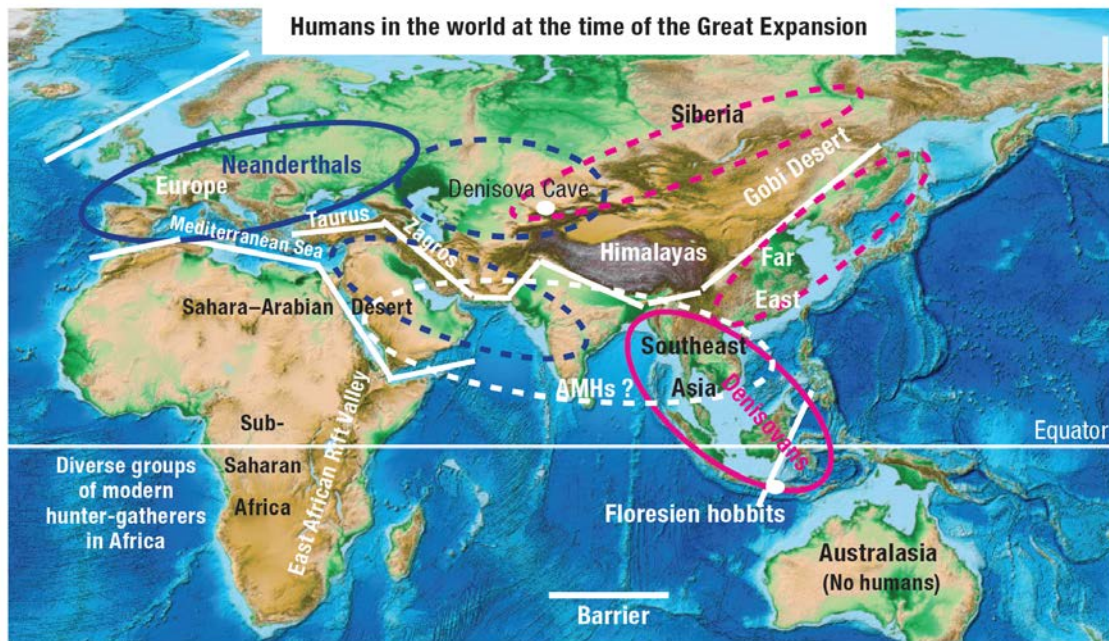
People emerged in southern Africa with cultures on a par with modern hunter-gatherers by 70 thousand years ago (70 ka) and eventually spread throughout Africa and the world.

Upon leaving Africa and entering Eurasia, our ancestors soon encountered the Neanderthals. We share a common ancestor with Neanderthals that left Africa long ago, with the Neanderthals (*Homo neanderthalensis*) evolving in Eurasia while our species (*Homo sapiens*) evolved separately in Africa. We know from the DNA extracted from Neanderthal bones that these encounters included intermingling (i.e., sex) and production of offspring. Just how romantic or not such intermingling was is unknown. What is known is that it took place on more than one occasion up until when the Neanderthals became extinct around 40 thousand years ago.

The offspring of these unions had an equal mixture of our species' and Neanderthal's DNA. Some of these offspring then mated with others and passed Neanderthal genes down the line. However, the amount of Neanderthal DNA became greatly diminished over time, with most people today outside of sub-Saharan Africa having only between 1.8% and 2.6% Neanderthal DNA. The loss of Neanderthal DNA from our genome reflects the fact that the Neanderthals became extinct and many of their genes carried by people were selected against, with those having them not successfully passing them along to the next generation. Although any individual has a small percentage Neanderthal DNA, the specific Neanderthal DNA that each person carries is not the same, such that if everyone's different bits are added up then roughly 20% to 30% of the Neanderthal genome survives scattered among people living today.

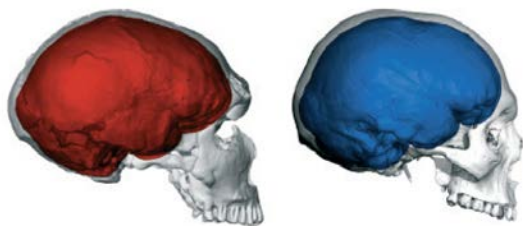
But 20% to 30% of a genome scattered about the population does not a species make and the Neanderthals, along with all our other cousins living in Eurasia became extinct during the course of

the Great Expansion. Prior to the Great Expansion there were as many as five different co-existing species in our human family tree. Why did all the others, including the Neanderthals become extinct and not us?



Possible distribution of our cousins living in Eurasia at the time of the Great Expansion. People exiting Africa most likely first encountered Neanderthals in the Middle East and continued to interbreed with them until they became extinct by around 40 thousand years ago.

Some argue that the Neanderthals were already in decline when we arrived; others claim that our arrival is what ultimately did them in. But how the extinction of the Neanderthals unfolded remains unclear. The Neanderthals were a successful species, having a long history of surviving the highly variable climate cycles of Europe. They hunted in cooperative groups using stone tipped spears, made use of body paint and buried their dead. They had a brain similar in size to ours (approximately 1500 cc) at the time of their extinction, but we know little about how their brain was structured. One way to gain insights into how the brains of Neanderthals and people differ is to compare their social organisation and culture. Several recent papers on DNA extracted from fossil bones shed some new light on how the social organisation of Neanderthals compares to people living in Eurasia soon after the Neanderthals became extinct.

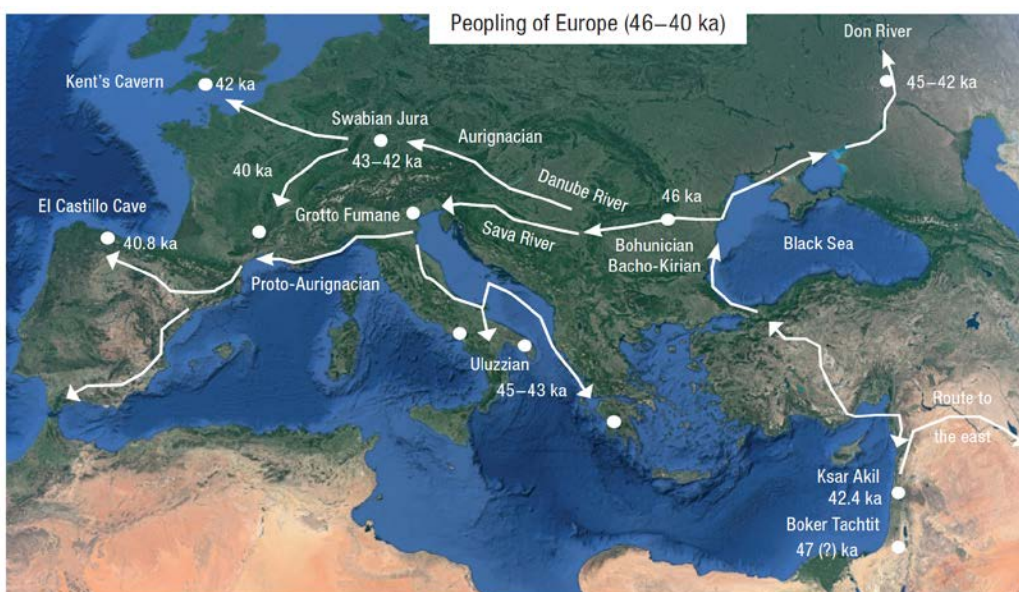


Both Neanderthals (left, red) and people (right, blue) independently evolved big brains, but differences in social organisation and culture suggest significant differences in structure (image Philipp Gunz/Max Plank Institute for Evolutionary Anthropology).

The first paper by Kay Prüfer and others (2017) presents a high-quality Neanderthal genome assembled from DNA extracted from a female's fossil bones from Vindija Cave in Croatia dated to around 50 thousand year ago. The only other high-quality Neanderthal genome is for an individual from the Altai region of southern Siberia. The DNA from Croatia did not show the extreme inbreeding of the Altai individual, but was found to contain a third fewer gene variations than present-day Eurasians. The low level of gene variation (low heterozygosity) found in fossil bones from both Croatia and southern Siberia suggests that Neanderthal population sizes were relatively small and geographically isolated and included instances of extreme inbreeding.

The second paper by Martin Sikora and others (2017) presents the DNA sequence extracted from fossil bones of a number of people (*Homo sapiens*) from the Sunghir site located 190 km east of Moscow and dated to 34 thousand years ago. The four individuals studied from Sunghir are associated with burials containing grave goods such as heavily beaded clothing, with many beads stained black and red (the site was covered in red ochre). The artefacts suggest that those living at Sunghir had cultures on a par with modern-day hunter-gatherers.

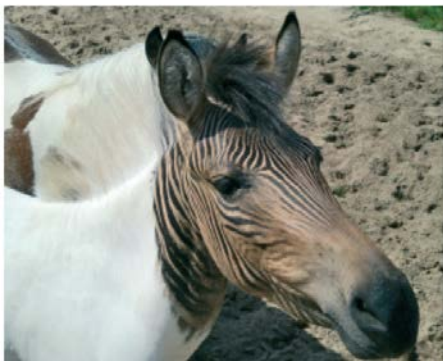
The genomes indicate small population size, but in contrast to the small, geographically isolated populations of the Neanderthals, the genomes of the Sunghir people suggest that they were connected to wider social networks. These results suggest that the people living in Eurasia soon after the extinction of the Neanderthals had already established social organisations similar to modern-day hunter-gatherers. The large amount of gene variation (high heterozygosity) among the Sunghir individuals suggest that these groups mated (married) outside of their groups (exogamy), which implies greater mobility and cultural exchange among groups. These groups likely travelled over large areas seasonally and by exchanging mates with other far-ranging groups they were able to minimise inbreeding. This social behaviour is consistent with that observed among modern hunter-gatherers, which helps them to sustain low genetic relatedness among members of their small groups.



The spread of people into Europe having the equivalent of modern hunter-gatherer cultures replaced the resident Neanderthals by around 40 ka, but not before some interbreeding took place (ka = thousands of years ago).

These latest DNA results indicate a greater degree of social networking in people compared to the Neanderthals and this may have been a key factor to our species successful replacement of the Neanderthals along with other established groups living in Eurasia. Strong social networks would have facilitated the spread and retention of innovative cultures, while reducing genetic relatedness among individuals in small, mobile groups. Widespread social networks ensured genetic mixing to avoid inbreeding and spread cultural adaptations that allowed people to move successfully into many different and new environments. The Neanderthals and presumably our other cousins established in Eurasia lacked these traits, a lack which perhaps only became critical in competition with people as they spread across the landscape.

The successful interbreeding between people and Neanderthals suggests that hybridisation was important throughout human evolution. Hybridisation is when two species successfully breed to produce viable offspring, offspring capable of breeding and having offspring of their own. In biology, many of us learned that two different species by definition cannot produce viable offspring. But biology is messy and it turns out that some closely related species can interbreed. Primates, the large group of animals to which we belong are known for interbreeding, for example among closely related species of monkeys and baboons.



A zorse is a horse-zebra hybrid. The fossil DNA record indicates that human species could interbreed to produce hybrids (photo: Christine and David Schmitt).

Our last shared common ancestor with the Neanderthals lived in Africa 630 to 520 thousand years ago (Prüfer and others, 2017). And even though the group that moved into Eurasia to evolve into the Neanderthals were isolated from those who remained in Africa to evolve into us for at least 400 thousand years, we were still able to successfully interbreed. Interbreeding (hybridisation) is important because it increases gene flow. By successfully interbreeding with Neanderthals, the newcomers were able to acquire new genes. Many of the new genes were beneficial because they had been modified by natural selection to be useful traits for Neanderthals living in Eurasia as opposed to Africa. For example one of the retained genes from Neanderthals allowed us to adapt to low UV radiation in the northern hemisphere where there is less sunlight. Other adaptations involved properties of the skin to the generally colder and drier climates of Eurasia. However, hybridisation is a random mixed bag and along with the good genes were the not so good genes, such as those associated with lupus and Crohn's disease and greater susceptibility to diabetes.

The interbreeding of our species with the Neanderthals provides strong evidence that hybrids were likely common throughout the millions of years of human evolution. Groups isolated at times either through cultural differences or physical barriers would have evolved separately and diverged away from other groups. When barriers fell, previously isolated groups were reunited. Successful

interbreeding during these reunions would have facilitated evolution by mixing closely related but different gene pools. Thus, rather than the traditional linear branching of species leading up to us, one can imagine a far more complex scenario where many closely related but geographically and genetically distinct groups are periodically mixed and through interbreeding give rise to new traits.

Further reading

Bergström, A. and Tyler-Smith, C., 2017. Paleolithic networking. *Science* 358, 586-587 (doi: 10.1126/science.aaq0771).

Prüfer, K., and others, 2017. A high-coverage Neandertal genome from Vindija Cave in Croatia. *Science* 358, 655-658 (doi: 10.1126/science.aao1887).

Sikora, M. and others, 2017. Ancient genomes show social and reproductive behavior of early Upper Paleolithic foragers. *Science* 358, 6595-662 (doi: 10.1126/science.aao1807).

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