New research may show that Neanderthals did not go extinct

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27 December 2011

The recently reported results of genetic research comparing samples of fossil Neanderthal DNA with that of modern populations around the world appear to indicate that modern humans outside of Africa derive some portion of their genetic material from Neanderthals. This finding, if supported by further research, has important implications, not only in answering the longstanding question of what happened to the Neanderthals, but more importantly for our understanding of the relative weight of cultural versus biological adaptation in human evolution.

Since the discovery of human-like fossils in the Neander Valley of German in the mid-19th century, anthropologists and others have debated the question of how closely Neanderthals, as this fossil group was named, were related to modern humans. The question soon became entangled in the larger issue of biological evolution in general after the publication of Darwin's *On the Origin of Species*. Neanderthals provided the model for the concept of the "cave man" as a hulking and dull-witted brute who was either the primitive ancestor of modern humans or an evolutionary side branch which eventually became extinct.

Early anatomical comparisons of Neanderthals and modern humans were skewed because one of the first specimens was later determined to have suffered deformities due to arthritis, thus making his skeleton appear more different from modern humans than it really was. However, even as the discovery of additional fossil specimens yielded a more accurate representation of Neanderthal anatomy, varying interpretations continued about whether these people were fundamentally distinct from modern humans.

There was no doubt that Neanderthals tended to have a heavier bone structure and a stockier build than early modern humans. Since Neanderthals were found in Europe and the adjacent Near East during the last Ice Age, it seemed reasonable to interpret their anatomy as an adaptation to the cold, harsh climate of glacial regions in contrast to the taller, thinner build of early modern humans who were adapted to the warmer climate of Africa. Short, round physiques are better at retaining heat, while tall, slender bodies are better at dissipating it. The question remained, however, whether these differences were of such a degree as to indicate that Neanderthals were a separate species from modern humans.

In modern evolutionary biology, species are defined by reproductive isolation. Members of distinct species, no matter how similar in appearance they may be, cannot mate and produce reproductively viable offspring. An instructive example is that of horses and donkeys. They can mate and produce living offspring, but the resulting individuals, mules, are sterile. Therefore, there is no gene flow between horses and donkeys, so these are separate species. Dogs and wolves, on the other hand, can mate and produce reproductively viable offspring. These are not separate species.

The longer two populations of the same species live in geographically separated areas, thus limiting interbreeding, the more likely they are to become genetically distinct, due both to random variation and selective pressures. In particular, the more their biological forms evolve to adapt to the differing conditions of their distinct environments, the more likely it is that they will become sufficiently different genetically to split into separate species.

The question is therefore posed – what effects did biological adaptation to the differing environments of glacial-age Europe and relatively warmer contemporaneous Africa have on Neanderthals and early modern humans, respectively? Did these effects lead to such marked differences that the two populations could no longer mate and produce reproductively viable offspring? This question is of more than simply "historical" interest. It bears on the issue of when culture (abstract, symbolic thought and technology) became the predominant mode of human adaptation.

Most animals adapt and evolve via changes in their physical/biological form (bigger teeth to more effectively capture and kill prey, feathers or fur for warmth, etc.). Animals enhance their physical adaptations with varying degrees of behavioral flexibility. In some species – apes, dolphins, and crows, for example – learned behavior, complex social structures, and sophisticated communication systems have become highly developed. But only humans have made the leap to fully abstract thought and overwhelming reliance on technology. Clearly this was a process that took place over millions of years and involved both biological and cultural evolution.

The dialectic between the two forms of evolutionary adaptation has undoubtedly been extremely complex. The interaction cannot be seen as merely a gradual, quantitative shift from one to the other. There are likely to have been times of relatively rapid, significant change interspersed with ones of slower evolutionary change, even though the former may be difficult to identify precisely due to the fragmentary nature of the fossil and archaeological records. Nevertheless, over the millions of years of hominin evolution, culture became increasingly important. Today, culture is the primary way in which humans adapt to their environment, though physical adaptation continues as well.

When did cultural adaptation become predominant? This is an important question because once the qualitative shift did occur, the accumulation of biological differences between even far-flung human groups would tend to be dampened, since the pressure of natural selection would have been buffered by culture. This would mean that humans around the world would be more likely to remain members of a single species, even if local groups developed some physical differences.

All currently living humans are members of the same species – *Homo sapiens*. Fossil evidence seems to indicate that early hominins (i.e., prior to the genus *Homo*), primarily members of the genus *Australopithecus*, encompassed several species, apparently adapted to different diets. With the appearance of *Homo*, about 2.5 million years ago, characterized by larger brains and the first identified evidence of stone tool use, humans began spreading out of Africa, eventually covering much of Eurasia. For most plant and animal species, such a wide geographic distribution would eventually lead to speciation (formation of separate species).

Anthropologists have defined a number of species in the fossil record of

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the genus *Homo*, including *H. habilis, H. erectus*, and several others which predate the appearance of modern humans – *Homo sapiens*. Do these physical forms represent successive chronological stages of a single evolving lineage or were there a number of branches, only one of which ultimately led to modern humans? These competing interpretations are known, respectively, as the unilineal (or single species) and multilineal hypotheses. The degree of reliance on culture would likely have an important bearing on which pattern human evolution followed.

Previous genetic research comparing the Neanderthal and modern human DNA, published only a few years ago (see Moore 2008), indicated significant differences between the two groups, seeming to support the interpretation that Neanderthals were a separate species. However, these interpretations were based on as yet incomplete sequencing of the Neanderthal genome. The newly published research provides additional insight into the relationship between these two groups.

Since fossils don't reproduce, it is not possible to directly observe whether mating between members of possibly distinct groups can produce reproductively viable offspring. Anatomical differences seen in the fossilized bones of closely related populations are not necessarily a reliable indicator of whether distinct species are represented. Furthermore, archaeological sites, composed of stone tools, food waste, etc., often do not contain the physical remains of the individuals who created them. Therefore, in situations in which multiple forms of humans may have been present, it is not necessarily easy to determine which group is associated with what kind of technology.

Fossil evidence of anatomically modern humans first appears in southern Africa a little less than 200,000 years ago. Movement of modern humans out of Africa is currently estimated to have begun at roughly 80,000 years ago. These migrations were relatively rapid, on an evolutionary scale, and demonstrate effective adaptation to a wide variety of climates. Evidence of modern humans appears in Australia by about 40,000 years ago, if not earlier, a continent they could only have reached by boat.

Modern humans moving into Eurasia would have met other humans already resident in much of that land mass. What was the nature of these encounters? If members of the resident and immigrant groups were biologically compatible (i.e., belonged to the same species), it is likely that, whatever the specifics of the interactions may have been, mating took place and genetically blended populations developed. If they were not biologically compatible, then, based on the fact that there is only one species of humans currently living on the planet, the pre-existing resident populations were driven to extinction, by whatever mechanisms (not necessarily the direct killing of one group by the other).

In Europe and the Near East the resident human populations prior to the arrival of modern humans were Neanderthals. The temporal overlap between these two groups, based on the fossil and archaeological records, was brief, in evolutionary terms, less than ten thousand years (perhaps much less). After that, no evidence of Neanderthals has been found. Based on the two, alternate scenarios described above, either the Neanderthals became extinct or they merged with the immigrant modern humans. If the latter is the case, then current populations in these regions are, in part, descendants of Neanderthals.

The available fossil and archaeological records are scant on this topic. A few sets of human remains have been found which seem to represent a mixture of Neanderthal and modern human characteristics. However, given the extremely small sample size, these assessments are in no way definitive. Furthermore, these individuals could have been "mules," as described above (i.e., the living products of Neanderthal/modern human matings, but reproductively sterile).

Neanderthal and modern human stone tool technologies were quite distinct, the former being notably simpler than the latter. At a few sites, stone tool assemblages, known as Chatelperronian, have characteristics which some researchers have interpreted as the product of Neanderthals attempting to mimic modern human tool forms. Even if this is true, it only means that Neanderthals had the mental capacity to learn the new technology, at least to some extent. It does not indicate whether the two groups were merging biologically.

Currently available fossil evidence indicates that Neanderthals and modern humans both evolved from a common ancestral species, *Homo heidelbergensis*, which existed about a half million years ago. That species already had a relatively sophisticated stone tool technology and, presumably, other technologies using perishable materials which have not survived. Did *H. heidelbergensis* already rely on technology to such a degree that culture had a substantial influence on biological evolution? If so, then whatever physical differences might develop between its descendent populations, in this case Neanderthals and early modern humans, the differences may not have risen to the level of creating separate species.

The debate over what happened to the Neanderthals, and by extension all other pre-modern human populations, has been argued for decades. Shifts in this debate have been influenced not only by new discoveries, but to some degree by wider social thought – whether humans are viewed as predominantly aggressive and individualistic or cooperative and social. Simplistic and largely inappropriate analogies have been drawn between these ancient encounters and modern colonial situations. However, since the question is ultimately a genetic one – could Neanderthals and modern humans successfully reproduce – the lack of direct genetic data posed a serious problem.

The newly published research makes progress in overcoming this problem. In recent decades the methods of genetic research have been advanced substantially. Of particular relevance is the development of a practical technique for DNA sequencing, resulting in the decoding of the human genome, and of techniques for the extraction of DNA from ancient bone. As a result, not only has the modern human genome been sequenced, but a substantial portion of Neanderthal DNA as well.

Recently reported research by Yotova et al. (2011) combined these techniques to compare Neanderthal DNA with that of current human populations around the globe. The results indicate that non-African humans have a small amount (9%) of genetic material on their X chromosomes that appear to be derived from Neanderthals. Other studies put the percentage somewhat lower, 2-3% (Currat and Excoffier 2011).

The distinction between Africans and non-Africans is consistent with the "Out of Africa" model for the spread of modern humans. The likely route for modern humans leaving Africa would have taken them northward into the Near East, where they would have first encountered Neanderthals, and then either northwest into Europe or eastward into Asia. The admixture of Neanderthal genetic material suggests that 1) modern humans merged biologically, at least to a limited degree, with the resident populations in the areas into which they migrated and 2) that there was relatively little "reverse flow" of people going back to Africa once they had left, at least until recent times.

It is not necessarily implied that there was a complete melding of the two populations. The bulk of Neanderthals may still have ultimately become extinct. However, the new data does suggest that some degree of interbreeding did take place. It may be that although reproductively viable offspring were produced, they were somehow impaired as compared with "full" members of either parent's population, reducing their overall reproductive success. The available data is simply not able, at this point, to clarify this issue.

The acquisition of some Neanderthal physical characteristics may actually have been advantageous to the modern humans moving northward into the difficult conditions of the last glacial maximum. As described above, modern humans evolved in the warm environment of Africa, giving them relatively tall, thin physiques. Such bodies are not

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well adapted for retaining warmth in a glacial climate. While the newcomers already had, or rapidly developed, the technology to produce sewn clothing and other cultural adaptations to deal with the cold, a slightly more compact body form would have been an added advantage.

Other recent research suggests that Neanderthals were not the only variety of archaic humans with whom early modern humans had genetic exchanges. There is evidence that some genetic material from the recently identified Denisovans, a group roughly contemporary with Neanderthals living in Central Asia, may also have made its way into modern humans helping them more effectively cope with local diseases (Abi-Rached 2011).

As discussed previously, these findings, if supported by further research, would be consistent with the interpretation that human evolution, over at least the last half million years, has been substantially influenced by cultural adaptation. The dialectic between nature and culture renders human evolution, while still rooted in the former, nevertheless in many ways qualitatively distinct from that of other species. Humans are indeed, as put in a recent book by Timothy Taylor (2010), "artificial apes" (see Guelpa 2011).

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