

Engraving of long horn bull, by Thomas Bewick.

Cattle are the most important domestic animals for many modern societies. But when did deliberate cattle-breeding start? Archaeologists disagree about the answer, so we examined the DNA from ancient and modern cattle to find out.

The volcanic ash of Pompeii, the waterlogged deposits of Viking Dublin, and the salty and wet conditions on the *Mary Rose* (Henry VIII's warship that sank in the Solent in 1545) evidently provided good, stable conditions for preserving DNA in bones. Cow bones from more 'traditional' British prehistoric, Roman and medieval sites gave very disappointing results, probably because DNA does not survive well in alternating wet and dry

conditions. We also studied DNA from Wanlip, a Bronze Age (1500 BC) site on gravel; Bury Hill and Danebury, Iron Age (c.300 BC) hill forts on chalk; Abingdon, an Iron Age settlement on gravel; Piddington Roman villa c.AD 300, on clay; and Abingdon medieval settlement (c.AD 1300), on gravel.

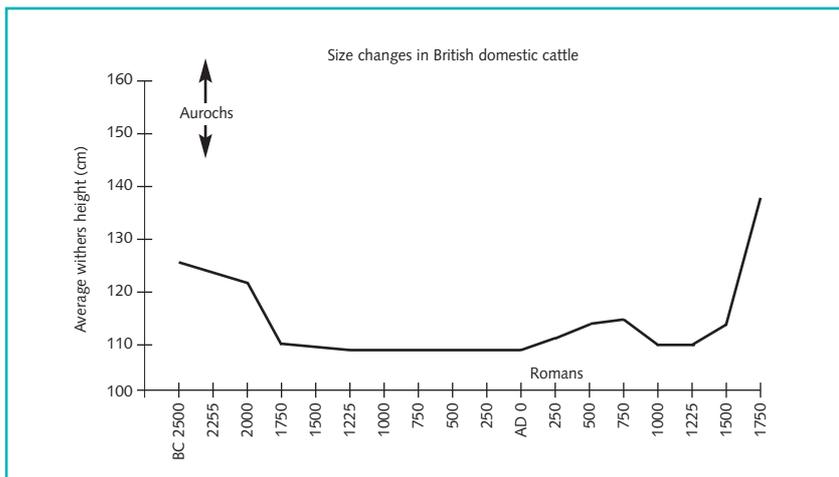
There has been considerable fluctuation in the size of European cattle over the last few thousand years (see graph), but

the similarities we found in the DNA from the bones from Pompeii, Dublin and the *Mary Rose* suggest that these changes are more likely to be the result of changing management practices than of selective breeding. Deliberate breeding for stock improvement as we understand it today still looks to be a comparatively recent development.

Analysis of the DNA from modern cattle has also shown that most African and European cattle are genetically very similar, suggesting a relatively recent common ancestor. However, some modern breeds that have a 'primitive' appearance, such as the White Park Cattle, do retain sequences that distinguish them from the majority. This suggests that there was more genetic diversity in the past, and that this has been depleted by modern breeding.

We also showed that DNA could be used to help archaeologists distinguish small fragments of cattle bone from bones of closely related animals, such as buffalo, bison and yak, a major problem for archaeologists in Africa and Asia.

Size changes in British cattle over the last 4000 years



Molecular Signatures from the Past

The Ancient Biomolecules Initiative is a five-year programme to understand the fate of biological molecules in archaeological and fossil materials, and to explore the applications of this new knowledge. The Initiative is funded by the Natural Environment Research Council.

# Cattle ancient and modern: the science in detail

The size of British cattle has varied considerably over time. Wild cattle 10,000 years ago were much larger than modern cows, but following the appearance of domestic cattle around 5,500 years ago they got steadily smaller. Before the Roman conquest they only measured about a metre at the withers. Average size increased in Roman times, decreased again during the medieval period, then steadily increased over the past 1,000 years, especially over the past few centuries.

What do these changes signify? The general view has been that prehistoric and Medieval cattle were small because they were poorly fed and managed, but opinions have differed about British cattle in Roman times. Were they larger because they were better managed, or because the Romans introduced new stock? Historians argue that modern breeding has really only been going on over the past few hundred years, but the size fluctuations might be telling a rather different story. Could DNA help us understand the history of cattle breeding and management in Britain?

We compared the DNA in blood samples from modern breeds with ancient DNA from cattle bones - mainly from archaeological sites in Britain spanning the past 4,000 years. We

studied both the usual modern breeds such as the Limousin, and 'rare breeds' such as Chillingham and White Park which are generally thought to be survivors from ancient stock. For the archaeological samples, we selected bones from sites not only of different periods (prehistoric, Roman, medieval, post-medieval) but also with different soils and geology, as we wanted to understand the conditions in which ancient DNA survives.

We found that African and European cattle breeds cannot be distinguished by comparing slowly evolving genes. Only their fast-evolving DNA sequences differ. This tells us that African and European cattle have not been separated long enough for diagnostic mutations to accumulate in the slowly-evolving sequences.

**Do European cattle breeds retain signatures of genetic diversity from the Mesolithic period? By comparing many DNA sequences, we found that some individuals of the 'traditional' or 'primitive' breeds (White Park and Hungarian Grey) have gene sequences that differ from those of the more inter-bred modern cattle. Their DNA may include sequences that were much more common in ancient times. Such sequences may be useful markers in analysing DNA from bones from archaeological sites.**

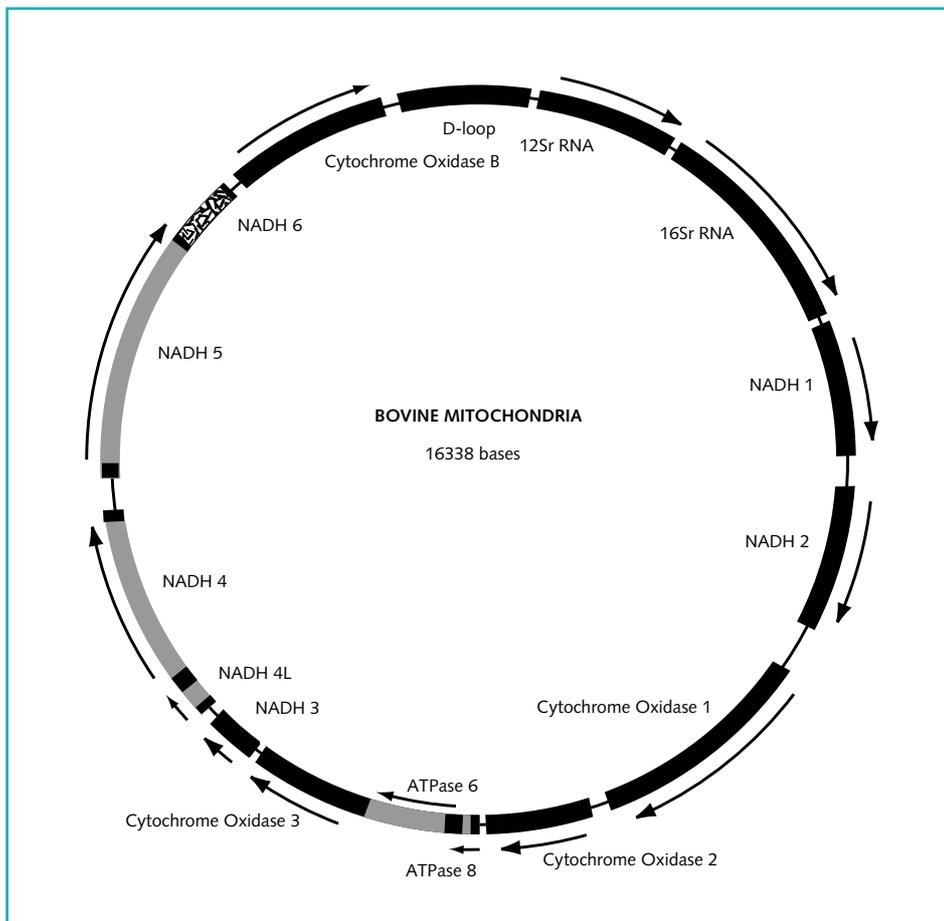
It is sometimes hard for an archaeologist to identify a species from fragments of bone. DNA technology should be able to help. We examined five genes from a range of bovid species across Africa, Europe, Asia and North America. We built a phylogenetic tree showing the molecular genetic relationships, and identified gene sequences which will be diagnostic for closely related bovid species.

## Methods

Contamination of ancient DNA with modern DNA is a major problem. We therefore collaborated with other laboratories and used a range of methods to check the samples from which DNA could be successfully extracted. The results were entirely consistent: either the different laboratories all found DNA in a particular bone, or none of them did. Further work is in progress.

The Coding genes on bovine mitochondria. The diagram was drawn from the sequencing data of Anderson et al (1982). The tRNA genes are not shown. Genes shown in shading other than

black represent loci with overlapping reading frames. All the coding genes with the exception of the NADH6 are L strand sense. NADH6 is H strand sense.



Histology of cattle bone from a Viking cow from circa 940 AD excavated at Woodquay, Dublin. Growth of bone involves destruction and replacement of the existing haversian systems. In the bottom left hand corner of the slide several incomplete haversian systems can be seen, showing this process in progress (shown by the arrows). This suggests that the bone came from a growing animal. This photograph was taken in the transitional area between compact and spongy bone, hence the larger spaces (marked \*) of the spongy bone which would have contained bone marrow in life. (Haematoxylin and Eosin stain, x 252).

Four cattle metacarpals (below) showing size changes (centimetres) from Iron Age to Roman to medieval to modern.



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