Digging for DNA

Excavation with a difference

Are we part Neanderthal? Was the Black Death really caused by Bubonic plague? And are all modern human beings really descended from one woman who lived 100,000 years ago? Recent advances in the techniques for extracting DNA from ancient remains can help answer these sorts of question.

A new branch of archaeology – biomolecular archaeology – attempts to shed new light on the movement of populations, agricultural practices, diets and diseases in ancient times. Some of this information comes from tiny amounts of DNA found in ancient teeth and bones. These fragments can be copied to provide enough material for further tests, which, in turn, allow archaeologists to begin to find answers to their questions.

Ask the ancestors

Neanderthal people lived in Europe before the arrival of our ancestors, the Cro-Magnons. These two types of humans lived side by side for at least 10,000 years. During this time the Neanderthals seemed to die out. But was there any inter-breeding between the two groups? Are we part Neanderthal?

New fossil finds, including that of a child burial, found recently at Laghar Velho in Portugal may indicate interbreeding. It's even been suggested that we get our red hair from Neanderthals.

But other evidence shows it's *unlikely* that we're descended from Neanderthals. In 1997 ancient DNA was extracted from the bones of the original specimen of Neanderthal man found in 1856 in the Neander Valley in Germany. Analysis reveals a last common ancestor some 600,000 years ago, and evidence from mitochondrial DNA (mDNA) – DNA that is passed down from mother to child largely unaltered – shows a big difference between modern humans and Neanderthals. In modern humans we can expect up to eight different mutations between two samples of mDNA from two different people. The researchers found 27 differences between Neanderthals and modern humans while there are 57 mDNA mutation differences between modern humans and chimpanzees. This shows that there is such a large genetic difference between modern humans and Neanderthals that we are not descended from Neanderthals. But this is based on evidence from just one sample.

The argument about whether we are, in part, descended from Neanderthals will continue, because to some extent we do not like to accept the possibility that our ancestors contributed to the extinction of a fellow human species.

Migrating mothers

When we inherit our DNA from our parents, we get more or less equal quantities of nuclear DNA from Mum and Dad, but we get our mitochondrial DNA from Mum, from the mitochondria in the egg. This allows us to trace our maternal ancestry. Over time, changes (mutations) can occur in DNA. These changes are inherited, giving rise to new lines.

If our mDNA is similar to somebody else's, it means we have the same great, great, great, great (many times over) grandmother. By examining the mDNA of modern populations it is possible to identify 'clusters' of present-day people with similar sets of mutations, which can be traced back to a single maternal ancestor in the distant past. It is also possible to guess at when that ancestor arrived in an area.

Evidence from mDNA suggests that most Europeans are descended from 11 founder mothers who arrived at some time between 10 and 45,000 years ago. Their descendants are now living side by side from Ireland to Siberia. More amazingly, all modern humans might be descended from one women who lived in Africa 100,000 years ago.

mDNA has also shown that Polynesia was colonised from east Asia, not South America, and Native North Americans arrived even earlier than we thought.

Disease dynasty

Schistosomiasis is a disease that afflicts 200 million people worldwide and one in 10 Egyptians. It is a parasitic worm that lives in humans. Anyone swimming, washing or fishing in contaminated water soon becomes infected. Once the parasites penetrate the skin, they migrate through the muscle and make for the liver, where they mature.

In Egypt there are now two species of worm. *Schistosoma haematobium* congregates in the bladder and urinary system. *Schistosoma mansoni* infects the intestines and liver. The worms themselves do little harm but their spiny eggs hook into their host's tissue, causing bleeding and inflammation. This triggers scarring and the formation of calcified tissue, and if untreated the disease can lead to bladder cancer or liver failure. Ancient Egyptians suffered from Schistosomiasis too. Evidence comes from mummies. When the Egyptians embalmed the dead, their parasites were also preserved – including schistosomes.

Scientists researching vaccines against Schistosomiasis decided to examine the disease in mummies to see how the disease had co-evolved with humans. A molecular marker was designed that showed the outlines of schistosome eggs in lurid, glowing green. Thousands of samples of mummies from different periods of Egypt's history - men, women and children from all levels of society, from aristocrat to peasant - were tracked down. Ideally, the scientists wanted pieces of bladder, intestines and liver: the organs most likely to contain eggs or worms. Some Egyptian embalmers treated internal organs separately from the rest of the body and stored them in jars, which makes sampling easier. Others wrapped up the treated organs and replaced them inside the body, but not always in the right place, the intestines might be packed into the chest for example. But with careful use of an endoscope, it is often possible to locate and sample the required organs.

One sample came from the bladder of a mummy of a woman who had lived around the first or second century AD. Earlier X-rays had revealed calcified tissue in her bladder – almost certainly a sign of schistosome infection. When the scientist Tricia Rutherford looked under the microscope she saw the outlines of several eggs, clearly enough to identify the parasite as *S. haematobium*. Then, to her astonishment, she found something else. 'There was the outline of the head of a worm,' says Rutherford. 'You could even see the suckers on it.' (*New Scientist*, 08.12.01).

In ancient Egypt people would have been at risk of infection with *S. haematobium*. But the jury is still out on when *S. mansoni* first appeared in Egypt. It seems to be a modern arrival and so far it's not been found in mummies. Samples from 50 mummies show that 30 per cent were infected with schistosomes. If Schistosomiasis was widespread, much of the population would have been unwell, yet they created an amazing civilisation. One explanation might be that people carried fewer worms so they suffered less severe symptoms. Another possibility is that schistosomes could have become nastier over the past few millennia. Whatever the case, DNA extracted from the remains of parasites in mummy tissue will allow scientists to investigate the evolution of the worms by comparing the genes from ancient and modern schistosomes. Whether this will lead to a vaccine we will have to wait and see.

Black Death caused by Bubonic plague?

Until recently, it has been accepted that the Black Death that ripped through Europe in the Middle Ages was caused by bubonic plague. A recent book, *Biology of Plagues*, challenges that theory. 'If you look at how the Black Death spread,' says Susan Scott, one of the authors, 'one of the least likely diseases to have caused it is bubonic plague' (*New Scientist*, 24.10.01).

Bubonic plague, *Yersinia pestis*, is a flea-borne bacterial disease of rodents that jumped to humans. It was assumed that it spread across Europe via rats. But Iceland suffered from the Black Death and Iceland has no rats. This and many other pieces of evidence make it unlikely that the Black Death was actually caused by Bubonic plague.

DNA is now being extracted from human remains buried in plague pits to find out what really caused the Black Death. Scott and Duncan, the authors of the book, believe it was some kind of haemorrhagic filovirus such as Ebola, since the one consistent symptom was bleeding. In fact they think 'haemorrhagic plague' would be a good new name for the disease. It will probably take DNA evidence to persuade the majority that Scott and Duncan are right, because the idea that the Black Death was caused by Bubonic plague is so well entrenched.

Weighing the evidence

The examples above show that DNA can provide evidence for certain interpretations of the past. But DNA is just one tool among many, and the quality of the answers it can provide depend on the material available, extraction techniques and on the questions the archaeologist asks. The resources and tasks outlined below allow you to find out more about these and other stories. Its worth remembering that in archaeology, like other branches of science, the investigator often sets out to find evidence for their own favourite theory, and there is no such thing as completely objective truth. But trying to discover the truth is still the ultimate aim.

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What you need to do:

Compile a project portfolio or write an essay on the uses of DNA analysis in archaeological investigations. It should cover topics such as:

Background information about DNA and the human genome.

Background information about the ways DNA can be analysed.

What are the limitations of this technology, what precautions must be taken?

The controversies surrounding the attempts to extract dinosaur DNA from bones and insect DNA from amber.

Examples of investigations that have been helped by DNA evidence.

If possible, include some DNA evidence from a local excavation.

Resources that might help you:

Jones, Martin. *The Molecule Hunt: Archaeology and the Search for Ancient DNA*. 2001

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www.nhm.ac.uk (The Natural History Museum, via 'Interactive' see ' Science Casebook')

www.eibe.org (see *DNA profiling*)

If you want to go further:

One of the first applications of DNA technology outside research laboratories was in forensic science, but it is now used in animal pedigree checking, wildlife protection, food safety control, medical diagnosis and screening. For General Studies the potential of DNA technology could be looked at with reference to any of these applications.