EMBO reports

The A to T of historical evidence

Historians, archaeologists and geneticists are teaming up to answer historical questions

Howard Wolinsky

The remains of King Richard III (1452–1485), who was killed with sword in hand at the Battle of Bosworth Field at the end of the War of the Roses, had lain undiscovered for centuries. Earlier this year, molecular biologists, historians, archaeologists and other experts from the University of Leicester, UK, reported that they had finally found his last resting place. They compared ancient DNA extracted from a scoliotic skeleton discovered under a car park in Leicester—once the site of Greyfriars church, where Richard was rumoured to be buried, but the location of which had been lost to time—with that of a seventeenth generation nephew of King Richard: it was a match. Richard has captured the public imagination for centuries: Tudor-friendly playwright William Shakespeare (1564–1616) portrayed Richard as an evil hunchback who killed his nephews in order to ascend to the throne, whilst in succeeding years others have leapt to his defence and backed an effort to find his remains.

The application of genetics to history is revealing much about the ancestry and movements of groups of humans, from the fall of the Roman Empire to ancient China

Molecular biologist Turi King, who led the Leicester team that extracted the DNA and tracked down a descendant of Richard's older sister, said that Richard's case shows how multi-disciplinary teams can join forces to answer history's questions. "There is a lot of talk about what meaning does it have," she said. "It tells us where Richard III was buried; that the story that he was buried in Greyfriars is true. I think there are some people who [will] try and say: "well, it's going to change our view of him" […] It won't, for example, tell us about his personality or if he was responsible for the killing of the Princes in the Tower."

The discovery and identification of Richard's skeleton made headlines around the world, but he is not the main prize when it comes to collaborations between historians and molecular biologists. Although some of the work has focused on high-profile historic figures—such as Louis XVI (1754–1793), the only French king to be executed, and Vlad the Impaler, the Transylvanian royal whose patronymic name inspired Bram Stoker's *Dracula* (Fig 1)—many other projects involve population studies. Application of genetics to history is revealing much about the ancestry and movements of groups of humans, from the fall of the Roman Empire to ancient China.

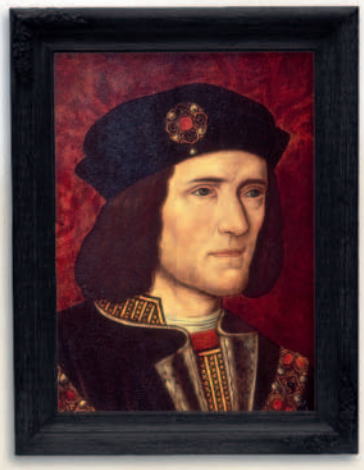
Medieval historian Michael McCormick of Harvard University, USA, commented that historians have traditionally relied on studying records written on paper, sheepskin and papyrus. However, he and other historians are now teaming up with geneticists to read the historical record written down in the human genome and expand their portfolio of evidence. "What we're seeing happening now—because of the tremendous impact from the natural sciences and particularly the application of genomics; what some of us are calling genomic archaeology—is that we're working back from modern genomes to past events reported in our genomes," McCormick explained. "The boundaries between history and pre-history are beginning to dissolve. It's a really very, very exciting time."

…in the absence of written records, DNA and archaeological records could help fill in gaps

McCormick partnered with Mark Thomas, an evolutionary geneticist at University College London, UK, to try to unravel the mystery of one million Romano-Celtic men who went missing in Britain after the fall of the Roman Empire. Between the fourth and seventh centuries, Germanic tribes of Angles, Saxons and Jutes began to settle in Britain, replacing the Romano-British culture and forcing some of the original inhabitants to migrate to other areas. "You can't explain the predominance of the Germanic Y chromosome in England based on the population unless you imagine (a) that they killed all the male Romano-Celts or (b) there was what Mark called 'sexual apartheid' and the conquerors mated preferentially with the local women. [The latter] seems to be the best explanation that I can see," McCormick said of the puzzle.

Ian Barnes, a molecular palaeobiologist at Royal Holloway University of London, commented that McCormick studies an unusual period, for which both archaeological and written records exist. "I think archaeologists and historians are used to having conflicting evidence between the documentary record and the archaeological record. If we bring in DNA, the goal is to work out how to pair all the information together into the most coherent story."

Patrick Geary, Professor of Western Medieval History at the Institute for Advanced Study in Princeton, New Jersey, USA, studies the migration period of Europe: a time in the first millennium when Germanic tribes, including

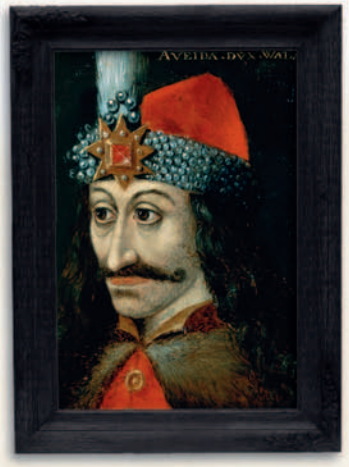


Richard III
King of England

Historical record
Most well-known as an ugly, evil hunch-back, particularly as portrayed in William Shakespeare's play.

Archaeological evidence
A skeleton found in a car park in Leicester, UK, is thought to be Richard's. The skeleton, and reconstruction of his head based on the skull, confirms that he had scoliosis, but suggests that he would have been quite feminine and relatively handsome.

Molecular evidence
Comparison of DNA from the skeleton with that of two matrilineal descendants of Richard's eldest sister, Anne of York, confirms that these are likely to be his remains (www.bbc.co.uk/news/uk-england-leicestershire-21063882). Comparison of the skeleton's Y-chromosome DNA with paternal-line decendants will improve the certainty of this conclusion.



Vlad III Dracula
Prince of Wallachia

Historical record
Vlad was a member of the Barasub dynasty, which ruled Wallachia (now part of Romania) for almost three centuries. He died in 1476 and became known posthumously as Vlad the Impaler, owing to his excessive cruelty and habit of executing his enemies by impaling them on spikes. However, this reputation may have been inflated by his enemies for political reasons. Romanians rather see him as something of a hero, who used very harsh but fair measures to raise Wallachia from economic ruin and rescue it from the corrupt ruling elite.

Molecular evidence
Genetic comparison of modern-day Romanians with the surname Barasub, and others from Ukraine, Hungary and Bulgaria, found a variety of Y-chromosome lineages among them, indicating they cannot all be descendants of Dracula [2]. Perhaps a disappointment to some and a relief to others.

Louis XVI
King of France and Navarre

Historical record
Louis was executed by guillotine in 1793 during the French Revolution. People dipped rags or handkerchiefs in his blood to keep a memento of the death of their deposed king.

Physical evidence
Many such rags or blood-stained items have surfaced over the years, but historians have had no way to verify whether the blood is Louis's.

Molecular evidence
Now, comparison of DNA from blood stains in a gourde—which held a blood-stained rag—with DNA from the mummified head of Louis's ancestor, Henri IV, have confirmed that the blood in the gourd is almost certainly Louis's. Both samples included a rare partial Y-chromosome, indicating that the samples were from paternally related males (www.telegraph.co.uk/news/worldnews/europe/france/9773174/Louis-XVI-blood-mystery-solved.html).

Fig 1 | The use of molecular genetics to untangle history. Even when the historical record is robust, molecular biology can contribute to our understanding of important figures and their legacies and provide revealing answers to questions about ancient princes and kings.

the Goths, Vandals, Huns and Longobards, moved across Europe as the Roman Empire was declining. "We do not have detailed written information about these migrations or invasions or whatever one wants to call them. Primarily what we have are accounts written later on, some generations later, from the contemporary record. What we tend to have are things like sermons bemoaning the faith of people because God's wrath has brought the barbarians on them. Hardly the kind of thing that gives us an idea of exactly what is going on—are these really invasions, are they migrations, are they small military groups entering the Empire? And what are these 'peoples': biologically related ethnic groups, or *ad hoc* confederations?" he said.

Geary thinks that in the absence of written records, DNA and archaeological records could help fill in the gaps. He gives the example of jewellery, belt buckles and weapons found in ancient graves in Hungary and Northern and Southern Italy, which suggest migrations rather than invasions: "If you find this kind of jewellery in one area and then you find it in a cemetery in another, does it mean that somebody was selling jewellery in these two areas? Does this mean that people in Italy—possibly because of political change—want to identify themselves, dress themselves in a new style? This is hotly debated," Geary explained. Material goods can suggest a relationship between people but the confirmation will be found in their DNA. "These are the kinds of questions that nobody has been able to ask because until very recently, DNA analysis simply could not be done and there were so many problems with it that this was just hopeless," he explained. Geary has already collected some ancient DNA samples and plans to collect more from burial sites north and south of the Alps dating from the sixth century, hoping to sort out kinship relations and genetic profiles of populations.

King said that working with ancient DNA is a tricky business. "There are two reasons that mitochondrial DNA (mtDNA) is the DNA we wished to be able to analyse in [King] Richard. In the first instance, we had a female line relative of Richard III and mtDNA is passed through the female line. Fortunately, it's also the most likely bit of DNA that we'd be able to retrieve from the skeletal remains, as there are so many copies of it in the cell. After death, our DNA degrades, so mtDNA is easier to retrieve simply due to the sheer number of copies in each cell."

Geary contrasted the analysis of modern and ancient DNA. He called modern DNA analysis "[…] almost an industrial thing. You send it off to a lab, you get it back, it's very mechanical." Meanwhile, he described ancient DNA work as artisanal, because of degeneration and contamination. "Everything that touched it, every living thing, every microbe, every worm, every archaeologist leaves DNA traces, so it's a real mess." He said the success rate for extracting ancient mtDNA from teeth and dense bones is only 35%. The rate for nuclear DNA is only 10%. "Five years ago, the chances would have been zero of getting any, so 10% is a great step forward. And it's possible we would do even better because this is a field that is rapidly transforming."

But the bottleneck is not only the technical challenge to extract and analyse ancient DNA. Historians and geneticists also need to understand each other better. "That's why historians have to learn what it is that geneticists do, what this data is, and the geneticists have to understand the kind of questions that [historians are] trying to ask, which are not the old nineteenth century questions about identity, but questions about population, about gender roles, about relationship," Geary said.

DNA analysis can help to resolve historical questions and mysteries about our ancestors, but both historians and geneticists are becoming concerned about potential abuses and frivolous applications of DNA analysis in their fields. Thomas is particularly disturbed by studies based on single historical figures. "Unless it's a pretty damn advanced analysis, then studying individuals isn't particularly useful for history unless you want to say something like this person had blue eyes or whatever. Population level studies are best," he said. He conceded that the genetic analysis of Richard III's remnants was a sound application but added that this often is not the case with other uses, which he referred to as "genetic astrology." He was critical of researchers who come to unsubstantiated conclusions based on ancient DNA, and scientific journals that readily publish such papers.

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Thomas said that it is reasonable to analyse a Y chromosome or mtDNA to estimate a certain genetic trait. "But then to look at the distribution of those, note in the tree where those types are found, and informally, interpretively make inferences—"Well this must have come from here and therefore when I find it somewhere else then that means that person must have ancestors from this original place"—[…] that's deeply flawed. It's the most widely used method for telling historical stories from genetic data. And yet is easily the one with the least credibility." Thomas criticized such facile use of genetic data, which misleads the public and the media. "I suppose I can't blame these [broadcast] guys because it's their job to make the programme look interesting. If somebody comes along and says 'well, I can tell you you're descended from some Viking warlord or some Celtic princess', then who are they to question."

…the cases in which historians and archaeologists work with molecular biologists are rare and remain disconnected in general from the mainstream of historical or archaeological research

Similarly, the historians have reservations about making questionable historical claims on the basis of DNA analysis. Geary said the use of mtDNA to identify Richard III was valuable because it answered a specific, factual question. However, he is turned off by other research using DNA to look at individual figures, such as a case involving a princess who was a direct descendant of the woman who posed for Leonardo Da Vinci's Mona Lisa. "There's some people running around trying to dig up famous people and prove the obvious. I think that's kind of silly. There are others that I think are quite appropriate, and while is not my kind of history, I think it is fine," he said. "The Richard III case was in the tradition of forensics."

Nicola Di Cosmo, a historian at the Institute for Advanced Study, who is researching the impact of climate change on the thirteenth century Mongol empire, follows closely the advances in DNA and history research, but has not yet applied it to his own work. Nevertheless, he said that genetics could help to understand the period he studies because there are no historical documents, although monumental burials exist. "It is important to get a sense of where these people came from, and that's where genetics can help," he said. He is also concerned about geneticists who publish results without involving historians and without examining other records. He cited a genetic study of a so-called 'Eurasian male' in a prestige burial of the Asian Hun

Xiongnu, a nomadic people who at the end of the third century B.C. formed a tribal league that dominated most of Central Asia for more than 500 years. "The conclusion the geneticists came to was that there was some sort of racial tolerance in this nomadic empire, but we have no way to even assume that they had any concept of race or tolerance."

Di Cosmo commented that the cases in which historians and archaeologists work with molecular biologists are rare and remain disconnected in general from the mainstream of historical or archaeological research. "I believe that historians, especially those working in areas for which written records are non-existent, ought to be taking seriously the evidence churned out by genetic laboratories. On the other hand, geneticists must realize that the effectiveness of their research is limited unless they access reliable historical information and understand how a historical argument may or may not explain the genetic data" [1].

Notwithstanding the difficulties in collaboration between two fields, McCormick is excited about historians working with DNA. He said the intersection of history and genomics could create a new scientific discipline in the years ahead. "I don't know what we'd call it. It would be a sort of fusion science. It certainly has the potential to produce enormous amounts of enormously interesting new evidence about our human past."

CONFLICT OF INTEREST
The author declares that he has no conflict of interest.

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1. Di Cosmo N (2011) DNA, history, and archaeology [online]. *The Institute Letter* Spring. http://www.ias.edu/about/publications/ias-letter/articles/2011-spring/dna-history-archaeology-di-cosmo

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