Bojs, Karin. "DNA Sequences Provide Links with the East." *My European Family: The FIRST 54,000 years*. London: Bloomsbury Sigma, 2017. 254–266. *Bloomsbury Collections*. Web. 26 Apr. 2023. <<http://dx.doi.org/10.5040/9781472941480.0034>>.

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DNA Sequences Provide Links with the East

When researchers such as Marija Gimbutas, David Anthony and James Mallory formulated their theories about the arrival of the early Indo-Europeans in Europe, they based their writings solely on archaeological excavations and comparative linguistics (and, in Gimbutas's case, traumatic experiences in her youth). They had no DNA findings to go on. But now DNA results are starting to roll in.

When I meet James Mallory in Belfast in January 2015, I have already read up on all the findings of the last few years from ancient mitochondrial DNA and the few analyses that exist of ancient Y chromosomes. They provide some support for the steppe theory, though it is not entirely convincing.

The most significant study is lying in a plastic folder on the coffee table in front of Mallory. It has been sent to *Nature*, but at the time of my visit to Belfast it is still unpublished. To my great frustration, I am not allowed to read it. For the last few months I have been hearing that this study is under way, and I have tried to persuade three of the researchers to let me see it in advance. All of them turned down my request.

Mallory refuses too. But he does tell me one thing. Since he received the study three weeks ago, it has vastly strengthened his conviction that the Indo-European languages spread to central Europe from the steppes around the Volga and the Don. And he has been working on the issue for over 40 years.

What was generally known at the time of my meeting with Mallory in January 2015 was that there were quite a lot of results from ancient mitochondrial DNA, a few results from ancient Y chromosomes, and a fairly rough genealogical tree based on the Y chromosomes of men living now.

As I explained earlier, mitochondrial DNA is a small quantity of DNA that everyone inherits from their mother.

We have seen how Guido Brandt, the doctoral student from Mainz, conducted extensive analyses of hundreds of hunters and farmers living in Saxony-Anhalt, Germany, over a period of several millennia. The analyses show beyond a shadow of a doubt that farmers from the Balkans and Hungary reached Germany in a discrete wave of immigration some 7,500 years ago. But they also point to subsequent waves of immigration. One that arrived about 4,800 years ago shows up particularly clearly in the DNA material. It coincides with a new culture in the region, known as the Corded Ware culture, which is associated with new types of pottery, flint tools and burial customs.

Y chromosomes occur only in men, who inherit them from their fathers. DNA from Y chromosomes is harder to extract than the mitochondrial variety. Only very few such analyses of ancient DNA have been carried out so far. The R1 haplogroup is a particular useful source of information on the wave of immigration that appears to have come from the steppes in the east.

Haplogroup R1a and its twin, R1b, are the most common groups everywhere in today's Europe. Over half the men in Europe belong to one or the other. Curiously, however, archaeological material from western and central Europe shows no sign of them before about 4,800 years ago, to judge from the DNA analyses so far conducted.

In central Europe, the oldest evidence of Y chromosomes with R1a has been found in association with the Corded Ware culture. The first analyses were published in a German study, for which Guido Brandt again did much of the work. Brandt and other researchers examined DNA from four graves in Eulau, on the River Saale. A total of 13 individuals were buried there, divided up into what look like families.

Three of the graves are exhibited at the Museum of Prehistory in Halle. I take the opportunity to look at them on

my visit. The brown skeletons, with their grave goods, are displayed on a wall in the same positions they were found in. One of the labels reads 'The world's oldest nuclear family' – the title of the press release when the study on these graves was presented. A mother, a father and two sons lie close together. Both their DNA and their positions in the grave indicate that they are related. Both the man's arms are broken, and one of his sons has been struck on the head. Another grave contains what are apparently two siblings lying with their back to their stepmother or aunt. The adult woman is holding a baby to her, probably her biological child. She has been killed by blows from an axe. A third grave holds a mother and her little daughter. Another one, which is not on display, held a father and his two children.

All these people seem to have been killed at the same time. One individual has a stone arrowhead in her back, while two have fractured skulls. Several individuals have injuries to the arms, as if they had been trying to defend themselves against their enemies.

They died 4,600 years ago. Both the manner in which they were buried and the contents of their graves show clearly that the dead belonged to the Corded Ware culture. Their bodies are arranged in a typical way: the men lie on their right side, with their heads towards the west, while the women are placed on their left side, with their heads pointing eastward. Both sexes face towards the south. The children are facing their parents, and all the members of a family are placed close to each other.

Most of the dead from Eulau were women and children. There are only a few men, and they seem to have been slightly older. Researchers interpret this to mean that all the adolescents and the men in their twenties were away from home when the attack came. On returning home, they met a terrible sight; dead bodies were strewn everywhere. So the young people buried their family members with care, in accordance with the traditions of the time. They held a funeral meal that included meat. Animal bones bearing scrape marks have been found in all the graves. Beer or mead may

also have been part of the tradition. The terracotta shards found may be the remains of drinking vessels. The men and boys were buried with the stone axes typical of their culture, while the grave goods for women and girls were flint tools and jewellery made of animals' teeth.

The researchers behind the DNA study note that the people of Eulau were massacred at a time of turbulence and violence in central Germany. At exactly that time, the Corded Ware culture was beginning to become common in the region, and the graves of the men and boys show a new patrilineal ancestry.

Peter Underhill, an American geneticist at Stanford University, has devoted a great deal of effort to constructing the family trees of living men belonging to various subgroups of R1a. His most recent article describes research involving over 16,000 men from 126 different populations in Europe and Asia. He has used this data to construct a genealogical tree for R1a. However, Underhill's genealogical tree is low resolution. He has not had access to any of the latest input from individuals researching their family history, he tells me by email.

This is where my uncle Anders and I come in, making our own modest contribution to science.

In the nineteenth century it was common for private individuals to contribute to new scientific discoveries. Charles Darwin developed the theory of natural selection at home, in his country house south of London. Mary Anning made her living from selling fossils in Dorset; though she had hardly any schooling, she discovered many pieces of evidence, which helped lay the foundations for the theory of evolution. Beatrix Potter ran a farm and wrote picture books for children, but she also presented groundbreaking new findings about fungi and their propagation.

Today's research is more technically sophisticated. It has become rare for amateurs to be able to contribute anything.

But it does happen. I have come across several examples in my time as a science journalist. Amateur astronomers discover celestial phenomena, which their professional counterparts can investigate further. The best-informed experts on particular species of flowers and subgroups of insects are often private individuals. Amateur geologists discover caves, fossils and minerals, thereby helping professionals in the field.

And now, thanks to DNA technology, people looking into their family background can help complete the picture of our common history.

I bought a new test for family history researchers called Big Y, which is sold by the company Family Tree DNA. This test was – and, at the time of writing, still is – one of the most detailed analyses of Y chromosomes that can be ordered by a private individual.

It is my own patrilineal ancestry I want to research – the line of my father, Göran, and my paternal grandfather, Eric. Being female, I have no Y chromosomes. My grandfather and my father are both dead. However, my uncle Anders agreed to have the test done. Anders is a retired history lecturer who taught in upper secondary schools and universities for many years. He and his wife had no children of their own, but when they were students in Uppsala and my four cousins were orphaned, they moved down to Lund to lend a hand. Sadly, I had relatively little contact with my uncle as a child, so I am all the happier that we have a joint project now.

My uncle and I are pioneers; we are among the hundred or so family history researchers in Sweden to take the first tests with Big Y. Our data can be combined with that of many others doing simpler tests.

Together, we contribute far more data than that available to Peter Underhill – a professional researcher – from his European material. Although he has been able to use samples from a total of several thousand men, most of his analyses are fairly low resolution. Only eight samples in Underhill's study were analysed at a really high resolution, and none of those are from Scandinavia. This means that high-resolution

results from family history researchers like us can enable whole new genealogical trees to be constructed for Europe, and, in particular, Scandinavia. The trunk and most of the larger branches are based on the work of professional researchers. But our DNA helps fill in the picture. With our help, previously unknown 'side shoots' appear. Branches that were previously indistinct now take on far more definite contours.

The genealogical tree to which Uncle Anders and I have contributed shows how a man belonging to haplogroup R1a made his way towards Sweden about 4,500 years ago. He bore a new and unique mutation called Z284. That being rather dull and technical, I shall call him 'Ragnar' for simplicity's sake.

Ragnar's forefathers seem to have come from areas of southern Poland about 4,800 years ago. He himself was to be the forefather of the vast majority of men of Scandinavian descent who belong to haplogroup R1a – about one in every six men in Sweden.

The person who has contributed most towards constructing Ragnar's genealogical tree is a genealogy researcher from Härnösand called Peter Sjölund. Trained as an environment and health inspector, his day job is as a business development manager in environmental chemistry. In his free time – in the evenings, at night and at weekends – he writes about aspects of Sweden's history, using DNA analyses from private individuals.

The first time we meet, we are both speaking at a seminar on DNA for family history researchers. Peter Sjölund's talk is about how DNA analyses enabled him to dispel some ancient myths about the legendary Bure family. He shows how a great many Swedes who believe themselves to be the descendants of a particular mediaeval ancestor are no such thing. After our respective presentations, I invite him home for a pizza. I am impressed by his expertise, his capacity to absorb the new technology, and his ability to examine sources with a critical eye – just like a professional researcher.

Sjölund's preliminary conclusion is that 'Ragnar' lived in Denmark, probably in Jutland or the region that is now German Schleswig-Holstein. There are indications that my forebear Ragnar belonged to the Corded Ware culture. Feeling that I need to know more about this culture, I travel to Cracow in southern Poland to interview the Polish archaeologist Sławomir Kadrow.

Cracow's old town centre is one of the most picturesque you could hope to find. It is girded by the River Vistula, one of Europe's most important transport arteries for thousands of years. In the heart of the Old Town lies its famous square. It is vast, with a building in the middle where long lines of stallholders are selling amber jewellery. The cafés and restaurants around the square sell mead, the traditional honey wine that is still popular in Poland. It is autumn when I visit Cracow, and the weather is cold, so the mead is served hot in little cups. In summer it is drunk cold. It tastes very sweet, with a tinge of acidity, more or less like a dessert wine, though without the pungency lent by grapes.

I use the day before the interview I have arranged with Sławomir Kadrow to visit Cracow's archaeology museum. The first thing to meet the eye in the entrance is the world's oldest pictorial evidence of a wheeled wagon. The image adorns a terracotta vessel about 5,600 years old, which was found in the village of Bronocice, a few dozen kilometres from Cracow. What visitors get to see is a reconstruction. The real vase is in fragments, which are kept in the museum's storeroom. But the stylised image is unmistakable; the wagon has four wheels, two axles and a pole with a yoke for draught animals. The person who drew this picture must have seen wagons rolling past in real life – there's no doubt about that.

On the morning when I am to meet Kadrow, it is pouring down and most tourists are indoors. Kadrow's place of work is the Cracow section of the Polish Academy of Sciences, a

large stone building just a few hundred metres away from the main square. I have to wait nearly half an hour, as the downpour has brought traffic to a standstill. But when Kadrow arrives, he takes the interview very seriously and spends the whole morning with me.

‘What exactly was the Corded Ware culture?’ This is my first and most important question. The need to answer it is my reason for travelling all the way to Cracow. Poland and the Vistula were the heartlands of the Corded Ware people; that is why it is so important to talk to Polish experts.

Kadrow does not hesitate for a second. ‘The Corded Ware culture was a fusion,’ he says. A fusion. A mix. A blend of people and cultures; that seems to be a recurrent theme. The word ‘fusion’ recurs constantly in the course of my interviews with the world’s leading archaeologists. The most significant stages of Europe’s development seem to have followed in the wake of migrations, encounters and fusions. Modern humans interbred with Neanderthals in the Middle East, the Ice Age culture known as the Solutrean developed completely new types of sophisticated tools when people were forced to live in close proximity during the most extreme period of cold, immigrant farmers merged together with groups of local hunting folk in Scandinavia, and so on.

My next question is a predictable one: ‘So which groups merged to form the Corded Ware culture?’

The reply is unexpected. ‘The most important, by a very long way, was the Funnel Beaker culture.’

The Funnel Beaker people! They were the farmers who were the first to arrive in Denmark and Sweden. Could the key influences have come from our direction – from Scandinavia? Some German researchers – both the DNA researchers from Mainz and Bernd Zich, the more traditional archaeologist from Halle – have been thinking along these lines. They think some of the Funnel Beaker people from the north migrated towards central Europe at about the same time as the Gökhem farmers built their passage graves in Västergötland some 5,500 years ago. Moreover, the pottery vessel from Bronocice with the world’s first picture of a

wheeled vehicle was found among remains from the Funnel Beaker culture.

Kadrow points out on a map the encounters between cultures and the migrations that he thinks were most significant in the development of the Corded Ware culture. One factor was the Funnel Beaker farmers from Jutland. There was a culture known as the Globular Amphora culture in south-eastern Poland, a region also influenced by the Tripolye culture from Ukraine. The groups from Jutland and south-eastern Poland met at some point or other, and resulted in the genesis of the Corded Ware culture.

And there were indeed influences from the steppes in the east as well, says Kadrow. All the evidence points to an expansion of people from the steppes, moving from east to west. From Hungary, they spread northwards to Germany and Poland. Their burial sites show a new culture and people who were 10 centimetres (four inches) taller than those already living in the region.

Kadrow's predecessor at the archaeological institution in Cracow viewed the Corded Ware culture as being simply a straightforward extension of the existing farming culture. 'But now the Corded Ware culture is regarded as something radically new. Like a revolution,' he says.

Naturally, Kadrow is familiar with David Anthony's theory that equestrian herders from the steppe introduced the forerunner of the Indo-European languages to many different areas. He is somewhat sceptical about this. In particular, he has doubts about Anthony's strong emphasis on the role of horses. They certainly became very important at a slightly later stage in the history of Europe and Asia. However, there is no evidence of horse-drawn wagons earlier than 4,000 years ago. And the earliest examples were found at a remote location in the steppe, near the River Tobol east of the Urals. Horses may well have been domesticated as early as 7,000 years ago. However, according to Kadrow they served only as a source of meat initially, not as a means of transport. Oxen and ox-drawn wagons played a far more significant role, at least for the first 1,500 years after the invention of the wheel.

Kadrow wants to emphasise another factor that he thinks was even more significant than horses when the Indo-European languages and the new ideas began to spread out over the world. It is one he thinks David Anthony and other proponents of the steppe theories have underestimated. He wants to focus on boats.

I ponder Kadrow's words for a whole year. The more facts I gather, the more convinced I am that he is right. Boats played a more important part in Europe's early history than is generally recognised. Most researchers have underestimated the role of sea voyages. If we place more emphasis on boats, several apparently irreconcilable pieces of the puzzle fall into place.

One example is the old discussion about whether the cradle of the Indo-European languages was the steppe north of the Black Sea, or Anatolia, which lies to the south of it. Both camps may be right. One of the groups involved may have been a group of farmers who started out from Turkey, travelled by boat to the northern shore of the Black Sea and settled along the Don. And it was only then that the great migration began, which took them in all directions.

It might seem a tricky thing to carry lambs, goats and calves long distances in a small boat. But the farmers who colonised Cyprus did just that, paddling more than 80 kilometres (50 miles) across open water – over 10,000 years ago.

If one accepts that people crossed the Black Sea by boat early on – and the Caspian Sea as well, no doubt – it is easier to understand that the oldest pottery in eastern Europe was found on the shores of the Don, that it is nearly 9,000 years old, that it was found in the settlements of people who kept livestock, and that it closely resembles pottery of the same era from the Middle East, south of the Black Sea.

Finally, the long-awaited DNA study comes out. It is published in *Nature*, and, to my relief, I manage to incorporate

the results before this book goes to print. These were the results that convinced James Mallory from Belfast that he had been on the right track for the last 40 years as regards the origin of the Indo-European languages.

A large international team of researchers has compared nuclear DNA from a total of 94 individuals from Russia and the rest of Europe. The oldest of them lived in the Old Stone Age or Palaeolithic, the most recent in the Bronze Age. The researchers analysed the DNA of 69 of these individuals themselves, while the other 25 DNA sets had already been published previously.

On seeing the results, I understand Mallory's relief. The new comparison shows very clearly that the Corded Ware culture, which turned up suddenly in central Europe 4,800 years ago, was associated with a major migration from the eastern steppes – just as Gimbutas, Anthony, Mallory and many others had claimed. Three quarters of the German Corded Ware people's DNA matches that of the Yamnaya people from the pastoral culture of the Russian steppes – 2,600 kilometres (1,600 miles) away.

The Yamnaya people, in their turn, were also a mixture, bearing DNA from two separate sources. Their origins can be traced in part back to earlier Stone Age hunters in Russia. They have a distinctive north-eastern genetic signature, which researchers have found in Stone Age hunters all the way from Karelia to Lake Baikal in Siberia. However, the Yamnaya also bear genetic material from the south, from farmers who had started their journey in eastern Anatolia or Armenia. This result also ties in neatly with David Anthony's hypothesis that horses were domesticated when newly arrived farmers from the south and hunters already living in the steppe met and inspired each other.

What also emerges clearly from the new study in *Nature* is that Y chromosomes belonging to haplogroups R1a and R1b, which hardly ever occurred in western Europe before the Corded Ware culture, were very common in Russia. The type of Y chromosomes that now predominate in European men thus originated in the eastern steppes.

I recognise most of the names in the study's long list of authors. I have interviewed many of them for my research over the last few years: the first author, Wolfgang Haak, from Australia; the Swede Fredrik Hallgren, who contributed DNA samples from the Stone Age people of Motala; Johannes Krause from Tübingen; the Hungarian archaeologists Eszter Bánffy and Anna Szécsényi-Nagy, whom I met at the seminar in Pilsen; and, of course, Guido Brandt, the doctoral student from Mainz whom a more high-tech rival on the tram in Pilsen called an 'idiot' on account of the comparatively simple DNA technology he uses.

However, I have not met the main author of the study, the geneticist David Reich from Boston, or his collaborator, the mathematician Nick Patterson. The latter has a background in military code-breaking in the UK and the US during the Cold War and has also worked in finance, developing data models to predict stock exchange movements.

That combination of relatively simple DNA technology and mathematics is one of the keys to the groundbreaking *Nature* study of European history. The research team analysed a limited but carefully selected amount of nuclear DNA. Restricting their study to a comparatively small quantity of DNA freed up enough financial and other resources for them to analyse more than twice as many Stone Age and Bronze Age individuals than all previous studies put together. And it was this balance that enabled them to draw their conclusions.

Science is not just about using the most cutting-edge technology available. It is also about asking the right questions, and using exactly the right level of technology to answer them.

Only three months later another major study is published in *Nature*, led by researchers in Gothenburg and Copenhagen. They have examined even more individuals from the period in question, a total of about 100 from both Europe and Asia. The results support the theory that the Indo-European languages were disseminated by Yamnaya pastoralists from the Russian steppes. First they spread Indo-European languages to the

west, throughout Europe, via the Corded Ware and Bell Beaker cultures. About 1,000 years later, a wave spread from the steppe eastwards and southwards, towards India, Afghanistan and Iran. Horses and horse-drawn wagons played a decisive role in the latter wave of migration.

The new DNA results show that the Yamnaya herders were genetically predisposed to be tall. Archaeologists had already noted their unusual height, judging on the basis of the skeletons found in graves from that period. Their height was not just a result of the large herds they kept as steppe pastoralists, giving them access to ample amounts of nutritious food; it was also a specific genetic trait.

The new DNA studies provide no support for the old notion that 'Aryans', the first speakers of Indo-European languages, were particularly blond or blue-eyed. The Yamnaya herders seem to have been quite dark, both in comparison with today's Europeans and with their contemporaries, the farmers of western Europe. On average, they seem to have been even darker-skinned than the Stone Age hunters of Scandinavia. Nearly all Yamnaya pastoralists seem to have been brown-eyed, while blue eyes appear to have been common in western and northern Europe for several millennia.

The two new *Nature* studies now provide far clearer confirmation of the picture we have sketched. Europe's population was largely formed by three major waves of immigration. The Ice Age hunters were the first to arrive, followed by the farmers from the Middle East just over 8,000 years ago. Later, about 4,800 years ago, came a wave of pastoralists from the eastern steppes. But when did this third wave arrive in Sweden?