In everyday life, a string—such as a shoelace—is usually used to secure something or hold it in place. When we tie a knot, the purpose is to help the string do its job. All too often, we run into a complicated and tangled mess of string, but ordinarily this happens by mistake.

The term “knot” as it is used by mathematicians is abstracted from this experience just a little bit. A knot in the mathematical sense is a possibly tangled loop, freely floating in ordinary space. Thus, mathematicians study the tangle itself. A typical knot in the mathematical sense is shown in Figure 1. Hopefully, this picture reminds us of something we know from everyday life, a string—such as a shoelace—is usually used to secure something or hold it in place. When we tie a knot, the purpose is to help the string do its job. All too often, we run into a complicated and tangled mess of string, but ordinarily this happens by mistake.

Such questions might not sound like mathematics, if one is accustomed to thinking that mathematics is about adding, subtracting, multiplying, and dividing. But actually, in the twentieth century, mathematicians developed a rather deep theory of knots, with surprising ways to answer questions like whether a given tangle can be untangled.

But why—apart from the fact that the topic is fun—am I writing about this as a physicist? Even though knots are things that can exist in ordinary three-dimensional space, as a physicist I am only interested in them because of something surprising that was discovered in the last three decades. Much of the theory of knots is best understood in the framework of twentieth- and twenty-first-century developments in quantum physics. In other words, what really fascinates me are not the knots per se but the connections between the knots and quantum physics.

The first “knot polynomial” was actually discovered in 1923 by James W. Alexander. Alexander, a Princeton native who was one of the original Professors at the Institute, was a pioneer of algebraic topology. But the story as I will tell it begins with the Jones polynomial, which was discovered by Vaughan F. R. Jones in 1983. The Jones polynomial was an essentially new way of studying knots. Its discovery led to a flood of new surprises that is continuing to this very day.

Even though it is very modern, and near the frontier of contemporary mathematics, the Jones polynomial can be described in a down-to-earth way that one could explain it to a high school class without compromising very much. There are not many frontier developments in modern mathematics about which
they interacted with other peoples: trade or raid, tribute or conquest. Understanding the genetic legacy of peoples identified as Xiongnu can bear upon how we connect the dots between populations where unusual concentrations of wealth and power or centers of advanced technology may be found. Following genetic traces, one could hope to track the story of steppe nomads, as it were, from rags to riches. But I must admit having been often confronted with a sense of alienation that makes it difficult to assess how to use genetic data. I have the feeling that such evidence is at the same time too much and too little. Relevant studies have been published at an impressive rate in useful, a historical and archaeological context, and therefore one could say that testing the adequacy of the historical assumptions and conclusions must just as urgently be making sure that the tests are done correctly. Let me give a concrete example. Often we read that a particular individual whose DNA is being extracted and tested was a “nomad” or a “Xiongnu” when dealing with samples coming from Iron Age sites in Mongolia, northern China, or Kazakhstan. Yet there is no evidence to associate the individual whose genome we are looking at with an identifiable Xiongnu population or even with “nomads.” These categories are highly problematic to begin with, and once the genetic results are classified as such (Xiongnu or nomad) we only add to the difficulty of unraveling an already convoluted and confusing picture. A recent article (2006) presented the test results of samples of ancient human DNA from the site of Egyin Gol, an Iron Age necropolis in northern Mongolia, conventionally dated by archaeologists between the third century B.C.E. and the fourth or fifth century C.E. The site has been attributed to the Xiongnu culture, and the inhabitants regarded as Xiongnu. The authors surmise that some events must have happened there, since they mention many locations and events in the Baikal lake-horsetribe contact zone between Siberian and Central Asian tribes, and significant ethnic events occurred (e.g., wars, territorial conquests, and population movements). They also state: “the formation and development of the Mongolian population was thus a complex process affected by the mixture of ethnic and cultural or linguistic processes rather than a migratory or genetic one.” One is at a loss to make sense of these conclusions, which essentially restate what historians have taken for granted for a very long time. What the genetic tests tell us, as described by the researchers, is that (1) the people whose DNA was extracted were quite close to the present-day population of Mongolia, and (2) the maternal lineages have a different pattern of distribution with respect to paternal ones. To go from these two pieces of information, in themselves quite valuable, to the historical conclusions stated in the article requires a leap that is both unnecessary and unfounded. If we use a known (or presumed known) historical picture to explain a given result, does genetics contribute to modify and increase historical knowledge? Novel results should be used first and foremost to generate new research hypotheses. The tendency to explain the distribution of genes according to assumed patterns of behavior of certain peoples and societies is quite common in ancient DNA studies. Ultimately, these assumptions go back to historical, anthropological, and archaeological models, and sometimes not the best of them. Inevitably one runs the risk of historical narratives that not only accept as given the existing historical narratives, but may confirm particularly poor versions of them. Going back to the Xiongnu, I am surprised that they are taken often as an ancient population in their own right, or, in the best of cases, that variations in the genetic composition of people assumed to be Xiongnu are attributed to the existence of multiple sets of populations within a large empire, to the effects of Xiongnu conquests and subsequent mixing with a great variety of people, or even to what some have defined as “racial toleration” within their empire. In reality, in every case I have seen, the evidence that shows for certain that the people examined were “Xiongnu” (whatever that may mean) or belonged to any empire is next to nil. To attribute genetic admixture to ready-made historical...
ANDREA KANE

DNA, HISTORY, AND ARCHAEOLOGY (Continued from page 12)

notions of political expansion and conquest means also that scenarios built as hypotheses by historians and archaeologists are never going to be questioned.

My concern with the way in which geneticists access and deploy historical arguments leads me to another consideration. That DNA evidence can provide clues to unrecorded historical events is surely one of the key potential uses of ancient DNA, but how can we make sure that such a clue is historically meaningful? If ancient DNA can lead to the discovery or even the solution of unknown human events—migration, war, settlement, enslavement, conquest, etc.—it is necessary to make sure that genetic data is interpreted according to scenarios that make sense historically and archaeologically, and often this requires first of all a greater sensitivity toward what we may call the “identity” of an excavated site. Secondly, a certain acquaintance with how ancient populations may have been structured socially, ethnically, and politically is required. It makes a difference if we regard an intrusive genetic element as appears in a common tomb or in an elaborate elite burial. In other words, the categories used by historians, archaeologists, and anthropologists when they examine ancient remains can be complicated and may not be easily mapped to a biological context.

I believe that historians, especially those working in areas for which written records are nonexistent, 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. What historians bring to the table depends on how “testable” their historical hypotheses are. To give an example again based on our Xiongnu problem, if DNA research could help form a picture of the genetic distribution in various regions that are regarded as the homeland of early nomads—northern China, Mongolia, Tuva, Transbaikalia, etc.—this would be in itself a great advance, but since this is, in practice, impossible, one might seek to identify those sites that are most promising. Based on what I have been able to cobble together from existing studies, it would be interesting to see whether patterns of genetic distribution may correlate with advanced technology (for instance metallurgy), with centers of political power, and with early trade routes. Such a rough and untested hypothesis might be a starting point for a cooperative project between historians, archaeologists, and geneticists. Any result in that direction would take us one step forward in our understanding of large cultural and demographic events in central, northern, and east Asia, and of the fateful genesis of ancient nomadic empires.

Peter Goddard, Director of the Institute, addressing the Friends in May 2010

In Honor of Hans Kohn

In November, School of Historical Studies Faculty and Members joined Immanuel Kohn, a Trustee Emeritus of the Institute, and his wife Vera Kohn to dedicate a new room for seminars and gatherings in Full Hall. The room, which was made possible by the Kohns’ support, is named in honor of Immanuel Kohn’s father Hans Kohn, a distinguished historian of nationalism and a Member in the School of Historical Studies in 1948 and 1955.

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In addition to Edward Witten, Charles Simonyi Professor in the School of Natural Sciences (see article, page 1), and Paul Hodgson (see article, above), recent Friends talks have been presented by William Grimes of the New York Times and Harold Shapiro, President Emeritus and Professor of Economics and Public Affairs at Princeton University and an Institute Trustee. Upcoming speakers include Tarik O’Regan, a composer and Director’s Visitor, and Marilena LoVerde, the Friends of the Institute for Advanced Study Member in the School of Natural Sciences.

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