observations of weather during the first seven centuries BC, and which remain largely unexploited. As Pfister and Wanner stated[7] in 2002, "Worldwide, many thousand volumes with daily observations exist, but have not yet been analyzed for their climatic information. Let's get to work!"

Francis Ludlow and **Rhonda McGovern** are at the Trinity Centre for Environmental Humanities, School of Histories and Humanities, Trinity College, Dublin D02 PN40, Ireland.
e-mail: ludlowf@tcd.ie

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Human migration

Native South Americans reached Polynesia early

Paul Wallin

DNA analysis of Polynesians and Native South Americans has revealed an ancient genetic signature that resolves a long-running debate over Polynesian origins and early contacts between the two populations. **See p.572**

For many years, scholars have speculated about how Polynesia was initially populated. On page 572, Ioannidis *et al.*[1] now describe a genetic approach that they used to address the issue of Polynesian origins and interactions.

The early peopling of Polynesia attracted worldwide interest in 1947, when the Norwegian explorer Thor Heyerdahl set sail on the *Kon-Tiki* expedition to test his migration theory[2]. The crew left Peru on a wooden raft, and after 101 days and a voyage of more than 7,000 kilometres, they reached Polynesian shores, thus demonstrating the possibility of early travel from South America to these Pacific islands. Heyerdahl challenged the scientific community's view that evidence pointed instead to the peopling of Polynesia by people travelling east from Asia, and his idea that Polynesia was initially populated by South Americans was generally criticized by scholars.

The same scientific community nevertheless discussed cultural contacts between the two regions, because a South American plant, the sweet potato, has a long history of cultivation in eastern Polynesia. The idea that Polynesians voyaged to South America and introduced the plant on their return to Polynesia became the accepted explanation for this[3]. Rapa Nui (also known as Easter Island) is the best-known example considered concerning such contacts[4]. It is a part of Polynesia that is located relatively close to South America, and in Rapa Nui there is evidence of large, ancient sweet-potato fields, extraordinary old stonework and a specific birdman cult – all of which are features in common with those of South America.

Ioannidis and colleagues analysed the DNA of people from Rapa Nui, and also studied DNA of individuals from 17 populations of Pacific islands and 15 Native American populations from the Pacific coast of South America. Genome-wide DNA analyses of 807 people (analysing predominantly present-day individuals) enabled the authors to search for evidence of ancestors from different populations who produced offspring together – thereby generating a combined genetic signature of the two populations, described as an admixture. The authors compared the dominant Polynesian DNA markers with those of people from other regions, including Europe, America, Africa and Melanesia. A computational method called an ADMIXTURE analysis allowed Ioannidis and colleagues to work out a person's probable genetic ancestry and ancestral geographical origins through studies of gene flow. Their main discovery is that several eastern Polynesian populations have signs of a background signature (genetic traces from distant ancestors) that originated from Native South American people.

> **"Future research should assess the possibility of more than just one early contact from South America."**

How did Ioannidis and colleagues solve this complex task of genetic unravelling? In their admixture studies, they could trace and distinguish between different modern colonial admixtures; for example, in French Polynesia, there was a large French influence, whereas Spanish and Chilean groups were part of the population history in Rapa Nui. A key discovery came from their analysis of people from Rapa Nui – a signature could be assigned to Native South American populations from northern coastal regions of South America, and this component was independent of other large historical, or more-recent, admixture events. This signature exists in the genetic background, indicating that it is an old and stable hallmark of admixture. A surprising finding is that this signal was also identified in other eastern Polynesian populations, for example in populations in Mangareva, in North Marquesas and South Marquesas, and in Palliser in the Tuamotu Islands (Fig. 1). These other islands lie farther from South America than does Rapa Nui, although for people sailing from South America they are destinations that would be aided by favourable trade winds and currents.

Ioannidis *et al.* investigated the estimated timing of admixture events using a method called tract-length distribution analysis, which assesses the length distributions of the genomic segments inherited from different ancestral populations. As expected, this statistical approach suggests that the European admixtures in Polynesia first date back to colonial phases of AD 1750–1860.

The authors made the notable discovery that an initial admixture event between Native South Americans and Polynesians took place in eastern islands of Polynesia around AD 1150–1230. Previous work[3,5] is consistent with a model of populations spreading eastwards from Asia possibly having reached eastern Polynesia by that time. The exception to this South American admixture timeframe is Rapa Nui, which had a later admixture, dated to around AD 1380. This later date for Rapa Nui is surprising, because it is the closest site to South America studied and has been cited as the 'typical' example of a location with possible early connections to South America. However, the timing difference might be due to a more complex genetic history there because of relatively recent Chilean genetic input.

When Ioannidis and colleagues searched for similarities between the genetic signatures of Native South Americans found in Polynesia and those of Indigenous populations in northern coastal areas of South America, the connection to Colombian populations was especially strong. The earliest genetic signal of Native Southern Americans found by the authors in Polynesia was from people of the Southern Marquesas islands, and the authors argue that Colombians mixed with Polynesians there around AD 1150. This date is so early that it could even suggest South Americans reached there before Polynesians arrived, which would make Heyerdahl partly right if it were the case that South Americans first settled at least the area of eastern Polynesia that has signs of early admixture.

The authors propose that the Native South American genetic signatures they found were probably the result of a single ancient contact. Their model suggests that the mixed population then spread from central eastern Polynesia around AD 1200 to other Polynesian islands during an early eastern Polynesian expansion, and finally reached Rapa Nui. These spectacular results have major implications for future discussions concerning early migrations and interactions in Polynesia. Rapa Nui itself is not suggested to be the initial point of contact between Polynesians and South Americans, but the admixture identified there is thought to have arisen elsewhere in Polynesia in a population that eventually reached Rapa Nui (Fig. 1).

The authors also raise other possible contact scenarios: for example, that Polynesian populations made voyages to South America and then returned to Polynesia along with South American people, or that people returned to Polynesia who carried Native South American genetic heritage. Ioannidis *et al.* suggest that further genetic studies will be needed to address such alternative hypotheses.

What are the implications of the authors' results for future research? From an archaeological viewpoint, the next step would be to assess how well their model fits with material-culture studies, ethno-historical records, linguistics and evidence of plant and animal distributions. Linguistic research[6] has led to the proposal that a general, intermixed central eastern Polynesian language group developed owing to interactions between different populations. That study suggested that Rapa Nui was not included as part of this network, but that the language used in Rapa Nui instead split directly from an early language group termed Proto-Eastern Polynesian[6]. This suggests that the first inhabitants to reach Rapa Nui arrived there quite early.

It is worth reflecting that, for the model in which the people settling on Rapa Nui who were from elsewhere in eastern Polynesia and had a gene admixture event dated to around AD 1380 — those arrivals therefore reached an island that was probably already populated by other Polynesians. Radiocarbon dating evidence[5,7,8] places the initial settlement phase of Rapa Nui to at least AD 1200. However, the building phase of the elaborate monumental stone structures there took place around AD 1300–1400, which is early compared with when similar such construction occurred in the central region of eastern Polynesia[9]. If this stonework is a result of cultural contacts, it could imply that another independent connection with Native South Americans took place on Rapa Nui during that timeframe. This offers another explanation for why Rapa Nui had a late timing for the estimated admixture date.

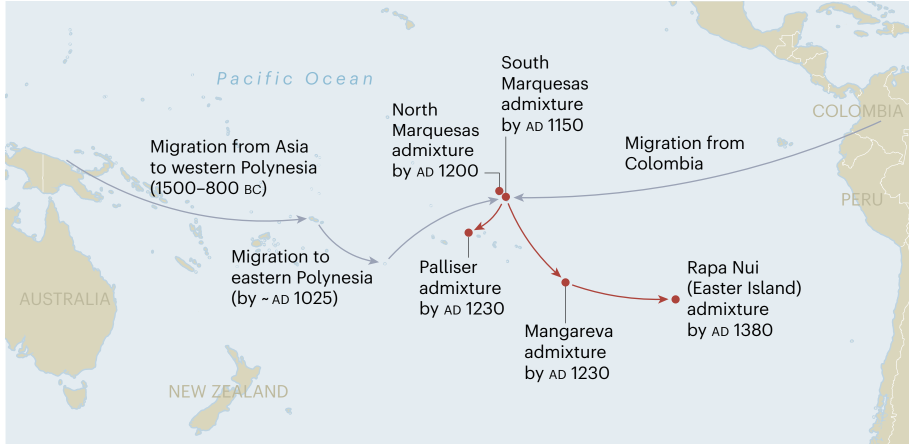

Figure 1 | Genetic clues reveal early migration from South America to Polynesia. Ioannidis *et al.*[1] report a DNA analysis of Polynesians and Native American people from South America, focused mainly on modern populations. The authors shed light on the early peopling of Polynesia by uncovering signs of ancient encounters between Polynesians and South Americans (probably those from Colombia), which resulted in a genetic signature called an admixture indicating that children had parents from both populations. The earliest signs of such admixture in Polynesia were estimated to have occurred on the Southern Marquesas islands in AD 1150. Previous studies[3,5] indicate that populations moving eastwards from Asia had populated this area by around that time. The authors find evidence for the same type of population admixture being present between AD 1150 and AD 1230 in nearby islands, and then in Rapa Nui (also known as Easter Island) by AD 1380. Some Polynesian islands, including Rapa Nui, have characteristics in common with those of ancient South America, such as elaborate stonework and the sweet-potato plant. But an early role for South Americans in the peopling of the Polynesian islands had not previously been widely accepted.

Genetic studies of specimens of early sweet-potato plants in herbarium collections from the eighteenth century suggest that such plants found in Polynesia originated from the northern coasts of South America, and some genetic variations found in the specimens indicate the possibility of several introduction events in Polynesia[10]. Future research should assess the possibility of more than just one early contact from South America, as well as considering long-reaching interaction networks and voyaging between islands[11], possibly also including Rapa Nui.

DNA studies will be necessary to answer some of the remaining questions, and should analyse living populations not included in the authors' study, as well as DNA extracted from ancient bones. Nevertheless, Ioannidis and colleagues' core findings have finally solved the mystery about a possible early Native South American physical presence in eastern Polynesia, and that is a great contribution.

Paul Wallin is in the Department of Archaeology and Ancient History, Uppsala University, Campus Gotland, Visby SE-621 67, Sweden.
e-mail: paul.wallin@arkeologi.uu.se

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