Ancient genomics

Population history of Rapa Nui rewritten

Stephan Schiffels & Kathrin Nägele

By analysing the ancient genomes of individuals from Rapa Nui, researchers have overturned a contentious theory that the remote Pacific island experienced a self-inflicted population collapse before European colonization. See p.389

Few stories in our human past spark as much imagination as the discovery of the most remote islands in the vast Pacific Ocean. Rapa Nui, sometimes known by its colonial name of Easter Island, is perhaps an extreme example, being one of the most isolated places on Earth. It was peopled more than 800 years ago by Polynesian seafarers, who sailed against the prevailing winds and currents and with masterful navigation. On page 389, Moreno-Mayar *et al.*[1] report a genetic study that greatly advances scientists' understanding of the island's inhabitants and their ancestors.

The authors analysed the remains of 15 individuals that had ended up in a museum in Paris during the late nineteenth and early twentieth centuries, like the remains of many others from colonized regions. Studying such samples from European anthropological collections can be problematic, because these collections often reflect colonial practices that are still perpetuated today, and such remains are often the subject of requests for repatriation. In the case of Rapa Nui, the excavation of ancestors buried on the island is often not allowed, emphasizing the sensitivity of such a project. Moreno-Mayar *et al.* worked with government institutions and local communities to obtain consent for this study, and explicitly mention that this line of research will eventually facilitate repatriation. It is hoped that the scientific results will convince authorities to pursue this goal, so that ultimately the individuals examined in this study can be laid to rest where they came from.

The geographical location of Rapa Nui between Central Oceania and South America, as well its colonial history, are reflected in the mixture of Pacific, South American and European ancestry found in the Rapa Nui people today[2]. A key interest is to understand how the South American component arose. Evidence from present-day genomes points to an old admixture (the mixing of groups with different genetic ancestries), which pre-dates European contact and possibly even the initial settlement of Rapa Nui. However, such a signal could be obscured by more recent events, and, moreover, it contradicts evidence from ancient genomes that lack such admixture[3].

The question of contact between Pacific islanders and South Americans before the arrival of Europeans also crops up in a long debate among scholars in archaeology and linguistics. There is rising support for such contact. For example, it had been thought that chickens were introduced to the Americas by European sailors, but the presence of chicken bones in South American archaeological sites that pre-date European colonization, and that are derived from the same genetic lineages as chickens found across early Polynesian sites, indicates contact between South America and the Pacific before Europeans arrived[4].

The ancient Rapa Nui genomes studied by Moreno-Mayar *et al.* are predominantly of ancestries similar to those of other Pacific islanders, but 6.0–11.4% of their genetic material can be traced to coastal South American ancestors (Fig. 1a). These genetic ancestry components are not distributed uniformly across the genome, but are inherited in blocks, and the lengths of these blocks provide information about the time elapsed since people of both ancestries first met and had offspring: the more recent this admixture, the longer the blocks are expected to be, on average. Given the relatively high quality of the 15 genomes studied here, the authors were able to confidently identify blocks of South American descent and estimate that admixture with Rapa Nui ancestors occurred 15–17 generations before the individuals studied lived.

Figure 1 | Rapa Nui genetic ancestry and population dynamics. **a**, Moreno-Mayar *et al.*[1] examined the genomes of 15 ancient individuals from Rapa Nui, a remote island in the Pacific Ocean. Analysis of gene variants (alleles) that ancient Rapa Nui individuals shared with Pacific island and Native American populations revealed that these individuals exhibited a mixture of Polynesian ancestry and American ancestry — evidence of contact between Pacific islanders and coastal South Americans before European contact. **b**, By modelling population dynamics throughout Rapa Nui's history using genetic data, the authors show that there was a decrease in population during initial settlement of the island by Pacific islanders, followed by a period of continuous growth. The data strongly contradict a popular narrative about Rapa Nui history, which asserts that the island experienced a population collapse caused by overconsumption of resources in the seventeenth century, before contact with European colonizers. (Adapted from Fig. 2b of ref. 1.)

Combining this estimate with radiocarbon dating (giving an indication of how long ago these individuals lived), the authors estimated that the admixture occurred in the fourteenth century — around 400 years before European contact in 1722, and only a few hundred years after Rapa Nui's initial settlement. This finding leaves no doubt that such admixture did actually happen. This naturally leads to the question of how it happened, given the island's remoteness from the South American coast. Although the idea remains speculative, it is plausible that seafarers who reached Rapa Nui from the west were also capable of reaching South America and returning, thereby potentially bringing people from South America and Rapa Nui together.

What happened after the initial settlement of Rapa Nui? Remarkably, genetic data contain traces of past population dynamics, such as periods of growth or decline, through patterns of ancestry shared between individuals. These patterns are indicative of the average degree of relatedness between pairs of people. The smaller a population was in the past, the more abundant and longer those shared fragments are expected to be. Through mathematical modelling of these patterns, it becomes possible to infer ancestral population sizes through time. Usually, island settlements are associated with a reduction in genetic diversity because the founding individuals are a subset of the original population. And indeed, the genomes of the ancient Rapa Nui islanders suggest that there was a reduction in population size coinciding with the initial settlement of the island around 1200, followed most probably by steady growth until at least 200 years ago (Fig. 1b).

This result might not seem all that exciting, were it not for probably the most popular, albeit scientifically contested, theory about Rapa Nui's history[5]. According to this narrative, when Europeans arrived on the island, they found a miserable community with only a few people remaining after overconsumption, violence and cannibalism during the seventeenth century. The latest results join a growing amount of evidence that Rapa Nui could, in fact, sustain a large population despite environmental changes, with first historical accounts describing the island as 'earthly paradise'[6]. An analysis of satellite imagery showing the extent of rock gardens on the island, which was published this year[7], suggests that the inhabitants found ways to manage the land sustainably and protect it from erosion. The study concludes that there were never more than 3,000 people living on Rapa Nui — a number close to that observed by the first colonizers and far from a previous estimate of 15,000 inhabitants[5] — implying that the hypothesized collapse was always a fantasy.

Regardless of the mounting evidence against precolonial collapse, the narrative persists as a cautionary tale of what happens when people consume more than their environment can produce — a story with striking parallels to the current climate crisis. Perhaps this study will serve as the final nail in the coffin for this idea, instead providing a hopeful story about humans' resilience and capacity to learn to manage resources sustainably in the face of environmental changes.

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Materials science

Conduction tuned in a perovskite semiconductor

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A family of semiconductors known as perovskites has great promise for use in optoelectronic devices. A much-needed strategy for adjusting the density of charge carriers in these materials unleashes their potential. **See p.344**

The foundation of modern electronics is a process known as doping, in which impurities or defects are introduced to a semiconductor to modify its conductivity and generate mobile charge carriers. Researchers have developed methods for the controlled doping of several widely used semiconductor families, with one notable exception: the halide perovskites (hereafter referred to simply as perovskites). There has been an explosion of interest in these materials over the past ten years, because of their potential applications in solar cells and in conventional and quantum light-emitting devices. On page 344, Xiong *et al.*[1] report a dopant compound that enables the electrical conductivity of a perovskite to be tuned, albeit over a modest range, and which can even switch conduction between the two modes mediated by positive and negative charge carriers.

"The authors report a dopant compound that enables the electrical conductivity of a perovskite to be tuned."

The importance of controlling carrier concentrations for the field of electronics cannot be overstated. For example, the development of methods to control the purity of silicon, and of processes for doping it, were key advances that led to silicon replacing germanium as the element of choice for making transistors[2]. Today, doping is used to control whether a semiconductor is n-type (in which most of the charge carriers are electrons) or p-type (in which most of the carriers are positively charged quasiparticles, called holes), and to adjust the concentration of the carriers. As such, doping is the basis for engineering technologies ranging from transistors to light-emitting diodes (LEDs) and semiconductor lasers — enabling applications such as the computer processor and smartphone displays.

Various chemical strategies for perovskite doping have been explored, such as varying the ratios of the starting materials in the chemical reactions used to make the perovskites and introducing external dopants (positively or negatively charged ions, or organic molecules) to these semiconductors[3]. The first of these approaches involves a mechanism in which charged defects form in the perovskite crystal lattice[4]. The second approach is more common and effective, and is known as charge-transfer doping or, when the dopant is a molecule, as molecular doping. In this approach, charge is transferred between the perovskite and the dopant without changing the perovskite's lattice structure[4]. Although previously reported doping strategies have improved