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# PRESS RELEASE

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## In the Neolithic, agriculture took root gradually

A UNIGE study shows that European hunter-gatherers and Anatolian farmers coexisted and gradually interbred.

**The transition to agriculture in Europe involved the coexistence of hunter-gatherers and early farmers migrating from Anatolia. To better understand their interaction dynamics, a team from the University of Geneva (UNIGE), in collaboration with the University of Fribourg and Johannes Gutenberg University Mainz, combined computer simulations with ancient genetic data. The results show that population mixing increased locally over time during the Neolithic expansion, at each stage of the farmers' advance along the "Danube route" toward Central Europe. Published in *Science Advances*, the study provides new insights into this pivotal period in human history.**

The shift from a hunter-gatherer lifestyle to an agricultural one marked a major turning point in human history. In Europe, this transition began almost 9,000 years ago, with the migration of farmers from the Aegean region and western Anatolia (modern-day Anatolian Turkey), who followed the "Danube route", eventually reaching Central Europe (present-day northern Germany). Before the hunter-gatherer lifestyle was fully replaced, the two cultures coexisted for several generations.

Scientists have long debated whether this transition occurred through knowledge transfer from nearby farming communities or through interbreeding between the populations as the farmers migrated. Archaeological evidence – such as the coexistence of cultural artifacts from both groups – combined with paleogenomic analysis of well-preserved human remains, has confirmed the hypothesis of population migration and admixture.

### Modeling the Encounter Between Two Worlds

In this study, the group led by Mathias Currat, senior lecturer in the Department of genetics and evolution at UNIGE's Faculty of science, aimed to better understand how these populations interacted over time. The team focused on the demographic dynamics along the "Danube route": did the groups intermingle consistently from the outset, or did the mixing intensify over time? Using computer models, the researchers simulated the Neolithic expansion by incorporating geographic positions, biological parameters (such as population sizes, reproduction rates, and migration patterns), and interaction variables (such as genetic admixture rates and potential competition).

"These simulations generated thousands of genetic scenarios, which we then compared with data from 67 prehistoric individuals from regions where the two groups had coexisted. By applying statistical methods, we were able to estimate the most likely demographic parameters," explains Mathias Currat. The findings reveal that at

**High resolution pictures**

each stage of the farmers' expansion toward northwestern Europe, genetic mixing with hunter-gatherers was initially rare but increased locally over time. "Our results show that the Neolithic transition was not characterized by violent confrontation or complete replacement, but rather by prolonged coexistence with increasing levels of interbreeding," adds Alexandros Tsoupas, a researcher in Currat's team and the first author of the study.

### **More Numerous and More Mobile Farmers**

The study also estimates the demographic advantage of early farmers: their effective population size was roughly five times larger than that of the hunter-gatherers. Although rare, some farmers made long-distance "migration jumps," helping to accelerate their expansion into Central Europe.

These findings provide a nuanced answer to a longstanding debate: the Neolithization of Europe was not a simple colonization process, but a complex one involving contact, cohabitation, and gradually increasing admixture. The study also highlights the power of combining ancient genetics with modeling approaches to reconstruct key chapters of human history.

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