

Researchers reconstruct the oral microbiomes of Neanderthals, primates, and humans

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Grauer's gorilla specimens at the Royal Museum for Central Africa in Tervuren (Belgium), showing typical dental calculus deposits on the teeth that are stained dark likely as a result of their herbivorous diet. Credit: Katerina Guschanski

Living in and on our bodies are trillions of microbial cells belonging to thousands of bacterial species, known as the microbiome. These microbes play key roles in human health, but little is known about their evolution. In a new study published in the *Proceedings of the National Academy of Sciences*, a multidisciplinary international research team led by scientists at the Max Planck Institute for the Science of Human History (MPI-SHH) investigated the evolutionary history of the hominid oral microbiome by analyzing the fossilized dental plaque of humans and Neanderthals spanning the past 100,000 years and comparing it to those of wild chimpanzees, gorillas, and howler monkeys.

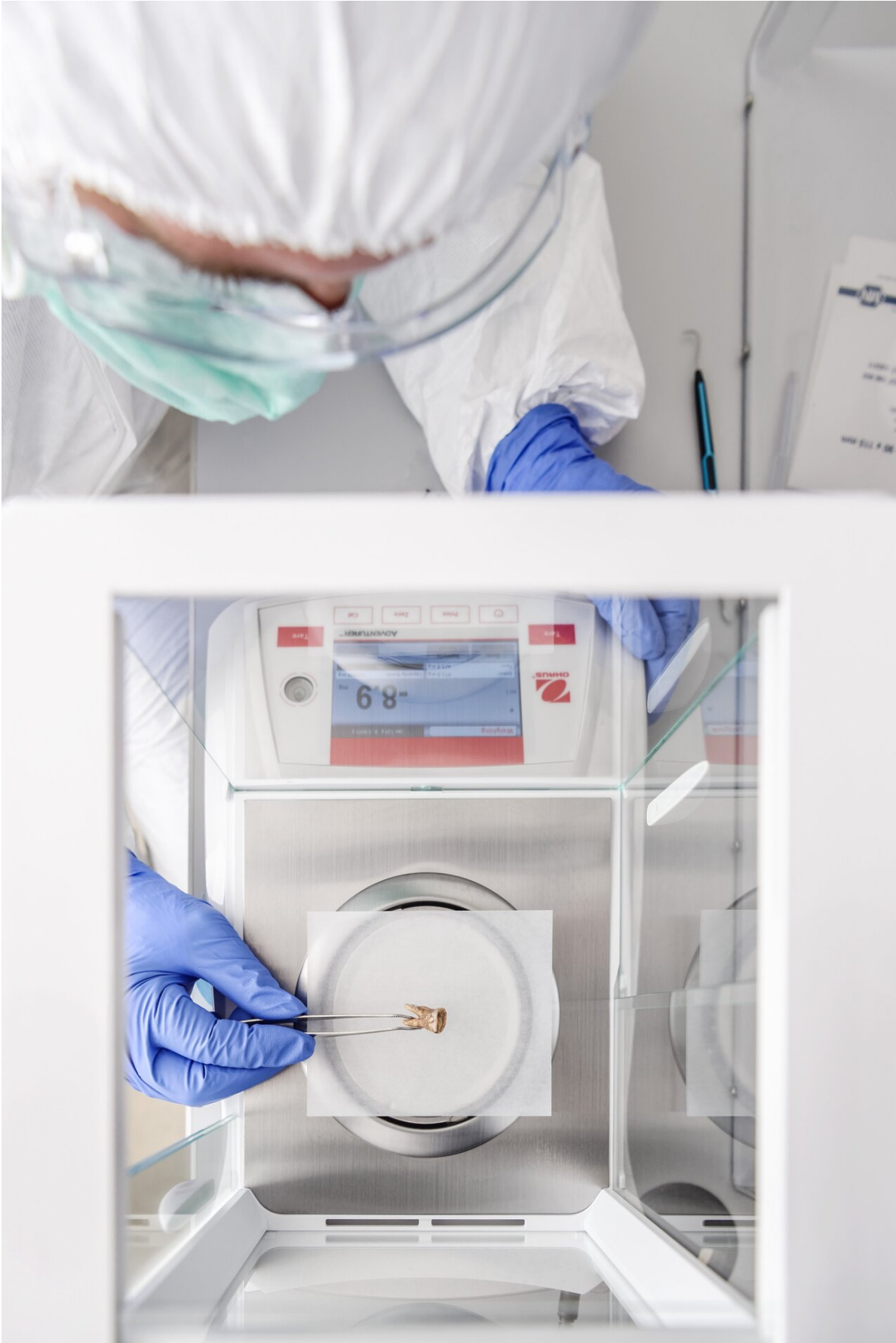
Researchers from 41 institutions in 13 countries contributed to the study, making this the largest and most ambitious study of the ancient oral [microbiome](#) to date. Their analysis of dental calculus from more than 120 individuals representing key points in primate and [human evolution](#) has revealed surprising findings about early [human](#) behavior and novel insights into the evolution of the hominid microbiome.

The most challenging jigsaw puzzle in the world

Working with DNA tens or hundreds of thousands of years old is highly challenging, and like archaeologists reconstructing broken pots, archaeogeneticists also have to painstakingly piece together the broken fragments of ancient genomes in order to reconstruct a complete picture of the past. For this study, researchers had to develop new tools and computational approaches to genetically analyze billions of DNA fragments and identify the long-dead bacterial communities preserved in archaeological dental calculus. Using these [new tools](#), researchers reconstructed the 100,000-year-old oral microbiome of a Neanderthal from Pešturina Cave in Serbia, the oldest oral microbiome successfully reconstructed to date by more than 50,000 years.

"We were able to show that bacterial DNA from the oral microbiome

preserves at least twice as long as previously thought," said James Fellows Yates, lead author and doctoral candidate at the Max Planck Institute for the Science of Human History. "The tools and techniques developed in this study open up new opportunities for answering fundamental questions in microbial archaeology, and will allow the broader exploration of the intimate relationship between humans and their microbiome."



Small pieces of dental calculus can reveal huge insights regarding past interactions between humans and their resident microbes. Credit: Werner Siemens Foundation, Felix Wey

An enduring microbial community

Within the fossilized dental plaque, researchers identified ten groups of bacteria that have been members of the primate oral microbiome for over 40 million years and that are still shared between humans and their closest primate relatives. Many of these bacteria are known to have important beneficial functions in the mouth and may help promote healthy gums and teeth. A surprising number of these bacteria, however, are so understudied that they even lack species names.

"That many of the most important taxa are poorly characterized is a surprise to oral microbiologists who have been working on these bugs for years," said Floyd Dewhirst, Senior Member of Staff at the Forsyth Institute and a coauthor on the study. "We're still learning about new members of this community, and these results give us new species to target for full characterization."

Paleolithic connections

Although humans share many oral bacteria with other primates, the oral microbiomes of humans and Neanderthals are particularly similar. Nevertheless, there are a few small differences, mostly at the level of bacterial strains. When the researchers took a closer look at these differences, they found that ancient humans living in Ice Age Europe shared some bacterial strains with Neanderthals. Because the oral

microbiome is typically acquired in early childhood from caregivers, this sharing may reflect earlier human-Neanderthal pairings and child rearing, as has also been already indicated by the discovery of Neanderthal DNA in ancient and modern human genomes.



Close-up of ancient dental calculus on an ancient human tooth. Credit: Werner Siemens Foundation, Felix Wey

Researchers found that Neanderthal-like bacterial strains were no longer found in humans after ca. 14,000 years ago, a period during which there was substantial population turnover in Europe at the end of the last Ice Age.

"Oral bacteria provide an unexpected opportunity for reconstructing the interactions of humans and Neanderthals tens of thousands of years ago," said Irina Velsko, postdoctoral researcher at the MPI-SHH and a coauthor on the study. "The intersection of human and microbial evolutionary biology is fascinating."

An early love of starch

Among the biggest surprises was the discovery that a subgroup of *Streptococcus* bacteria present in both modern humans and Neanderthals appears to have specially adapted to consume starch early in Homo evolution. This suggests that starchy foods became important in the human diet long before the introduction of farming, and in fact even before the evolution of modern humans. Starchy foods, such as roots, tubers, and seeds, are rich sources of energy, and previous studies have argued that a transition to eating starchy foods may have helped our ancestors to grow the large brains that characterize our species.

"Reconstructing what was on the menu for our most ancient ancestors is a difficult challenge, but our oral bacteria may hold important clues for understanding the early dietary shifts that have made us uniquely human," said Christina Warinner, lead senior author of the study and a professor with joint appointments in Anthropology and Microbiome Sciences at Harvard University and the MPI-SHH. "Bacterial genomes evolve much more quickly than the human genome, making our microbiome a particularly sensitive indicator of major events in our distant and recent evolutionary past."

It's important food for thought—the humble bacterial plaques that grow on our teeth and that we carefully brush away every day hold remarkable clues not only to our health, but also to our evolution.

More information: James A. Fellows Yates et al., "The evolution and

changing ecology of the African hominid oral microbiome," *PNAS* (2021). www.pnas.org/cgi/doi/10.1073/pnas.2021655118

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