Pearly time capsule

The discovery that fossilised teeth are bursting with ancient microbial DNA sheds new light on the lives of our ancestors and our own health, finds Sharon Levy

ALMOST a millennium ago, a middle-aged man was buried in a graveyard in Dalheim, Germany. He had taken some hard knocks in his life – a fist fight had torn incisors from his jaw. And oral hygiene was clearly not a priority: his remaining teeth carried a thick coating of plaque, the gunk that modern people battle with toothbrush and dental floss. We should thank this unknown man for his grim chompers, however, for his dental plaque is now opening a surprising new window to the past. Inside it is a beautifully preserved record of the microbial community in his mouth when he was alive.

We have just begun to understand that the microscopic organisms that live inside and on us are not necessarily pests or freeloaders. Outnumbering our own cells by 10 to 1, they form ecosystems called microbiomes that play a vital role in keeping us healthy. Which microbes we harbour depend on our environment, diet and lifestyle. Since our ancestors co-evolved with an array of microbes and parasites that people in most developed countries no longer encounter, human microbiomes must have shifted over the millennia as we made the transitions from hunter-gatherers to farmers to urbanites. But bacterial remains rarely survive the ravages of decomposition and fossilisation, so direct study of ancient microbiomes seemed out of reach. The discovery that plaque holds the well-preserved remains of a rich microscopic community has been a revelation.

Looking at microbiomes of the past is more than mere voyeurism. In modern developed nations there has been a surge in inflammatory conditions such as asthma, allergies, diabetes and gum disease. A growing body of evidence suggests that this trend is the result of shifts in our internal ecosystems. "Life in urban environments, with antibiotics and advanced sanitation, represents a fundamental change in our relationship with microbes," says anthropologist Cecil Lewis at the University of Oklahoma in Norman. "We've benefited from that change, but now we're learning that we are also increasing our risk of inflammatory diseases." Knowing how and why our microbiomes have changed could provide new ways to treating these conditions.

Unknown signatures

Just a decade ago, researchers believed they had identified all the dominant species of bacteria that live inside humans, by growing laboratory cultures of people's microbiomes. That notion was proved drastically wrong when advanced DNA-sequencing techniques revealed the genetic signatures of a multitude of previously unknown bacterial species that do not grow under laboratory conditions. "Many of these are unnamed species, and we know nothing about them or what they do," says Christina Warinner, an archaeological geneticist working in Lewis's lab. At the same time, developments in the sequencing of ancient DNA have allowed us to reconstruct genomes from ever older and more degraded samples. This has made it possible to look at the microbiomes of long-dead people.

Lewis was among the first to try this. Intrigued by the idea that some of our health problems are caused by unbalanced modern microbiomes, he wanted to study ancient people and the communities of microorganisms they carried. He knew it wouldn't be easy. DNA decays rapidly in the weeks after death and even extracting human genetic material from old bones can be an arduous, hit-and-miss proposition. Microbial DNA would be even harder to come by, as the soft tissue generally associated with microbiomes rarely survives for long after death. Nevertheless, DNA from ancient microbiomes has turned up in a handful of remains, including Ötzi the Iceman, a 5200-year-old frozen mummy found near a retreating glacier on Italy's Alpine border with Austria. So, in 2007, Lewis began looking for more sources.

He searched several promising samples, including a 1600-year-old mummy from Chile and 3000-year-old fossilised faeces from Texas. In each case he drew a blank; the extracted DNA came from microbes that had contaminated the samples. The breakthrough came in 2012 when he managed to extract ancient microbial DNA from two samples of 1400-year-old human faeces found in a prehistoric cave dwelling at the edge of the Rio Zape in Durango, Mexico. This time, he found microbes reflecting ancient gut flora rather than contaminating bacteria from soil. The community of microorganisms was remarkably similar to that found in Ötzi's remains. There were notable differences from the gut microbiome of modern city dwellers, however. In particular, people living in the cave at the Rio Zape harboured plenty of bacteria in the genus *Treponema* – a group that has disappeared from the innards of modern urbanites – and their gut communities were dominated by *Prevotella*, a group that today is most common in rural people living in remote undeveloped areas.

Lewis suspects that these bacteria are associated with the digestion of plant matter. Plant fossils found in the Rio Zape cave

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