Trapped dental 'calculus' holds clues to ancient human diets and health

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Many ancient human teeth, including specimens tens of thousands of years old, still hold onto tiny pieces of food -- and even bacteria. Anthropologists are studying the tartar attached to ancient human teeth to learn more about the plants people ate and the pathogens they carried long ago.

Tartar, also known as dental calculus, is a hard substance that toothpaste ads promise to obliterate and dentists scrape away. It builds up on human teeth after dental plaque solidifies. A dentist might scrape away 30 milligrams of a patient's calculus each visit. Sets of teeth from hundreds or thousands of years ago might have up to 20 times that much, a mass roughly equal to a small paperclip.

Scientists are only beginning to explore the variety of materials caught in calculus, which preserves organic materials that are often fleetingly

preserved in other settings. This allows scientists to address questions that are very difficult to answer using established archaeological methods.

"There are so many time periods in human history where we have theories about what they ate but we really have no idea," said Amanda Henry, a physical anthropologist at the Max Planck Institute for Evolutionary Anthropology, in Leipzig, Germany.

Seeds and grains often degrade slowly and animal bones typically last even longer. But finding direct evidence of vegetable consumption is more difficult. Vegetables such as cabbage and carrots were important foods in medieval Europe, but evidence to confirm their consumption is hard to come by. Reconstructing the full diet for people living in earlier periods is even more difficult.

"We know very little about the vegetable and salad portion of the diet," said Christina Warinner, an archaeological geneticist at University of Zurich's Centre for Evolutionary Medicine, in Switzerland. "[Studying calculus] could potentially be an entirely new way of approaching that."

Small Fossils, Big Information

Calculus contains pollen grains and microscopic fossilized plant pieces called phytoliths, in addition to starch grains and even bacteria. Fragments of bacterial DNA found in calculus can help identify specific pathogens that were once present in the mouths of ancient people.

The plant evidence can be definitive enough to suggest the species that was consumed, or it may suggest what part of a plant was eaten, such as a fruit or leaf. This can help track the use, spread and evolution of food plants, including agricultural varieties, through time and space.

Researchers can examine the calculus directly on the tooth with a microscope. But for further analysis, they carefully scrape the material off ancient teeth with common dental tools to avoid contaminating the samples with modern material. From that scraped-off tartar, they then carefully remove non-organic material to concentrate the food remnants.

Scientists use microscopes and molecular methods to examine the samples. Examining the small bits of food they find is challenging some long-held beliefs about ancient peoples and helping to answer significant questions.

Henry has been studying Neanderthal diet and working to confirm her initial results that they ate plants regularly. Some researchers have long argued that Neanderthals were primarily carnivores who depended on meat and fat.

"We were able to show that [Neanderthals] did eat plant foods and they processed these foods," said Henry. "It's the first time we have evidence of what those plant foods are."

Henry and her collaborators identified grass seeds, tubers that may have been related to water lilies, and at least in a location in present-day Iraq, the foods had been cooked.

Jaime Pagan-Jimenez, a Puerto Rico-based anthropologist working at Leiden University in the Netherlands, recently began analyzing calculus to obtain more evidence in his study of diets throughout the Caribbean islands.

Pagan-Jimenez had already studied starch grains found in artifacts used to process and cook foods, concluding that the people who first lived on the Caribbean islands were, in at least many cases, cultivating a variety of food plants, such as corn, sweet potato, beans, and more. His findings

also challenged the idea that the area's main food crop was manioc, a root also known as cassava or yucca. The new technique allows him to confirm what foods actually reached the mouth.

"We had the chance of seeing directly in the human tooth what plants they were eating at different time periods and sub-regions in the Caribbean islands," Pagan-Jimenez wrote to Inside Science in an email.

That evidence changes the interpretation of other archaeological findings.

"It turns out that these tools that we've called manioc scrapers were not at all used for processing manioc," said Henry.

Starch grains, such as those found in cooking pots, are well-established evidence of food processing and consumption. Scientists also look for clues about food consumption in the atomic makeup of bones and tooth enamel. However, calculus allows researchers to attain a greater level of detail.

"For starch grains studies in archeology, human dental calculus is the last piece of the 'broad picture' for acquiring direct information on the whole process of plant preparation and consumption as food," said Pagan-Jimenez.

Health Hints

Dental plaque contains all manner of information about an individual's health. It can contain clues about tuberculosis, stomach ulcers and more. Since calculus is formed from plaque, it seemed natural to Warinner to investigate the preservation of health information.

"It seems like a great way to actually access so much health information

about ancient peoples that otherwise has been really, really hard to do," said Warinner.

One significant modern change is a highly processed diet, which is often accompanied by fluoridated water. How does the state of modern people's mouths differ from that of their ancestors? Because calculus can preserve oral bacteria, it opens new doors to scientists.

"One of the things we don't know very well is what actually is our natural or ancestral state of health in our mouth," said Warinner. "We can look at specific dental diseases and try to understand how they have changed over time."

Warinner said that in addition to bacteria from the mouth, calculus also contains bacteria that originated in other areas of the body. These bacteria can provide more information on the array of tiny organisms that inhabit the human body, called the microbiome. Doctors are becoming increasingly aware of the relationship between this collection of flora and human health. Data gathered from genetic material found in samples such as calculus is termed metagenomic, and can greatly enhance scientists' ability to research the historical microbiome.

"[Calculus] allows us unparalleled access to these more distant organ systems that we've almost never had access to in the archaeological record except in some exceptional circumstances," said Warinner.

"The idea that metagenomic data from archaeological dental calculus can provide a glimpse of ancient human diet and health is very clever, and if validated, it will be a very exciting discovery!" wrote Cecil Lewis, a molecular anthropologist at the University of Oklahoma, in an email.

Warinner is currently studying samples from medieval Germany, in part to establish the reliability of calculus research. She's looking at

pathogens, including those that cause ailments such as colds and flus. The method may allow Warinner and others to compare how certain diseases affected people throughout history and across continents.

"We could look at how their virulence has changed over time," said Warinner. "Were they more virulent in the past than today, or not?"

Clean Sample

Techniques to deduce ancient diets and disease from dental calculus are still being established and verified. Molecules of DNA in dental calculus are often degraded, and the more time has passed, the lower the chance that the sample is pristine, which makes interpretation more complicated.

Scientists are also uncertain as to how comprehensively calculus can portray diet. Not all foods that are consumed will be found in calculus. Although finding evidence that a food was in a person's mouth is significant, it doesn't necessarily explain how often the food was eaten, or what proportion of the overall diet it represented.

"We must be conscious that ancient people did not only eat starchy seeds or tubers; they also ate leaves, flowers, and so on," said Pagan-Jimenez.

"What percentage of a person's diet is represented in that record? We don't know," said Henry. "Any technique, you need to work out all the bugs before all academics buy it.

Scientists are still forming a full picture of all the components found inside ancient dental calculus, said Warinner.

Henry said she planned to examine calculus "for other kinds of plant residues or even animal food residues." She said that the technique may

help solve an important mystery: when humans began cooking their food -- answers currently range from a few hundred thousand to more than 1.5 million years ago.

Both Henry and Warinner said they planned to reveal more findings, about Neanderthal diet and respiratory pathogens, respectively, in the near future.

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