# Extra gene copies were enough to make early humans' mouths water

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A member of the Hadza tribe of Tanzania roasts basketball-sized tubers, the type of starchy food thought to have been a crucial addition to the diet of early humans. Photo by N. Dominy.

To think that world domination could have begun in the cheeks. That's one interpretation of a discovery, published online September 9 in *Nature Genetics*, which indicates that humans carry extra copies of the salivary amylase gene.

Humans have many more copies of this gene than any of their ape relatives, the study found, and they use the copies to flood their mouths with amylase, an enzyme that digests starch. The finding bolsters the idea that starch was a crucial addition to the diet of early humans, and that natural selection favored individuals who could make more starchdigesting protein.

"Extra gene copies are an easy way for evolution to ramp up expression of a protein," said Nathaniel Dominy, assistant professor of anthropology at University of California, Santa Cruz, and one of the paper's authors. "Why wait for chance mutations to improve gene function" Natural selection can favor duplicate copies of a gene that already works well, and enzyme production will increase."

Other primates eat mainly ripe fruits containing very little starch. A new ability to supplement the diet with calorie-rich starches could have fed our large brains and opened up new food supplies that fueled our unrivaled colonization of the planet, Dominy said.

The researchers sampled saliva from 50 European-American undergraduates and found as many as 15 copies of the amylase gene per person. By comparison, all 15 chimpanzees they sampled had exactly two copies each. Students with more copies of the gene also had higher concentrations of the enzyme in their spit.

Next, the team studied groups of humans with differing diets. They found a similar correspondence between the amount of starch in a group's diet and the average number of amylase gene copies its individuals possessed. For example, the Yakut of the Arctic, whose traditional diet centers around fish, had fewer copies than the related Japanese, whose diet includes starchy foods like rice, Dominy said. The same pattern existed for two Tanzanian tribes--the Datog, who raise livestock, and the Hadza, who primarily gather tubers and roots.

"Even though they're closely related genetically and live close to each other geographically, still there are big differences in the average number of copies in these populations," Dominy said. "So we felt like geography and relatedness are not driving these differences. It's got to be diet."

For Dominy and his coauthors, the finding goes beyond the mouth. In pondering human origins, Dominy said, anthropologists have long been stumped by the sudden, nearly simultaneous increases in our brain size, body size, and geographic range, while other apes changed little. Early humans simply must have found some source of better nutrition to make it all possible, they reasoned.

"That's the big mystery of paleoanthropology," Dominy said. "What changed" Why did our earliest human ancestors deviate from the pattern we see in living apes to evolve this incredibly large brain, which is very energetically expensive to maintain, and to become a much more efficient bipedal organism""

For years, the answer was thought to be the growing importance of meat in the diet, as early humans learned to hunt. But, Dominy pointed out, "Even when you look at modern human hunter-gatherers, meat is a relatively small fraction of their diet. They cooperate with language, use nets; they have poisoned arrows, even, and still it's not that easy to hunt meat. To think that, two to four million years ago, a small-brained, awkwardly bipedal animal could efficiently acquire meat, even by scavenging, just doesn't make a whole lot of sense."

Some anthropologists have begun to suspect the new source of food consisted of starches, stored by plants in the form of underground tubers and bulbs--wild versions of modern-day foods like carrots, potatoes, and onions. Once early humans learned to recognize tuber-forming plants, they opened up a food source unknown to other apes.

"It's kind of a goldmine," Dominy said. "All you have to do is dig it up."

Tubers may have been especially critical for the first widely successful humans, known as Homo erectus, who may have learned to cook with fire. Since this idea was proposed, about a decade ago, researchers have been looking for evidence to support or refute it--no easy task for a theory that concerns highly perishable food consumed two million years ago. But in work earlier this year, Dominy and his colleagues found that animals eating tubers and bulbs produce body tissues with an isotopic signature that matches what has been measured in early fossilized humans.

The new discovery is a separate line of evidence pointing to the importance of starch in human beginnings, Dominy said. When early humans mastered fire, cooking starchy vegetables would have made them even easier to eat, he added. At the same time it would have made extra amylase gene copies an even more valuable trait.

"We roast tubers, and we eat French fries and baked potatoes," Dominy said. "When you cook, you can afford to eat less overall, because the food is easier to digest. Some marginal food resource that you might only eat in times of famine, now you can cook it and eat it. Now you can have population growth and expand into new territories."

Source: University of California - Santa Cruz

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