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EVOLUTION

The first supper

Diet-directed evolution shaped our brains, but whether it was meat or tubers, or their preparation, that spurred our divergence from other primates remains a matter of hot debate.

BY MICHAEL EISENSTEIN

Given the millions of years since our ancestors parted ways, it's unsurprising that a chimpanzee's idea of a good meal differs from our own. "When I visited our study site in Uganda, I followed a chimp in the forest for a day and tried to eat everything it ate," recalls Svante Pääbo, an evolutionary geneticist at the Max Planck Institute in Leipzig, Germany. "It's too disgusting and not digestible — you can't really do it."

Part of the reason is genetics. In 2008, Pääbo and colleagues found evidence for accelerated evolution of both the regulatory and coding sequences of diet-related genes shared by chimpanzees and humans[1]. Many anthropologists now believe that radical changes in diet may have been a major driver of hominin evolution and possibly even the primary factor that propelled our genus *Homo* forward by enabling us to survive and thrive.

One evolutionary milestone was encephalization: an enlargement of the brain estimated to have begun roughly 1.8 million years ago when *Homo habilis* transitioned to *Homo erectus*. What powered this growth spurt remains a subject of ongoing debate.

MEAT AND POTATOES

A big brain is a huge investment in metabolic terms. One model advanced in the mid-1990s, the expensive tissue hypothesis, suggests our ancestors settled that bill by gaining access to more nutrient-rich diets, which spurred brain growth while reducing gut size. Scientists have suggested that the wealth of vitamins, proteins and fats in meat was a major boon and there is evidence our ancestors used stone tools to carve up their food as early as 2.5 million years ago. An article published in *Nature* this year reported the find of 3.4 million year-oldfossil bones scarred by cutting tools, pushing the date back further still to australopithecines.

"There's fairly decent evidence that meat was likely a piece of the diet of australopithecines," says Josh Snodgrass, an anthropologist at the University of Oregon, "but they were probably eating diets that were much more plant-based." Given the richness of nutrients in meat, Snodgrass believes that even minor changes would have had a big impact on caloric intake and contends that use of more sophisticated tools may have increased consumption of meat in early hominins. "Access to high-quality animal foods was probably at least one of the major driving factors in allowing [encephalization] to happen," he says.

On the other hand, the pursuit of a steak dinner is not without hazards, according to David Braun, an archaeologist at the University of Cape Town in South Africa. "There are multiple consequences of making that shift," he says. "There are costs of predator-prey interaction, of entering into a niche that hominins aren't necessarily all that well-adapted to, and all kinds of parasitological costs."

Dartmouth College anthropologist Nathaniel Dominy favours the view that our ancestors might have put their tools to better use in unearthing root vegetables. He has observed how modern hunter-gatherers survive in an African savannah-like environment that may not be radically dissimilar from where *H. erectus* flourished. He suggests that tubers offered an essential buffer against the vicissitudes of the hunter lifestyle. "Modern hunter-gatherers have language, technology and iron-tipped spears, yet they still struggle to get enough meat to survive," he says. "It's hard to imagine a bunch of hominins without those accoutrements getting a lot of meat." Tubers were abundant and may have provided the staple nutrients needed to make brain growth adaptive when easy access to meat was no sure thing.

However, efficient tuber digestion depends on another major technological advance — cooking. "Most tubers absolutely require roasting," says Dominy. Harvard University anthropologist Richard Wrangham believes this is not a problem. In 1999, he published a controversial article promoting his hypothesis that controlled fire and cooking became a component of the hominin toolbox as early as two

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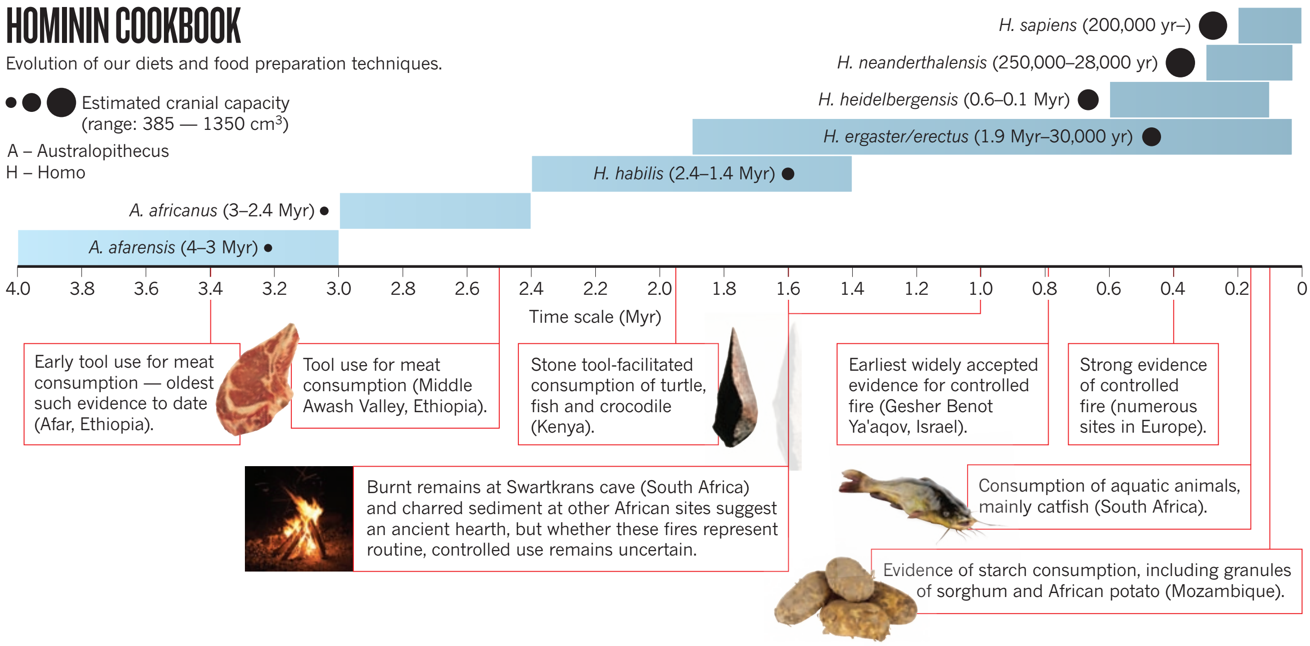
HOMININ COOKBOOK

Evolution of our diets and food preparation techniques.



million years ago. Wrangham has since developed this concept to explain how our ancestors maximized the nutritional benefits of tubers, meat and other foodstuffs. "It has not been appreciated by most people until recently that cooking has a large effect on net energy gain," says Wrangham. "Normally it's considered necessary because it enlarges the possible diet and makes food safer, but energy is such a key variable for evolutionary adaptation."

Preliminary analyses by Wrangham and colleagues suggest that cooking may have made proteins and starches more digestible while simultaneously reducing the cost to the immune system of fending off parasites or bacterial infection.

THE HARD FACTS

Many anthropologists remain wary of the evidence gap in Wrangham's hypothesis. The earliest sign of controlled fire comes from Israel, dating back some 800,000 years — considerably shorter than 2 million years. Nevertheless, Braun is hesitant to rule out Wrangham's theory, pointing out that remains of cooking fires can be ephemeral. The evidence found at the Israeli site is particularly unusual. "Gesher Benot Ya'aqov is the kind of place archaeologists dream of," he says. "Wood is preserved there, as are all kinds of activities that aren't preserved elsewhere."

Braun has encountered similar challenges: a recent study by his team at a 1.95 million year old site in Turkana, Kenya, found remains of bones and stone tools indicating that predecessors of *H. erectus* may have routinely eaten fish and other marine life[2]. If this represents a true dietary pattern, then 'brain food' may have lived up to its name by providing an abundant source of the polyunsaturated fatty acids that fuel the growth of the cerebral cortex.

Nevertheless, an early role for aquatic animals in the hominin diet remains controversial as archaeological evidence points to seafood only becoming a regular item on the menu between 150,000 and 200,000 years ago. This could be explained by the challenges of actually finding evidence of these foods being prepared. "The preservation that happened at that particular site, I think, is unusually good," says Braun. "We usually use marks on bone surfaces as a determining factor of whether something is part of the diet [and] those don't preserve really well for aquatic animals."

Unfortunately, any efforts to link food choice to human evolution will continue to depend on what can be unearthed at such sites: evidence from the genetic record is likely to be harder to find. Pääbo and colleagues assembled a draft of the Neanderthal genome[3]. This offers a wealth of information on human evolution over the past 50,000 years. However, there is an expiration date for such analyses. "Even in the permafrost, which is probably ideal, [the limit is] somewhere on this side of a million years — and it's much more realistic to say half a million years, maximum," says Pääbo. As such, any hope of obtaining usable genomic data from our early African ancestors is a pipe dream, and attempts to characterize hominin genetic evolution generally focus on our closest extant kin — the chimpanzee and bonobo.

> ***The pursuit of a steak dinner is not without hazards.***

Some of the best evidence might be found lining the fossilized jawbones of our ancestors. Peter Ungar, a paleoanthropologist at the University of Arkansas, has been using digital analysis to chart the 'landscapes' of ancient teeth down to the subtle abrasions that cover the chewing surfaces. "Those scratches are the actual result of a hominin passing food across its teeth, and we can relate that to what the animal was adapted to doing," he says.

Based on a growing collection of both *H. habilis* and *H. erectus* samples, Ungar sees a striking transition to teeth that are thinly enamelled and highly textured, which are clues to a diversification in diet. "If our *Homo* ancestors were processing their food outside of the mouth more with tools, then you're not going to get the same selective pressures to maintain big, thickly enamelled, flat teeth," he says. "Teeth with thinner enamel and more relief are actually better for shearing and grinding tougher foods, like meat and leaves." He suggests that although individual *H. erectus* may not have necessarily indulged in a diverse diet, they developed a capacity to rely on a broad array of 'fallback foods' — a skill that would have proved useful in the rapidly changing climate of the early Palaeolithic, and enabled humanity to settle far beyond the continent of Africa.

Braun considers this a reasonable theory, but he also appreciates the need for further investigation into the nutritional building blocks of this increasingly diverse diet. "For every 10 years of field work, we answer one or two questions," he says. "It's going to require a lot more boots on the ground." In the meantime, anthropologists and archaeologists will have to continue to content themselves with reconstructing the Palaeolithic buffet one course at a time. ■

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1. Somel, M. *et al. PLOS one* **3**(1): e1504 (2008).
2. Braun, D. R. *et al. Proc. Natl Acad. Sci. USA.* 1;**107**(22):10002–10007 (2010).
3. Green, R. E. *et al. Science* **328,** 710–722 (2010).