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Early humans who hunted animals for meat developed bigger brains than plant eaters.

BRAIN FOOD

Clever eating

Consumption of animals helped hominins to grow bigger brains. But in a world rich with food, how necessary is meat?

BY SUJATA GUPTA

Around 6 million years ago, primates started moving from tropical forests into the savannahs. Unlike today, these prehistoric expanses were humid and probably provided a year-round supply of fruit and vegetables. But then, some 3 million years ago, the climate changed and the savannahs — along with their plentiful food supply — dried up.

Many mammals, including some primates, went extinct, but others adapted. Archaeologists working at sites in modern Ethiopia have discovered animal remains that date back almost 2.6 million years. The telltale cut marks on their bones are almost certainly signs of butchery[1], says Manuel Domínguez-Rodrigo, a palaeoanthropologist at Complutense University in Madrid.

Only two types of primate survived the climate catastrophe, says Domínguez-Rodrigo. There was a "plant-processing machine on the one hand and a meat-eating machine on the other hand", he says. "The meat-eating machine evolved a bigger brain."

The meat-eating machine became us.

To build and maintain a more complex brain, our ancestors used ingredients found primarily in meat, including iron, zinc, vitamin B12 and fatty acids. Although plants contain many of the same nutrients, they occur in lower quantities and often in a form that humans cannot readily use. For instance, red meat is rich in iron derived from haemoglobin, which is more easily absorbed than the non-haem form found in beans and leafy greens. Furthermore, compounds known as phytates bind to the iron in plants and block its availability to the body. As a result, meat is a much richer dietary source of iron than any plant food (see 'Meat efficiency'). "You would need to eat a massive amount of spinach to equal a steak," says Christopher Golden, an ecologist and epidemiologist at Harvard University in Cambridge, Massachusetts.

The implications for cognitive health are huge. There is a clear, but underappreciated link between meat and the mind, says Charlotte Neumann, a paediatrician at the University of California, Los Angeles, who has studied meat eating in Africa and India for the past three decades. Deficiencies in the micronutrients found in meat have been linked with brain-related disorders, including low IQ, autism, depression and dementia. Iron is crucial for the growth and branching of neurons while in the womb; zinc is found in high concentrations in the hippocampus, a crucial region for learning and memory; vitamin B12 maintains the sheaths that protect nerves; and omega-3 fatty acids such as docosahexaenoic acid (DHA) help to keep neurons alive and to regulate inflammation.

MEAT FOR THE POOR

In the 1980s, researchers began to suspect that a lack of meat in some poor rural villages was contributing to a spectrum of childhood problems, including short stature, weakened immunity, social difficulties and poor school performance. When researchers from five universities studied the effects of chronic malnourishment in Mexico, Kenya and Egypt, they found that children who consumed the greatest amount of meat and dairy products scored highest on physical, cognitive and behavioural tests, particularly in Kenya[2]. But was the absence of meat really to blame? What the researchers needed was a controlled study.

So Neumann began a trial in Kenya[3]. Her team selected 12 schools with children aged 6 to 14, and gave some of the children mid-morning snacks. Schools were divided into four groups: the control group was not given a snack, whereas the other three received variations on githeri, a traditional porridge that consists of maize (corn), beans and greens. One group received a basic version, the second received the basic githeri with a glass of milk, and the third had meat added; all githeri were balanced to contain the same amount of calories. The study continued for more than 2 years and spanned 2 cohorts, the first with 525 students and the second with 375. The students' physical health and classroom performance were measured every three or six months. Compared with the other groups, students in the meat group had greater muscle mass and fewer health problems, and even showed greater leadership in the playground. Cognitive performance was stronger, too: the meat group outperformed other groups in maths and language subjects[4].

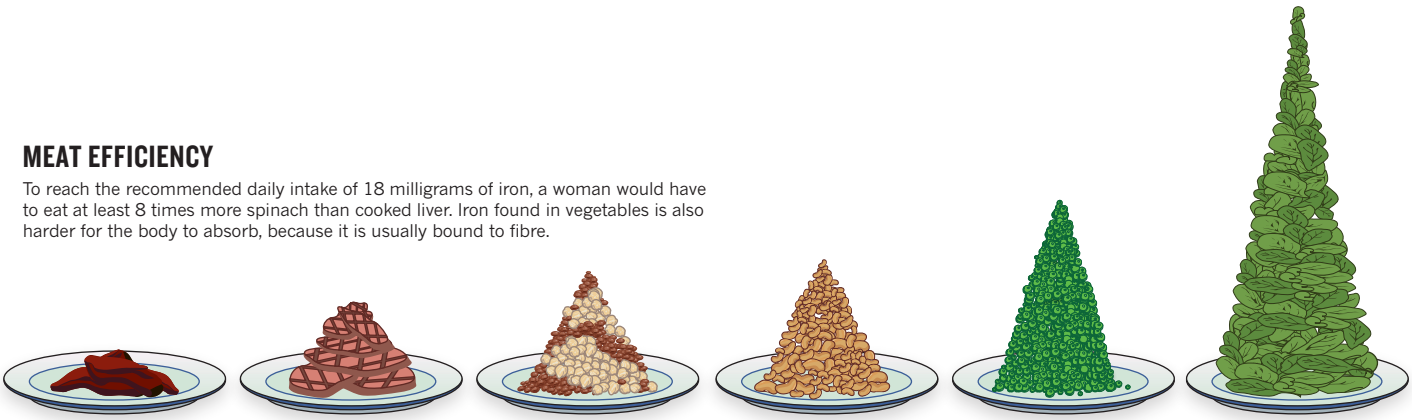
Neumann was not surprised by the results. The typical diet in rural Kenya is subsistence-based and does not include many nutrients that help the brain to grow. The challenge now is to get people to consume more meat, which is widely regarded as too expensive. What people don't realize, Neumann says, is that to nourish the brain, pretty much any animal matter will do: "Meat can be a worm, caterpillar or termite. It doesn't have to be butcher meat."

MEAT FOR THE RICH

But how does meat fit into a richer diet? "A lot of the studies that have demonstrated the importance of meat, vitamin B, animal products and protein generally have been carried out in populations receiving very little nutrition," says Diane Hosking, a healthy-ageing

MEAT EFFICIENCY

To reach the recommended daily intake of 18 milligrams of iron, a woman would have to eat at least 8 times more spinach than cooked liver. Iron found in vegetables is also harder for the body to absorb, because it is usually bound to fibre.



These data are approximate and will vary depending on factors such as preparation technique, soil or feeding conditions, and time between harvesting and intake. Analysis by F. Mori Sarti based on data from http://ndb.nal.usda.gov and http://www.unicamp.br/

researcher at the Australian National University in Canberra.

To fill this gap, Hosking and her team asked 352 Australians aged between 65 and 90 years old — who were cognitively healthy and predominantly from a middle- or high-income background — to recall what sorts of food they ate growing up[5,6]. For instance, how often did they eat items such as carrots, meat, fish or cake? The researchers then administered cognitive tests.

Hosking found no correlation between the volunteers' test performance and their consumption of meat as children. The results contradicted what Neumann and others have observed in developing countries. What's more, contrary to conventional wisdom, participants who consumed more fish during childhood and as adults were actually slower on measures of cognitive speed. (The fish might have contained neurocontaminants such as mercury, she says.)

There are several issues that affect these results, says Hosking. One is that people don't eat single foods, but patterns of foods, making it difficult to tease out the importance of an individual food type, such as meat. In the older Australians for instance, those who ate meat were also more likely to consume packaged desserts and snack foods.

Moreover, what the animal eats also matters. Livestock and poultry in Western nations are often raised in large facilities and fed diets that consist mainly of maize and soya, whereas animals from poor villages are typically farmed on a much smaller scale and forage for a greater variety of foods, which increases the nutrient content of their meat. Given these sorts of variations, Hosking says, "we have to be very cautious about making dietary recommendations … for people who have access to large quantities of food."

MEAT IN THE BRAIN

The micronutrients in meat have become an essential part of our diet over millennia. A few years ago, archaeologists in Tanzania unearthed fragments of a child's skull dating back 1.5 million years. Deformities on the bones suggested that the child had died from porotic hyperostosis, a condition thought to result from a deficiency in vitamin B12 — found exclusively in animal-derived foods. Humans started eating dairy products only in the past 5,000 years, meaning that the child had almost certainly died from a lack of meat[7]. So, by at least 1.5 million years ago, says Domínguez-Rodrigo, humans had become so adapted to eating meat that without it they would die.

Research is starting to provide some clues as to how meat helps the brain to function. Bradley Peterson, director of the Institute for the Developing Mind at Children's Hospital Los Angeles in California, has investigated why low iron levels in children are correlated with lower IQ and poor concentration[8]. Using magnetic resonance imaging, Peterson and his colleagues mapped out what happened in the brains of newborn infants of 40 adolescent mothers — a group known to be at high risk for iron deficiency. Although most of the women reported taking prenatal vitamins with iron, 58% had iron levels below normal and 14% met the criteria for mild anaemia.

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As the brain develops, says Peterson, neurons become increasingly complex, forming branch-like dendrites covered with spines — much like a growing tree. The brain images that his team took showed a correlation between neuron complexity in an infant and the amount of iron in the mother's diet. "The higher the iron intake throughout pregnancy, the more mature or the more complex grey matter was at the time of birth," says Peterson, who is continuing to track the mothers and babies to see how those variations play out.

Beyond simple measures of micronutrient intake, individual requirements are also influenced by a person's genetics. So far, much of the research has focused on how people process omega-3 fatty acids, chiefly DHA and eicosapentaenoic acid (EPA), which are crucial for human cognitive health.

Omega-3 fatty acids are found primarily in oily, wild fish, such as salmon and tuna, but pasture-raised animals are also a good source. (Animals fed only soya or maize have fewer omega-3s.) In 2012, researchers discovered that most African populations, but not European populations, carried a variant of the *FADS* gene that made them more efficient at converting omega-3s in plants into a usable form, meaning that they required less from animal sources[9]. Conversely, a 2014 paper reported that people carrying a variant of the *APOE* gene (11–17% of US individuals of European descent) that confers a greater risk of developing late-onset Alzheimer's disease, derived little benefit from eating fatty fish[10]. "One size does not fit all around nutritional recommendations," says Hosking. Put another way, the nutrients found in meat are important for health and cognition, but only up to a point. "Meat packs a lot of minerals and vitamins in just a small amount of food," says Domínguez-Rodrigo. "Eating meat is like eating a power bar."

So the key question becomes how much meat should a cognitive-health-conscious person eat. Too little can delay development and cognition. But too much, particularly if it is low quality and mass produced, is associated with other health concerns, such as heart disease and cancer, along with memory problems later in life. A person's life stage matters: pregnant women need more iron, as do babies and children. Genetics also play a part, but we don't yet know all the particulars. All these caveats make for a murky takeaway. ■

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