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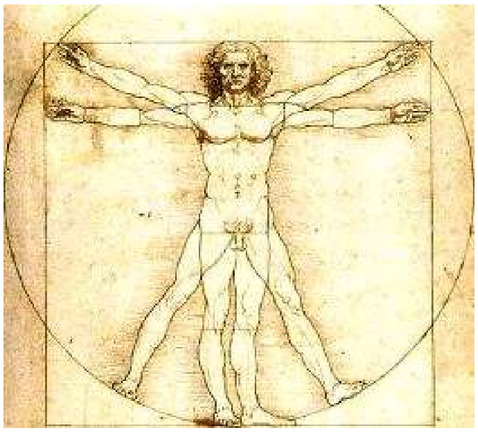
You Are What Your Ancestors Ate: What Diet Tells Us about Our Biological Memories



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If you're trying to eat a healthy di
to think about more than what yo
own plate. Thanks to the ways in
evolution has shaped human biology, it also matters what your mother and her mother ate, and what your distant ancestors ate tens of thousands of years ago. This essay aims to convince you that when it comes to diet – or for that matter any aspect of human health – our understanding is enriched by taking our evolutionary history into account.

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Why is a Healthy Diet Healthy?

It is a well-known fact that eating too much saturated fat is a bad idea. Why is saturated fat bad for our health? Several decades of biomedical research have provided insights. For instance, we know that saturated fats reduce the capacity of the liver to remove low density lipoprotein particles from the blood stream. This increases the concentration of "bad" cholesterol and triglycerides, which elevate one's risk of developing atherosclerosis and cardiovascular diseases.

These details of mechanism explain how saturated fats initiate changes in biology that lead to disease, and allow us to identify healthy behaviors and possible roles for pharmaceuticals. However, these facts do not tell us why saturated fats are bad for us, which was the question that we set out to answer. Explaining why is a different task, for it requires that we explain why our biology responds to this particular nutrient in this way.

The answer to this question is not as obvious as you might think, because there is nothing inherently dangerous about saturated fat. After all, your pet cat could eat nothing but meat and fat and be perfectly healthy. As pure carnivores, the natural diet of all cats is very high in protein and saturated fat, and low in carbohydrates, and cats have evolved metabolisms that are well suited to processing this blend of nutrients. As one example, their cells preferentially use proteins as a source of energy, while the ability of these cells to use carbohydrates, which are scarce in the cat diet, has been reduced. The evolution of the cat's metabolism around their habitually high meat intake means that cats can tolerate high levels of protein and fat but are prone to developing diabetes when fed a quantity of carbohydrates similar to that of the typical human diet.

Although the specifics are different, the same logic can be applied to human health. While it's impossible to know the diet of our ancestors with certainty, there is much that can be inferred. We know, for instance, that for millions of years, until the rise of agriculture roughly 10,000 years ago, humans and their ancestors subsisted by foraging on wild plants and animals. Wild plants tend to be high in fiber and low in simple sugars, while meat from wild animals is very lean in comparison to domestic beef, and also has a different fatty acid profile. Natural selection sifted though the human gene pool during this extended evolutionary history of human foraging, and retained those metabolism-influencing genes that are well-matched to this diet. Thus, our genetic makeup contains a "memory" of our ancestors' diets and our bodies have been shaped by evolution to expect something similar. As our modern diet deviates from this biological expectation, health problems emerge, much as they would for a carb-loading carnivore.

Medicine and Evolutionary Biology Focus on Different Levels of Causation

The above discussion explores two different levels of explanation. The first focuses on the molecular and physiologic mechanisms that make us prone to health problems when we consume large quantities of saturated fats. This level of inquiry, which examines the nuts and bolts of how a system works, addresses the question of proximate causation. Most biomedical research aims to clarify the biological mechanisms that underlie healthy and pathological states and thus is primarily concerned with answering questions of proximate causation. The second explanation above addresses why it is specifically saturated fats that harm our health, even though these nutrients are perfectly healthy for carnivores. This is a question of evolutionary origins, or ultimate causation.

From an evolutionary perspective focused on ultimate causes, our current dietary problems are largely the result of an interaction between two diets: that typically consumed by our ancestors, which human metabolism became adapted to genetically over many thousands and even millions of years, and the diet that many of us now consume, which is rapidly deviating from this ancestral pattern under the influence of institutions like industrial agriculture and market capitalism. The accelerating pace of human lifestyle change, and the glacial pace of change in our genetic architecture, means that our diets increasingly come into conflict with our genome. Our genetic memory of past lifestyles – which set up our bodies to expect conditions similar to those experienced by our distant ancestors – is the ultimate cause of many current metabolic disease epidemics, including the recent rise in obesity, diabetes, and cardiovascular diseases, and other widespread health problems like depression, myopia and allergy.

Developmental Plasticity: Why Genes Only Loosely Dictate Our Fate

The copy errors in DNA (mutations) that allow genetic adaptation to environmental conditions, such as diet, are rare; thus, it takes many generations, and for a species with a long lifespan, many thousands of years, for substantial genetic change to consolidate around new environmental challenges. As a result, the ability of natural selection to sift through the gene pool – though powerful over the long haul – is not an effective means of adjusting to the myriad changes in our environments that occur over shorter periods, such as changes in climate or ecology that shift by decade or generation.

Natural selection has solved this problem by building organisms with a shortcut to biological change. When the conditions that members of a species confront are variable, individuals who can cope biologically with this change are more likely to survive and reproduce. As a result, genes have been favored that have the ability to produce a range of possible traits in response to the specifics of the local environment that are encountered. As one well-documented example, children grow slower and reach puberty at a later age when faced with nutritional stress. This type of environmental responsiveness of developmental biology is called developmental plasticity, and it allows a greater degree of flexibility in species, such as humans, that inhabit unpredictable environments.

One example of developmental plasticity promises insights into the causes of many adult chronic diseases. Research during the past two decades has established that an individual's weight at birth predicts their future susceptibility to diseases such as hypertension, diabetes and heart attacks, with individuals born light more likely to develop these conditions as adults. Animal model work is clarifying the proximate mechanisms that underlie these associations. As one example, in a nutritionally stressed pregnancy, the passage of maternal stress hormones across the placenta slows fetal growth rate and also alters development of the pancreas and muscle in a fashion that reduces the offspring's ability to extract glucose from the blood stream.

It may be that the lingering effects that these developmental adjustments have on adult disease risk are merely the unintended side-effects of adaptations made by the fetus to improve its chances of surviving a nutritionally stressful prenatal environment. For instance, a smaller fetus has lower nutritional needs, and the reduced ability of their muscle to clear glucose from the blood stream could spare energy for the glucose-hungry brain, which is fragile and very large relative to the body at this age. However, an evolutionary perspective inspires the question of whether at least some of the lingering postnatal effects of these responses are not accidents, but might instead be propagated by evolution because they confer some biological advantage after birth. Some of the adjustments initiated by the nutritionally-stressed fetus in utero, such as a tendency to deposit more abdominal body fat, and the blunted response of muscle to insulin that increases glucose in the bloodstream, could provide additional advantages after birth if the postnatal environment is also nutritionally stressful. In this way, mothers could pass their biological memories, reflecting their own lifetime of experiences of stress in the local environment, along to their children, allowing developmental adjustments to be made in anticipation of stressful conditions after birth. The downside is that these same adjustments increase their future susceptibility to developing diseases like diabetes and heart attacks, especially if they experience improved nutrition and go on to gain excess weight as a child or adult.

Biological Memories and Human Health

While much remains to be learned about the evolutionary origin and function of fetal developmental plasticity, this new research is showing that the health impacts of what you eat must be understood in light of not two but at least three diets. The first is the genetic memory of the diet of your distant ancestors, which is reflected in the architecture of a metabolism that expects nutrient intake to be consistent with our long evolutionary history of subsisting on foraged wild foods. The second is the diet of your recent matrilineal ancestors - your mother and grandmother - which helped shape the intrauterine environment that nurtured you as a fetus and passed along a memory of relatively recent environmental conditions.

An evolutionary perspective shows that the impact on health of the third diet - that which you yourself eat - can best be understood against the backdrop of these past diets. Although it is a much broader field than covered in this short essay, one important aim of evolutionary medicine to understand the ultimate causes of human health problems by studying our biological memories. For it is largely the biological memories that we inherit, which reflect adjustments to environments experienced by our ancestors across multiple timescales, that determine whether our current behaviors have beneficial or detrimental influences on our health, happiness and longevity.

Further Reading

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Chapter 1

Viewable lectures from the Yale Symposia on Evolution in Health and Disease

The Evolution and Medicine Review

Evolutionary medicine editorial (*Science* magazine)

For questions about this essay, please contact onebook@northwestern.edu