Will The Real Paleo Diet Please Stand Up? Amylase Variation Between Human and Non-human Primates

Charles Worl
Faculty Sponsor: Prof. Jethro Gaede (Anthropology)

ABSTRACT

The degree to which humans can digest starch is a fundamental difference between humans and non-human primates. This adaptation in early man led to the ultimate colonization of the planet. The advent and control of fire occurred simultaneously with a drastic increase in brain size, a primary distinction in the genus homo. This makes sense in biological anthropology because starch must be cooked in order to access adequate amounts of nutrition. Amylase converts starch into glucose. By the same token, the brain runs on glucose. With a reliable energy source, irrelevant of location or season, early man was able to have a dependable fuel source that allowed for human migration out of Africa. With a focus on the salivary amylase gene and its specific function, this paper compares and contrasts salivary levels of amylase between the great apes. The results are useful for both human and non-human primate dietary guidelines.

MLA Citation
Taxonomy categorizes organisms into kingdoms, phyla, class, order, family, genus and finally species (Bailey). Now, as it were, we are all cousins by contiguity, we all evolved from a singular, biological twitch in some smorgasbord of hydrogen, carbon, and various other elements necessary for life to occur some three and a half billion years ago (Bryson). Once life began, it has never stopped doing what it does best: reproducing. In order to engage in reproduction, one (or two) must take in the necessary fuel, as in kilocalories. Engaging in the act of reproduction is not guaranteed by virtue of being. Rather, it is a competitive dance of the highest degree. Therefore, only those who eat enough, who are vital enough and healthy enough will see to it that their genes are passed on. Kilocalories, also known as food, are first and foremost the primary concern of all species. One evolutionary constraint that all animals face, with the exception of humans, is a species-specific diet. When an animal strays from its specific diet, by choice or otherwise, degenerative and sometimes fatal repercussions follow.

There is an epidemic of obesity, chronic disease, and premature death amongst three types of animals in this world: humans, cats, and dogs. I would like to add to this list captive animals, specifically some of our closest kin: orangutans, chimpanzees, and gorillas. Great apes in zoos across the nation are facing the same chronic ailments that humans are facing in the first world and other westernizing nations. Orangutans are suffering from diabetes, chimpanzees are dying from heart disease, and gorillas are undergoing anesthesia for cardiac ultrasounds (Great Ape Heart Project). Approximately 2% of orangutans in North America suffer from diabetes (Dierenfeld). “According to an article published in the SAGE journal, *Veterinary Pathology*, Arrhythmogenic Right Ventricular Cardiomyopathy [ARVC], a human heart disease that causes sudden cardiac death in teenagers and young adults, particularly healthy athletes, has now been identified in chimpanzees” (Human Heart Disease). A gorilla’s heart is structurally similar to a human heart, and the implications are relevant (Bressanin). “Primates held in captivity are at increased risk of death from heart-related disease, they can get high blood pressure, high cholesterol, and heart failure” (Great Ape Heart Project).

The Great Ape Heart project highlights this theme in the 2012 White Paper, “A Collaboration to Understand Heart Disease, Reduce Mortality, and Improve Cardiac Health in all Four Great Ape Taxa”; “Obesity is not uncommon in captive apes, and there is evidence they have metabolic abnormalities” (Great Ape Heart Project). It isn’t all monkey business. Moreover, obesity and metabolic syndrome affect nearly one in three Americans and are the direct result of improper diet (PCRM). Obesity isn’t only a risk factor for cardiovascular disease in humans but for non-human primates as well (Great Ape Heart Project). A nutritional focus reveals that amongst both human and non-human species, an improper diet can lead to insulin resistance, obesity, and hypertension that can increase the risk of cardiovascular disease (Great Ape Heart Project). The difference between the diets of wild and captive apes is the main precursor to the problem at hand.

Great apes are mainly herbivorous by nature, meaning they typically feed on plant matter when available. In contrast, zoo nutritionists are inclined to offer orangutans 14% of their diet as nutritionally complete primate biscuits and the remaining 86% as produce, with higher proportions of raw vegetables and leafy green vegetables than fruit (Dierenfeld). By dry weight the diet consists of 50% biscuits and 50% plant matter (Dierenfeld). However, as noted by Dierenfeld in his 1997 paper, “Orangutan Nutrition,” published in *Nutrition Advisory Group to the Association of Zoos and Aquariums*, “the specific dietary requirements of vitamins, minerals, fat and protein for orangutans are not known” (Dierenfeld). All captive great apes are given nutritional supplementation in the form of processed foods with vitamins and minerals added (“Primate Diet Dry”). The primary ingredient in these supplemental food-like substances is starch. Starch is a semi-crystalline granule that is very difficult to digest (“Diet and the Evolution of Human”). Recently it has been discovered that humans...
have abundant numbers of the gene known as salivary amylase, the enzyme responsible for breaking down starch into sugar (“Diet and the Evolution of Human”). Other great apes have the ability to hydrolyze starch as well, but to a much lesser degree (“Diet and the Evolution of Human”). Human and chimpanzee DNA is approximately 2% different, but that 2% difference, which includes the ability to digest starch more readily, was crucial for the evolution of humanity’s earliest ancestors (McDougall).

Examination of the number of copies of the gene that is responsible for digesting starch has found an average of six copies in humans, compared to only two copies found in other primates (McDougall). This genetic difference results in the production of six to eight times higher levels of starch-digesting enzymes in human saliva. Therefore, the limited ability of chimpanzees and other great apes to utilize starch tied their species to the tropical jungles where fruits and foliage were abundant all year long (Mercader). Biological anthropologist Nathaniel Dominy of Dartmouth College theorizes that humans probably gained this adaptation as opposed to great apes losing it (“Diet and the Evolution of Human”). These particular mutations, which led to the gene that produces salivary amylase, allowed for a distinct advantage in our ancestors who ventured out of Africa.

The unique traits that humans have, like the ability to think abstractly and to communicate with language, as well as a large brain, and the ability to walk upright are no doubt characteristics of an awesome animal. According to a paper published in Nature Genetics, “hominine evolution is characterized by dietary shifts, facilitated in part by the development of stone technology, the control of fire, and most recently, the domestication of plants and animals” (“Diet and the Evolution of Human”). Chiefly, starch has become an increasingly prominent component of the human diet.

Examining the amount of amylase in humans and our closest primate relatives may provide insight into our own evolutionary history (Diet and the Evolution of Human). To better explain human evolution, there must have been something extraordinary, and that something is starch. Humans were remarkable animals long before engaging in agriculture and the domestication of animals. The factors that caused humans “to exploit what anthropologist John Tooby and evolutionary psychologist Leda Cosmides have jointly described as the cognitive niche” (Lisle & Goldhammer), can be explained by shedding a little light on the matter. Fire didn’t come under modern hominids’ control until about 1.8 million years ago (Wrangham). Interestingly enough, Harvard primatologist Richard Wrangham suggests that starchy plants were important sources of food for humans as early as 1.8 million years ago (Anthony). Cooking is the next logical step in this equation. Cooking allowed for greater digestion, allowing greater access to calories. Starches wouldn’t have been important foods until we learned to control fire because starch granules are not efficiently digested in their raw state. We know that we ate meat but not as much as popular media suggests. Anatomically speaking, we aren’t designed for meat eating. In fact, the enamel on our teeth is too thick, the cusps of our teeth are too short, and our canines are too blunt (Berthaume). We simply don’t have the adaptations that tigers and bears have to eat meat. Instead, we developed a face and mouth that is excellent for eating plants.

Current mainstream thought links starch directly to the epidemic of obesity and type II diabetes (PCRM). Starch, however, was vital to human evolution. The reports that starch is somehow unnatural to humans or that starch was the downfall of human health and that we should eat more like our “paleolithic ancestors who consumed a diet of only meat, supplemented by fruits, vegetables, nuts, and seeds” is a façade (Cordain 71).

Starch granules from plant food trapped in the dental calculus on 40-thousand-year-old Neanderthal teeth, revealed that the once-thought savagely primitive man actually shared a sophisticated diet with their contemporaries (“Starch Grains Found on Neanderthal”).

Research presented in a 2011 issue of Proceedings of the National Academy of Science shows that even the Neanderthals ate a variety of plant foods; starch grains have been found on the teeth of their skeletons everywhere from the warm eastern Mediterranean to chilly northwestern Europe. It appears they even cooked, and otherwise prepared, plant foods to make them more digestible-44,00 years ago (McDougall).

We know that an early pre-human, Australopithecus, was eating starch almost two million years ago (Mercader). Traces in their teeth of what they had eaten then, as well as over a lifetime of foraging...
revealed they were grass eaters (Mercader). This information is important because it heeds way for a new way of thinking. No longer can we perpetuate schools of thought that hold on to the primitive understanding of man and his emphasis on hunting when the latest science clearly states otherwise. Fortunately, it’s turning out that our brains are more plastic than ever thought before.

The brain requires only twenty watts of energy to function normally, similar to a conventional light bulb (Magistretti). However, as far as the body’s energetic budget goes, the brain is a glutton (Magistretti). “The brain takes up less than 2% of body weight but may burn up to 50% of the body’s fuel (Greger). This value means that the brain uses, per unit mass, twenty-five times more energy than the rest of the organism (Magistretti). “What is news, however, is the role glycogen plays in the acquisition of long-term memory” (Anthony).

A 2011 article published in the journal Cell titled Astrocye-Neuron Lactate Transport is Required for Long-Term Memory Formations shows that glycogen in brain cells called astrocytes is necessary for the consolidation of short-term, transient memory into long-term memory. The effect of glycogen cannot be imitated by glucose, regardless of quantity (Anthony).

In other words, it is the direct storage of glucose in the liver and muscle tissue that literally feeds the brain. The formation of glycogen is the direct result of glucose intake in the form of carbohydrates. The most dense source of carbohydrates in the plant kingdom are found in the storage organs of plants, in the form of starch, and this includes rice, potatoes, yams, corn, beans, barley, etc. The glycogen that allows our brain to consolidate short-term memory into long-term memory is allowing us to engage in such practices as recalling the past and planning for the future. Professor of Bioethics at Princeton, Peter Singer, has argued that this is the quintessential difference between humans and non-human animals (Bengtsson). The ability to look to the future and learn from the past defines the human experience.

As we look to the future, a grave prospect is at hand. Predictions have been made that the great apes will be extinct by the twenty-second century (News). Unregulated jungles in West Africa and the popularization of “bushmeat” can be partly to blame (Primatologist). Simultaneously, palm trees are being cut down at an alarming rate in Indonesia, the primary habitat of the orangutan (Orangutans and Oil Palm Plantations). Strikingly, more than two million human children die each year due to hunger-related issues (Global Hunger) while 141 trillion calories are discarded each year in the United States (Barclay). By adopting lessons learned from the fossil record and the human genome, we can mitigate these dire realities and predictions. The insights provided by the analysis of the salivary amylase gene must play a domineering role in the application of dietary appropriations for all of the great apes. "The future of nutrition is now inseparable from the future of humanity" and the great apes (Humanity Past and Future).

WORKS CITED


