The Nutrition Academy

Fundamentals of Functional Nutrition Course

HISTORY OF NUTRITION TRENDS

MODULE 1

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History of Nutrition Trends

Lesson 2

Hunters and gatherers

Anthropology and diet

An evolutionary perspective

Historically, the survival of a species depends on its ability to adapt to a dynamic environment which is reflected through a gradual heritable change in genes over many generations [1,2]. Humans developed as highly adapted hunters and gatherers from approximately 2.6 million to about 10,000 years ago, before the dawn of agriculture [3]. From that time on human adaptation was no longer so necessary for survival and to a certain extent, it was thought to signal the end of our evolving human **genome** [1].

Accordingly, it is suggested that as a species we are essentially genetically identical to our ancestors at the end of the Paleolithic period about 40,000 years ago. The appearance of agriculture some 10,000 years ago and the Industrial Revolution some 200 years ago introduced new dietary pressures for which it is suggested that humans could not possibly adapt genetically in such a short period [4-7]. This shift from preagricultural wild foods to postindustrial semi/ultra-processed foods has had a major impact on health and wellbeing. It is suggested that evolutionary adaptation of microbial species that inhabit the human gastrointestinal (GI) tract would not have occurred during this time scale, and this has significantly impacted gut health and contributed to disease [7,8].

Thus, it is suggested that we are genetically adapted to the environment of our ancestors; that is, to the environment that our ancestors once survived in and the conditions that were selected for their genetic makeup [6]. Because diet represents a major environmental factor in evolution, understanding the ancestral diet of *Homo sapiens* may serve as a model for health and disease prevention in modern societies [9].

Learning Objectives

Following Lesson 2 you will be able to:

1. Have an appreciation for how the environment impacts the development of novel evolutionary traits.
2. Define the Paleolithic diet as the diet of our ancestors.
3. Describe how variations in genetic adaptation can lead to dietary specialisation

It is important to have some knowledge of the evolution of humans and how our nutritional requirements have changed. Accordingly, I will next introduce the basic concepts of evolution.

It is not a requirement to understand evolution in detail in this course, but to have some basic knowledge to help you understand the evolution of humans and how we got to where we are now. An excellent website that helps explain evolution in more detail is given below. Take the time to visit this site and look around. It is colourful and interactive, easy to navigate, and fun to learn. Website: http://evolution.berkeley.edu/

Galapagos Land Iguana diverged from a common ancestor approximately 10 million years ago.

Evolution

What is evolution?

Evolution is a process that explains how we ('we' is used collectively here to mean humans and all other animals, plants, trees, bacteria, viruses etc.) evolved with such complexity and variation. Evolution can simply be defined as changes that evolve through time. For example, cultures can evolve, languages can evolve, and tastes can evolve. However, in the context of human evolution, it is about **biological evolution**. This type of evolution occurs more specifically through the changes in **frequencies** of different forms of a **gene,** called alleles. More appropriately known as allelic frequency.

An allele is an alternative form of a gene. An individual inherits two alleles for each gene, one from the mother, and one from the father. If the two alleles are the same, the individual is homozygous for that gene. If the alleles are different, the individual is heterozygous. Thus, the frequency of an allele refers to how common an allele is in a population.

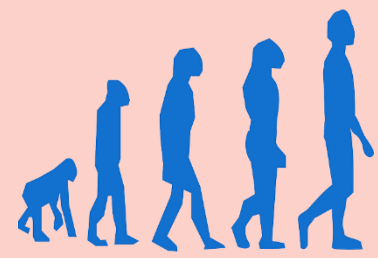
Let us use an example to explain this. Cystic fibrosis is a common genetic disease occurring in about 1/3500 births [11]. The most common form of cystic fibrosis is caused by a DNA mutation that codes for a protein that transports chloride called the cystic fibrosis transmembrane conductance regulator (CFTR) gene [12]. This affects how chloride is transported and leads to disease in multiple organ systems including the endocrine, reproductive, gastrointestinal, and the pulmonary system [12].

People with cystic fibrosis have mutations in both alleles for the CFTR gene. However, some people are carriers of cystic fibrosis and do not have the disease. This is because they carry only one mutation in one allele of the CFTR gene while the other allele does not contain a mutation. The allele that does not have the mutation is sufficient to produce the CFTR protein and chloride ion transport functions properly [13]. Therefore, in the context of allelic frequency, there will be individuals in a population that have a percentage of two normal alleles, two mutated alleles, and one normal and one mutated allele.

In an evolutionary context by identifying changes in the frequency of specific alleles from generation to generation, you can then determine whether the organism has evolved. For example, suppose you identify three different alleles in a population of frogs called allele A, allele B, and allele C. In the population of frogs, allele A occurs 50% of the time, allele B occurs 30% of the time, and allele C occurs 20% of the time. Thus, the frequencies of the alleles are 50%, 30% and 20% respectively. Therefore, **biological evolution** is the change in the frequency of one or more alleles over time. These changes in alleles could be beneficial to the organisms and therefore this might provide a survival advantage (more on this below).

A note on evolution

I realise that not everybody will agree with the current theory of evolution. However, the purpose of this **Lesson** of **Module 1** is not to create a divergence between belief systems, but to provide a backdrop on how nutrition and dietary requirements evolved in the context of the span of human existence.



A gene is like a blueprint for life. It is a unit of heredity. A gene is also called deoxyribonucleic acid (DNA) which gets passed on from parent to offspring. DNA is a long molecule made up of a sequence of chemicals that store genetic information. The information that is stored in a

Biological evolution is the change in inherited traits over successive generations in populations of organisms. When a genetic variation is introduced into a population by gene mutation, the evolutionary modification of traits can occur.

Adaption is the key evolutionary process whereby the greater the fitness of traits and thus a species becomes, the more chance the species will survive in specific or changing ecological habitats [10].

Lions and Zebras, Serengeti,

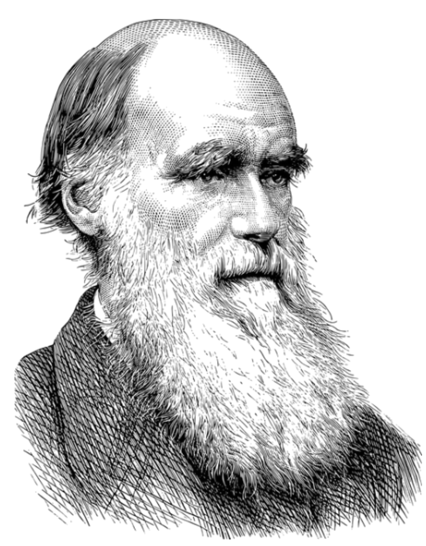
Natural selection

The theory of evolution

You probably are familiar with **Charles Darwin**. One of his most famous theories was what he coined **natural selection**. Darwin recognised that some characteristics of an organism get passed on from one generation to the next. Moreover, he realised that the process of evolution by natural selection is driven by the **fitness** of the organism. In short, fitness is how well an organism can reproduce. Those organisms that have genes that increase their fitness will more likely be passed on to the next generation [14].

Some evolutionary changes are **adaptive**. What this means is that a specific character or trait in an organism has changed because of natural selection in a way that makes the specific character or trait better suited to perform its function. For example, we know that lions of the African savanna hunt zebra for food. The zebra runs from the lion and those zebras that are slowest get eaten, leaving the faster zebras to reproduce. In the next generation, the zebras are faster on average than those of the previous generation and therefore have an adaptive advantage in running faster from their predators.

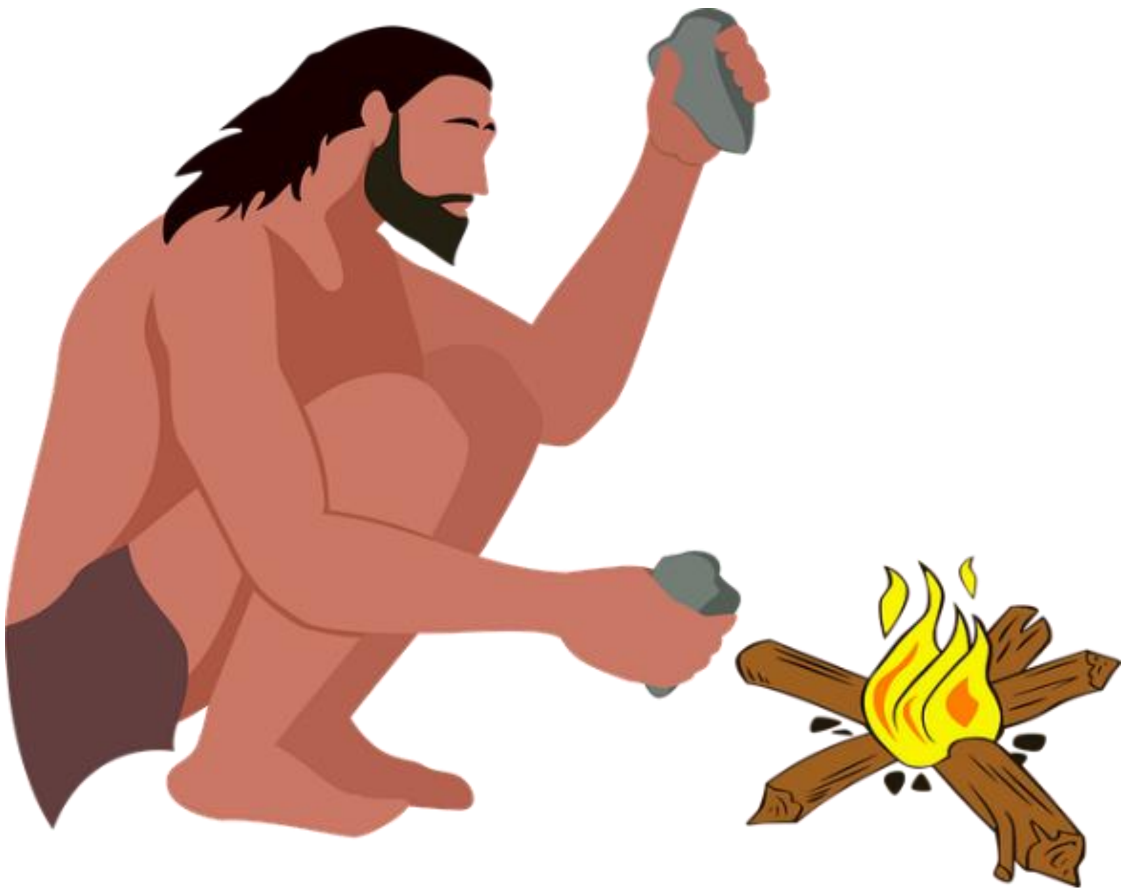
The key observation underlying natural selection is that populations can increase in numbers **exponentially** [15], It is difficult to fathom the enormity of this growth. For example, a single *Escherichia coli* bacterium undergoes cell division every 30 seconds. At this rate, it would take less than a week for the bacteria population to exceed the mass of the Earth [15]. What is true for bacteria is also true for every other species (except for the poor Mule and worker honeybee). Darwin used elephants as an example, calculating that the number of descendants of a single pair of elephants would reach more than 19, 000, 000 (19 million) in only 750 years [16]. The Earth would be overrun with bacteria, elephants and all other species including humans. But this does not happen. The reason is surprisingly simple. Most offspring produced do not survive to have offspring of their own.



Most population sizes for all species remain relatively stable, Darwin realised there was a massive contradiction between the number of offspring produced and the number that can be sustained by the available resources and this created a "struggle for existence" [15].

This selective force on a population by the environment is what drives adaptive responses and changes in genes through mutations to allow some individuals to survive and others not to survive. A good example is giraffes. The ancestors of modern giraffes were animals like deer and had short necks. However, the trees in their habitat were tall, and those early giraffes with slightly longer necks had an advantage. The longer-neck giraffes could eat more and therefore reproduce more, so in subsequent generations, their necks were longer [17]. According to Darwin "the individuals which were the highest browsers and were able during dearths to reach even an inch or two above the others will often have been preserved" [18].

In summary, evolution is the change in the relative gene frequencies or traits in a group of organisms over time. Natural selection is the process where some individuals, because of possessing specific traits, leave more descendants than other individuals that don't have these traits. Over time, these traits are favoured.



Caveman and fire

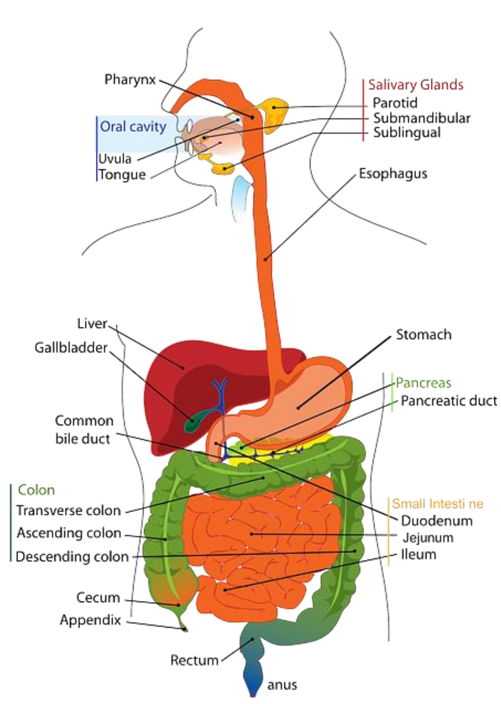
The rise of Homo sapiens

What did the Paleolithic diet look like?

The specific evolutionary **lineage** that ultimately led to modern humans began with the split from ancestors of today's chimpanzees and bonobos at some point ~9.3 million and ~6.5 million years ago [21,22]. Thereafter, prehuman's developed an upright posture and bipedalism, an increase in brain size, and the use of rudimentary tools [19]. The subsistence activities of these emerging humans at first resembled those of the other higher primates, but about 2.5 million years ago, animal meat was highly favoured as an increasingly important dietary component[19].

Early hominid fossil remains show clear craniodental changes which indicate a move away from specialised dental structures that were more suited to mastication of coarse foliage, to a more generalised dental structure indicative of the consumption of hard nuts, fruits, and meat [5].

Furthermore, if you look at the dietary preferences and the suitability of a species to a certain food type there are some major differences. Both pure herbivores (folivores and frugivores) and pure carnivores (such as felids) have physiological and metabolic adaptations suited to their diet. Humans fit neither category, but are true omnivores, falling between the largely frugivorous relatives such as chimpanzees and the adaptations of true carnivores. Carnivores tend to have a well-developed acid stomach and a long, small intestine. A sac-like stomach or well-developed colon is associated with plant-based diets. The human gut has a simple stomach structure, an elongated small intestine, and a reduced colon which is suggestive of a diet high in meat [5].



The human digestive system and expansive small intestine

Hunters and Gatherers

Model for public health

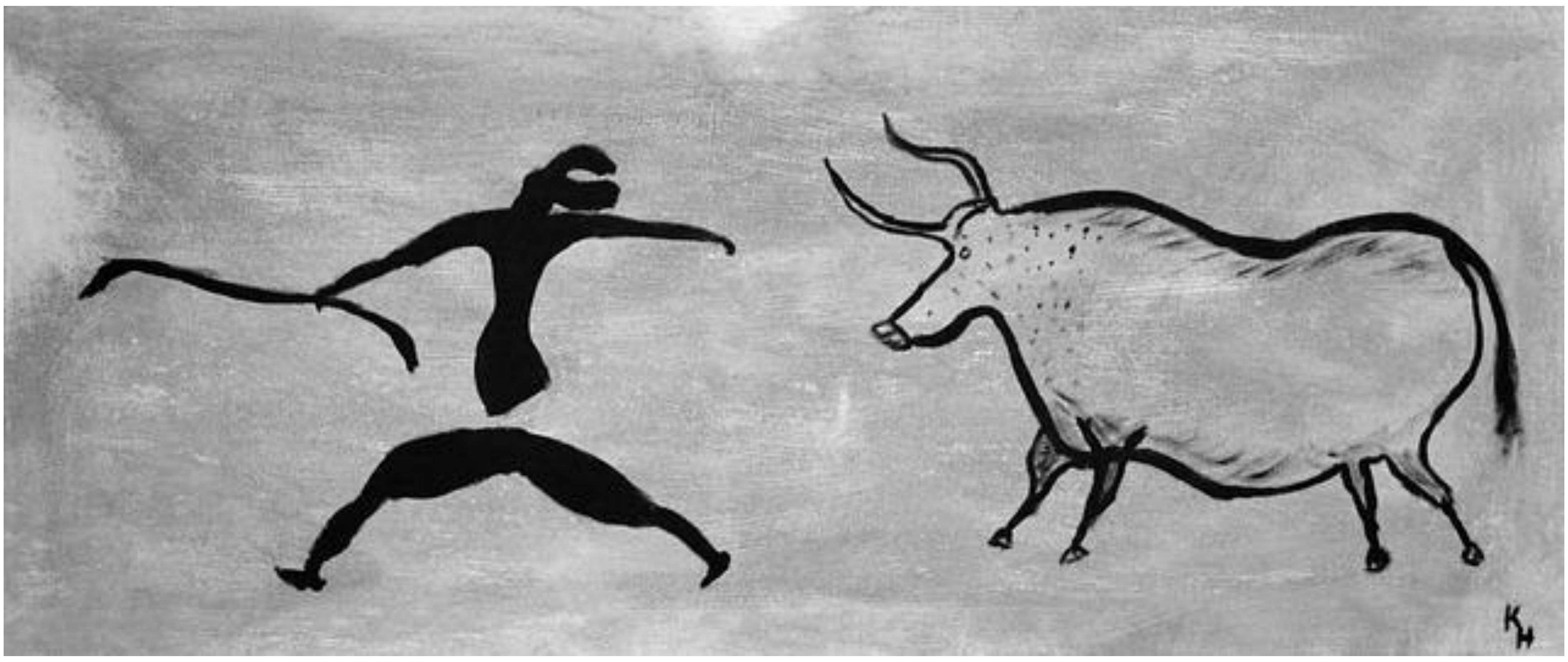
"*The poets tell us it was gold and silver, but the philosophers assure us it was iron and corn, which first civilized man, and ruined humankind*". Rousseau, 1755.

A frequent idea in Western thought is that life was better in the past. The lost Garden of Eden in Genesis to the Golden Age of ancient Greece describes a utopian past where humans lived in balance with nature, were healthy, and were well-provided for [19].

Rousseau's thoughts on human origins, the philosophy of the Nobel Savage of Enlightenment, and Marx and Engel's reflective descriptions of early farming, paint scenes of healthful idyll before the exploitation wrought by progress and industrialisation [19].

As the industry developed, a notable increase in non-communicable diseases occurred (diabetes, obesity, cancer, and heart disease). Thus, it became common practice in public health to draw on the hunter-gatherer past to explain the rise in non-communicable diseases [19,20].

There can be little doubt that understanding and mitigating disease from an evolutionary perspective is important. However, this is only as good as our understanding of the past. Without an accurate account of the past (diet, activity, disease etc.), wrong conclusions are likely to be made. "Can we be confident that conceptions of past employed in public health are not romanticized caricatures of some lost Eden"? [19].



Stone Age painting of the hunt.

What did the Paleolithic diet look like?

It's more than meat.

The Paleolithic diet is a modern interpretation of a diet humans consumed during the paleolithic era (also known as the "Old stone age") about 2.5 million years ago [23]. During the evolution of humans, changes in diet and food choices are indisputably a major driver of social and cultural advancements. These changes have contributed to watershed moments in human evolution such as brain development, construction of tools, family and social cohesion, and longevity [8]. However, to understand diet from an evolutionary perspective, data is needed that not only captures detailed dietary profiles from human foraging populations, but also the chemical composition of the foods that were consumed [8,24]. Unfortunately, data like these are rare, and studies into the nutritional habits of forages are quite diverse in their sampling techniques, methodology, standardisation, and analysis. This makes it extremely difficult to reach any consensus conclusion [19,24]. Similarly, the rate and magnitude of social and ecological change in many small-scale populations make it almost impossible to assess comparable datasets within and between populations [8].

Anthropologists can determine the types of food eaten by our ancestors by studying tooth decay

It's more than meat.

While it may be difficult to get an accurate representation of the evolution of human foraging and diet, this does not mean we have no idea. We can gain several insights into foraging behaviour through the chemical and biological sciences [29].

Anthropologists have several ways of determining the kinds of foods our ancestors ate. For example, chemical analyses of bone for trace elements such as calcium, tooth decay and abrasion, and fossilised waste.

Before the development of agriculture, our ancestor's dietary choices would have been mostly limited to wild plants and animal foods [20]. It is suggested that the "Paleolithic diet", an ancestral diet characterised by higher protein levels, less total fat, more essential fatty acids, lower salt, and higher fibre could serve as a reference standard for modern human nutrition [21].

This is because it is increasingly acknowledged that low rates of cardiovascular disease and other nutrient-related metabolic disorders have been observed among contemporary hunters and gatherers [22]. Moreover, several studies have shown the beneficial effects on metabolic syndrome, blood pressure, insulin secretion and glucose sensitivity, lipid profiles, and

In clinical trials on "normal" healthy sedentary subjects that ate a Paleolithic diet consisting of lean meat, fruit, vegetables, and nuts for 10 days, it was found that there was an observable improvement in blood pressure, a decrease in insulin secretion, an increase in insulin sensitivity, and an improvement in blood lipid profiles [23]. Similarly, a meta-analysis identified that a Paleolithic diet increased weight loss and was associated with a reduction in markers of chronic disease [28].

While the typical foods consumed by our bipedal ancestors are very much contested it is thought that the principal foods available to our ancestors included fruits and berries, shoots, flowers, buds and leaves, meat, bone marrow, organ meats, fish, shellfish, insects, eggs, roots, nuts, nongrass seeds, [22] and honey [24].

cardiovascular risk factors with a Paleolithic diet [25-27].

Honey bees.

What did the Paleolithic diet look like?

Honey was on the menu.

It appears that our ancestors had a sweet tooth for the golden stuff that was available a few months of the year. Paleolithic rock paintings show how people robbed bees' nests to collect honey [24]. Although we can argue about exactly how our ancestors ate and lived, the time we have spent in agrarian settlements rather than as hunters and gatherers is minuscule within the span of human evolution.

In her book Paleofantasy, biologist Marlene Zuk suggests that there is a strong body of evidence that our genome has gone through many changes since humans spread out across the globe and developed agriculture, and therefore it is difficult to determine a single way of eating to which were, and remain, best suited [25]. For example, in studies looking at genetic adaptations to nutrients, Hancock et al. [26] observed several changes in genes involved in nutrition in populations that depend on roots and tubers. Given that roots and tubers are rich in carbohydrates, the most significant changes in genes for populations that depend on this food source were in the starch and sucrose metabolism genetic pathway.

Other more recent examples of genetic adaptation due to dietary specialisation include:

1) Variations in the lactase gene (involved in breaking down lactose), a trait that is believed to be advantageous in agro-pastoral (herding) populations where milk is a major staple of the adult diet,[27] and
2) Variations in the amylase gene (breaks down starches into sugars) in agricultural populations [28].

The evidence related to the consumption of a Paleolithic diet can be interpreted as diets that are based principally on lean meats and plant foods, promoting health and longevity. And while adopting a diet like our ancestors once did may improve our health and well-being, it is interesting to note that despite our current consumption of non-Paleolithic diets, the lifespans of adults in most industrialised countries are increasing and populations remain relatively healthy into old age [18].

Summary

Early humans evolved from hunters and gatherers some 2.6 million years ago to approximately 10,000 years ago. During this time our genes were selected through changes in our physical and biological environment. This included changes in our genetics based on our early dietary requirements. Therefore, it is suggested that our dietary genes were selected long ago, and thus our modern diets are consequently "ill-suited" for our ancestral genes. However, recent evidence suggests that our human genome has evolved to different dietary requirements and thus our genes may be adapting to our modern diets. Accordingly, a major challenge associated with nutritional research is to understand how these changes in our genome reflect on our nutrition habits and lifestyles to ameliorate many of our modern lifestyle diseases.

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