Evolution of sweet and bitter taste

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The sense of taste is comprised of a relatively small number of basic or primary qualities, the main ones being sweet, bitter, salty, sour, umami and perhaps a few others (e.g. fatty, calcium). Since these qualities are present in many animal species it is presumed that evolution shaped the sense of taste to be able to detect compounds that have one or the other of these qualities. How did selection for these qualities come about? A general consensus is that each quality evolved to help the animal solve two primal problems: How to identify healthy nutrients and how to avoid ingesting unhealthy compounds such as poisons. Indeed, a major pressure likely comes in the co-evolutionary interplay between plants and their predators: The plant "wants' to avoid being eaten and hence produces unpleasant or dangerous ("bitter") compounds whereas the plant predator "wants" to identify parts of the plant that contain calories (sweet; umami), minerals (salty) and parts such as fruits that are immature and hence not ready to be consumed and dispersed (sour).

It is likely that the major plant predators that shaped evolution of taste systems were very primitive organisms and insects. Interestingly, it appears that the taste systems of many insect species have major similarities to those of mammals and in particular divide their taste world into appetitive (sweet, salty, amino acid) and aversive (bitter, sometimes sour) categories just like many mammals Monell-Breslin.

Most species of animals that consume plants, from flies to people, innately prefer sweet tasting carbohydrates such as fructose, sucrose, glucose and lactose (milk sugar) Monell and many other groups have studied this. The evidence for this comes from experiments with newborn or very young organisms that show immediate positive responses (e.g. increased sucking, relaxation, positive facial expressions) when first confronted with a sweetener Monell research has been at the forefront of this work for 40 years. There is one striking example of a group of animals that do not prefer sweetness – cats (including domestic cats, lions, tigers and other closely related species). These animals are strict carnivores and several behavioral studies have shown that they exhibit no interest in sweet substances Monell work – my studies. Indeed, recent work at Monell has demonstrated that cats have a defective sweet receptor rendering them blind to sweetness. This negative evidence supports the view that sweet taste serves to aid in the identification of sweet carbohydrates and suggests that when during evolution species lost interest in sweet sugars, the receptor was no longer needed and hence it atrophied.

Although for most adult foods the optimal levels of sweetness are often not the sweetest possible, evidence from studies of newborn or very young human babies suggests that the rule is: The sweeter the better Monell work. This age-related difference between young infants and adults may reflect physiological changes that occur during maturation as the adults have less need for calories for growth relative to the growing child Monell work and others. Unlike many of the other senses (e.g. vision, hearing, smell) the sense of taste

in general, and that of sweet taste in particular, remains robust into old age Monell work as well as others. This is an important point to remember in designing and preparing foods for older people. Monell interest – can sweet preferences be reduced in children to better their food choices?

A rejection of compounds humans call bitter is common across many phyla and this is thought to reflect the need to protect them from consuming toxic compounds. There are, however, many species differences in sensitivities to bitter compounds which are thought to reflect differences in ecological niches and food choices. Human studies suggest that a rejection of bitterness can be overcome in certain circumstances. For example, humans enjoy a certain level of bitterness of coffee, tea, beer and other alcoholic beverages. It is widely believed that this is learned behavior as a consequence of the reinforcing properties of ingredients in these beverages (e.g. caffeine, ethanol) Monell work as well as many others. Additionally, there are some individuals and ethnic groups that chose to consume bitter drinks and vegetables which may be a consequence of long-term exposure to these foods. Nevertheless, for the most part bitterness is rejected and this is particularly the case for human infants and children Monell work and others. It has been argued that this strong rejection by children is evolutionarily prudent: children may be at particular risk from toxic bitter compound ingestion.

This innately determined rejection of bitterness can be counter productive in some cases. Many of the bitter compounds found in vegetables, for example, are nutritionally valuable, at least in small amounts. Naturally occurring anti-oxidants and anti-inflammatory compounds are generally bitter and yet people are encouraged to ingest them. Perhaps the bitter rejection system evolved to be somewhat plastic so that, through experience, individuals could learn to appreciate some bitter foods that facilitate health. Monell interest: How can we promote eating of slightly bitter and healthy foods such as bitter ones, especially in children? Indeed, there are some intriguing primate studies that suggest that when ill some animals ingest bitter plants that otherwise would be rejected, presumably because they function as medicines curing the illness Not Monell work. The medicinal value of certain bitter compounds may thus be learned either through past individual experience and/or through social learning.

Both sweet liking and bitter disliking presumable were characteristics of humans since they first split off from other old world primates presumably over x million years ago. As humans evolved, and particularly over the past 30,000 years with the advent of fire, cooking of food, farming and domestication of animals, it seems likely that mechanisms underlying bitter and sweet taste may have undergone significant changes. Yet it is not clear what these changes might be. Additional comparative studies of existing apes and other old world monkeys as well as studies of different human ethnic groups could shed light on this interesting question. Monell interest: cross-cultural studies of taste preferences.

Selected references:

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