What we eat and drink: the influence of genetics

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Taste is important for nutrition: sweet provides information about the easily digested calories from sugar, bitter points to toxins in foods, sour warns us about acids in under-ripe fruit, and salty points us to valuable minerals. Thus it is not surprising that taste is an important part of food intake. But taste is not the only important determinant: cost, social influences, and food availability all play a role in human food intake1; 2; 3. What constitutes good food and drink is subtle, but extremes of most taste sensations, including bitter, sourness, and sting, as well as excessive sweetness, saltiness, and richness from fats, detract from the pleasant experience of most drinks and foods for most people. However, humans can tolerate and even like foods that go too far; for instance, we deliberately add tingling wintergreen oil to candies and drink carbonated sodas that can cause a burning sensation. Or we drink (and even prefer) very bitter tea. The observation that tingling, burning and bitter could be so popular deserves more research attention than it receives. The liking for sweet and fat also depend on concentration: For some people there is no such thing as "too sweet," while others finds more than moderate amounts of sweetness to be cloying. And although few people would eat a meal solely of oil or butter, people differ in how much fat is just right or too rich4. Some progress has been made in defining the genes and their alleles associated with the positive and negative aspects of food and flavor (Figure 1). Taking a ham and cheese sandwich as an example, a common American lunch, we might imagine that people with sensitive alleles might differentially detect the mild sweetness of the onion (TAS1R3)5 , or the savory glutamate taste of the tomato (TAS1R3)6; 7; 8, the bitterness of watercress(TAS2R38)9, the smell of the cheese (OR11H7P)10 or the 'boar taint" odor of ham (OR7D4)11. We envision that a combination of allelic differences might contribute to the range of liking for this ham and cheese sandwich. People who can taste the pleasant components (and not the unpleasant ones) may experience the ham sandwich as more desirable because of its taste. But how do differences in sensory experience translate to actual food consumption? Whether these individual differences in chemosensory experience affect food selection is the weak link in the chain of causality. People eat what they like, but they also eat for many other reasons. Simple explanations of the links between sensory perception and food intake are misguided: Just as people do not choose art or music based solely on how well they can hear or see, we do not choose food based solely on the reactions of the tongue or nose. Although genetic differences determine what we can taste and smell (and at what concentration), our taste is ultimately determined by our experiences, learning, and culture, in an artistic sense, as well as in our likes and dislikes of food and drink. However, perception is the first step toward liking: What cannot be perceived cannot be like or preferred. Therefore, it is worthwhile to pursue these questions. This focus on perception and taste is especially important in the realm of human health because most of the chemicals discussed that give rise to bitter taste have metabolic and behavior effects and many are drugs (caffeine, alcohol). People are always urged to eat diets higher in plant foods like vegetables but these foods are bitter to many. As another example, new medicines that need to be given in liquid forms can taste excessively bitter12. And some

bitter or stinging compounds are concentrated in plants to help them to fend off insects but also tickle our taste buds. Thus, to understand our greater desires for certain types of foods above others, and our avoidance of compounds we know we should consume, such as medicines or healthy but bitter vegetables, we must consider our genotype, which dictates our ability to perceive these compounds.

One aspect of taste and smell that does not receive enough attention is that for ethanol (or, in more colloquial terms, alcohol), is a commonly consumed drug which is also a food, and just over 50% of people living in the United States are regular drinkers 13. Because of alcohol's popular pharmacological effects, the attractiveness or off-putting taste and smell of alcohol and can be over looked 14. As a taste, ethanol has a complex quality: indirect evidence, mostly from the study of mice and rats, suggest it stimulates the sweet receptor15. One explanation for the connection between sweet and alcohol is that sweet fruits ferment and so the sweet-alcohol connection may help animals gauge the sugar/alcohol ratio in fruit and other fermented products16. In addition to sweet, genotype-phenotype studies in humans suggests that ethanol also stimulates at least one bitter receptor17 . Alcohol may also stimulate receptors for the common chemical sense, at least in rodents18. In addition, alcohol also has an odor and although the exact receptors are not known, based on other typical molecules it is likely to stimulate a number of different receptors and the patterns of receptor activation may differ based on concentration19. Although individual differences in alcohol intake are studied intensively because of the role of dependence and addiction to human health, we are aware of no studies which have examined, in humans, the heritability of alcohol perception. Although it is reasonable to expect large individual differences that may be due in part to genotype, this is a current gap in scientific understanding.

Figure 1. Example of how taste and smell genotypes may contribute to the perception of common foods. A ham sandwich contains bread, onion, tomato, watercress, cheese and ham. The low concentrations of sucrose in the onion will be detected by sweet receptors on the tongue, coded for by two subunits, TAS1R2 and TAS1R3. The glutamate in the tomato, perceived as a savory or umami taste, is sensed by the umami receptor, which is a heterodimer of TAS1R1 and TAS1R3. The bitterness of watercress is due to isothiocyantes (or structurally related compounds), and is detected by one or more bitter receptors, i.e., TAS2R38. Isovaleric acid is a component of cheese and gives it a characteristic odor which some people call "sweaty". This chemical stimulates at least one olfactory receptor, OR11H7P. Ham can contain androstenone which gives the meat an odor called boar taint. Some people perceive this odor as offensive and the receptor associated with this compound is OR7D4. In this example, people with two positive alleles (+/+) perceive the compound better than people with two negative alleles (-/-). Person 1 can taste the pleasant sweetness of the onion and the umami of the tomato but do not perceive the bitterness of the watercress or the unpleasant odors of the cheese or ham. Thus Person 1 prefers the ham sandwich more than Person 2.

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