Smell, Taste and Flavor

Both odors and tastes involve molecules that stimulate specific chemoreceptors (chemical receptors). Although humans commonly distinguish taste as one sense and smell as another, they work together to create the perception of flavor.

Our sense of smell is responsible for about 80% of what we perceive as taste which is why a person's perception of flavor is reduced if he or she has congested nasal passages. Without our sense of smell, our sense of taste is limited to only five distinct sensations: sweet, salty, sour, bitter and the “umami” or savory sensation. All other flavors that we experience come from smell. In very simplistic terms, the ability to perceive sweet, salt and umami is pleasurable, resulting in out seeking out such tastes and sour and bitter tastes are warning signs.

- SWEET taste indicates that a food contains carbohydrates which provide energy for the body. It is the most potent of the 3 pleasurable tastes and the last to deteriorate as we age.
- SALT suggests the food contains minerals and electrolytes.
- UMAMI indicates that a food will likely contain protein and fat. Protein is obviously necessary for the amino acids they provide as the building blocks for everything in our own bodies. Fat is an alternative “emergency” energy source.
- SOUR tastes often suggest that something is fermented and may be rancid. This may not be a problem in modern times, since we intentionally ferment foods and have proper storage abilities but, in the past, it indicated that something was off.
- BITTER suggests something is toxic and we need to avoid it. These toxic compounds are often a plants’ natural insecticides and herbicides, like the nicotine in tobacco or chlorogenic acid in coffee or the sulforaphane in kale and other cruciferous vegetables. Again, in modern times we understand that there are degrees of toxicity and that a small amount may actually be beneficial.

The words ‘taste’ and ‘flavor’ are used interchangeably to describe the unified perceptual experience of a food. But in scientific terms, flavor is both taste and smell, and flavor molecules are detected by receptors in the nose as well as by taste receptors in the mouth and throat. So, scientifically speaking, two boiled sweets with the same amount of sugar but different ‘flavors’ may taste identical (sweet), but smell distinct.

Flavor arises when the brain puts together inputs from various senses including taste (from the taste buds in the mouth), smell (picked up by the olfactory fibers in the nose) and touch (on the lips, tongue, cheeks…). Even hearing as well as the texture of food, influence flavor. Color seems to play a stronger role than odor in determining what we think we are tasting. When we eat, we use information from our eyes, ears, nose, tongue and lips to build up an impression of flavor. The bones and muscles in our face detect vibrations from crunch and resistance from chewiness. Receptors in the mouth detect chemical changes in saliva and alterations in friction from oils and powders. And, of course, we put all this together with our expectations, and our memories (both conscious and unconscious) of the last time we ate the food or the advertisement we saw for it yesterday. This integrated sensory system is a product of that billion-year arms race to extract energy from our ecosystem.

All the senses interact in many ways. Vanilla, technically a molecule you smell, when added to ice cream will make it seem sweeter, even without adding more sugar. Smell even influences touch. For example, apple-scented shampoo makes your hair feel shinier than other shampoos.

HOW SMELL WORKS. Air inhaled through the nostrils or up from the back of the mouth, passes over long ridges of bone and up towards the olfactory epithelium, where the olfactory nerves, the smell nerves, poke through the bone into the soft mucus-covered skin to touch the inhaled air. The olfactory system is the only example of the brain sending its own neurons into the environment like a probe. The eyes are externalized parts of the optic nerves, again an example of the brain being outside of the skull, but with the olfactory epithelium, the nerve endings are actually in the lining, getting stimulated. These olfactory nerves are covered in hundreds of different receptors, proteins with little pockets on them. Odorants (smell molecules) in the air you inhale bind these receptors and send information to the brain to be decoded (using a few hundred receptors to detect a trillion smells is a coding problem). Each smell molecule binds to more than one receptor, and each receptor binds many smell molecules. And they bind with different strengths for different times, thereby encoding a far greater range of possibilities than if it were one receptor per molecule.

The actual number of discriminable olfactory stimuli, i.e. smells, may be much higher than a trillion. You aren't just able to distinguish between individual molecules, but between mixtures of 30 different molecules. You can also distinguish mixtures of identical molecules in slightly different ratios. There are only 15 odorants for which science has established the lowest detectable threshold for dogs. But humans are better at detecting low doses of 5 of those molecules, all of which are fruit or flower odors of less significance to a carnivore presumably. But dogs are very good at detecting low levels of the carbolic acids released by their prey in body odors. There's a lot of literature showing humans' sense of smell is similar to, or even more sensitive than dogs, mice or rabbits for odorants in fruit. Mice are good at detecting the molecules found in the urine of mouse predators (although we aren't bad), and we are better than mice at detecting the smell of human blood. Humans can smell the stinky mercaptan added to gas to alert us to gas leaks, but dogs don't smell it at all. And humans can learn to follow a scent trail like a dog and we improve massively with a little training, indicating that our smell is an underused sense. Like our bones and muscles, it has become flabby and inactive. It may be that the same molecules may be perceived differently when sniffed compared with when they travel from the mouth to the nose. When smelled directly through the nose (orthonasal olfaction), stinky cheese can smell disgusting, and pretty much like socks. But it can have a delicious flavor when those odors come from the mouth backwards to the nose (retronasal olfaction).

We can learn that some smells are sweet, but this seems to be cultural. Ethyl butyrate smells 'sweet' probably because it is a smell usually associated experientially with the sweet taste of fruit juice. If paired with a sweet taste, it can make it taste sweeter and it can mask a sour taste. How we experience any flavor combination depends on how we have experienced it before. We learn that certain tastes and smells are congruent. We build these associations as flavors when we're very young, and they are extremely culturally specific. Cinnamon is nearly always a sweet spice in European cooking, but in Morocco they make a pigeon pie with cinnamon and sugar, and it's also widely used in savory dishes in many other places. Vanilla is sweet smelling in the West, where it tends to be mixed with sugar, but it smells salty to southeast Asians, in whose cuisine vanilla is often mixed with salt and fish.

If you go into the freezer for an ice cream bar, as you rip open the packet, it won't smell of anything, because it's too cold. Many companies add a caramel scent in the ribbing of the wrapper we tear open. The scent allows our dopamine reward system to respond to the sensory cue of opening the packet, which starts a craving. It also leads us to experience the chocolate and caramel in the bar more intensely. There's an important difference between leading and misleading. In the case of the frozen ice cream bar, the scent is leading you to expect real caramel and chocolate. But there are misleading sensory experiences, for example meaty smells in plant products, artificial flavors, gums that replace fats, all of these promising ingredients that aren't there. This is where we start to see the problem.

Smell is all about selecting safe and nutritious food, while avoiding toxic, unsafe food. It's one of the earliest warning systems for whether something is safe to eat. After all, by the time you can taste something, it may already be too late, but there is also the safety net of bitter receptors at the back of the mouth.

Toxin levels vary, and a piece of fruit may be edible for quite a narrow window, typically determined by exactly when the plant wants the animal to eat it and disperse the seeds. Smell saves the time-consuming trouble of having to put something poisonous in your mouth, although occasionally, sometimes we only realize something is off once we've started to chew.

A signature set of volatile molecules evaporates from almost every substance in the world. Smell involves the detection of these molecules using receptors in the nose. And it's fantastically precise. It's often said that we can detect 10,000 different smells, but that's a great underestimation. We can distinguish between more than 1 trillion potential compounds, meaning that you could take any two of the trillion and be able to say: 'Yes, those are different'.

Our legendarily poor sense of smell is exactly that, a legend. It does seem like we traded some smell resolution for improved vision, but we still outperform other mammals on some tests. While dogs are almost certainly better at detecting dog urine on lamp posts, experiments have shown that we're better at fruit and veg discrimination. This olfactory precision means we can tolerate similar molecules in cheese and socks. In fact, feces, breastmilk, rotting corpses, cheese and aged meat all share molecular signatures, but our olfactory system has evolved to distinguish between them.

French fries smell 'good' because the body and brain have linked the smell with the huge nutritional load of fat and carbs that follows. These associations that we learn between smell and taste, odors, and nutrients, are powerful and, of course, easily hacked.

Over the past half century or more, industrial animal and plant breeding has focused on size and looks, such that the flavor has been bred out of meat, tomatoes, strawberries, broccoli, wheat, corn, pretty much everything we eat. Part of the reason we are consuming so much is in search of missing tastes and flavor, which also indicate missing nutrition.

Tomatoes for example have a 'rose note', a really popular smell that's found in food, drink, cigarettes, perfumes and soaps. That rose note is made from a molecule called phenylalanine, which is an essential amino acid (i.e. a molecule that the body needs but cannot make). Another group of tomato flavors is made from carotenoids, such as vitamin A. In fact, we seem particularly sensitive to the flavors made from carotenoids: damascenone, found in tomatoes, berries, apples and grapes, can be detected at concentrations as low as two parts per trillion.

We are chasing flavors in search of missing nutrition is increasingly well evidenced.

The US Department of Agriculture quantifies 67 nutritional components in garlic which, while it seems like a lot, is just a fraction of the more than 2,000 distinct chemical components that garlic is known to contain. Estimates are that there are over 26,000 chemicals in some whole foods. It is these molecules that are stripped out by ultra-processing.

Flavors out of context may be messing up the body's ability to make the correct associations between a nutrient and a food. For this to happen the flavors have to be honest and to come from the food

If you put food in your mouth and chew, molecules go up your nose from the back of your mouth. This retronasal smell feels like taste, and you experience this kind of smelling as being 'in the mouth' but it isn't, and it makes a huge contribution to flavor. With a nose clip on, the two sweets will taste the same, sweet. But when you take the nose clip off and odors travel from the mouth to the nose, we can taste their different fruit flavors.

While flavors are really smells, molecules detected in the nose, flavor enhancers are really tastes. They're detected in the mouth, and include salt, sugar and molecules like monosodium glutamate, MSG.

The flavor enhancers glutamate, guanylate and inosinate, are used in Pringles potato chips.
These three are also recorded as "ribonucleotides" on various ingredient lists. This is another example of how the food industry hides ingredients.

Humans have evolved a very sophisticated detection system in our mouths for these molecules because they signify easily digestible protein, not the protein of raw meat, but the protein of perfectly aged or cooked meat. They're the signature of fermented fish and plants, rich meaty broths, vintage cheese. That's why foods with these molecules in them taste great. The molecules stimulate the receptors in your mouth and signal that there is some real nutrition on its way. When you swallow a bit of a flavorful risotto for example, your gut is primed to handle some rich meaty goodness, free amino acids. With the Pringles, it's a different story.

HOW TASTE WORKS. To understand taste properly, you must start with the tongue. Examine your tongue and you'll see little buds. These are not taste buds. They are papillae. Taste buds are invisibly small, don't look like buds (they're more like pits), and are found on the papillae, hundreds of them per papilla. Within each taste bud, there are around 100 specialized cells that have specialized receptors on them to detect molecules in your food, turn those molecules into a signal and send it to the brain. You taste all over your mouth and a bit at the back of your throat and, contrary to popular belief, there don't seem to be particular areas for each taste.

In fact, taste receptors are found throughout the body in the larynx, the testes and in the gut. There are bitter receptors in the lungs and sweet receptors in the brain, heart, kidneys, and bladder.

We have at least five types of receptors for five distinct tastes in our mouths: sweet, umami (savory), sour, salt and bitter. We may also have specific tastes for water, starch, maltodextrins (types of carbohydrates), calcium, various other metals and fatty acids, but it's remarkably difficult to be sure if we are truly detecting taste.

The mouth is also assessing chewing resistance, pastiness, gumminess, gelatinousness, and so on. Fatty taste may in fact be the alteration of the friction of the tongue against the mouth and teeth: oil is slippery in a different way from saliva.

Sweet taste is stimulated by all simple sugar molecules that we can use for energy. The sweetest naturally occurring carbohydrate is fructose, which is almost unpleasantly sweet. Glucose is a much milder experience. We also seem able to detect the breakdown sugars from starches that are similar to maltodextrin. We don't exactly taste them as sweet, but they do seem to activate brain areas associated with reward.

Salt taste comes from sodium salts and a few other compounds. Low-salt products often used by people with high blood pressure are made of potassium chloride, which does have a saltiness but doesn't taste exactly right. We are now fairly sure that there's a specific sodium channel in the skin of the mouth that detects salt. These sodium channels are found in skin-like tissues all over the body, moving sodium ions around, though how it detects salt concentration and then sends that information to your consciousness is still unclear.

Umami or savory taste comes from those three molecules familiar from UPF ingredients lists, glutamate, inosinate and guanylate:

- Glutamate is found in breastmilk, seaweed, tomatoes, scallops, anchovies, cheese, soy sauce, cured ham and many more foods.
- Inosinate is found mainly in fish, dried bonito and dried sardines. It starts to form as soon as a fish dies, reaching a maximum level about ten hours later.
- Guanylate is found mainly in dried shiitake and other mushrooms, forming from the breakdown of DNA in dying cells.

Sour taste comes from acids. A lot of different receptors for this taste have been proposed, but basically no one knows how we taste vinegar or ascorbic acid (vitamin C). Almost every other animal finds sour tastes aversive. But for humans, the taste may be useful. Sourness is, after all, a sign of fermentation rather than putrefaction. When bacteria ferment food, they produce acids that preserve it. Lactobacilli in milk digest the lactose into lactic acid making yogurt, which keeps up to 10x longer. Vitamin C is likely the original reason we held onto sour detection, because it's really the only nutritionally important sour taste. Unlike most animals, we can't synthesize vitamin C, and we don't eat enough fresh raw stuff to be guaranteed that we will obtain enough without specifically seeking it out. The combination of sweet and sour reflects ripe, vitamin-C-laden fruit that may be why we're drawn to that combination.

These four tastes, sweet, salt, sour and umami, are probably handled by basically 4 receptors. But bitterness is a different story. Bitter taste signals that something may be 'potentially toxic', and many different chemical structures taste bitterness. We need 25 different genes to detect bitterness, which gives us a great ability to detect toxins. But we can learn to love bitterness too. Bitter coffee will make a child gag and retch, but you can learn to associate the bitter taste with the exhilaration of the caffeine such that it becomes essential for making adult life bearable. Edible plants contain toxins inextricably linked to nutrients. These toxins tend to be destroyed by the liver, which handles all the blood coming from the gut. But even a food that contains small doses of multiple bitter compounds will be experienced as intensely bitter. Our mouths do a great job of accounting for the total dose of each toxin and whether the liver can handle it all.

Taste is important for omnivorous animals, whereas more specialist eaters have lost tastes. For example, cats have lost their sweet taste receptors. Pandas have lost a savory receptor. Sea lions seem to have very little taste at all, much of their prey is swallowed whole, but they can still smell. Whales and dolphins meanwhile seem to have lost the sense of smell entirely.

The tastes all affect each other too. If you make a cocktail of sucrose, MSG, sodium chloride, citric acid and quinine sulfate, and drink it, you will experience this cocktail as simultaneously sweet, savory, salty, sour and bitter. You're able to tease apart the individual components, but your enjoyment of each one is affected by the others.

Tastes can also influence tolerability. Gorillas will tolerate bitter plant tannins if the sugar content is high. The same is true for human children and almost any food. Likewise, quinine is quintessentially bitter, yet paired with sugar it becomes enjoyable in tonic water.

At particular concentrations and combinations, sweet, sour, salt and savory all 'enhance' flavor, making food more enjoyable. The best traditional foods from many cultures will use sour vinegar, sweet sugar or honey, savory umami flavors and loads of salt. Think of an Italian pasta dish: tomato and vinegar acids, sugar from the tomatoes, added salt and grated glutamate-rich parmesan. It's the same principle, but UPF companies take it to the next level.

The first versions of Coca-Cola contained both cocaine and caffeine. Cocaine and caffeine are both extremely bitter, so companies add lots of sugar to mask this. But that initial bitterness was actually an advantage. It was the extreme bitterness that allowed the addition of more sugar to the drink than would otherwise not have been possible.

We can't eat honey by the spoonful or handfuls of table sugar. They are literally sickly sweet. The reason for this is probably simple enough: the body doesn't want to absorb sugar at a rate that exceeds its ability to remove it from the blood. "Sweet blood" is harmful in lots of different ways. Sugar is food for bacteria, for one thing, and having lots of sugar in the blood also causes large shifts of water from cells into the blood. This increases the blood volume and makes the kidneys produce urine, resulting in dehydration. This is why peeing a lot is one of the first signs of diabetes.

Modern Coca-Cola still has caffeine bitterness, enhanced by an extreme sourness that comes from added phosphoric acid. Together, they allow a huge amount of sugar to be tolerated. But they don't do it alone. The drink's fizziness from carbonation contributes too, as does the suggestion that it be served ice-cold. For reasons that aren't entirely clear, you can suppress sweetness if you make something cold and fizzy.

Good cooks can enhance flavors and tastes by combining them, but I think UPF is the nutritional equivalent of speedballing. In the world of illegal drugs, speedballs are typically a mixture of a sedative, like heroin, with a stimulant, like crack cocaine. One puts you to sleep (opioid overdoses cause death by stopping breathing) while the other wakes you up (crack overdoses cause death by driving the blood pressure so high that patients have strokes). By mixing the two, users can take more of both. People also do this more benignly (but still frequently with deadly consequences) with caffeine and alcohol: an espresso martini or a vodka and Red Bull are entry-level speedballs, the stimulant caffeine offsetting the sedative effects of the alcohol. This wonderland approach to drug use is a theme of UPF tastes.

Whether we learn to want a particular flavor seems to depend on how much our blood glucose changes when we consume it.

So it may be that by using fizz, cold, acid and caffeine to give people a huge dose of sugar, and with it a massive calorie load and blood-glucose spike, cola producers are making you want their specific products more and more.

Sweet fizzy beverages are nearly as cheap or cheaper than bottled water. Obviously, it's more expensive to make cola, but once people buy one, they will buy more. Water is cheaper to produce, but it's hard to get people to drink lots of it.

The sweet taste in the mouth affects the body beyond just causing a little pleasure. If food contains an artificial sweetener, it is, by definition, UPF. These sweeteners used to be limited to little sachets and diet soft drinks.

Now they're in everything: breads, cereals, granola bars, 'lite' yogurts, no-added-sugar ice cream, flavored milk. They're added to condiments like reduced-sugar ketchup, sugar-free jam and sugar-free pancake syrup. They're even in medications, multivitamins and hygiene products like toothpaste and mouthwash. The most commonly consumed are cyclamate (50x sweeter than sucrose which is table sugar) and saccharin (500x sweeter than sucrose). Sucrose, first produced in 1879 as an accidental byproduct of coal tar processing, is the cheapest and oldest, and the global market is worth around $ 2.2 billion a year.

Sucralose is another artificial sweetener, 600x sweeter than sucrose. Varying quantities of sucralose, sugar, or both, decreased the body's response to insulin (insulin resistance) in a similar way to type 2 diabetes.

Drinking sweeteners increases preference for other sweet foods. A small study showed that the desire for sugar was reduced after a two-week break from all artificial sweeteners. One particular artificial sweetener, Splenda, which contains sucralose and maltodextrin, also seems to alter brain activity in rats in areas that control food intake, obesity and energy control, as well as having effects on the gut itself.

Artificial sweeteners also disrupt the microbiome. Sucralose disrupts the gut microbiome, even at levels approved by regulatory agencies, and certainly at levels humans frequently eat.

Phosphoric acid in your food is not extracted from fruit or vegetables. It's made by burning phosphorus-containing rocks in an arc furnace with coal. It's also used in semiconductor processing and to modify road asphalt. Colas were originally called phosphate sodas. They're early UPF. The phosphoric acid doesn't just rot teeth and disguise the sugar. It also may leach minerals out of bones.