The Senses: Smell & Taste

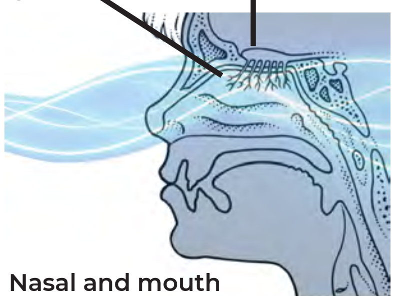
Written by Carl Sherman

Smell and taste are the oldest of the senses. They are essential for survival, having evolved to play key roles in such basic processes as feeding, mating, and avoiding danger.

As the two chemical senses, they work by allowing tiny bits—molecules—of the outside world into the body, and binding to them.

Smell

The molecules that activate the sense of smell (the technical name is olfaction) are airborne; they enter the body via the nose and mouth and attach to receptor cells that line the mucus membranes far back in the nose. In humans, there are millions of such cells altogether but only several hundred (400 is a good estimate) different types of olfactory receptors.



Nasal and mouth cavity from the side

One thing that makes olfaction unique among the senses is that its receptor cells are themselves neurons. Each olfactory receptor cell has filaments called cilia, with receptors designed to bind to specific molecules. Like all neurons, the cell also projects a thicker fiber called an axon. The axons come together in the olfactory nerve and go directly to the brain.

In other words, the olfactory nerve consists of neurons with one end in direct contact with the external world and the other in direct contact with the brain.

Whenever a detectable molecule, or odorant, attaches to an olfactory receptor, it generates a tiny electrical impulse. As these currents enter the complex network of the brain, it can quickly (sometimes within just two or three synapses, in a tenth of a second) recognize the odor.

How many odors can the human brain discriminate? Until recently, most scientists would have said something like 10,000; however, new research suggests a far greater number—perhaps a trillion.

How this is possible with messages from just 400 receptor cell types remains something of a mystery—and a testament to the brain's computing power.

The computation begins as signals are received and sorted out in the olfactory bulb, a structure on the underside of the front of the brain. From there, patterns are transmitted to the olfactory or piriform (meaning "pear-shaped") cortex in the higher brain for further processing.

The olfactory bulb also connects directly to the limbic system, the brain area that regulates emotion. This is why an odor may trigger nearly instantaneous feelings of fear or desire before you even become fully aware of what you're smelling. A network of connections with other parts of the brain give scents a matchless power to evoke detailed, emotionally charged memories and such complex mental states as nostalgia and longing.

The sense of smell plays a vital role in finding food, discriminating it from toxic substances, and appreciating its flavor (smell is a key component of what we commonly call "taste"—see Box).

Taste & Flavor

What we commonly call the "taste" of food or beverage is actually a multisensory phenomenon. While the sense of taste gives basic information about sweet, sour, bitter, and so on, most of the food experience (why a blueberry tastes different than a raspberry, for example) depends on the sense of smell.

When we chew food or sip wine, chemicals are vaporized into air passages that connect the mouth and the back of the nose, stimulating olfactory receptors and allowing us to realize the subtleties of flavor.

Other aspects of the taste experience, such as food texture and temperature, engage additional senses.

Pheromones are airborne chemicals emitted by individuals that elicit a physiological response in other members of the same species, via the olfactory system. In other animals, pheromones carry messages of alarm and aggression, and they play an essential role in sexual attraction and reproduction.

Whether pheromones work similarly in humans is controversial. Some research suggests so: airborne molecules of sex hormones seem to alter hormone secretion in the opposite sex. For example, the scent of female tears apparently dampens male sexual desire. However, the extent to which pheromones actually influence our actions remains uncertain.

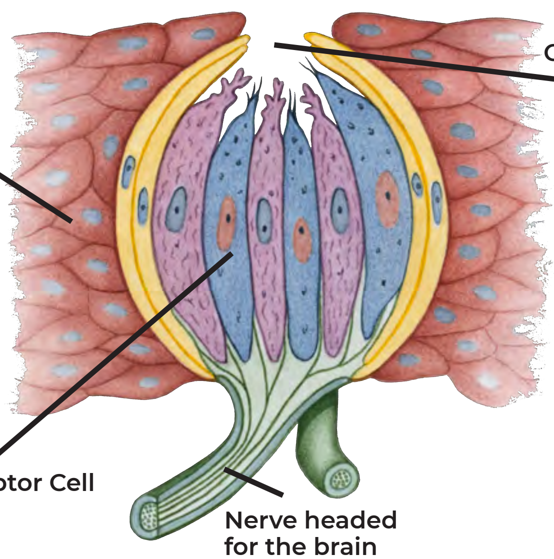
Taste

The other primary chemical sense, taste (technically, the gustatory system), responds to molecules dissolved in liquid.

These molecules enter the system via taste buds: pear-shaped structures in which receptor-bearing cells surround a central pore. There are millions of receptors on some 10,000 taste buds. Most are found in the familiar bumps called papillae that cover the surface of the tongue, but some line the roof of the mouth and the back of the throat.

Each taste receptor responds to one of five tastes: sweet, salty, sour, bitter—and a recently recognized addition, "umami," or savory. When a molecule of the appropriate taste binds to a receptor, the process changes the electrical charge in the receptor cell, triggering release of a neurotransmitter. This messenger chemical initiates an electrical impulse in a nearby neuron, which carries the signal to the brain.

Cross section illustration of a taste bud



It used to be thought that receptors for each taste were limited to one section of the tongue (the tip of the tongue for sweet, the sides for salt and sour, the back for bitter), but now we know that receptor types are more widely distributed (a single taste bud, in fact, may contain receptors for several tastes). There is no clear organization of taste receptors on the tongue.

Taste signals go from the mouth, via cranial nerves, to the medulla oblongata in the brainstem, then up to the thalamus and on to the cortex, where the sensation becomes a perception. You thus become aware of what you taste and can respond appropriately, swallowing food and spitting out possibly harmful substances. Connections from the lower brain allow taste to influence digestive processes directly.

Aging and Illness

Because taste and smell receptors are in direct contact with the environ ment, it's not surprising that they become blunted over the years. Smell, in partic- ular, typically declines, which can make food less appealing, adversely affecting appetite and sometimes contributing to poor nutrition in the elderly.

Complete loss of the sense of smell, anosmia, afflicts some six million Americans. The causes are varied and sometimes unknown. Marked decline in olfaction may also be a sign of neurological disorders. In fact, it sometimes occurs quite early in Parkinson's and Alzheimer's disease, even years before movement or cognitive problems are noticeable.