The Chemical Senses

Gustation (taste) and olfaction (smell) are both labeled chemical senses because their receptor cells respond to chemicals rather than physical energy. Our olfactory sense detects chemical molecules from the air we breathe and our gustatory sense detects chemicals that come into contact with the taste receptors in our mouths.

The Olfactory System

Receptors: **Olfactory cells** are located along the olfactory bulb in the nasal cavity. There are at least 100 different kinds of olfactory receptor sites, and about 10 million total olfactory cells. When different sequences of odor receptors fire, we are able to identify an estimated 10,000 distinct scents.

Olfactory cortex: Located in the temporal lobes, this is "wired" closely with the amygdala and the hippocampus, both of which are in the emotional limbic system, which may account for the power of emotionally charged memories triggered by smells. As mentioned earlier, the other senses are "wired" through the thalamus, the relay station of the brain. By the way, the phenomenon of a sense cueing a memory is called *redintegration.*

Anosmia: The term for the loss of the sense of smell.

Pheromones: Chemically produced odors that send signals (of sexual readiness, territory etc.) to other members of that species. The question is, "Do humans emit and respond to pheromones?" Many animal species clearly communicate through pheromones, but whether or not people do remains open to debate.

The Gustatory System

Receptors: **Taste cells**, clustered in groups called taste buds, are located within the small bumps of the tongue, called papillae. Their sensitivity tends to decline with age, especially in the case of those specialized most for **bitter** and **sour** tastes. Two other types of taste cells respond largely to **sweet** and **salty** tastes, which tend to be the preferred tastes of children. Recently, researchers have discovered a fifth taste category called **umami**. Umami receptors respond to savory or hearty flavors present in meats, cheeses, and foods that contain monosodium glutamate (MSG).

The five basic receptors for taste are located across the surface of the tongue. Many older textbooks have "tongue diagrams" that suggest specific localization of each of these taste areas on the tongue although we now know that these taste locales are *not* so strictly localized. Your gustatory sense is unique in that the receptor cells regenerate every week or two. As you age, however, these cells die off, which helps to explain our ever-evolving taste preferences.

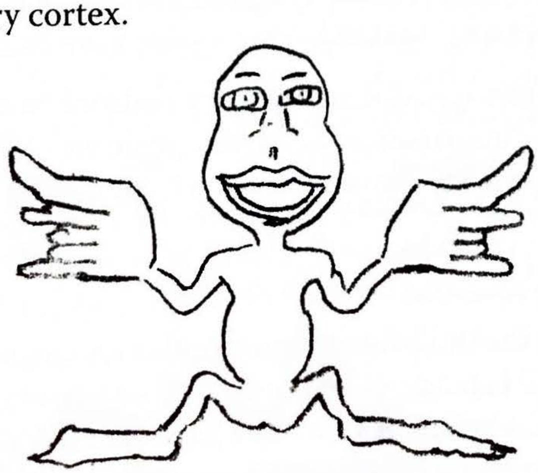
Much of the sense of taste comes from *interaction* with the sense of smell, which you can demonstrate to yourself by holding your nose while beginning to eat some chocolate or a jellybean. If you then release your nose, you should get a burst of that flavor, indicating it is largely an olfactory phenomenon. In addition to taste and smell, factors such as texture, temperature, appearance, and expectations all greatly influence your food preferences. There is also evidence to suggest a genetic component to taste preferences. **Supertasters,** the 25% of people born with an especially high number of taste buds, are very sensitive to potent tastes. **Nontasters**, on the other hand, have far fewer taste buds. The rest of the population falls in between these extremes.

The Body Senses

The Sense of Touch

Receptors: There are several different types of receptors located in **the skin**. However, the Advanced Placement Examination would not include questions about specific receptors like Meissner corpuscles, Ruffini endings or Merkel disks. These touch receptor cells respond to pain, pressure and temperature. Although the interaction among these cells is not completely understood, they appear to fire in various combinations, resulting in our experience of different touch sensations.

Sensory cortex: Located in the **parietal lobe** at the crown of the head. The left parietal lobe receives information from the right side of the body, while the right parietal lobe gets the information from the left side of the body. The more sensitive the area of the body is, the more surface area in the cortex is given over to that body part. For example, your fingertips and lips take up a large cortical area, whereas your forearm does not. You will see below a *sensory homunculus*, representing how we would look if our body parts were proportional to the layout of our sensory cortex.



"The Homunculus"

Pain: Pain is a great example of the interaction between *bottom-up* and *top-down processing*. Two people could suffer the exact same injury to the exact same part of the body, yet they may report drastically different experiences of pain. Why is this? There must be more to it than simple *sensation*. Your perception of pain is likely influenced by past experiences, the culture you grew up in, and individual biological factors.

No theory completely explains the mystery of pain, but it is widely accepted that there are two different pain systems. Two distinct sets of nerve fibers carry pain signals from the skin to the spine. *A-delta fibers,* which are heavily myelinated, work as an alarm system carrying the sharp immediate pain you feel to your brain. The dull and aching pain you later feel is carried to the spine and brain by *C fibers* that are processed partly in the limbic system, which may explain some of the emotional reactions that accompany pain.

The gate-control theory of pain suggests there is a kind of neurological "gate" in the spinal cord which opens and closes to both allow pain messages through to the brain and to stop those messages. Small fibers are thought to open the "gate" by sending pain signals. This gate can be closed by stimulating larger fibers in the injured area, which may explain why rubbing an injured area can temporarily relieve pain. The gate may also be affected by psychological factors. Anxiety and fear may open the gate while laughing or other mental distractions close the gate.

You may also find it interesting to look into **phantom limb pain,** a curious phenomenon found in people who have had a limb amputated or, in some cases, an organ removed. Long after the body part is gone, some people still report strong sensations of pain in the missing limb. What accounts for this? Perhaps the brain retains a kind of map of the missing body part and continues to send messages about it, despite its physical absence. Indeed, it may be the fact that the body part no longer exists that is at the root of the problem. A person with a painfully clenched hand can simply release the tension of the hand, providing relief from the pain. But if the brain is sending "Painfully clenched hand!" signals and there is no hand to unclench, the pain signals might well continue because of that lack of physical feedback.

The Kinesthetic System

Receptors: Proprioceptors (specialized sensory neurons) are found in joints, tendons, and muscles. They give us information as to the position of individual body parts and movement. When we perform any movement we rely greatly on this system.

The Vestibular System

This sense originates in the fluid-filled **semicircular canals** in the inner ear and governs whole body orientation and balance. It responds to changes in motion and body position, allowing us to maintain equilibrium. As you may have guessed, this system is closely tied to the cerebellum, which also plays a critical role in balance.

You might find it interesting to explore **synesthesia**, a fascinating and rare ability in some people who vividly experience one sense in terms of another; that is, to "see" musical notes or to "hear" certain colors. It's a highly engaging and mystifying topic to study.

Perception

"What the caterpillar calls the end, the rest of the world calls a butterfly"
(Lao-Tzu)

As we've already seen, 'perception' involves how we interpret sensory input from the top down - that is, from our brain/mind down to the world "as it is." It may help you to know that some refer to this top-down processing as *organismic variables*, which include all the things an individual organism brings to each sensory experience and which thus can make that sensory experience into a very different 'perception'. For example, each of us has a different **frame of reference**. A 7 foot tall man might describe an alleged bank robber as rather short while a young preschooler would be more likely to describe the same bank robber as being quite tall. Each of us is also often influenced by **perceptual set** (also called **perceptual expectancy**), in which what we expect to see, hear, taste, touch or smell *actually influences* what we experience. A closely related concept is that of a **schema**, which is a kind of framework we have in our heads based on previous experience. If asked to look at a photo of an office, we already expect certain things to be part of that office and might well be surprised to see things that do not fit our "office schema". A professional football player given a quick look at a panoramic image of a play in motion would be better able to "remember" details of that image because his experience has supplied him with a schema for