Taste and Smell Receptors

The Receptors For Taste And Smell Are Chemoreceptors

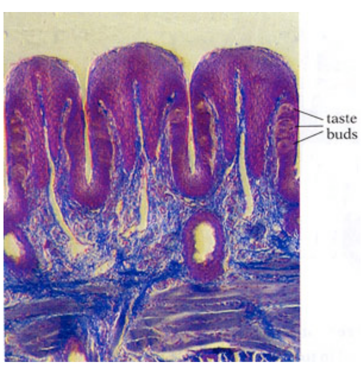
The receptors for taste and smell are stimulated by certain types of chemicals. The two senses are much alike, and when we speak of a taste sensation we are often referring to a compound sensation produced by stimulation of both taste and smell receptors. One reason why hot foods often have more “taste” than cold foods is that they vaporize more: the vapors pass from the mouth upward into the nasal passages and stimulate smell receptors. And one reason why a person with a cold cannot “taste” foods well is that, with nasal passages inflamed and coated with mucus, the smell receptors are essentially nonfunctional. Conversely, some vapors entering our nostrils pass across the smell receptors and enter the mouth, where they stimulate taste receptors.

In each case—taste and smell—chemicals must go into solution in the film of liquid coating the membranes of receptor cells before they can be detected. The major functional difference between the two kinds of receptors is that taste receptors are specialized cells that detect chemicals present in quantity in the mouth itself, while smell receptors are modified sensory neurons in the nasal passages that detect vapors coming from distant sources. The smell receptors can be as much as 3,400 times more sensitive than the taste receptors.

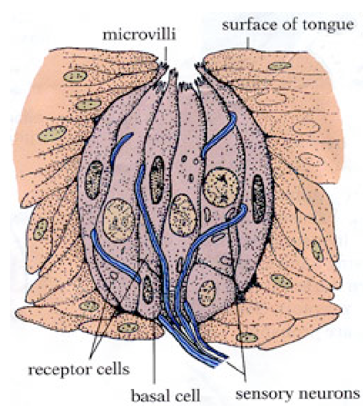
Taste Buds Have Specialized Receptor Cells

In terrestrial vertebrates the receptor cells for taste are located in **taste buds** (see Figure below). The majority of taste buds are located in pockets around the papillae on the surface and sides of the tongue, but there are some on the surface of the pharynx and larynx. Each taste bud contains about 40 specialized receptor cells and many supporting cells. Unlike the receptors for smell that are modified sensory neurons, the receptor cells for taste are not neurons, but rather specialized cells with slender microvilli on their outer ends. The microvilli protrude into the surrounding fluids through a narrow opening. Dissolved chemicals contacting the microvilli bind to specific receptor proteins on the microvilli, causing certain channels to open or close, thereby depolarizing the cell. The dendrites of the associated sensory neurons are in very close proximity to the receptor cells, so when a receptor cell is stimulated and depolarizes, it releases neurotransmitters which leads to the generation of an action potential in the associated sensory neuron.

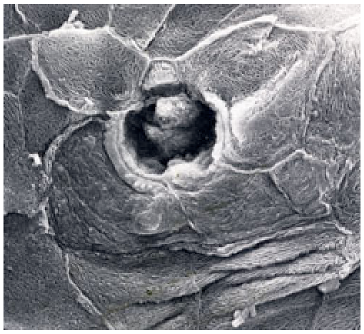
In humans there are four basic taste senses: sweet, sour, salt, and bitter. The receptors for these four basic tastes have their areas of greatest concentration on different parts of the tongue—sweet and salty on the front, bitter on the back, and sour on the sides. A few substances stimulate only one of the four types of receptors, but most stimulate two, three, or four types to varying degrees. The sensations we experience are thus produced by a blending of the four basic sensations in different relative intensities.



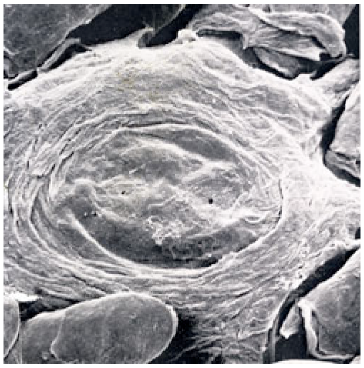
A section of mammalian tongue. The taste buds are oval structures located in the walls of the deep narrow pits.



The structure of a taste bud. Each taste bud contains specialized receptor cells bearing sensory microvilli that are exposed in pits on the tongue surface. The ends of sensory neurons (blue) are closely associated with the receptor cells.



Human taste buds (SEM at 2,800X). This tongue is covered not by protruding papillae, but by soft, overlapping sheetlike cells, each with its own intricate surface pattern which is doubtless as distinctive as a fingerprint.



Two fine pores that lead to the taste cells can be seen in this taste bud on the tongue of a vampire bat (1,300X).

The tongue of a three-week-old puppy contains flat, soft elements called circumvallate papillae. Taste cells are in the trenches (115X).

A guinea pig's tongue is raspy, rather than smooth like the puppy's (180X).

Smell Receptors Are Modified Sensory Neurons

The receptor cells for the sense of smell (olfaction) in terrestrial vertebrates are located in two clefts in the upper part of the nasal passages (See Figure below). Unlike the receptor cells for taste, which are specialized receptor cells, olfactory receptors are modified sensory neurons. The cell bodies of most of these neurons lie embedded in the epithelial layer of the walls of the olfactory area of the nasal chamber). Dendrites run from the cell bodies to the surface of the epithelium, where they bear a cluster of modified cilia, which function as the receptor sites. The axons of the sensory neurons transmit information to the olfactory bulb in the brain.

How does the olfactory sensory cell transduce the information from the environment into an action potential? A molecule that triggers and olfactory response is called an odorant. Odorants bind to specific receptor proteins on the olfactory hairs of the sensory cells. Each olfactory receptors has a particular binding site to which a particular odorant can bind, rather like a lock and a key. If the odorant molecule binds to a receptor protein, the receptor-odorant complex activates a G protein, which in turns activates an enzyme that triggers the production of a second messenger inside the sensory cell. The second messenger binds to sodium channels in the cell's plasma membrane and opens them, causing an influx of Na+ ions. If the cell depolarizes to threshold, and action potential is generated in the sensory cell.

The olfactory world has an enormous number of molecules that produce distinct smells. The number of receptor proteins is large, but not nearly as large as the number of possible odorants. A family of about 1,000 genes codes for the olfactory receptor proteins. Each receptor is found in a limited number of cells in the olfactory epithelium and those cells all send axons to the same regions in the olfactory bulb. A given odorant may bind to one or more receptor proteins, so each odorant can excite a unique selection of cells in the olfactory bulb. As a consequence, an olfactory system with a thousand different receptor proteins can discriminate a large number of smells[1].

From an evolutionary point of view, the olfactory sense is very old—the earliest vertebrates are thought to have had a well-developed sense of smell, and olfactory organs are found in all vertebrates. Odors can be used not only for locating food, but for recognizing family members, marking territories, and finding mates. To attract mates, for example, many different animals, including certain insects, aquatic invertebrates, and mammals, release special scents that contain information about their species, sex, reproductive readiness, and location. Some moths have incredibly sensitive smell receptors. The males are capable of detecting sex-attractant molecules released by females several miles away! Also, some animals use odors as alarm signals. For example, ants, snails, bees, and certain fishes release an alarm substance when injured as a warning to other members of that species.

Most animals depend to a far greater extent on olfaction than humans can fully appreciate. Although humans do have a good sense of smell—we can detect about 10,000 different odors—our olfactory capability is not as good as those of many vertebrates, especially fish and other mammals. A dog, for example, has up to 40 million nerve endings per square centimeter of nasal epithelium, many more than we do.

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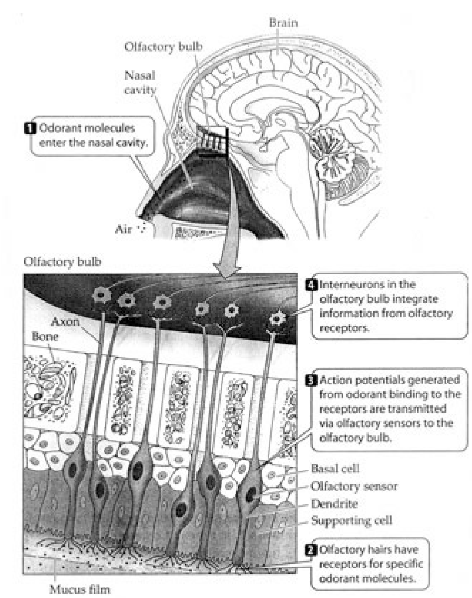
[1] Adapted from Purves,W., D. Sadava, G. Orians, and H. Keller, 2001. Life: The Science of Biology, Sinauer Associates, Sunderland, MA



Olfactory receptors communicate directly with the brain. The receptors of the human olfactory system are embedded in tissues lining the nasal cavity and send their axons to the olfactory bulb of the brain.

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