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Elucidate the pathway involved in taste

The tongue contains small bumps called papillae, within or near which taste buds are situated. In the tongue's taste buds, the taste receptors receive sensory input via two important mechanisms – depolarization and neurotransmitter release. Intake of salty foods leads more sodium ions to enter the receptor, causing the said mechanisms. The same is true with intake of sour foods (hydrogen ions) and sweet foods (sugar molecules), both of which result to the closing of K+ channels upon their entry.

There are three types of papilla, based on their appearance: vallate, foliate, and fungiform.

Structures Associated with Taste. The tongue is covered with papillae (a), which contain taste buds (b and c). Within the taste buds are specialized taste cells (d) that respond to chemical stimuli dissolved in the saliva and, in turn, activate sensory nerve fibers in the facial and glossopharyngeal nerves.

The number of taste buds within papillae varies, with each bud containing several specialized taste cells (gustatory receptor cells) for the transduction of taste stimuli. These receptor cells release neurotransmitters when certain chemicals in ingested substances (such as food) are carried to their surface in saliva. Neurotransmitter from the gustatory cells can activate the sensory neurons in the facial and glossopharyngeal cranial nerves.

From the axons of the taste receptors, the sensory information is transferred to the three taste pathways via the branches of cranial nerves VII, IX and X. The chorda tympani of CN VII (facial nerve) carries the taste sensory input from the tongue's anterior two-thirds. Then, the rest of the taste sensations from the throat, palate and posterior tongue are transmitted by the branches of CN IX (glossopharyngeal nerve) and CN X (vagus nerve). From these cranial nerves, taste sensory input travels through the nerve fiber synapses to the solitary tract, the ventral posteromedial thalamic nuclei , and the thalamus. In these three locations, there are clustered neurons which respond to the same taste (sweet, sour, salty or bitter).The thalamus relays the information to the primary gustatory cortex located in the somatosensory cortex. The primary gustatory cortext is where the perception of a particular taste is processed.

The neural taste pathway will undergo scrutiny from the perspective of starting within the tongue and moving away from it towards the brain. The three nerves associated with taste are the facial nerve (cranial nerve VII), which provides fibers to the anterior two-thirds of the tongue, the glossopharyngeal nerve (cranial nerve IX), which provides fibers to the posterior third of the tongue, and the vagus nerve (cranial nerve X), which provides fibers to the epiglottis region. Taste fibers categorize as special visceral afferent (SVA).

The branch of the facial nerve that innervates the anterior two-thirds of the tongue is the chorda tympani nerve. Another branch of the facial nerve, called the greater petrosal nerve, supplies innervation to taste buds of the soft palate. The cell bodies of the facial nerve associated with taste occur within the geniculate ganglion. Its central processes enter the brainstem at the pontomedullary junction and travel caudally to the medulla oblongata, where they synapse at the nucleus solitarius. The cell bodies of the glossopharyngeal nerve associated with taste are in the inferior ganglion of the glossopharyngeal nerve (petrosal ganglion). The central processes of the glossopharyngeal nerve travel through the jugular foramen, enter the brainstem at the level of the rostral medulla, and eventually synapse at the nucleus solitarius.

The cell bodies of the vagus nerve associated with taste exist in the nodose ganglion. Its central processes travel through the jugular foramen, to the medulla, and also synapse at the nucleus solitarius.

At this point, fibers from all three of these nerves have synapsed at the nucleus solitarius. Specifically, the synapse occurs in the rostral part of the nucleus solitarius known as the gustatory region of the nucleus.[1] The caudal area of the nucleus solitarius receives cardio-respiratory information, and it is known as the visceral region.

Next, the second-order fibers ascend ipsilaterally to the parvicellular division of the ventral posteromedial nucleus (VPMpc) of the thalamus, where the next synapse occurs.

The third order fibers travel ipsilaterally through the posterior limb of the internal capsule to terminate in the frontal operculum, anterior insular cortex, and in the rostral part of the Brodmann area 3B.[2] The overall function of these third-order fibers is to provide discriminatory taste sensations.Additionally, there are secondary fibers that travel from the gustatory cortex to the posterolateral portion of the orbitofrontal cortex (OFC). This area is where the integration of taste and smell takes place, as well as the phenomenon of food reward. The description of food reward is the enjoyment of a particular food at the time in which an individual is eating it.

The sense of taste affords an animal the ability to evaluate what it eats and drinks. At the most basic level, this evaluation is to promote ingestion of nutritious substances and prevent consumption of potential poisons or toxins. There is no doubt that animals, including humans, develop taste preferences. That is, they will choose certain types of food in preference to others. Interestingly, taste preference often changes in conjunction with body needs. Similarly, animals often develop food aversions, particularly if they become ill soon after eating a certain food, even though that food was not the cause of the illness - surely you have experienced this yourself. Food preferences and aversions involve the sense of taste, but these phenomena are almost certainly mediated through the central nervous system.

Taste Receptor Cells, Taste Buds and Taste Nerves

The sense of taste is mediated by taste receptor cells which are bundled in clusters called taste buds. Taste receptor cells sample oral concentrations of a large number of small molecules and report a sensation of taste to centers in the brainstem.

In most animals, including humans, taste buds are most prevalent on small pegs of epithelium on the tongue called papillae. The taste buds themselves are too small to see without a microscope, but papillae are readily observed by close inspection of the tongue's surface. To make them even easier to see, put a couple of drops of blue food coloring on the tongue of a loved one, and you'll see a bunch of little pale bumps - mostly fungiform papillae - stand out on a blue background.

Taste buds are composed of groups of between 50 and 150 columnar taste receptor cells bundled together like a cluster of bananas. The taste receptor cells within a bud are arranged such that their tips form a small taste pore, and through this pore extend microvilli from the taste cells. The microvilli of the taste cells bear taste receptors.

Interwoven among the taste cells in a taste bud is a network of dendrites of sensory nerves called "taste nerves". When taste cells are stimulated by binding of chemicals to their receptors, they depolarize and this depolarization is transmitted to the taste nerve fibers resulting in an action potential that is ultimately transmitted to the brain. One interesting aspect of this nerve transmission is that it rapidly adapts - after the initial stimulus, a strong discharge is seen in the taste nerve fibers but within a few seconds, that response diminishes to a steady-state level of much lower amplitude.

Once taste signals are transmitted to the brain, several efferent neural pathways are activated that are important to digestive function. For example, tasting food is followed rapidly by increased salivation and by low level secretory activity in the stomach.

Among humans, there is substantial difference in taste sensitivity. Roughly one in four people is a "supertaster" that is several times more sensitive to bitter and other tastes than those that taste poorly. Such differences are heritable and reflect differences in the number of fungiform papillae and hence taste buds on the tongue.

In addition to signal transduction by taste receptor cells, it is also clear that the sense of smell profoundly affects the sensation of taste. Think about how tastes are blunted and sometimes different when your sense of smell is disrupted due to a cold.

Taste Sensations

The sense of taste is equivalent to excitation of taste receptors, and receptors for a large number of specific chemicals have been identified that contribute to the reception of taste. Despite this complexity, five types of tastes are commonly recognized by humans:

Sweet - usually indicates energy rich nutrients

Umami - the taste of amino acids (e.g. meat broth or aged cheese)

Salty - allows modulating diet for electrolyte balance

Sour - typically the taste of acids

Bitter - allows sensing of diverse natural toxins

None of these tastes are elicited by a single chemical. Also, there are thresholds for detection of taste that differ among chemicals that taste the same. For example, sucrose, 1-propyl-2 amino-4-nitrobenzene and lactose all taste sweet to humans, but the sweet taste is elicited by these chemicals at concentrations of roughly 10 mM, 2 uM and 30 mM respectively - a range of potency of roughly 15,000-fold. Substances sensed as bitter typically have very low thresholds.

It should be noted that these tastes are based on human sensations and some comparative physiologists caution that each animal probably lives in its own "taste world". For animals, it may be more appropriate to discuss tastes as being pleasant, unpleasant or indifferent. Additionally, there are some clear differences among animals in what they can taste. Cats, for example, do not respond to sweets due to a deletion in the gene that encodes one of the sweet receptors.

Perception of taste also appears to be influenced by thermal stimulation of the tongue. In some people, warming the front of the tongue produces a clear sweet sensation, while cooling leads to a salty or sour sensation.

Taste Receptors

A very large number of molecules elicit taste sensations through a rather small number of taste receptors. Furthermore, it appears that individual taste receptor cells bear receptors for one type of taste. In other words, within a taste bud, some taste receptor cells sense sweet, while others have receptors for bitter, sour, salty and umami tastes. Much of this understanding of taste receptors has derived from behavioral studies with mice engineered to lack one or more taste receptors.

The pleasant tastes (sweet and umami) are mediated by a family of three T1R receptors that assemble in pairs. Diverse molecules that lead to a sensation of sweet bind to a receptor formed from T1R2 and T1R3 subunits. Cats have a deletion in the gene for T1R2, explaining their non-responsiveness to sweet tastes. Also, mice engineered to express the human T1R2 protein have a human-like response to different sweet tastes. The receptor formed as a complex of T1R1 and T1R3 binds L-glutamate and L-amino acids, resulting the umami taste. The bitter taste results from binding of diverse molecules to a family of about 30 T2R receptors. Sour tasting itself involves activation of a type of TRP (transient receptor potential) channel. Surprisingly, the molecular mechanisms of salt taste reception are poorly characterized relative to the other tastes.

Gustatory Nerve Impulses

Once the taste cells are activated by molecules liberated from the things we ingest, they release neurotransmitters onto the dendrites of sensory neurons. These neurons are part of the facial and glossopharyngeal cranial nerves, as well as a component within the vagus nerve dedicated to the gag reflex. The facial nerve connects to taste buds in the anterior third of the tongue. The glossopharyngeal nerve connects to taste buds in the posterior two thirds of the tongue. The vagus nerve connects to taste buds in the extreme posterior of the tongue, verging on the pharynx, which are more sensitive to noxious stimuli like bitterness.

Axons from the three cranial nerves carrying taste information travel to the medulla. From there much of the information is carried to the thalamus and then routed to the primary gustatory cortex, located near the inferior margin of the post-central gyrus. It is the primary gustatory cortex that is responsible for our sensations of taste. And, although this region receives significant input from taste buds, it is likely that it also receives information about the smell and texture of food, all contributing to our overall taste experience. The nuclei in the medulla also send projections to the hypothalamus and amygdalae, which are involved in autonomic reflexes such as gagging and salivation.