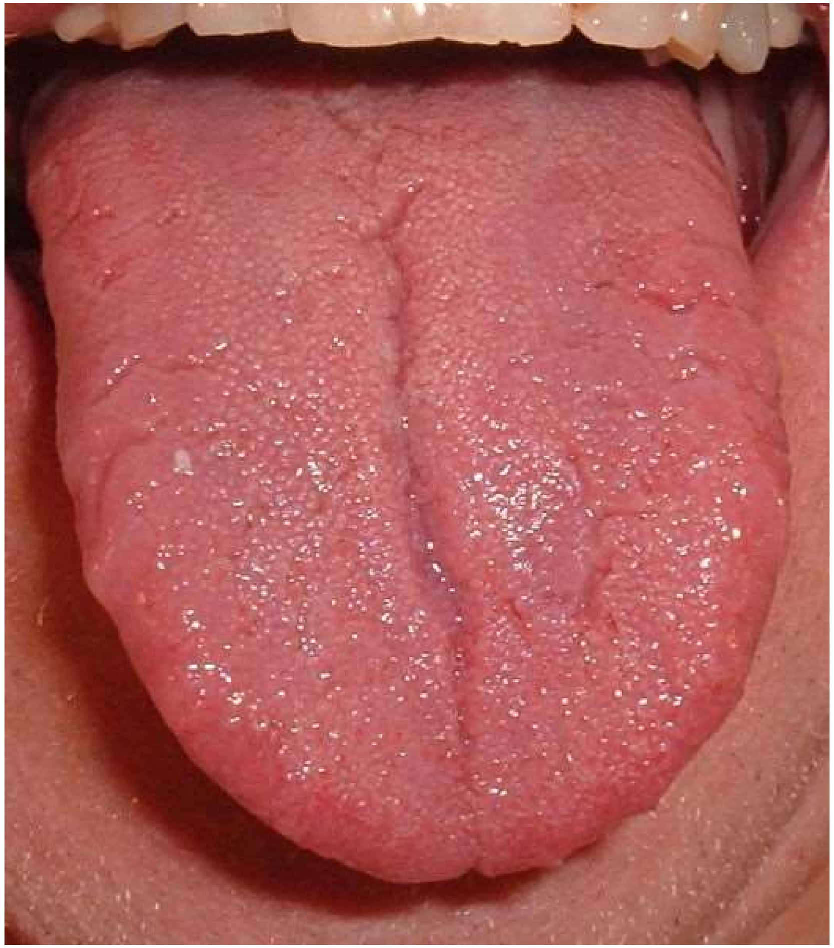
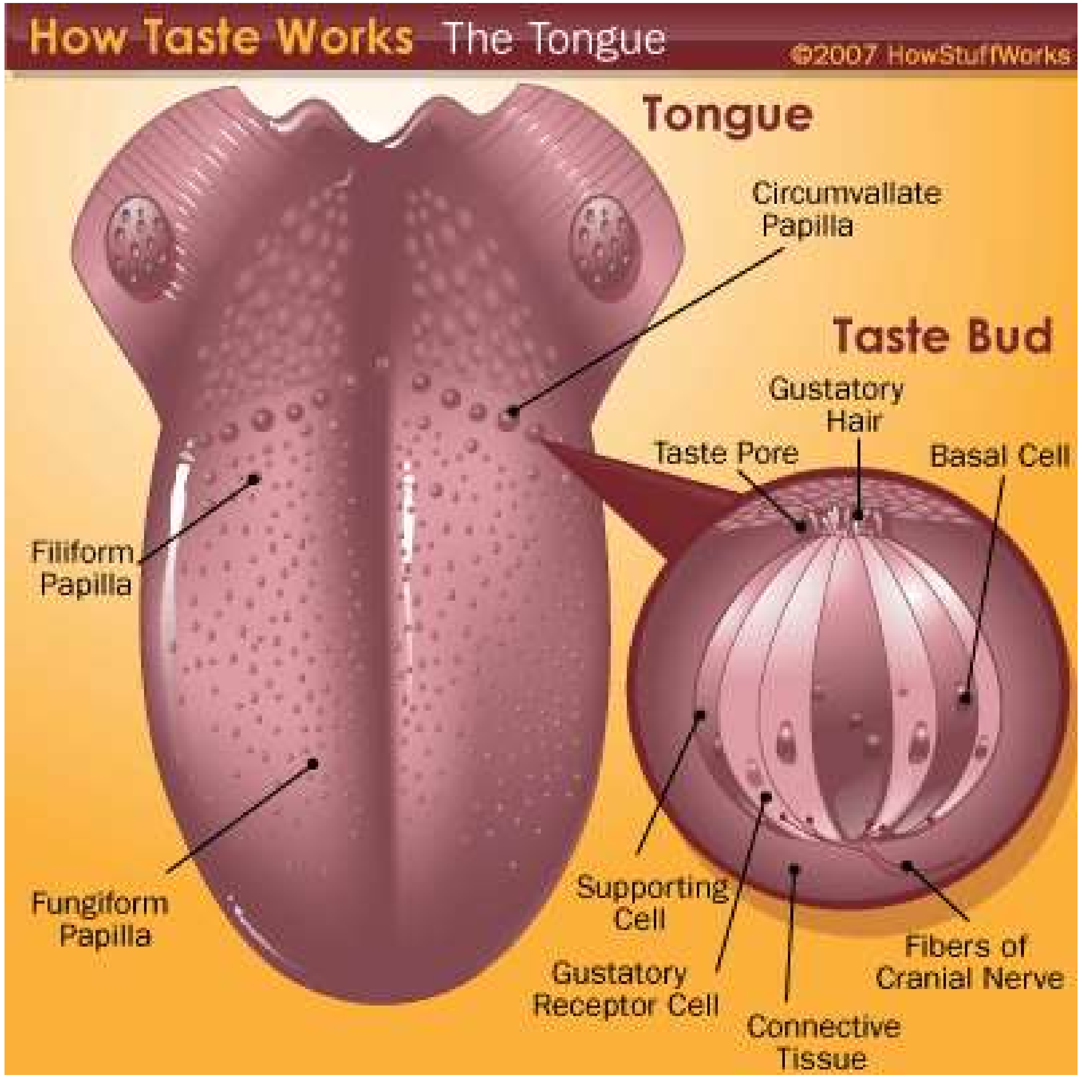
Taste Sensations




How Taste Works The Tongue
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Tongue
Circumvallate Papilla
Taste Bud
Gustatory Hair
Taste Pore
Basal Cell
Filiform Papilla
Fungiform Papilla
Supporting Cell
Gustatory Receptor Cell
Connective Tissue
Fibers of Cranial Nerve

The Chemical Senses : Taste

- Purpose
  - Provide us with information about the chemical quality of the environment (food, air)
  - Connect these perceptions with perceptions of our internal state (hunger, thirst)
  - Provide access to prior experiences stored in our memory
- History
  - Aristotle: cited “sweet” and “bitter”
  - Chinese Five Elements: bitter, sour, sweet, salty, and spicy.
  - Japanese and Indian: add one more to the basic five
  - Recently, receptors for basic tastes identified
    - Sour and Salty: ion channels
    - Sweet, Bitter: G protein coupled receptors

- Taste is a form of direct chemoreception.
- One of the traditional five senses.
- It refers to the ability to detect the flavor of substance such as food and poisons.
- Classical taste sensations include sweet, salty, sour, and bitter (recently umami and fatty acid taste)
- Taste is a sensory function of CNS.
- Receptors are found on the surface of the tongue.

- Primary sensations of taste:
  - Sour: caused by acids. Hydrogen ion concentration. The intensity of the taste sensation is proportional to the log of hydrogen concentration
    - Detected by hydrogen ion channels
    - Acidity detection
    - Ex: sour candy, lemon drops

$$pH=-\log[H+]$$

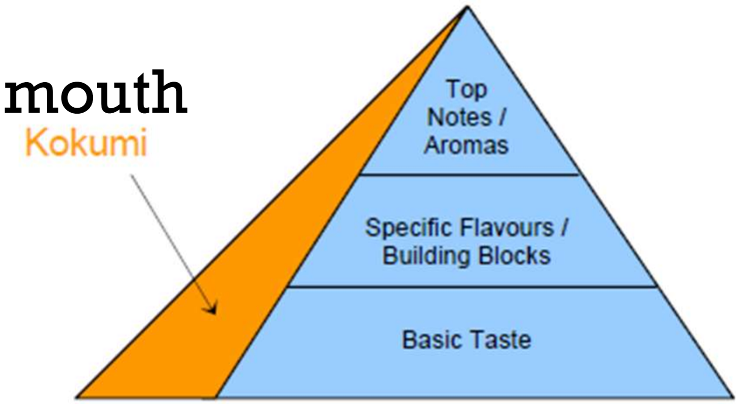
pH of a solution describes its acidity and is the negative logarithm (log) of its hydrogen ion concentration.

  - Salty: caused by ionized salts. Sodium ion concentration (NaCl)
    - Sodium chloride has an index of 1
    - Potassium chloride an index of 0.6 (salt substitute)
  - Sweet: caused by organic chemicals including sugars, glycols, alcohols, aldehydes, ketones, amides, esters, amino acids, glucose
    - Detected by G protein coupled receptors on the taste buds

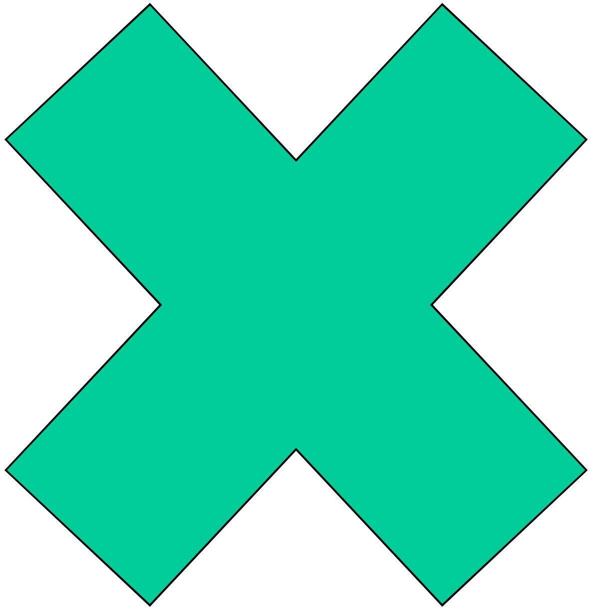
- Primary sensations of taste:
  - Bitter: Most sensitive. Not caused by any single type of chemical agent like sweet. Entirely organic substances such as (1) long-chain organic substances that contain nitrogen and (2) Coffee, Cocoa, Citrus peel, (3)alkaloids. Poisonous substances, thus rejection of food, protective function.
  - Umami: Sensation by glutamate. Commonly found in fermented and aged food. In English, described as meaty and savoury. Originally from Japanese meaning delicious flavour (*Umami* :旨味 : 진미). Fundamental taste in Chinese, Korean, and Japanese, but not much considered in Western cuisine. Rich in glutamate: cheese, soy sauce, and fish sauce.
    - Beef, lamb, parmesan
    - MSG (monosodium glutamate, 일본의 화학자 이케다 기쿠나에가 다시마의 맛 성분이 글루탐산임을 발견하고 MSG의 합성법을 특허등록) causes umami.

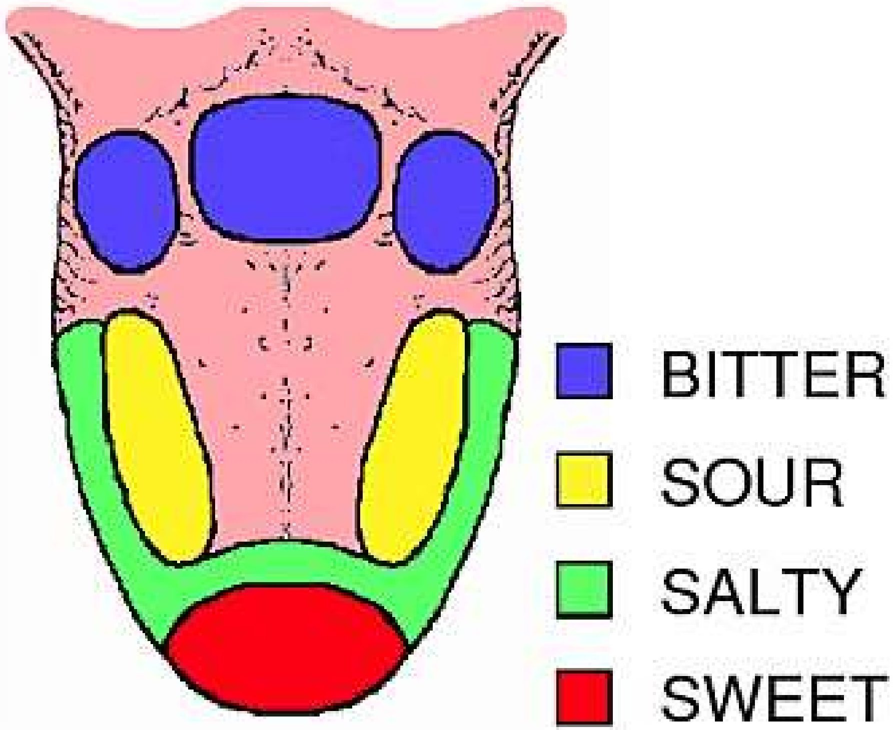
More Sensations on Tongue

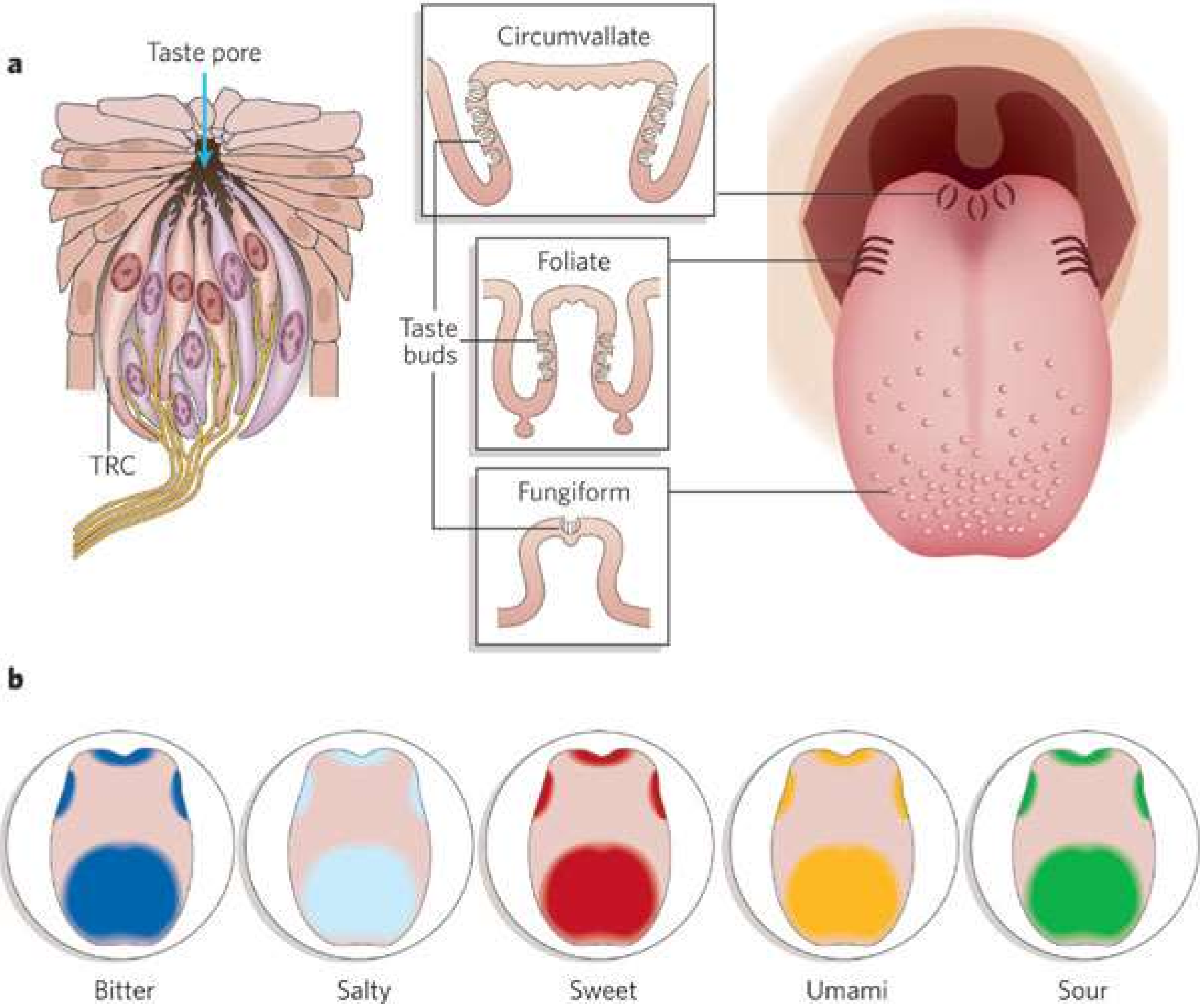
- Temperature
- Coolness: cool sensations such as fresh and minty
- Spiciness or hotness: ethanol and capsaicin for burning sensations. Notable in Mexican, Szechuan, Korean, Indonesian, and Vietnamese.
- Numbness: due to chili pepper.
- Fat or fatty acids
- Kokumi (농후미(일본식 표현: 코쿠미)): Japanese term for mouthfulness
- Kassaya: Indian term for sensation from tea, grapes, etc
- Metallic taste: taste such as blood in mouth



- **Taste Sensitive Areas in the Tongue**
- Tip: sensitive to all 4 qualities
- Anterolateral: salty
- Lateral: sour
- Back: bitter






a
Taste pore
TRC
Circumvallate
Foliate
Taste buds
Fungiform
b
Bitter
Salty
Sweet
Umami
Sour

Factors that Affects Taste Perception

- Aging
- Color/vision impairments
- Hormonal influences.
- Genetic variations
- Oral temperature
- Drugs and chemicals
- Temporal lobe lesions/tumors
- Plugged noses

Aftertaste

- Aftertaste is the persistence of a sensation of flavor after the stimulating substance has passed out of contact with the sensory end organs for taste. Some aftertastes may be pleasant, others unpleasant.
- Alcoholic beverages such as wine, beer and whiskey are noted for having particularly strong aftertastes. Food stuffs with notable aftertastes include spicy food, such as Mexican food (e.g. chili pepper), or Indian food (such as curry).

Taste Buds

- Taste bud and its function
  - Fig. 53-1
  - Taste bud: diameter of 1/30mm, length of about 1/16 mm, composed of 50 modified epithelial cells
  - Some of them are supporting cells called sustentacular cells
  - Others are taste cells
  - Taste cells are continually being replaced by surrounding epithelial cells. Some taste cells are young and some are mature.
  - Life span of each taste cells is about 10 days in lower mammals, but unknown for humans
  - Taste pore in Fig. 53-1

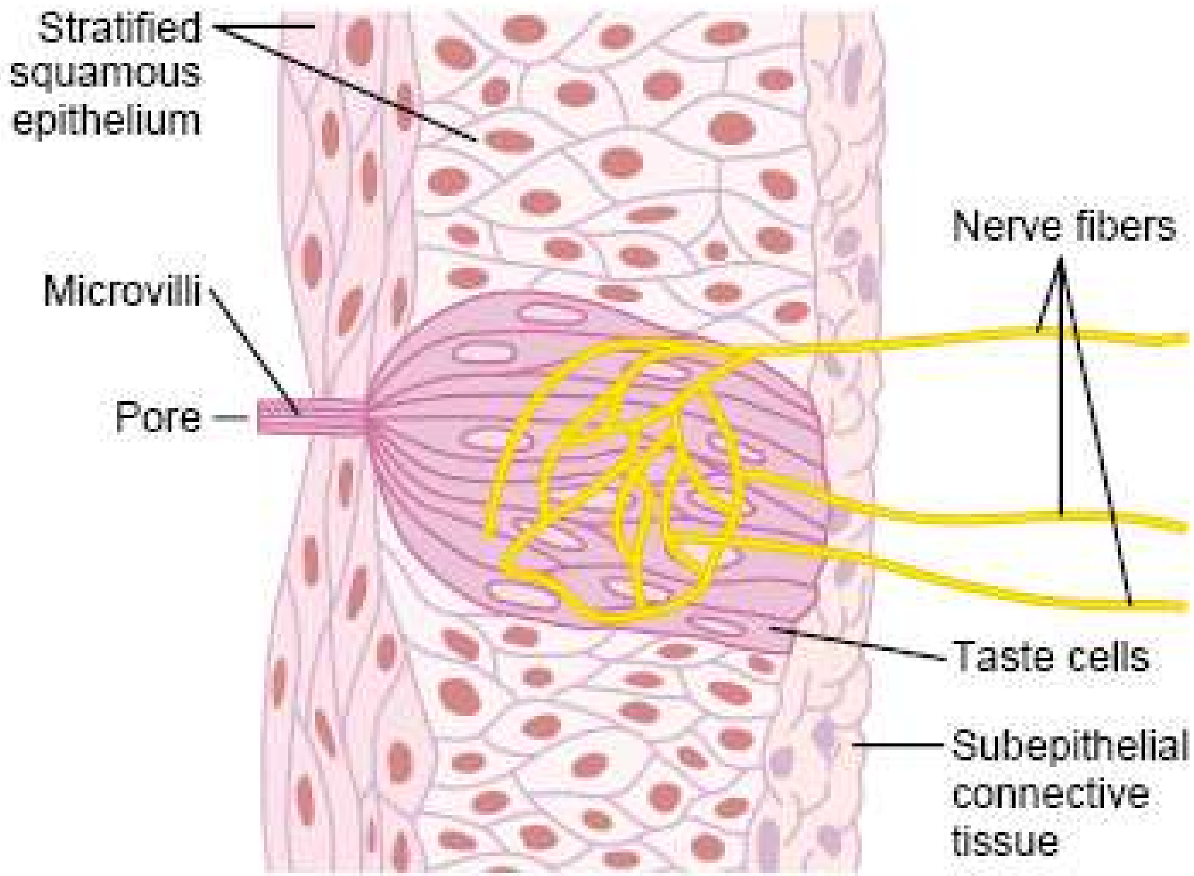
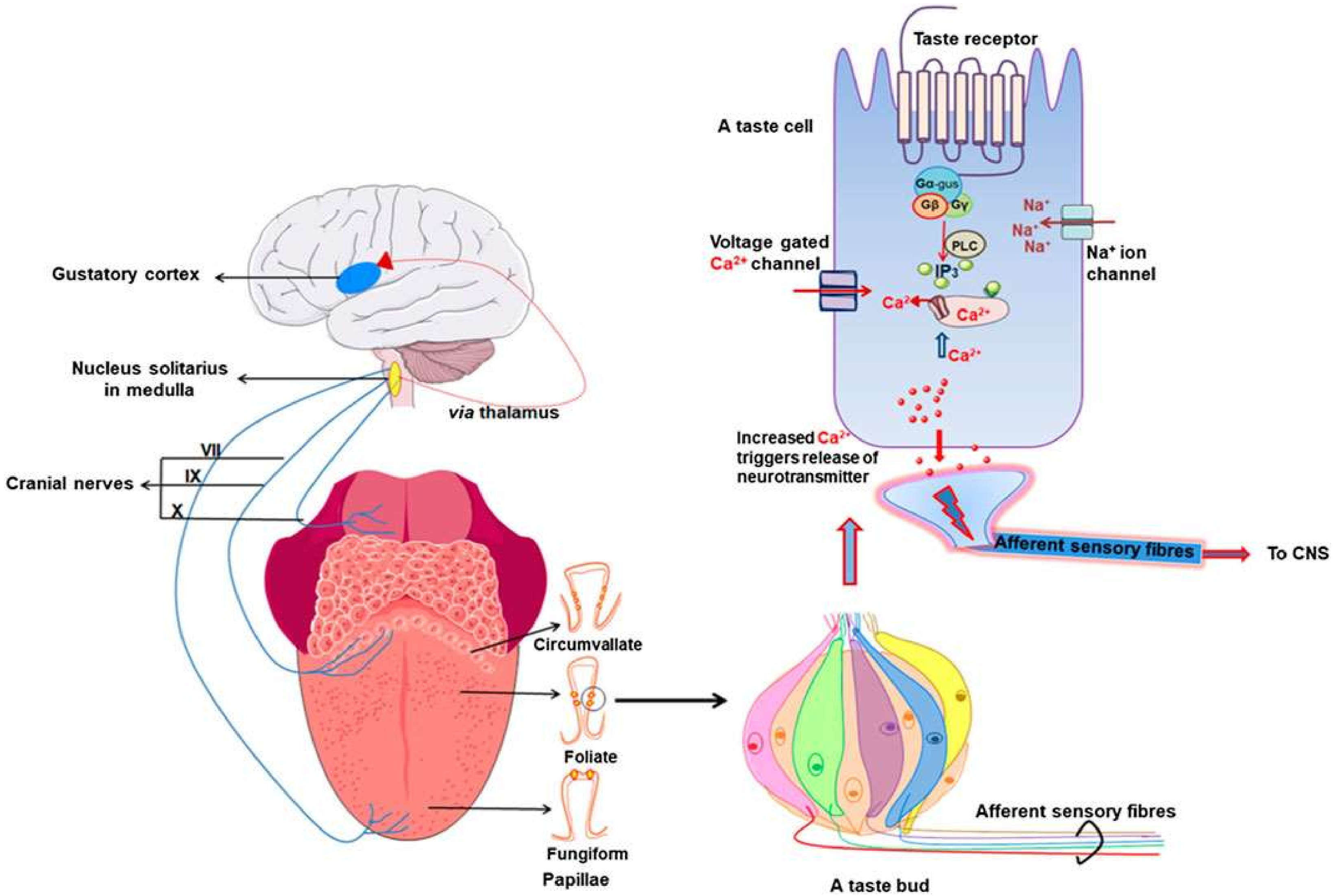
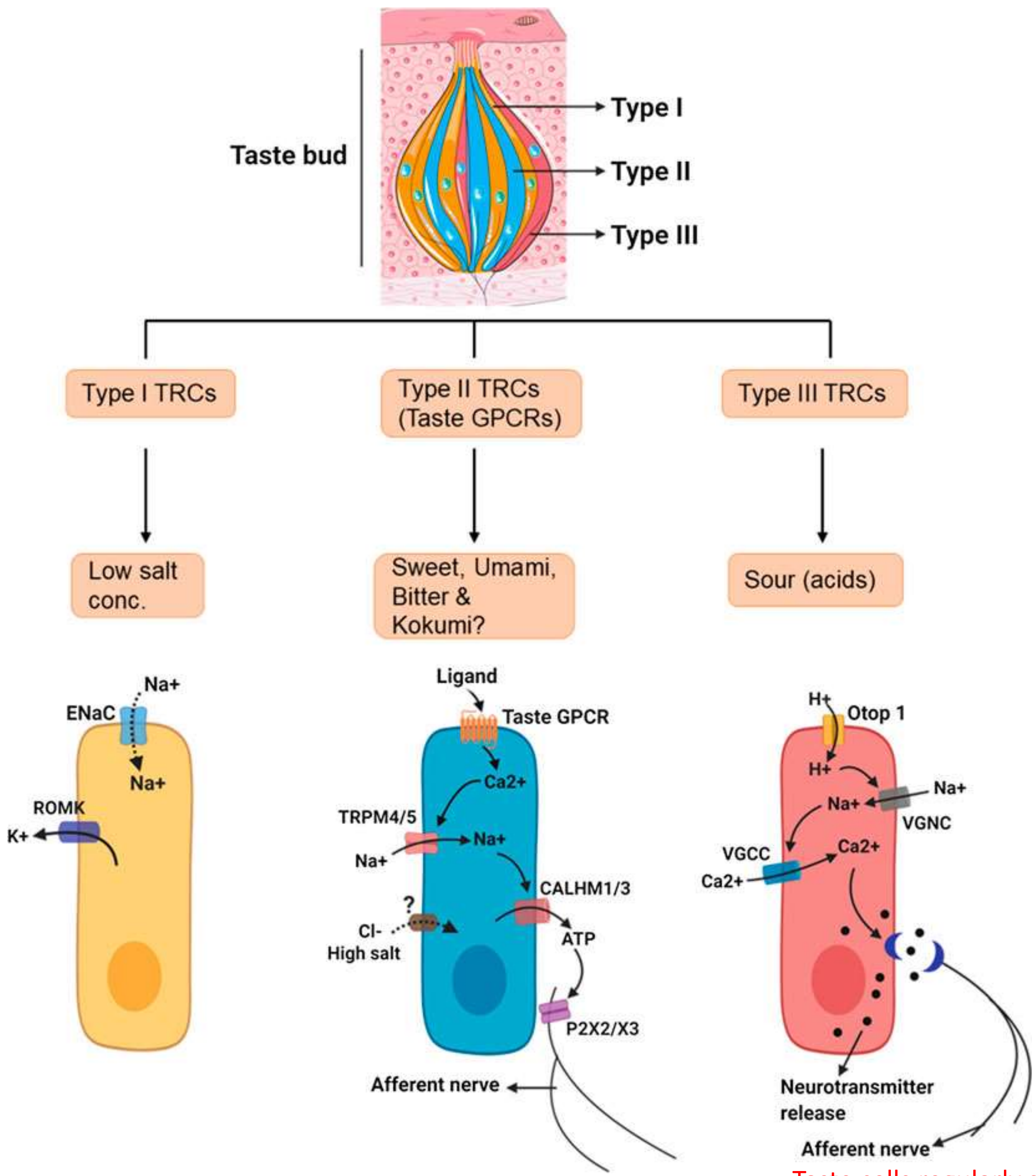


Figure 53–1

Taste bud.



Schematic diagram shows taste signal transmission between tongue and brain. Taste buds present in different papillae in tongue and palate contain taste receptor cells (TRC) which contain taste G protein-coupled receptors (GPCRs). Left side shows how afferent nerves transmit a signal to the gustatory cortex in brain via cranial/glossopharyngeal nerves. Right side shows taste bud with taste TRCs and simplified signal transduction pathway of taste receptor where taste GPCRs are activated by a tastant that in turn recruits a specific G protein that further induces intracellular calcium release.
https://www.frontiersin.org/articles/10.3389/fphar.2020.587664/full



Schematic representation of different types of taste receptor cells (TRCs) in taste bud with their attributed taste modalities and signal transduction.

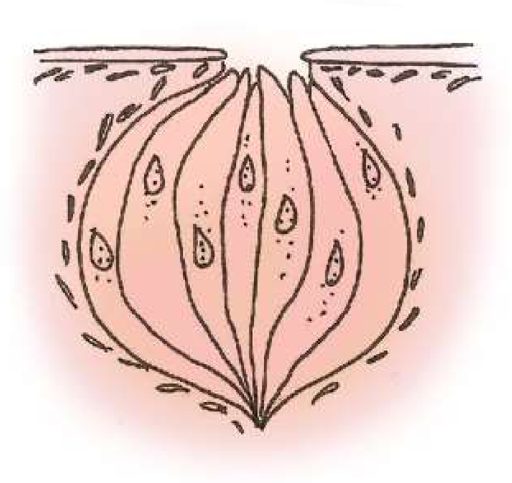
- Type I TRCs exhibit a support function similar to glial cells and express enzymes and transporters that remove extracellular neurotransmitters, and ion channels linked with the redistribution and spatial buffering of K+.

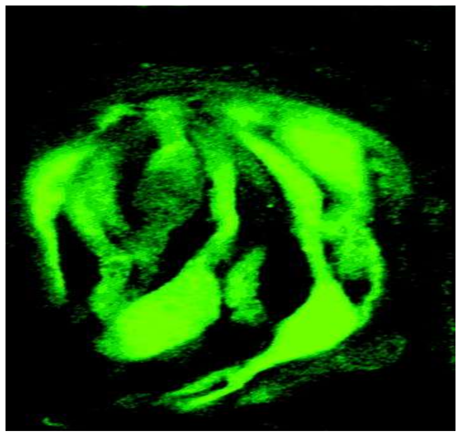
- Type II TRCs are receptor cells and express G protein-coupled receptors (GPCRs) on their surface that respond to sweet, umami and bitter tasting stimuli. The type II TRCs are fine-tuned and express either type 1 (TAS1R2/TAS1R3: sweet and TAS1R1/TAS1R3: umami) or type 2 taste (TAS2Rs; bitter) GPCRs and correspondingly respond to sweet/umami or bitter stimuli. Moreover, three isoforms of type 1 taste GPCRs (TAS1R1, TAS1R2 and TAS1R3) are often co-expressed and responses to both sweet and umami stimuli can be detected in the same cell. Interestingly, recent studies reported a novel subpopulation of cells with type II TRCs that transduce a signal in response to high salt concentrations (>150 mM) (AI)

- Type III TRCs are the least abundant and sense sour stimuli through the proton selective channel. As a consequence of expressing several synaptic proteins, they are termed presynaptic cells. Although both Type II and Type III TRCs require action potentials for transmitter release, their working mechanisms are quite different. Whereas, type III TRCs use a conventional synapse and SNARE mechanism like that in neurons to affect the release of synaptic vesicles, type II TRCs rely on action potentials to trigger the release of ATP through voltage gated channels

Taste cells regularly generate action potentials, but their functional significance in taste signaling is unclear!!!

- Taste hairs or microvilli protrude outward into the taste pore to approach the cavity of the mouth, providing the receptor surface the taste
- Taste nerve fibers stimulated by taste receptor cells
- Specificity of taste buds for the primary taste stimuli: each taste bud usually responds to only one of the four primary taste stimuli when the taste substance is in low concentration. But in high concentration, most buds can be excited by two, three, or even four of the primary taste stimuli.





- Mechanism of stimulation of taste buds
  - Receptor potential: taste cell becomes depolarized (loss of negative potential)
  - Decrease in potential is proportional to the log of concentration of the stimulating substance.
  - This change in electrical potential in the taste cell is the receptor potential for taste
  - Generation of nerve impulses by the taste bud: the rate of discharge of the nerve fibers from taste buds rises to a peak in a small fraction of a second but then adapts within the next 2 sec back to a lower, steady level even though the taste stimulus still remains.
  - A strong immediate signal is transmitted by the taste nerve, and a weaker continuous signal is transmitted as long as the taste bud is exposed to the taste stimulus.

- Transmission of taste signals into the central nervous system: Fig. 53-2
- Taste reflexes integrated in the brain stem: control the secretion of saliva during the ingestion of food
- Adaptation of taste: taste sensations adapt rapidly, often almost completely within a minute or so of continuous stimulation. Yet the major adaptation happens in the CNS, not at the receptor level. Different from most receptors we have learned.
- Taste preference and control of diet
  - Taste preference: needs of the body
  - Taste aversion

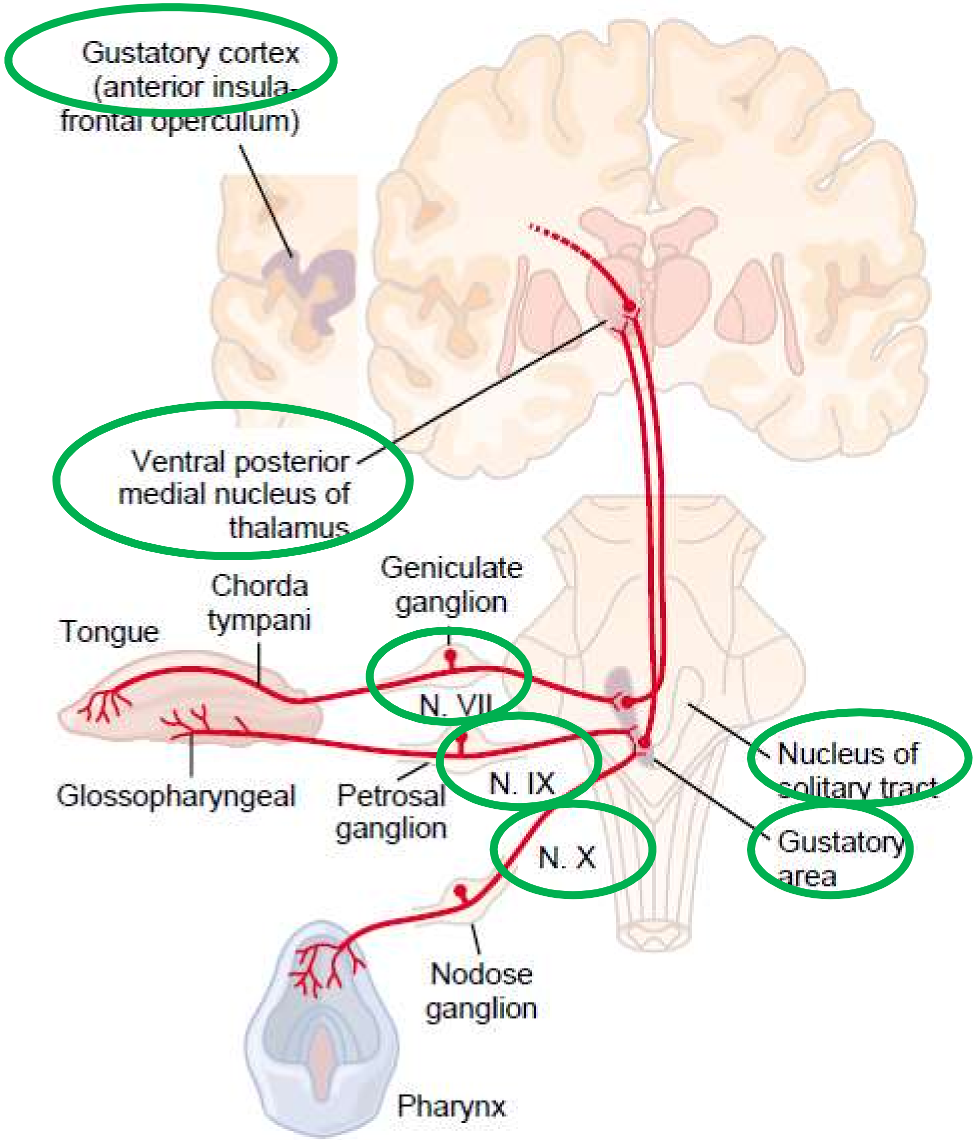
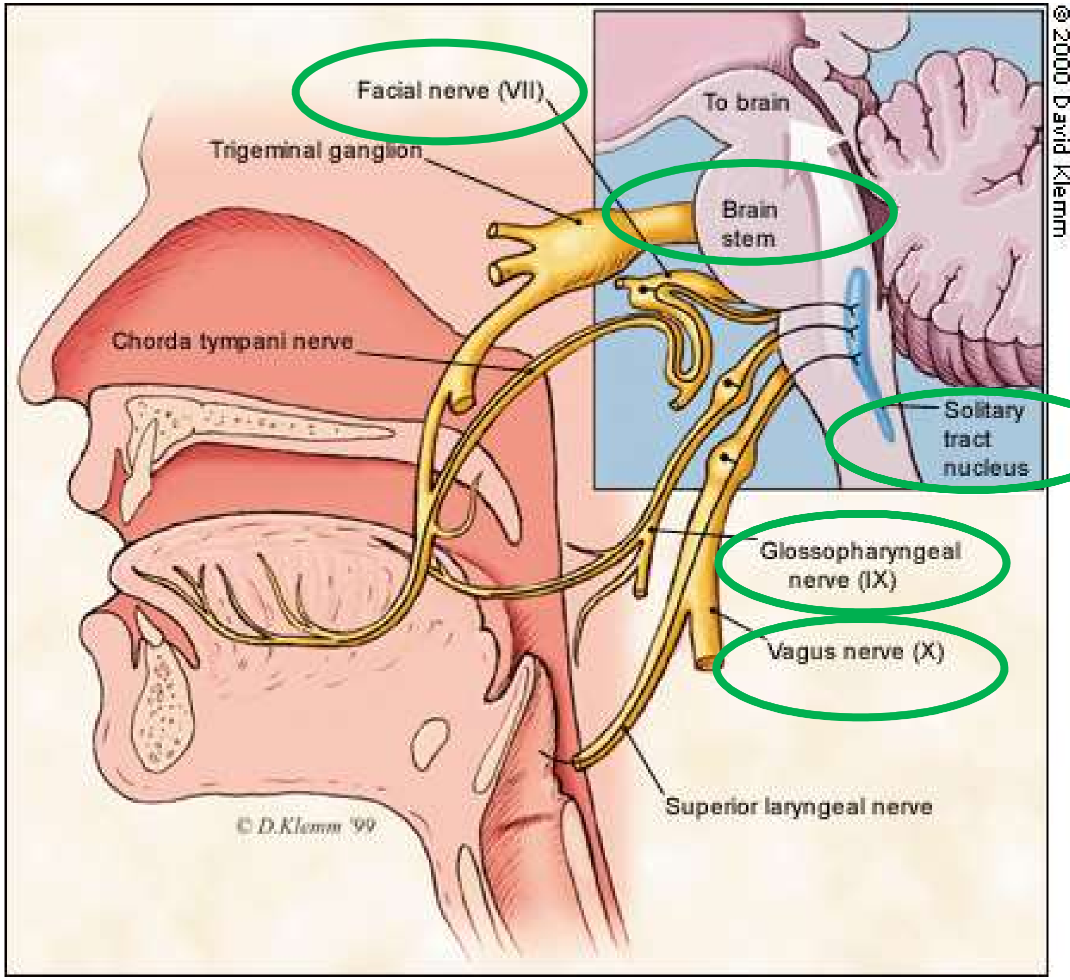
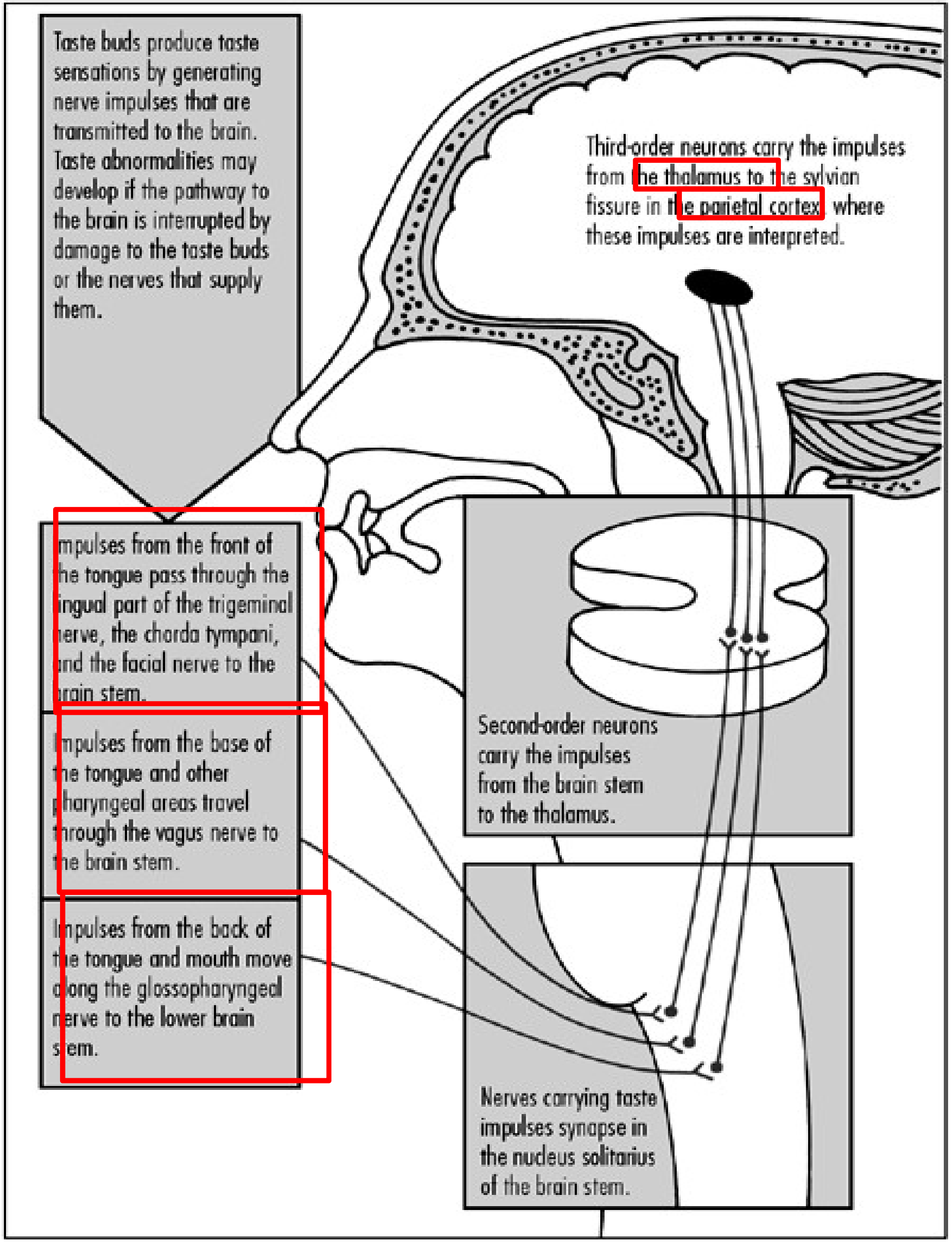


Figure 53–2

Transmission of taste signals into the central nervous system.

Anatomy of peripheral taste pathways. Multiple nerves, including cranial nerves VII, IX and X, transmit taste information from the mouth and pharynx to the brain via the brain stem.



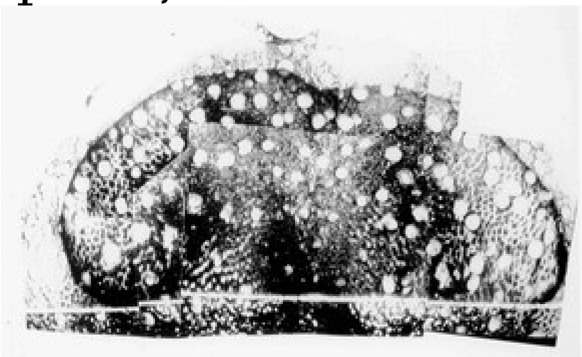

Taste buds produce taste sensations by generating nerve impulses that are transmitted to the brain. Taste abnormalities may develop if the pathway to the brain is interrupted by damage to the taste buds or the nerves that supply them.
Third-order neurons carry the impulses from the thalamus to the sylvian fissure in the parietal cortex, where these impulses are interpreted.
Impulses from the front of the tongue pass through the lingual part of the trigeminal nerve, the chorda tympani, and the facial nerve to the brain stem.
Impulses from the base of the tongue and other pharyngeal areas travel through the vagus nerve to the brain stem.
Impulses from the back of the tongue and mouth move along the glossopharyngeal nerve to the lower brain stem.
Second-order neurons carry the impulses from the brain stem to the thalamus.
Nerves carrying taste impulses synapse in the nucleus solitarius of the brain stem.

Disorders of taste

- Ageusia: complete loss
- Hypogeusia: partial loss
- Parageusia: unpleasant taste
- Dysgeusia: inaccurate taste

A **supertaster** is a person who experiences taste with far greater intensity than average. Women are more likely to be supertasters,

- A - Top surface of the tongue of a non-taster.
- B - Tongue of a supertaster. The small circles are fungiform papillae, each of which contains about six taste buds.



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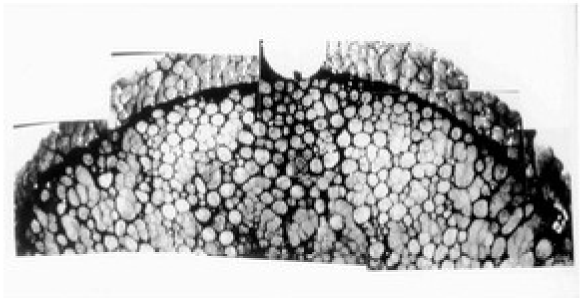

B

https://www.youtube.com/watch?v=K9JSBzEEA0o&ab_channel=AlilaMedicalMedia

Artificial Tongue

- Korean scientists develop electronic tongue
  - https://www.youtube.com/watch?v=-VHaHxAIDMs

- Artificial tongue detects fake whisky
  - https://youtu.be/mRD_v_hHeYA