Neurophysiology

Gustation

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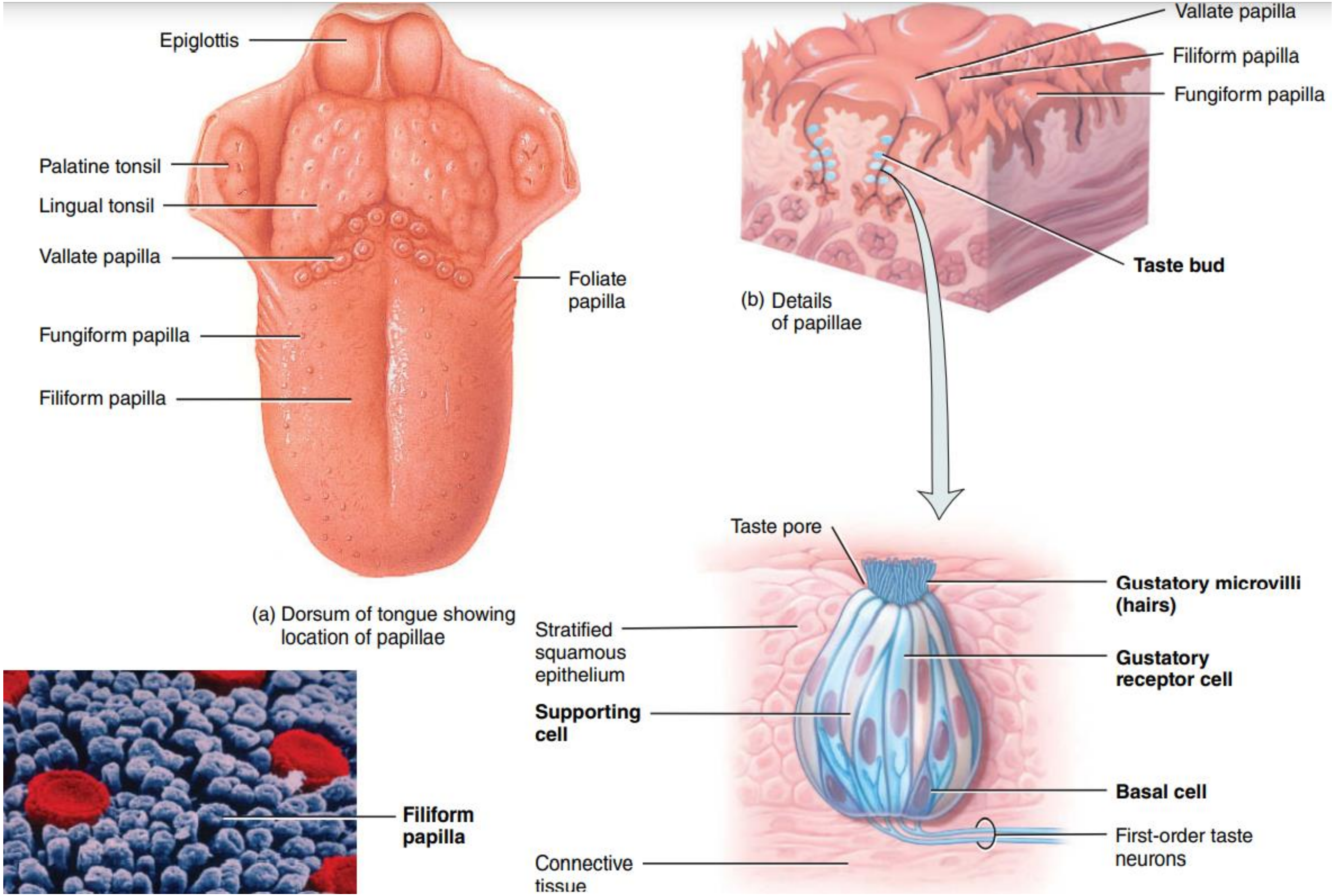
Taste



(a) Dorsum of tongue showing location of papillae

(b) Details of papillae

Sense of taste

- Taste is mainly a function of the taste buds in the mouth, but it is common experience that one's sense of smell also contributes strongly to taste perception. In addition, the texture of food, as detected by tactual senses of the mouth, and the presence of substances in the food that stimulate pain endings, such as pepper, greatly alter the taste experience.

- The importance of taste lies in the fact that it allows a person to select food in accord with desires and often in accord with the body tissues' metabolic need for specific substances.

Primary sensations of taste

- They are sour, salty, sweet, bitter, and “umami.”

- A person can perceive hundreds of different tastes. They are all thought to be combinations of the elementary taste sensations, just as all the colors we can see are combinations of the three primary colors.

Sense of taste

- **Sour Taste**. The sour taste is caused by acids—that is, by the hydrogen ion concentration—and the intensity of this taste sensation is approximately proportional to the logarithm of the hydrogen ion concentration.

- **Salty Taste**. The salty taste is elicited by ionized salts, mainly by the sodium ion concentration. The quality of the taste varies somewhat from one salt to another because some salts elicit other taste sensations in addition to saltiness. The cations of the salts, especially sodium cations, are mainly responsible for the salty taste, but the anions also contribute to a lesser extent.

Sense of taste

- **Umami Taste**. Umami, a Japanese word meaning “delicious,” designates a pleasant taste sensation that is qualitatively different from sour, salty, sweet, or bitter. Umami is the dominant taste of food containing L-glutamate, such as meat extracts and aging cheese.

Sense of taste

- **Sweet Taste**. The sweet taste is not caused by any single class of chemicals. Some of the types of chemicals that cause this taste include sugars, glycols, alcohols, aldehydes, ketones, amides, esters, some amino acids, some small proteins, sulfonic acids, halogenated acids, and inorganic salts of lead and beryllium.

- Note specifically that most of the substances that cause a sweet taste are organic chemicals.

Sense of taste

- **Bitter Taste**. like the sweet taste, is not caused by a single type of chemical agent. They are mostly organic substances, such as long-chain organic substances that contain nitrogen and alkaloids, which include many of the drugs used in medicines, such as quinine, caffeine, strychnine, and nicotine. Some substances that initially taste sweet have a bitter aftertaste, such as saccharin.

- The bitter taste, when it occurs in high intensity, usually causes the person or animal to reject the food. This reaction is important because many deadly toxins found in poisonous plants are alkaloids, and virtually all of these alkaloids cause an intensely bitter taste.

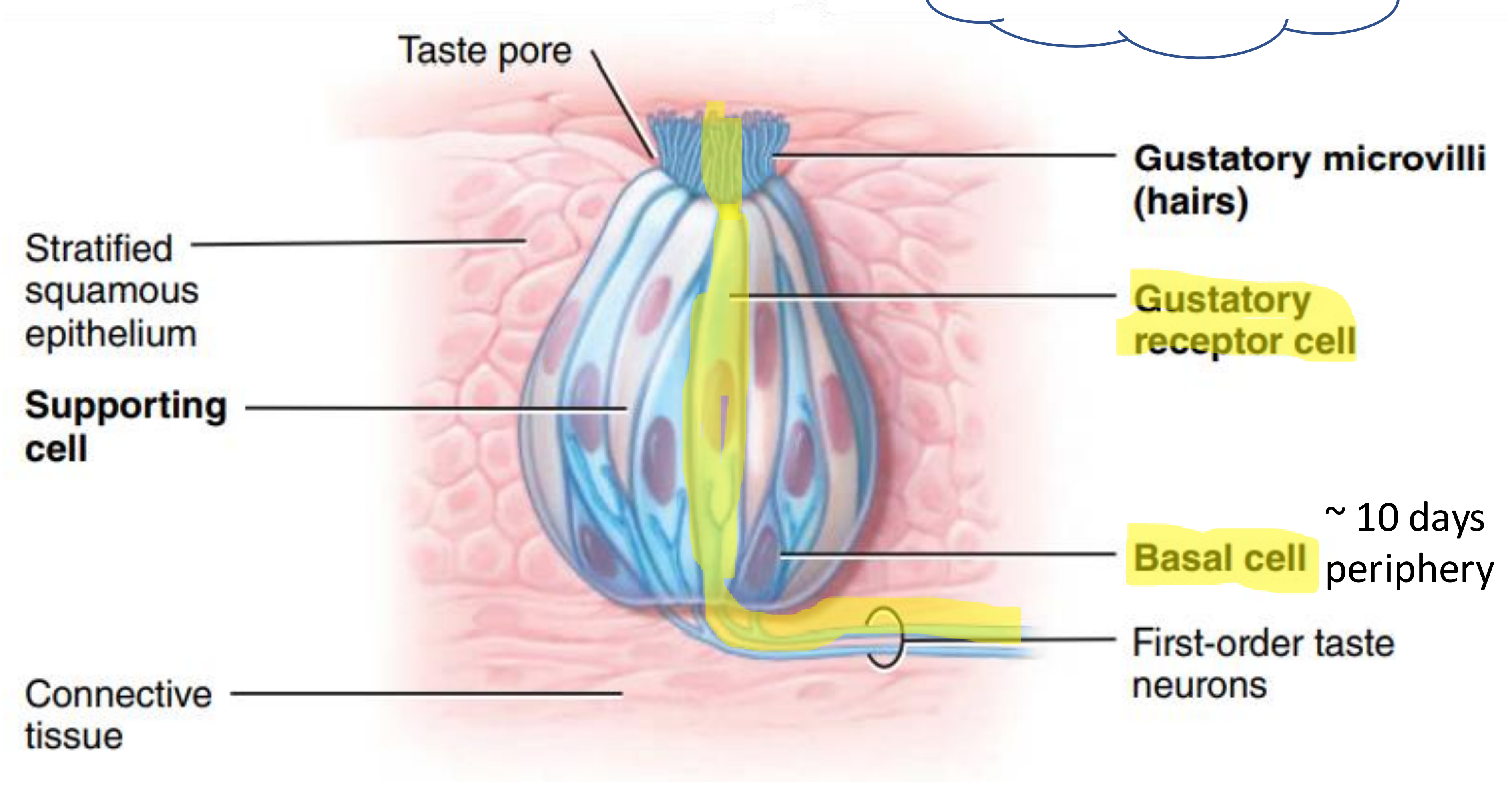
Threshold for taste

- The threshold for stimulation of the sour taste by hydrochloric acid averages 0.0009 M; for stimulation of the salty taste by sodium chloride, 0.01 M; for the sweet taste by sucrose, 0.01 M; and for the bitter taste by quinine, 0.000008 M.

- Note especially how much more sensitive the bitter taste sense is than all the others, which would be expected, because this sensation provides an important protective function against many dangerous toxins in food.

Taste bud

No. Decreases with age, so the taste sensitivity



~ 10 days
periphery

Taste buds

- The taste bud is composed of about 50 modified epithelial cells, some are supporting cells and others are taste cells.

- The taste cells are continually being replaced by mitotic division of surrounding epithelial cells, so some taste cells are young cells. Others are mature cells that lie toward the center of the bud; these cells soon break up and dissolve.

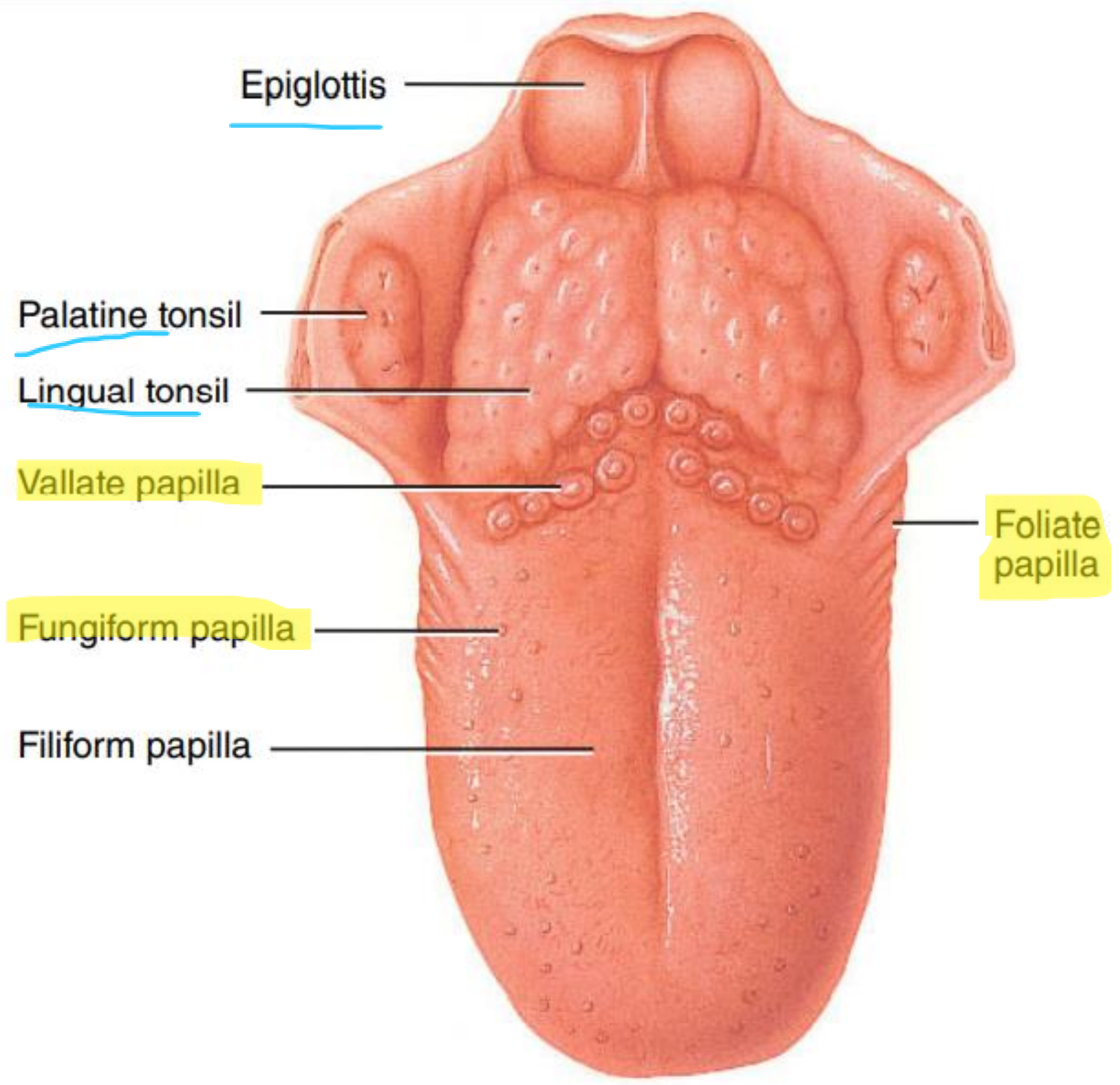
- Adults have about 10,000 taste buds, and children have a few more. Beyond the age of 45 years, many taste buds degenerate, causing taste sensitivity to decrease in old age.

Taste buds

- The average life span of each taste cell is about 10 days.
- The outer tips of the taste cells are arranged around a minute taste pore. From the tip of each taste cell, several microvilli protrude outward into the taste pore to approach the cavity of the mouth. These microvilli provide the receptor surface for taste.

- Interwoven around the bodies of the taste cells is a branching terminal network of taste nerve fibers that are stimulated by the taste receptor cells.

- Many vesicles form beneath the cell membrane near the fibers. It is believed that these vesicles contain a neurotransmitter substance that is released through the cell membrane to excite the nerve fiber endings in response to taste stimulation.



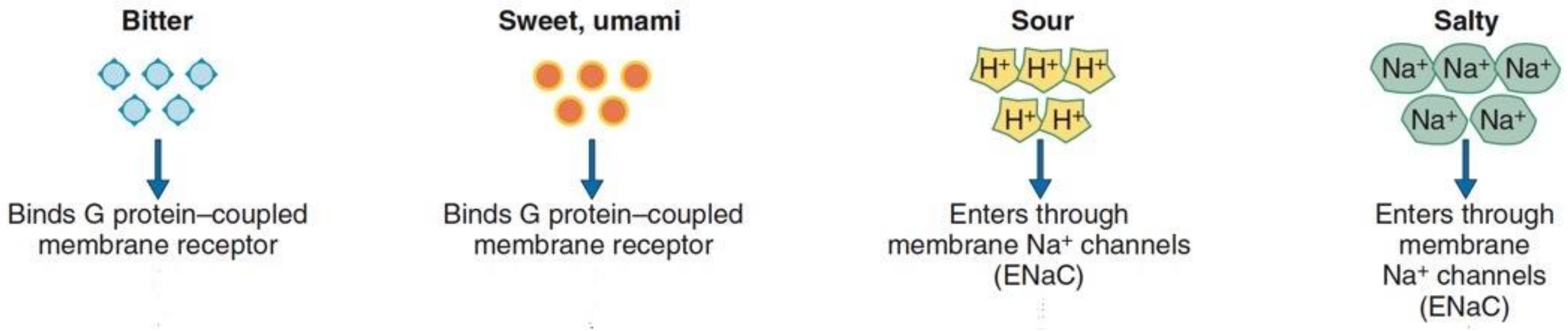
Epiglottis
Palatine tonsil
Lingual tonsil
Vallate papilla
Fungiform papilla
Filiform papilla
Foliate papilla

Location of taste buds

- The taste buds are found on three types of papillae of the tongue, as follows:
- (1) a large number of taste buds are on the walls of the troughs that surround the **circumvallate papillae**, which form a V line on the surface of the posterior tongue.
- (2) moderate numbers of taste buds are on the **fungiform papillae** over the flat anterior surface of the tongue.
- (3) moderate numbers are on the **foliate papillae** located in the folds along the lateral surfaces of the tongue.

- Additional taste buds are located on the palate, and a few are found on the tonsillar pillars, on the epiglottis, and even in the proximal esophagus.

MECHANISMS OF TASTE TRANSDUCTION



Taste transduction

- The mechanism by which most stimulating substances react with the taste villi to initiate the receptor potential is by binding of the taste chemical to a protein receptor molecule that lies on the outer surface of the taste receptor cell near to or protruding through a villus membrane.

- This action, in turn, opens ion channels, which allows positively charged sodium ions or hydrogen ions to enter and depolarize the cell. Then the taste chemical is gradually washed away from the taste villus by the saliva, which removes the stimulus.

Taste transduction

- The type of receptor protein in each taste villus determines the type of taste that will be perceived. For sodium ions and hydrogen ions, which elicit salty and sour taste sensations, respectively, the receptor proteins open specific ion channels in the apical membranes of the taste cells, thereby activating the receptors.

- However, for the sweet and bitter taste sensations, the portions of the receptor protein molecules that protrude through the apical membranes (GPCR) activate second-messenger transmitter substances inside the taste cells, and these second messengers cause intracellular chemical changes that elicit the taste signals.

Taste pathway

- Taste impulses from the anterior two thirds of the tongue pass first into the lingual nerve, then through the chorda tympani into the facial nerve, and finally into the tractus solitarius in the brain stem.

- Taste sensations from the circumvallate papillae on the back of the tongue and from other posterior regions of the mouth and throat are transmitted through the glossopharyngeal nerve also into the tractus solitarius, but at a slightly more posterior level.

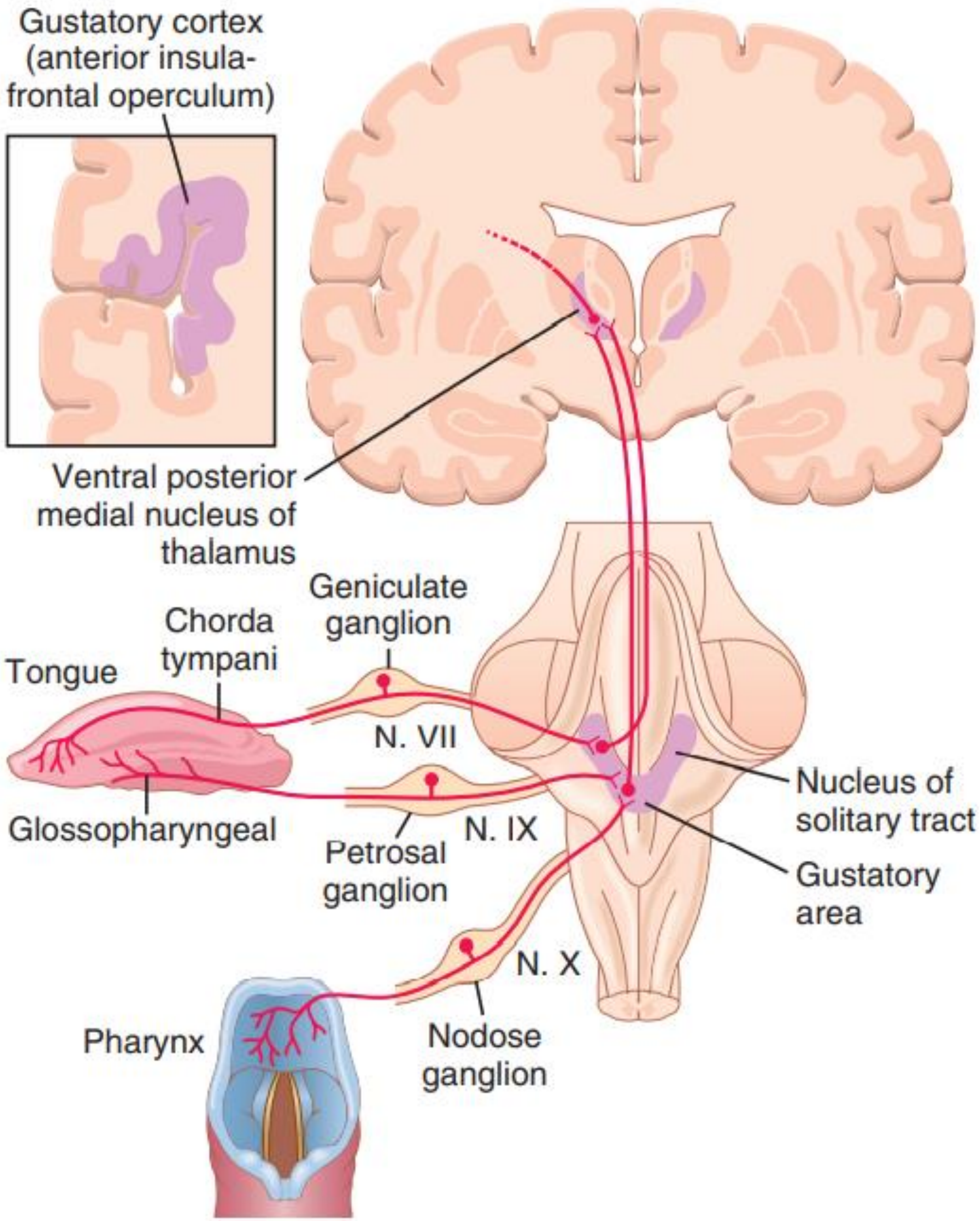
- Finally, a few taste signals are transmitted into the tractus solitarius from the base of the tongue and other parts of the pharyngeal region by way of the vagus nerve.

Taste pathway

- All taste fibers synapse in the posterior brain stem in the nuclei of the tractus solitarius. These nuclei send second-order neurons to a small area of the ventral posterior medial nucleus of the thalamus.

- From the thalamus, third-order neurons are transmitted to the lower tip of the postcentral gyrus in the parietal cerebral cortex, where it curls deep into the sylvian fissure, and into the adjacent opercular insular area. This area lies slightly lateral, ventral, and rostral to the area for tongue tactile signals in cerebral somatic area I.

- From this description of the taste pathways, it is evident that they closely parallel the somatosensory pathways from the tongue.



Gustatory cortex (anterior insula-frontal operculum)
Ventral posterior medial nucleus of thalamus
Geniculate ganglion
Chorda tympani
Tongue
N. VII
Glossopharyngeal
Petrosal ganglion
N. IX
Nucleus of solitary tract
Gustatory area
N. X
Pharynx
Nodose ganglion

Taste reflexes

- From the tractus solitarius, many taste signals are transmitted within the brain stem itself directly into the superior and inferior salivatory nuclei, and these areas transmit signals to the submandibular, sublingual, and parotid glands to help control the secretion of saliva during the ingestion and digestion of food.

References

- Guyton and Hall Textbook of Medical Physiology, 14^{th} ed.
- Principles of Anatomy and Physiology Textbook, Tortora, 15^{th} ed.
- Physiology Textbook,Costanzo, 6^{th} ed.

Thank you