CNS
Doctor 2021

Physiology

Modified (10)

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Neurophysiology

Gustation حاسة التذوُّق

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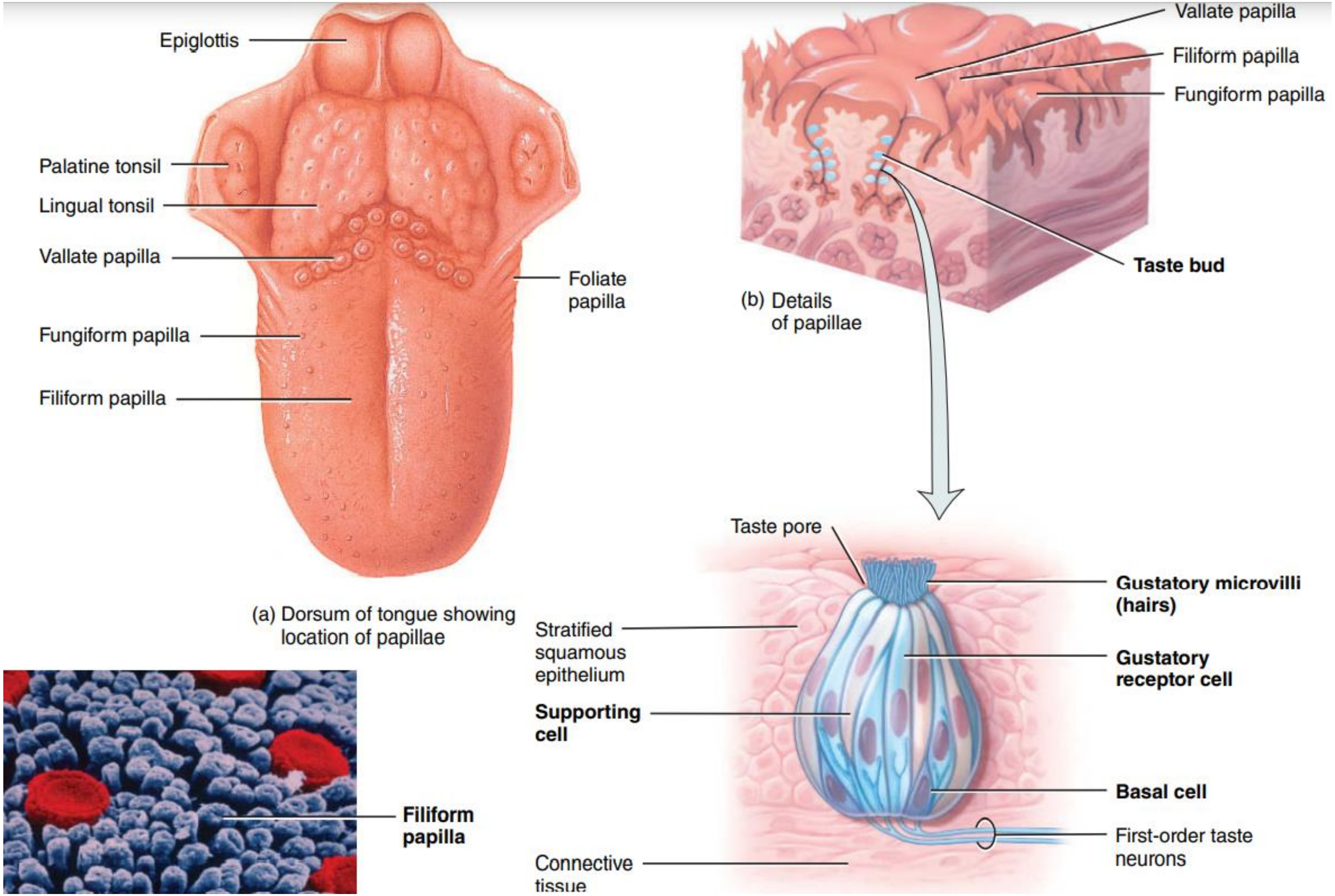
Sense of Taste



Gustation = sense of taste

- It is a chemical sense.
- The chemicals that we ingest in our mouth dissolve in the saliva so they can be detected by the receptor proteins located in the **taste buds** in the oral cavity; however, tasting process is much more complex, it doesn't only involve activation of the taste receptors but also many other sensory receptors are also involved in this experience, so it is a kind of holistic experience. Other receptors involved are:

1. **Olfactory receptors**, when you taste food, you also smell it because some of the volatile particles will go up to the nasal cavity to the olfactory epithelium and we smell food while it's in our mouth, and that contributes to the taste of what we eat. That's why some people with the flu cannot taste well, and it's not that there is a problem with their tasting, but it's because they can't smell well and the experience of tasting is different now, and this will resolve after the flu is gone.
2. **Tactile receptors,** because you want to feel the texture of the food and the movement of it in the oral cavity.
3. **Thermo receptors,** you feel if the food is hot or cold.
4. **Pain receptors** are activated when you taste chili pepper for example.

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.

5 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 (H+)**. 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 (Na+).** 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 (glutamate)**. (A new taste sensation added to the previous 4) 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 (organic chemicals).** The sweet taste is not caused by any single class of chemicals (not just sugar). 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** **(organic chemicals such as alkaloids)**. 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 and it is also why it has the **lowest threshold**.

Q true or false: The reason why bitter taste induces rejection, and it has the lowest threshold among taste sensations, is that the body tries to protect itself from potential poisonous substances.

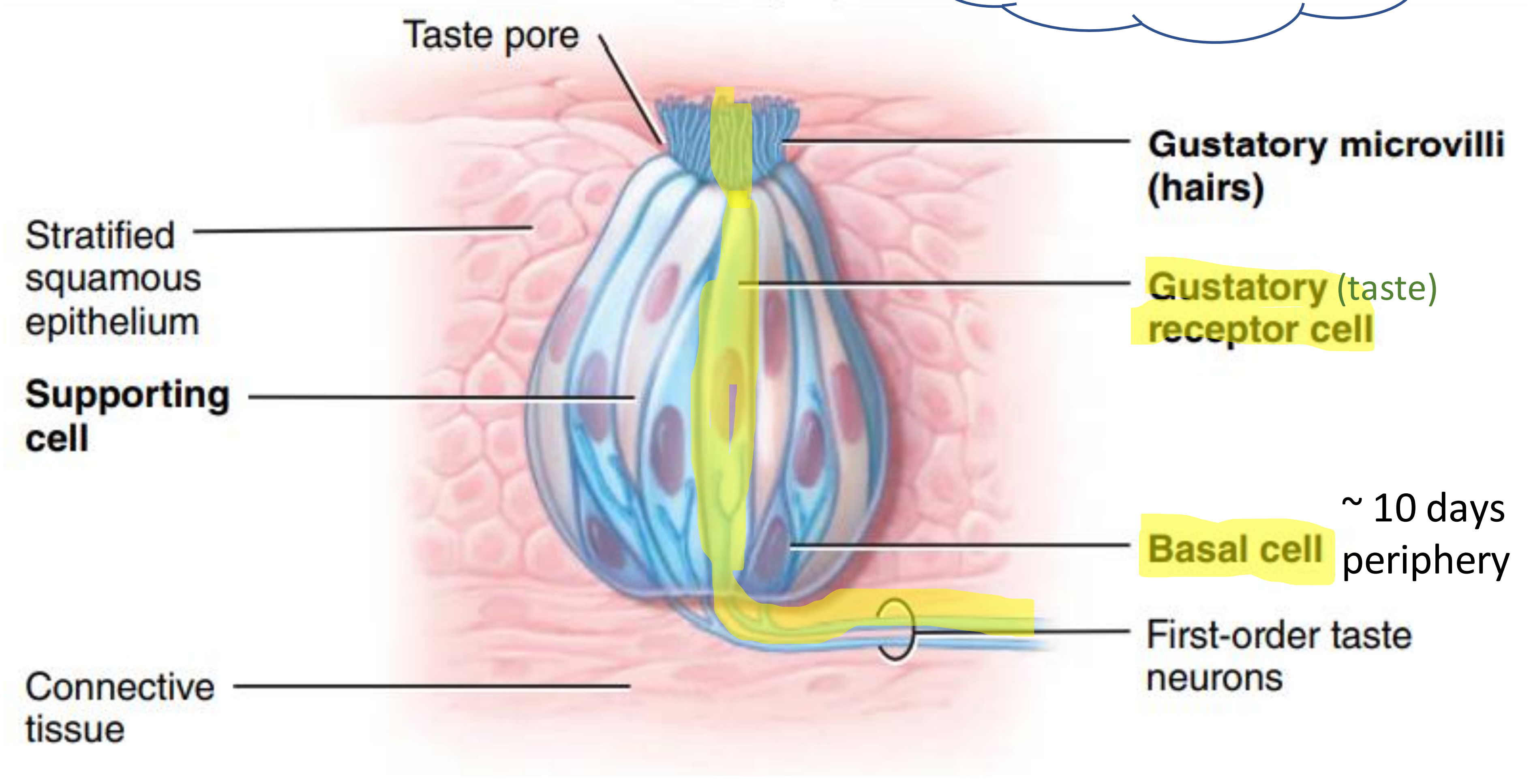
True (remember many toxins are alkaloids, which have bitter taste.)

Threshold for taste

- Taste in general has low threshold, but it varies with different categories of the 5 senses.
- 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



Taste buds

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

1. Taste receptors cells (with microvilli on top which contain the receptor proteins) and the body of these cells are connected to the 1st order taste neurons.
2. Supporting or sustentacular cells.
3. Basal cells (which help in regeneration of receptor cells).

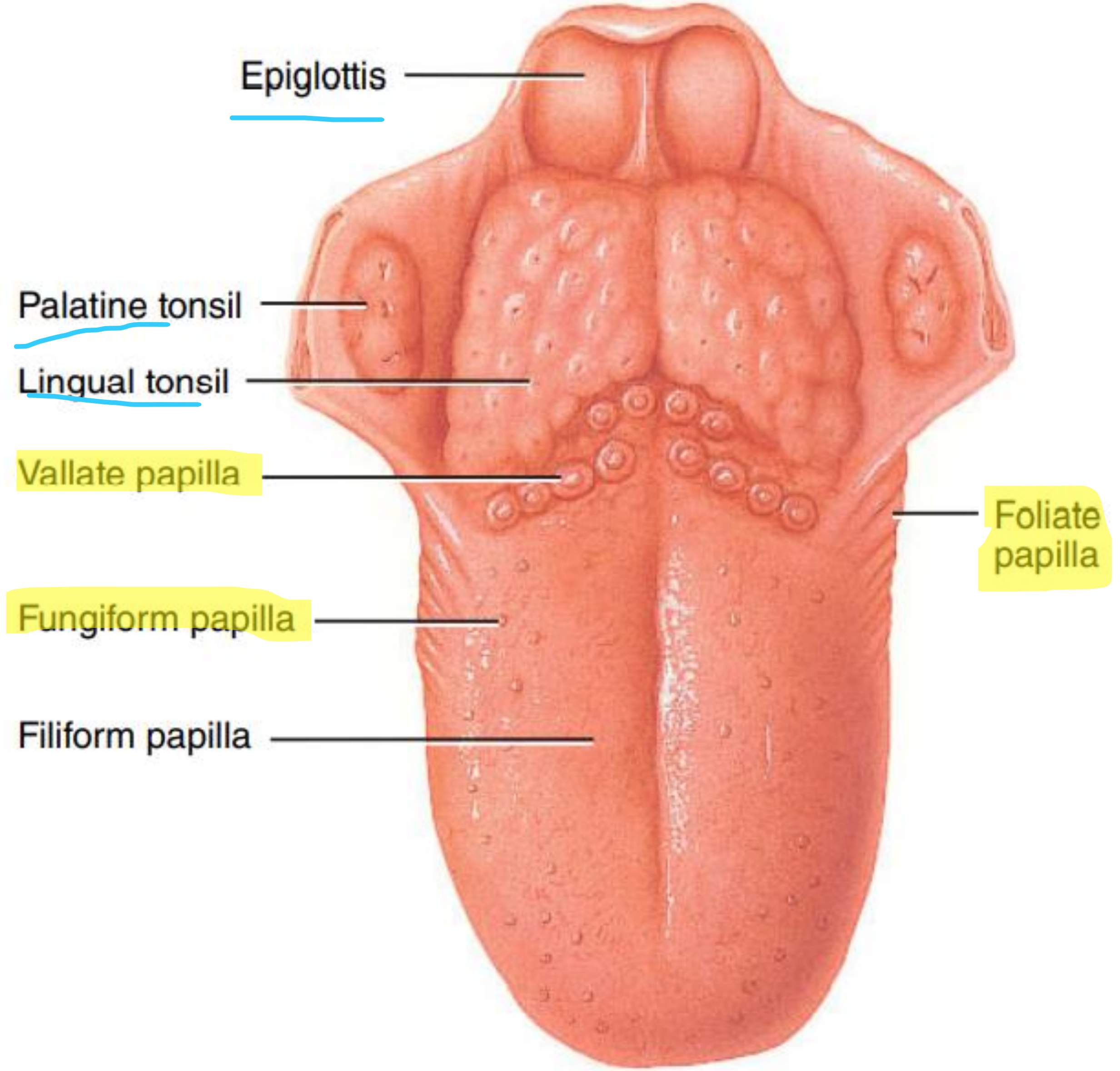
- The taste cells are continually being replaced by mitotic division of surrounding epithelial cells, a new taste receptor cell will be on the periphery then it will go all the way to the center, so some taste cells are young cells (in the periphery). Others are mature cells that lie toward the center 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.

Q: Where are the taste buds located?

Proximal part of the pharynx✓

Anterior part of the tongue✓

Palate✓

Tonsillar pillars✓

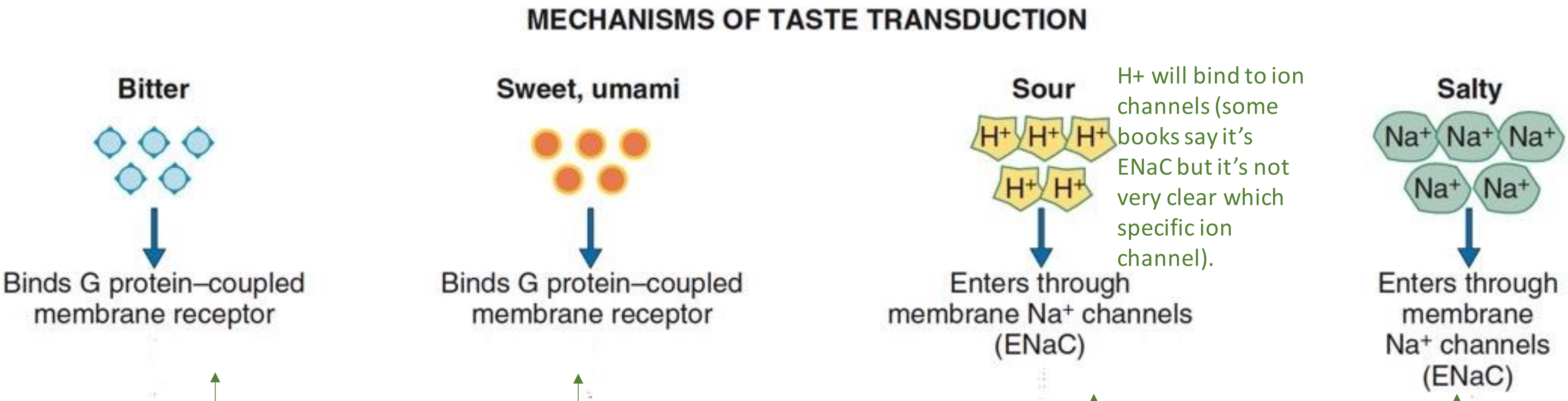
Posterior part of the tongue✓

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 (after being dissolved in the saliva) 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 (the higher the concentration of the substance, the higher depolarizing magnitude). Then the taste chemical is gradually washed away from the taste villus by the saliva, which removes the stimulus (the concentration of the tasting substance will decrease rapidly).

Taste transduction is different according to different types of tastes.



H+ will bind to ion channels (some books say it's ENaC but it's not very clear which specific ion channel).

G protein receptors of different types.

Act on ion channels

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

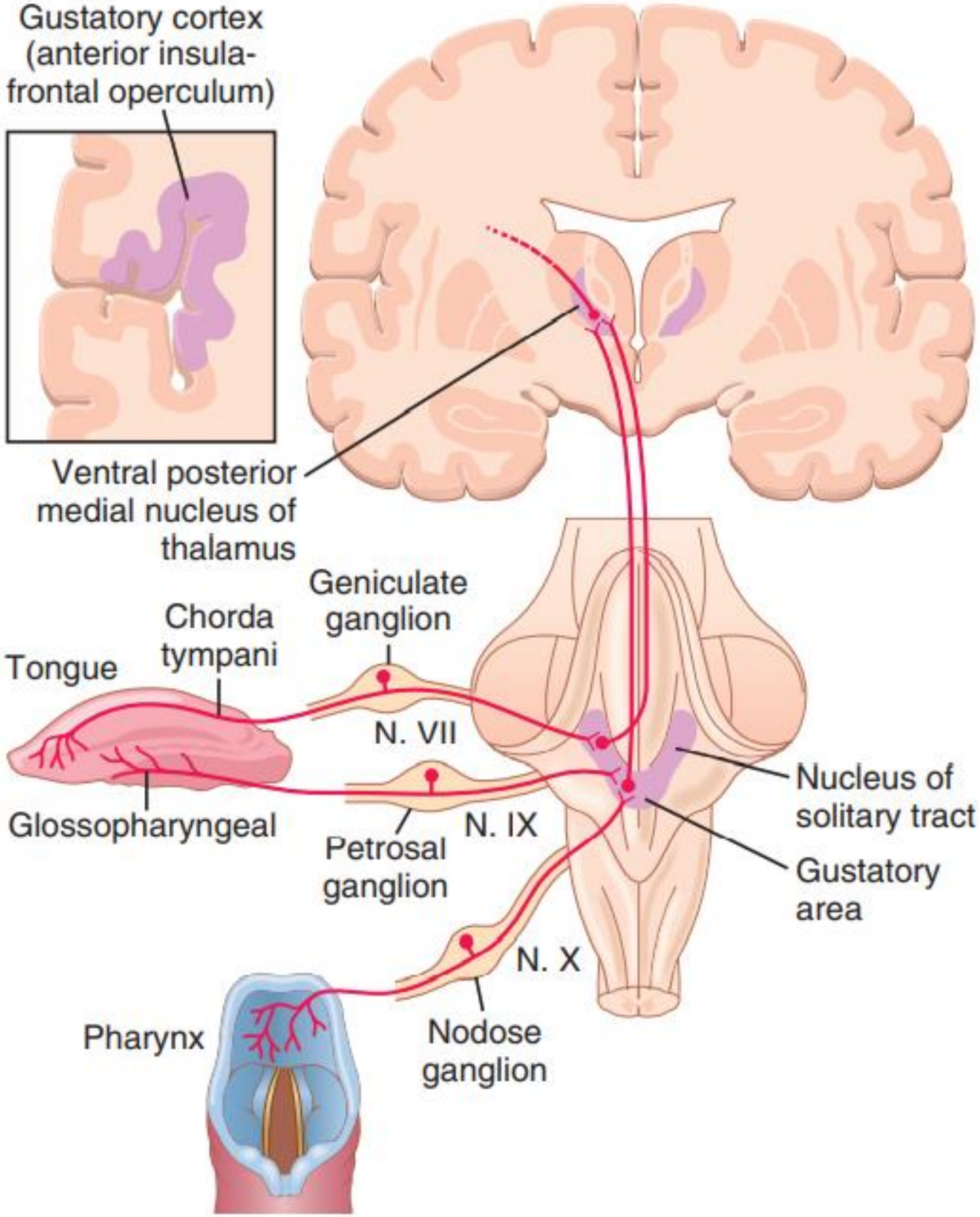
- After signal transduction, receptor potential develops at the taste receptor cells and that will activate 1st order neurons and if it reaches the threshold there will be generation of action potential.
- Unlike the previous special senses that we learned about before, which were transmitted by one nerve (vision through the optical nerve and olfaction through the olfactory nerve), taste however is transmitted through three cranial neves from different areas of the oral cavity.
- 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 in the brain stem (where 1st order neurons from all taste sensations terminate), 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 (1st order neurons) 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 (just near the somatosensory signals from the posterior column which are in the VPL (lateral)).

- From the thalamus, third-order neurons are transmitted to the lower tip of the postcentral gyrus in the parietal cerebral cortex (gustatory 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 which makes sense as we learned before because taste is affected by the texture of food.

- 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
Nodose
ganglion
Pharynx

Taste reflexes

- Production of saliva in response to the presence of food in the mouth produces the salivary reflex which follows a different pathway.
- 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, 14th ed.
- Principles of Anatomy and Physiology Textbook, Tortora, 15th ed.
- Physiology Textbook,Costanzo, 6th ed.

Additional 4 minute video summaries the main points :
https://youtu.be/K9JSBzEEA0o?si=L29eghC0MRywXGFd

Thank you

اللهم أغِثّ أهلَ غزة
أشدُّد أزرَهم
اربط على قلوبِهم
اللّهم كُنّ لهم ناصرًا ومُعينًا.