

Lecture:

Chemical Sensations: Smell and Taste

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الرجاء تحويل الجوال إلى وضع
الصامت مع الشكر



The Sensory System

The various sensations in the body include:

- 1. Somatic sensation:** from the skin and deep tissues (e.g. muscles, joints and bones), conducted to CNS through the somatic nerves.
- 2. Special senses:** reaching the CNS through specialized cranial nerves:
 - a. Sense of the vision.
 - b. Sense of the hearing and equilibrium.
 - c. Sense of the smell.
 - d. Sense of the taste.
- 3. Visceral sensation:** including all sensations from the internal viscera and reaching the CNS through the autonomic nerves.
- 4. Organic sensations:** e.g. hunger, thirst and sexual sensations.

Sensory Functional Modalities

1. **General Somatic Afferent (GSA): somatic sensory "afferent" fibers** arise from neurons in sensory ganglia and are found in all the spinal nerves, and conduct general sensations from the surface of the body through the dorsal roots to the spinal cord.
2. **Special Somatic Afferent (SSA): afferent nerves of the special senses**, (fibers include the optic nerve and the vestibulocochlear nerve).
3. **General Visceral Afferent (GVA): conduct sensory impulses (usually pain or reflex sensations)** from the internal organs, glands, and blood vessels to the central nervous system.
4. **Special Visceral Afferent fibers (SVA): afferent fiber that develop in association with the gastrointestinal tract.** They carry the special senses of smell (olfaction) and taste (gustation). The cranial nerves containing SVA fibers are the olfactory nerve (I), the facial nerve (VII), the glossopharyngeal nerve (IX), and the vagus nerve (X).

Special Sensations

- **Special Senses:** reaching the CNS through **specialized cranial nerves:**
 - I. Sense of the vision.
 - II. Sense of the smell.
 - III. Sense of the taste.
 - IV. Sense of the hearing and equilibrium.

I. Sense of the Smell

- **Functional Modality:** mediates the **special visceral afferent modality of smell** via **the olfactory nerve**.
- The axons of the olfactory nerves are **unmyelinated C fibers** and are among the **smallest** and **slowest** in the nervous system.
- Olfactory epithelium is also innervated by **trigeminal nerve**, which detects **noxious** or **painful stimuli**, such as **ammonia**.

- 
- The olfactory pathway has **no precortical relay** in the thalamus.
 - Projects to the thalamus **“Dorsomedial Nucleus”**, hypothalamus, amygdaloid body, and hippocampal formation.

The Olfactory Nerve (CN I)

- **Olfactory Nerve:** (Latin for "to smell").
- **Function:** Special visceral afferent nerve (smell).
- **Olfactory tract** located in the anterior cranial fossa and attached to the inferior surface of the frontal lobe.



The Sense of Smell

The smell sensation is a special sense, which is important:

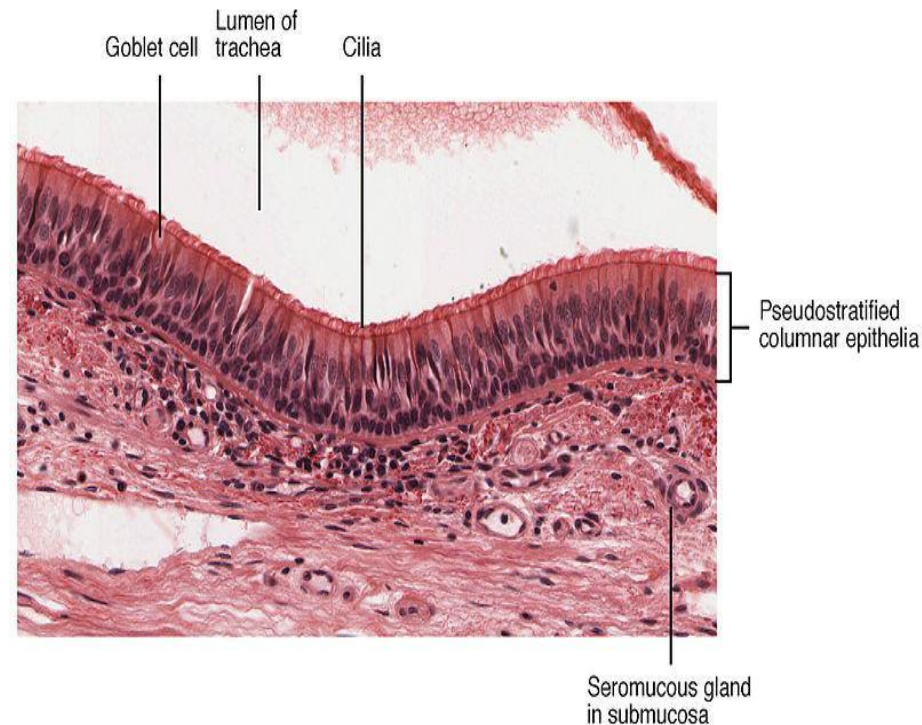
1. It determines the flavors of food (together with taste, touch and thermal sense).
2. It essential for gastrointestinal functions.
3. It is necessary for avoiding dangerous liquids or substance.

Properties of Olfactory Receptors

1. **Sensitivity:** the olfactory receptors are chemoreceptors.
2. **Discrimination of odorants:** the olfactory system can discriminate about 10,000 odors.
3. **Discrimination of odorants intensity.**
4. **Adaptation:** the **olfactory receptors** and **smell center** are adapt rabidly with continuous exposure to an odorant.

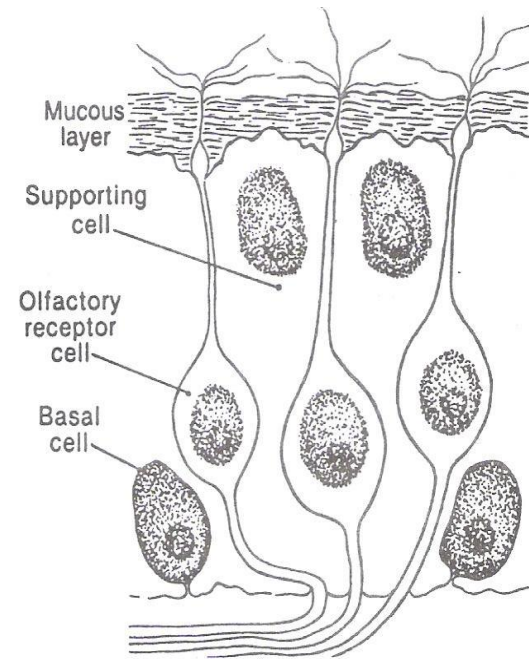
Nasal Epithelium

- Stratified squamous.
- Transitional cuboidal/columnar (non-ciliated).
- Pseudostratified columnar (ciliated).
- **Olfactory Epithelium**
 - Postero-superior nasal cavity.
 - Medial- nasal septum.
 - Lateral- superior turbinate.
 - Total area 2.5cm^3



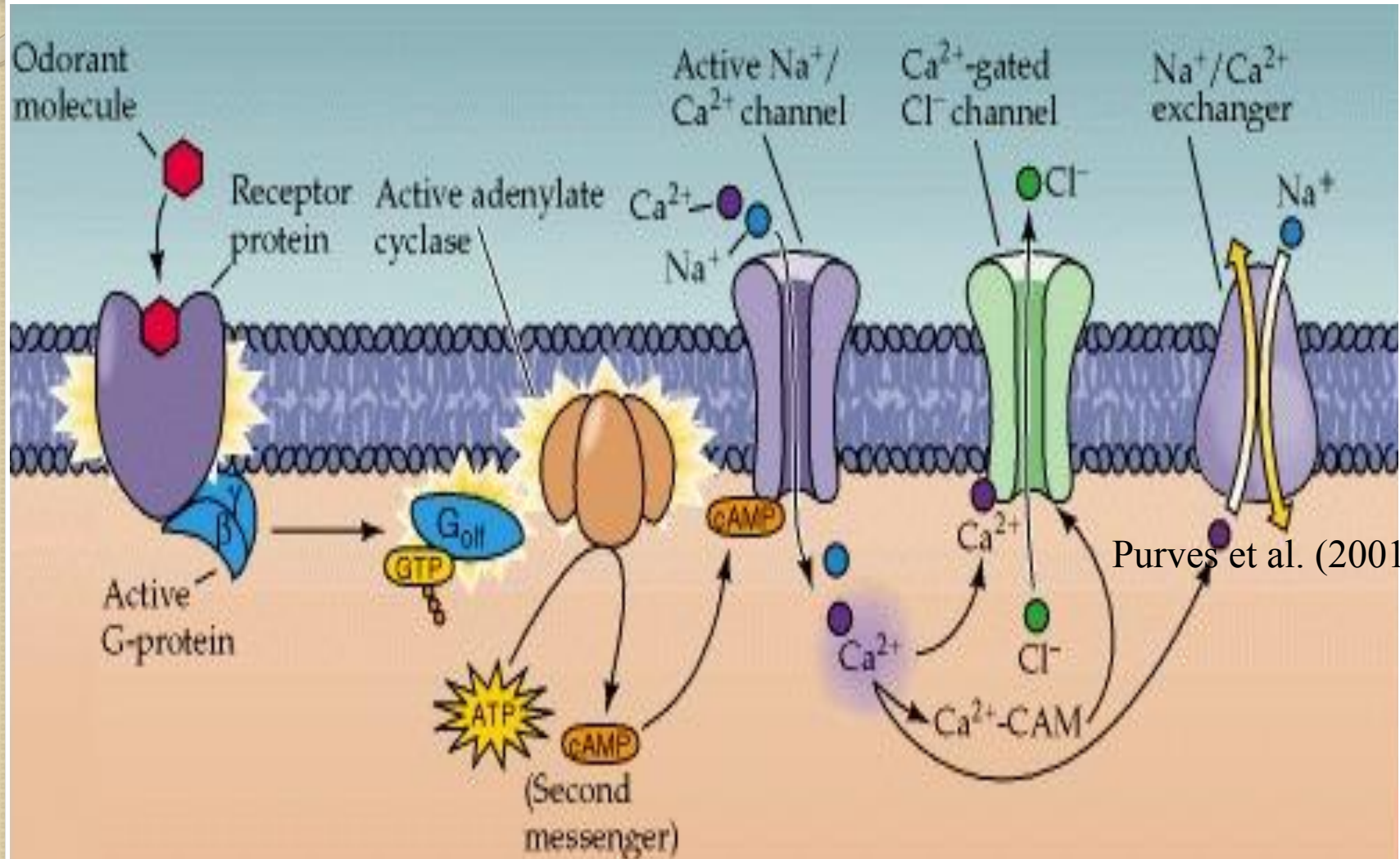
Olfactory Epithelium

- ◆ **Three components:** Epithelium, basement membrane, lamina propria.
- ◆ **Cell Types:**
 - **Olfactory receptor cells are bipolar neurons.**
 - Bowman's glands "Nasal glands".
 - Olfactory ensheathing cells
 - **Supportive Cells.**
 - **Basal cells.**
 - Microvillar cells **"another class of supporting cells"**.
- ◆ Replacement of receptor cells (about 60 days).



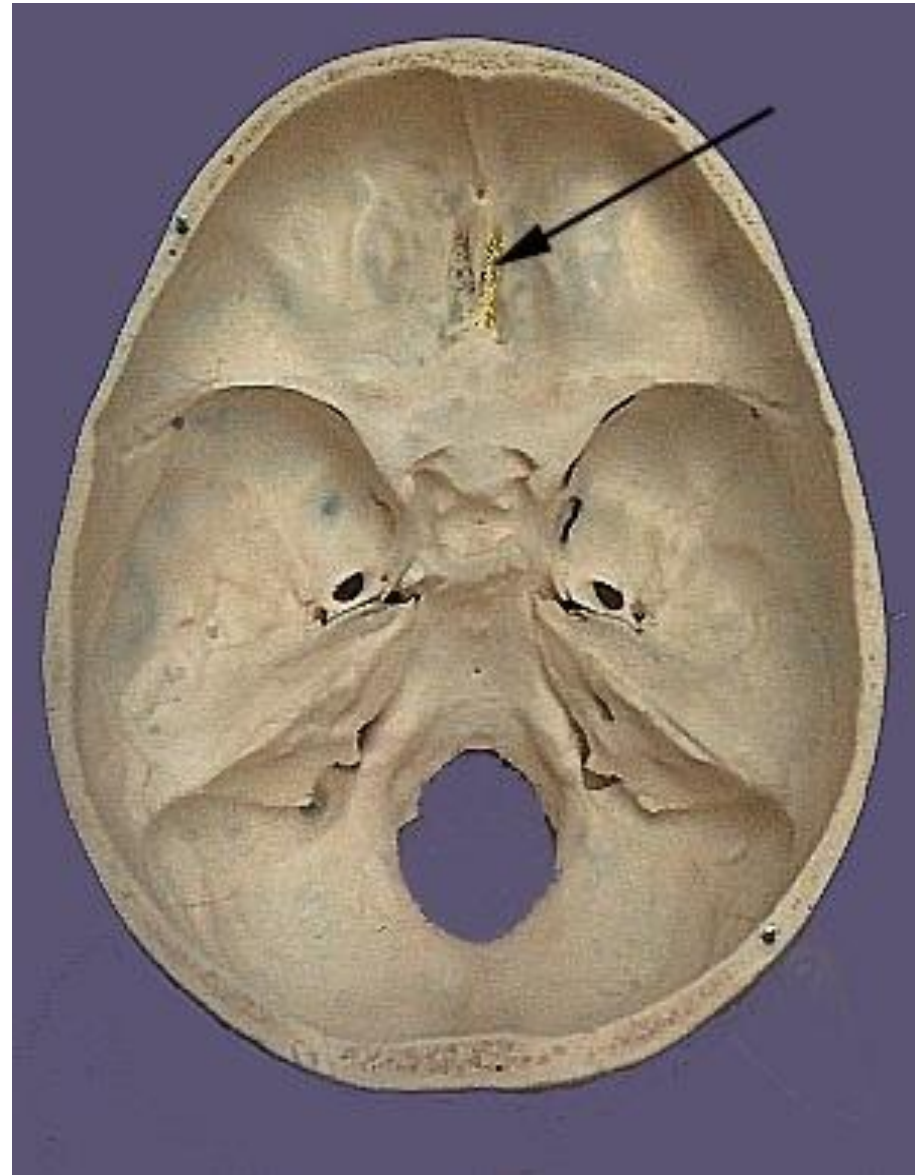
Olfactory Receptor Neurons

- Bipolar smell receptor neurons.



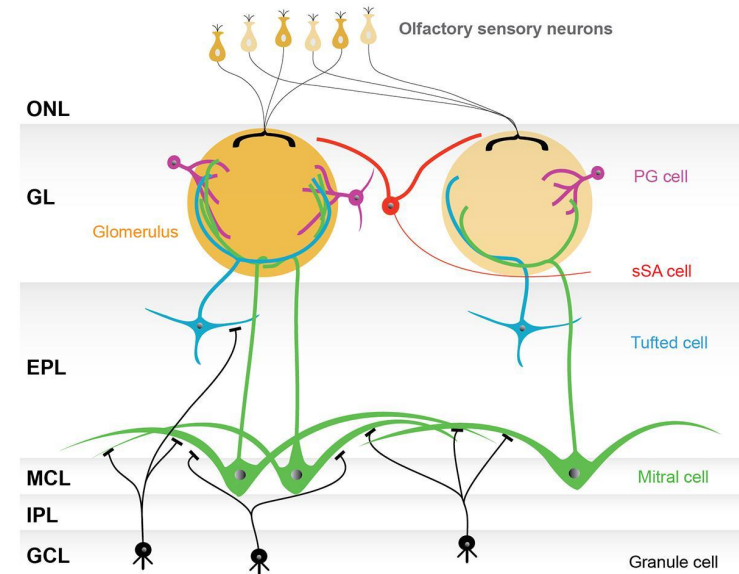
Cribriform Plate

- Part of the ethmoid bone
- Fila olfactoria
(unmyelinated axons) pass through perforations in cribriform plate.
- Pass from nasal cavity to the anterior cranial fossa floor.



Olfactory Bulb

- **Layer I**- Olfactory neuron layer “ONL”
- **Layer II**- Glomerular layer “GL”
- **Layer III**- External plexiform layer “EPL”
- **Layer IV**- Mitral cell layer “MCL”
- **Layer V**- Internal plexiform layer “IPL”
- **Layer VI**- Granule cell layer “GCL”

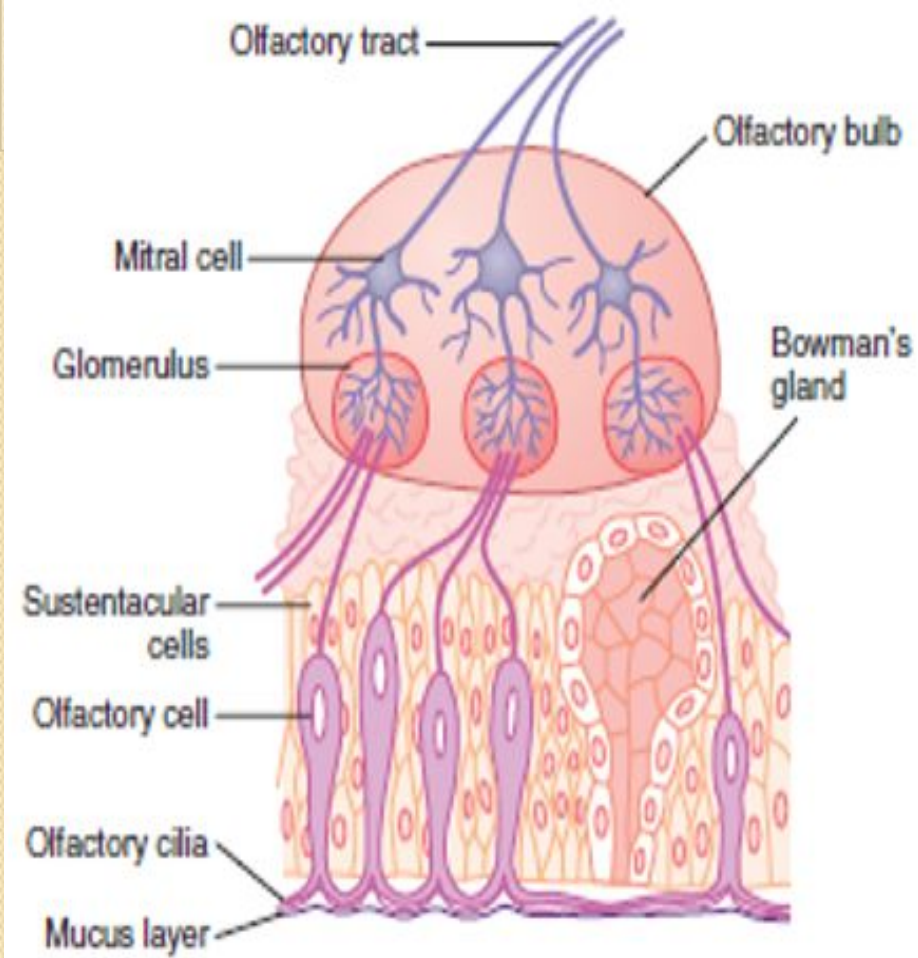
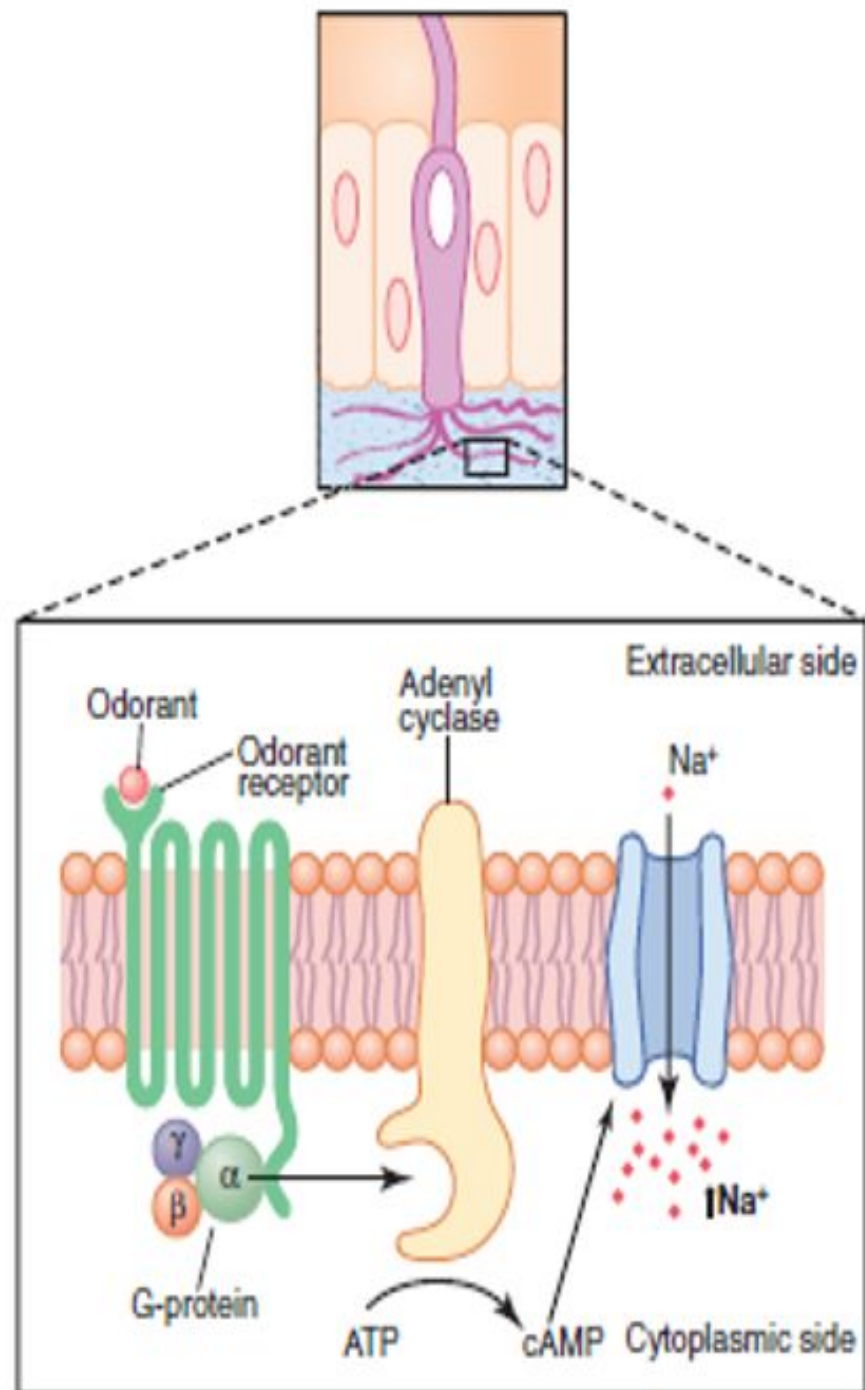


Odorant-Binding Proteins

- These receptors are protrude through the membrane of nasal cavity.
- They bind to the odorants forming a complex, which generate the receptor potential.

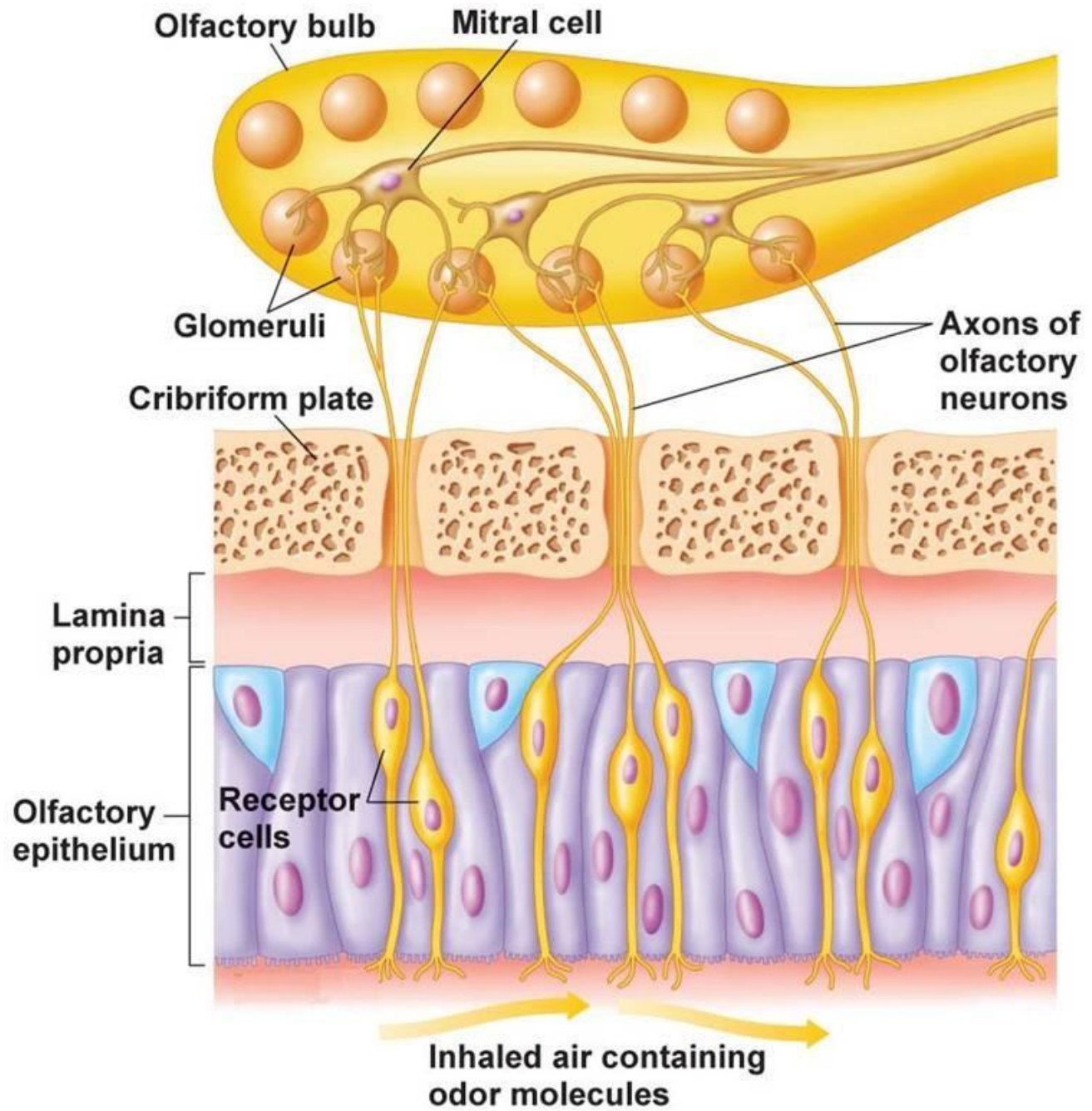
Stimulation of the Olfactory Cells

- The odorant substance, first diffuse in the mucus membrane and binds with a receptor protein.
- Such binding will activate **G-protein** “**Guanine nucleotide-binding proteins**” with activation of **adenylcyclase and phospholipase** → which finally open many **Na⁺ channels** → Na⁺ entry will generate receptor action potential in the receptor cells (**partial depolarization**).



Pathway of Smell Sensation

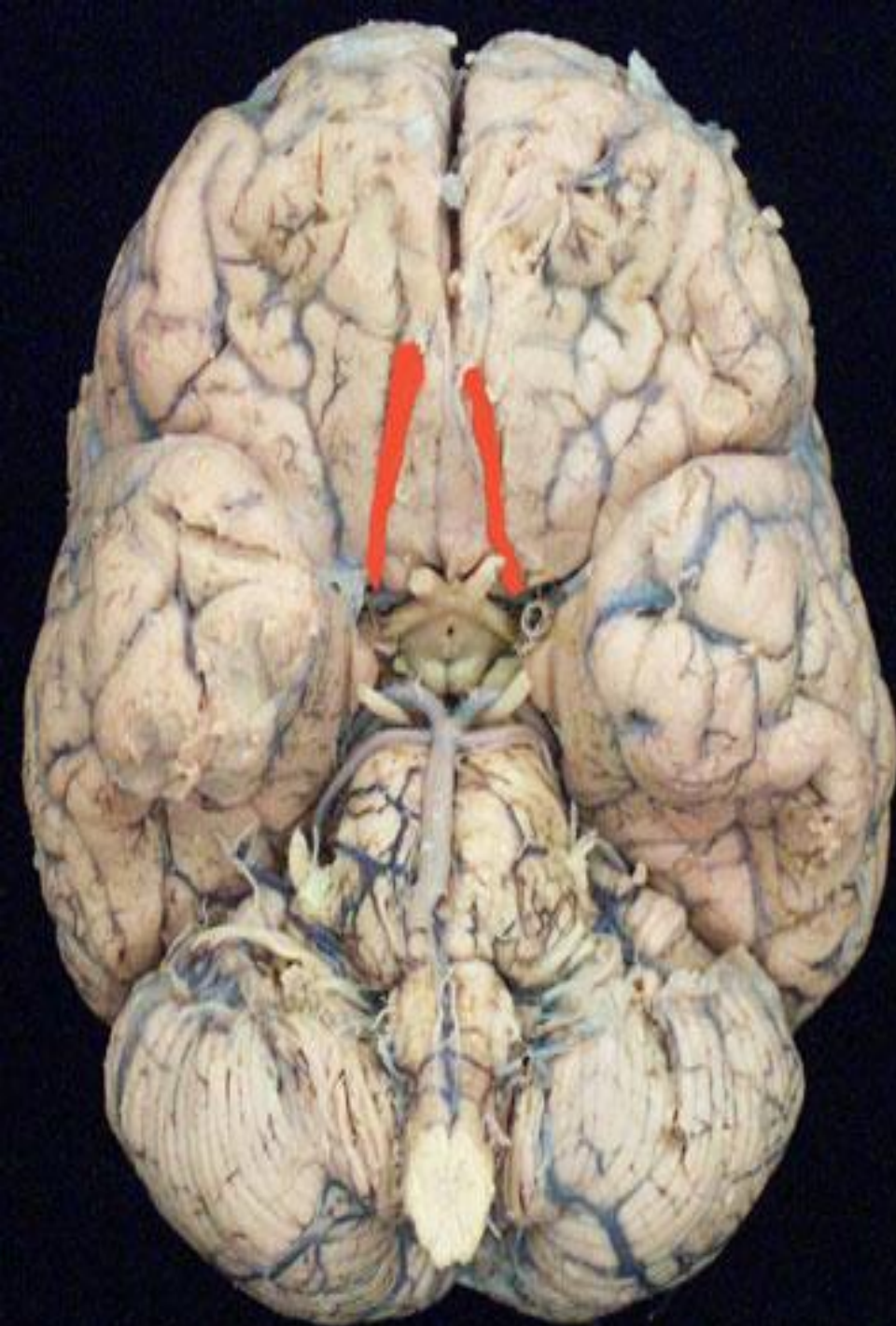
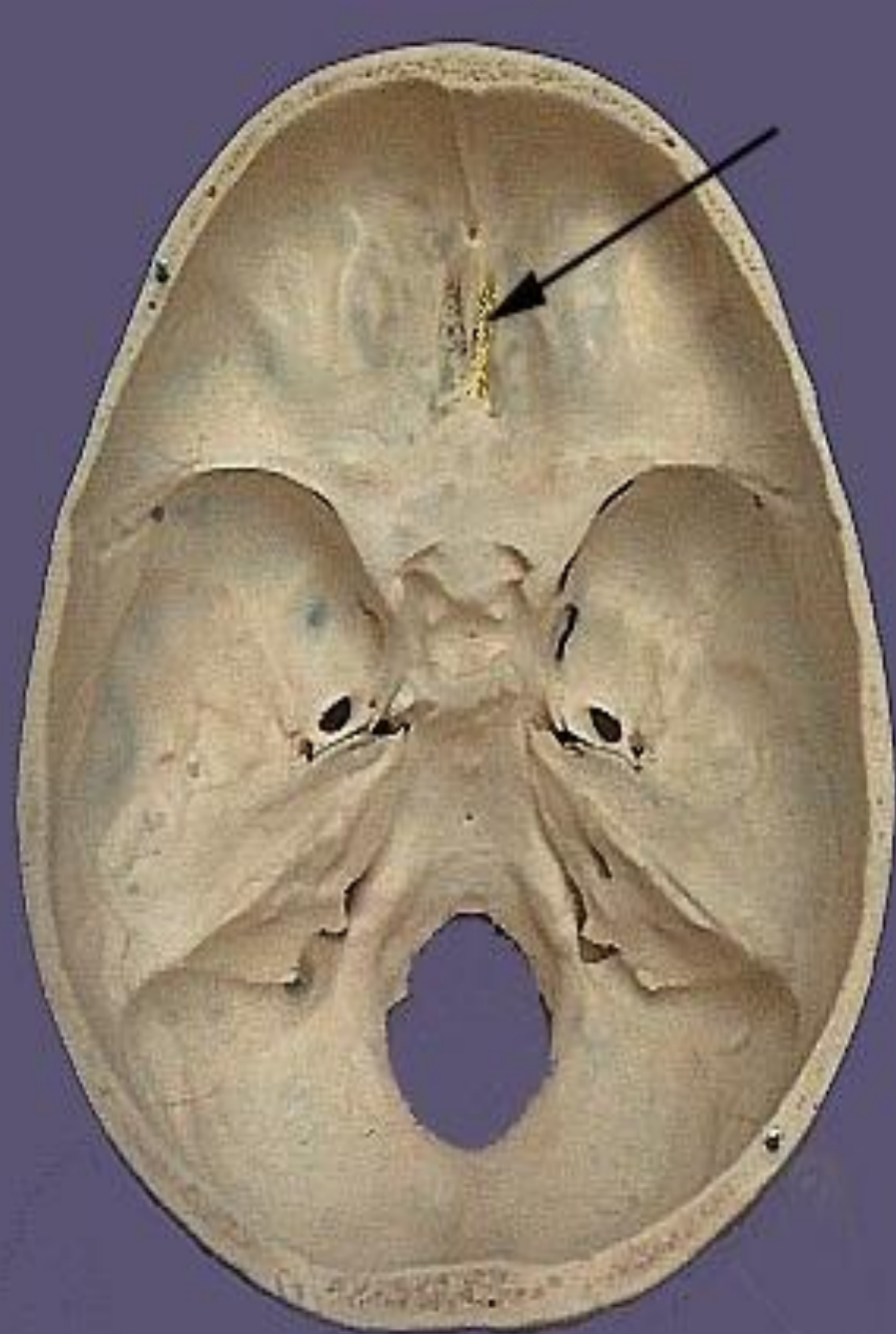
- I. First Neuron: **Bipolar cells (25 million chemoreceptors on each side)** in the olfactory mucous membranes of the superior nasal cavity → fibers of olfactory nerve (consist of about 20 small filaments on each side) → the cribriform plate of the ethmoid bone → olfactory groove → olfactory bulb where they relay in **the mitral and tufted cells.**



2. Second Neuron:

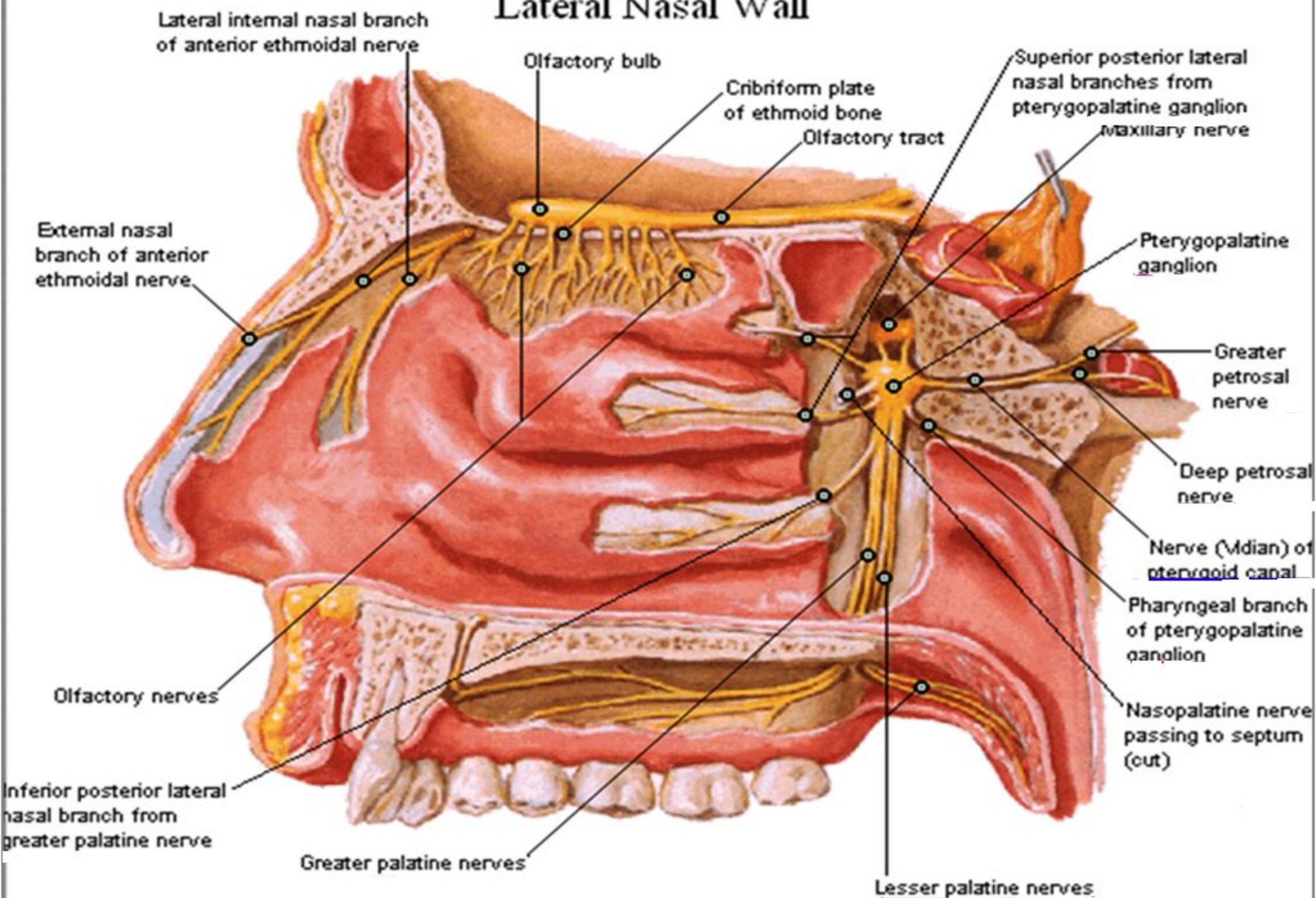
- The olfactory nerve fibers synapse with the dendrites of the **mitral and tufted cells (second order neuron)** of olfactory bulb called **olfactory glomeruli** → olfactory tract → passes along the **olfactory groove**.
- The olfactory tract → gives rise to the medial and lateral olfactory striae.
- Some fibers project collaterals directly via **lateral olfactory striae and anterior commissure to primary olfactory cortex**
- Ends in the uncus, parahippocampal, subcallosal, paraterminal gyri and amygdaloid body in temporal lobe (parts of the limbic system).

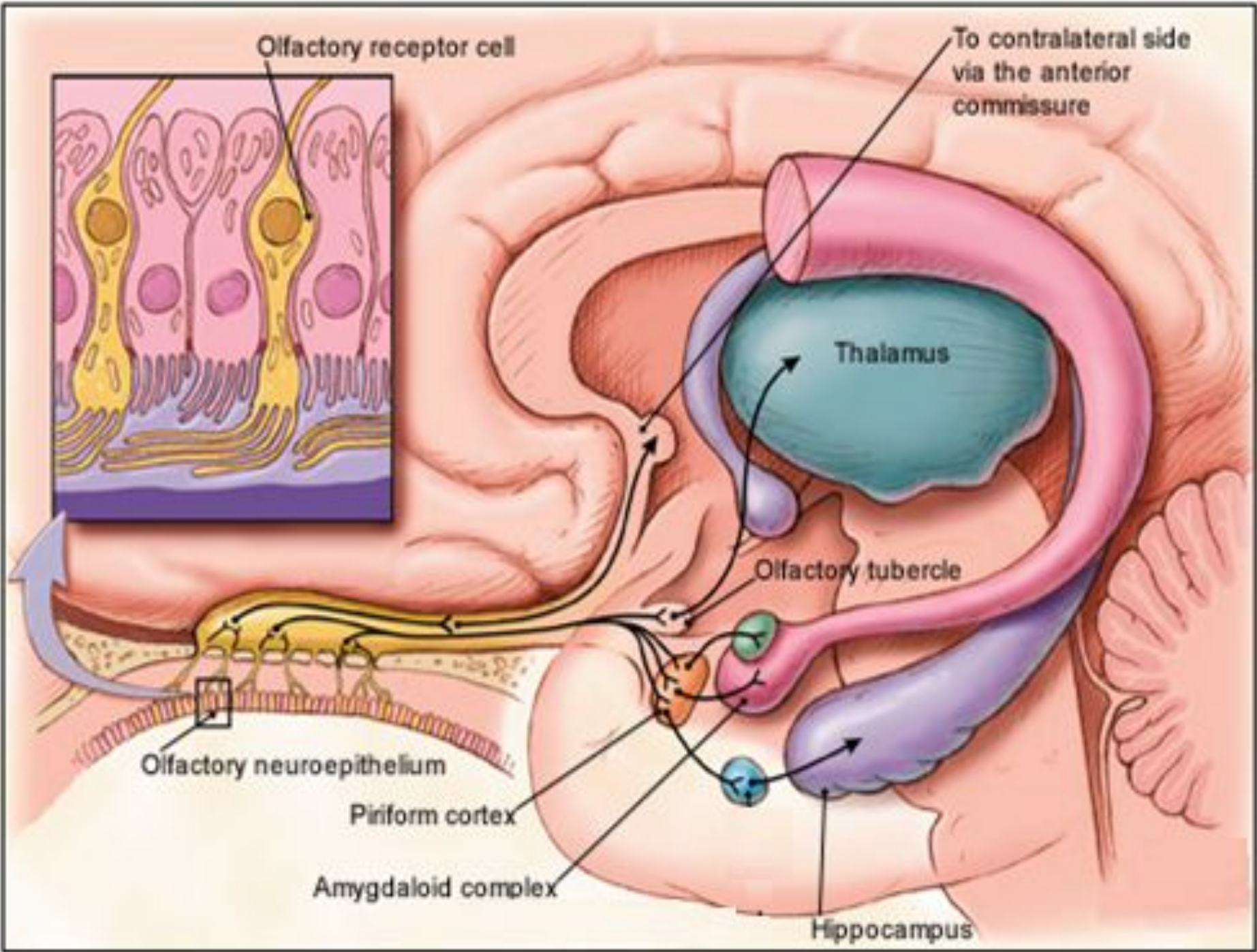
❖ **Note:** Unilateral lesion of temporal lobe does not cause anosmia as the sense of smell is bilaterally represented.



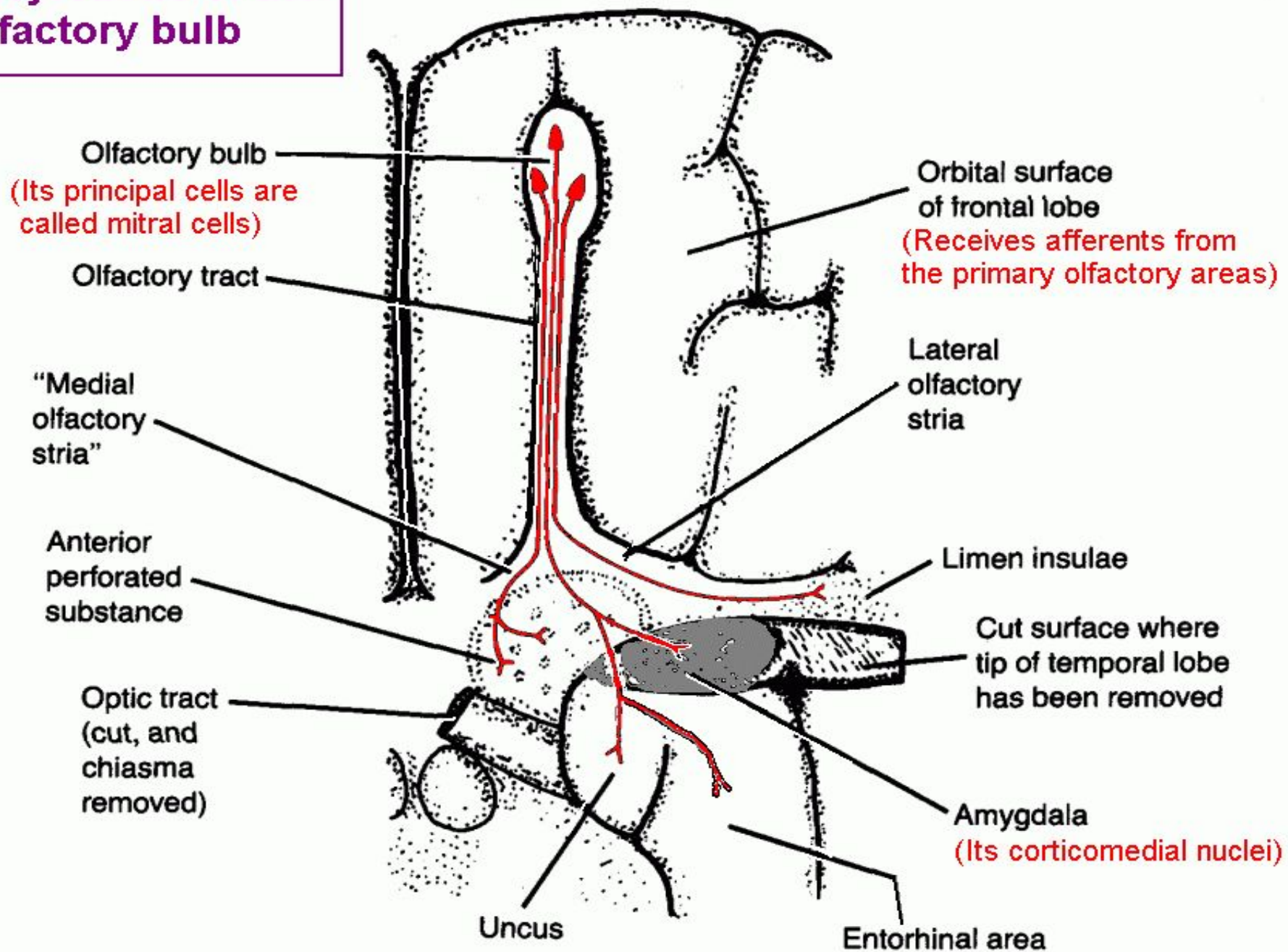
Nerves of Nasal Cavity

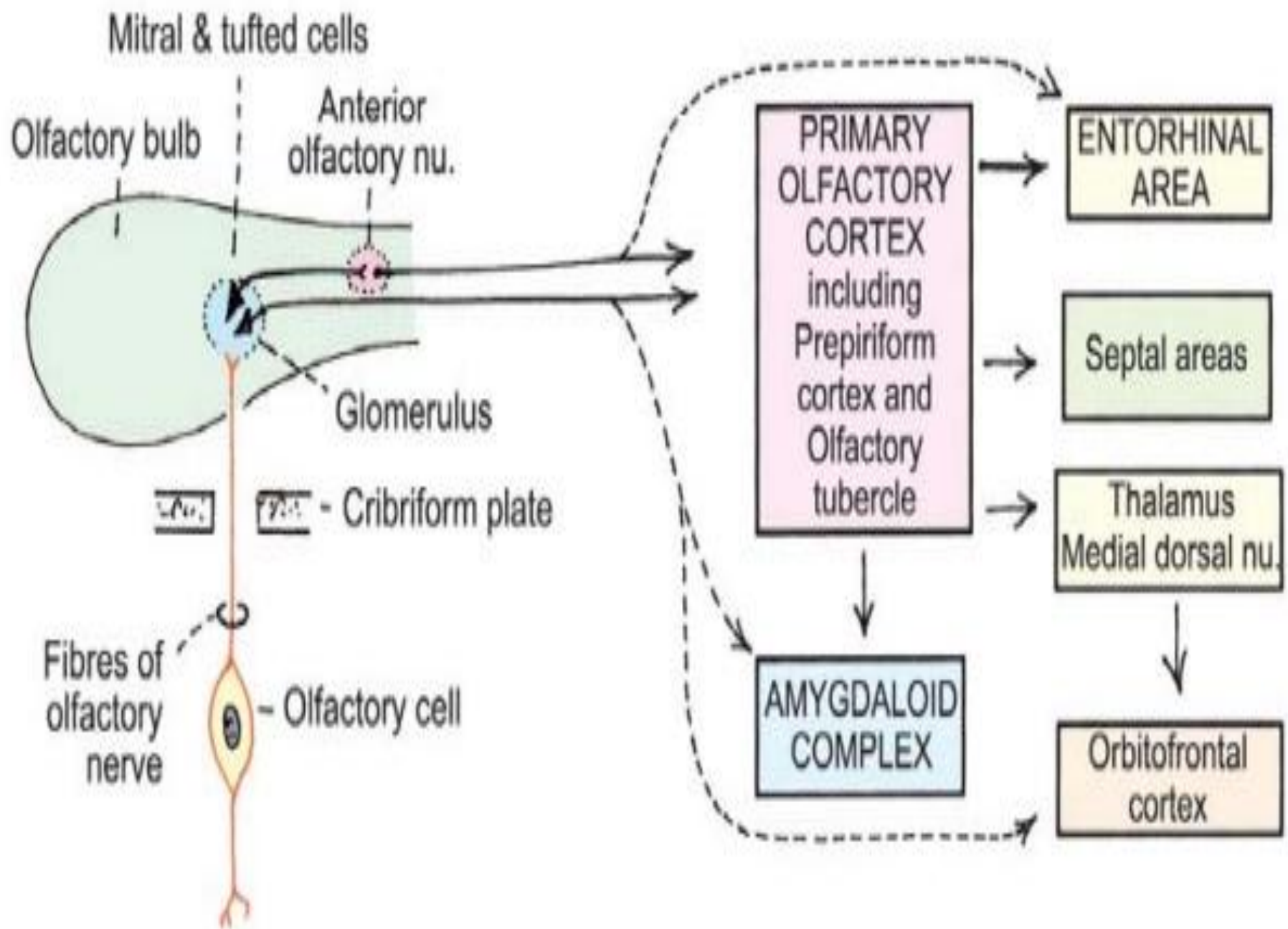
Lateral Nasal Wall

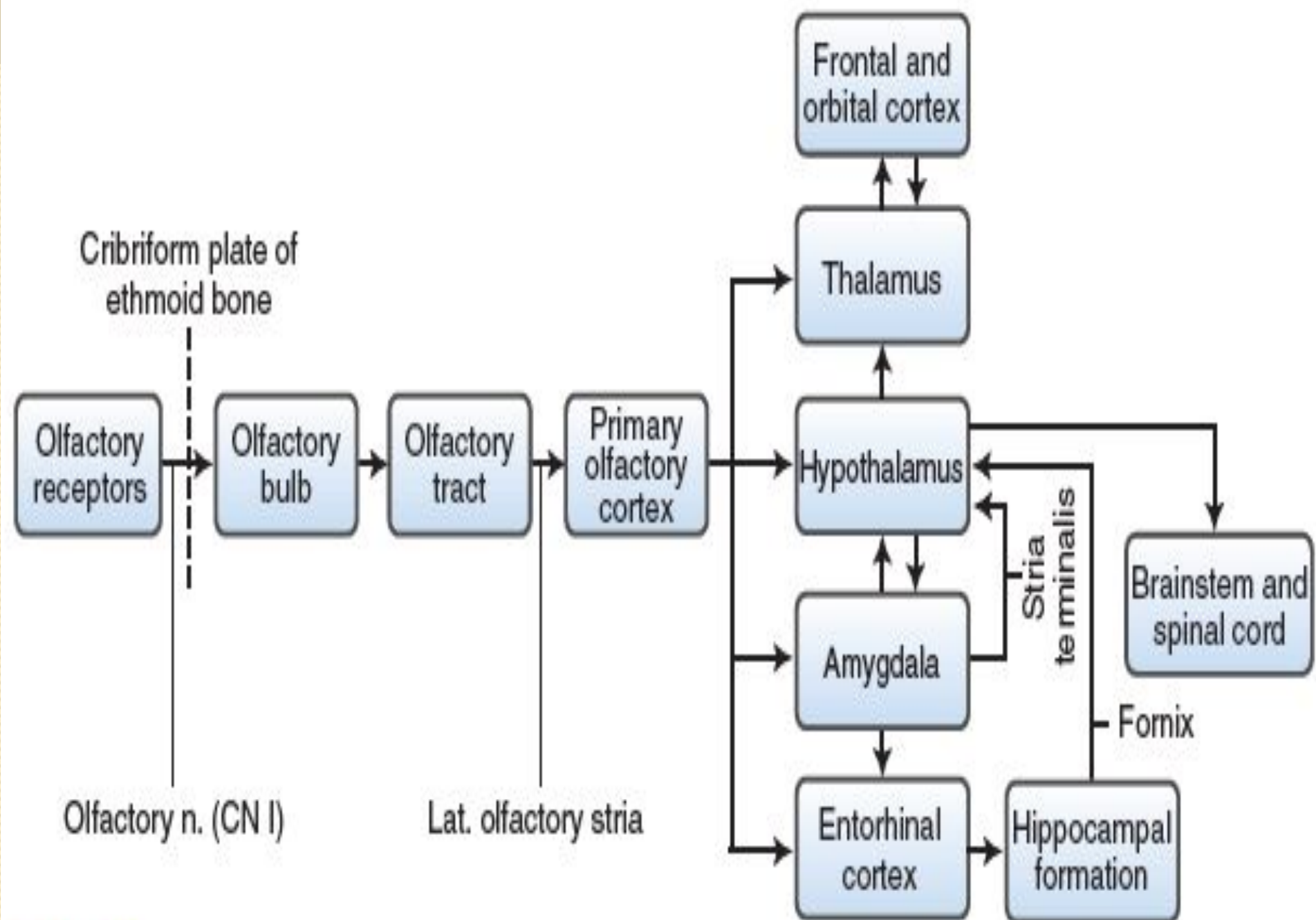




Projections of the olfactory bulb









Clinical Correlation

Lesion of the Smell Pathway

1. Unilateral hyposmia or anosmia.
2. Bilateral hyposmia or anosmia.
3. Parosmia (Smell hallucination)
4. Cacosmia (bad smell in chronic sinusitis)
5. Olfactory agnosia

Causes of Unilateral Anosmia

- **Traumatic:** skull base fracture
- **Inflammatory:** basal meningitis, abscess.
- **Neoplastic:**

- Olfactory groove meningioma →

Foster Kennedy syndrome:

1. **Ipsilateral anosmia:** due to pressure on olfactory pathway.
2. **Ipsilateral optic nerve atrophy:** due to direct pressure on the optic nerve.
3. **Contralateral papilleodema:** due to increase intracranial tension.



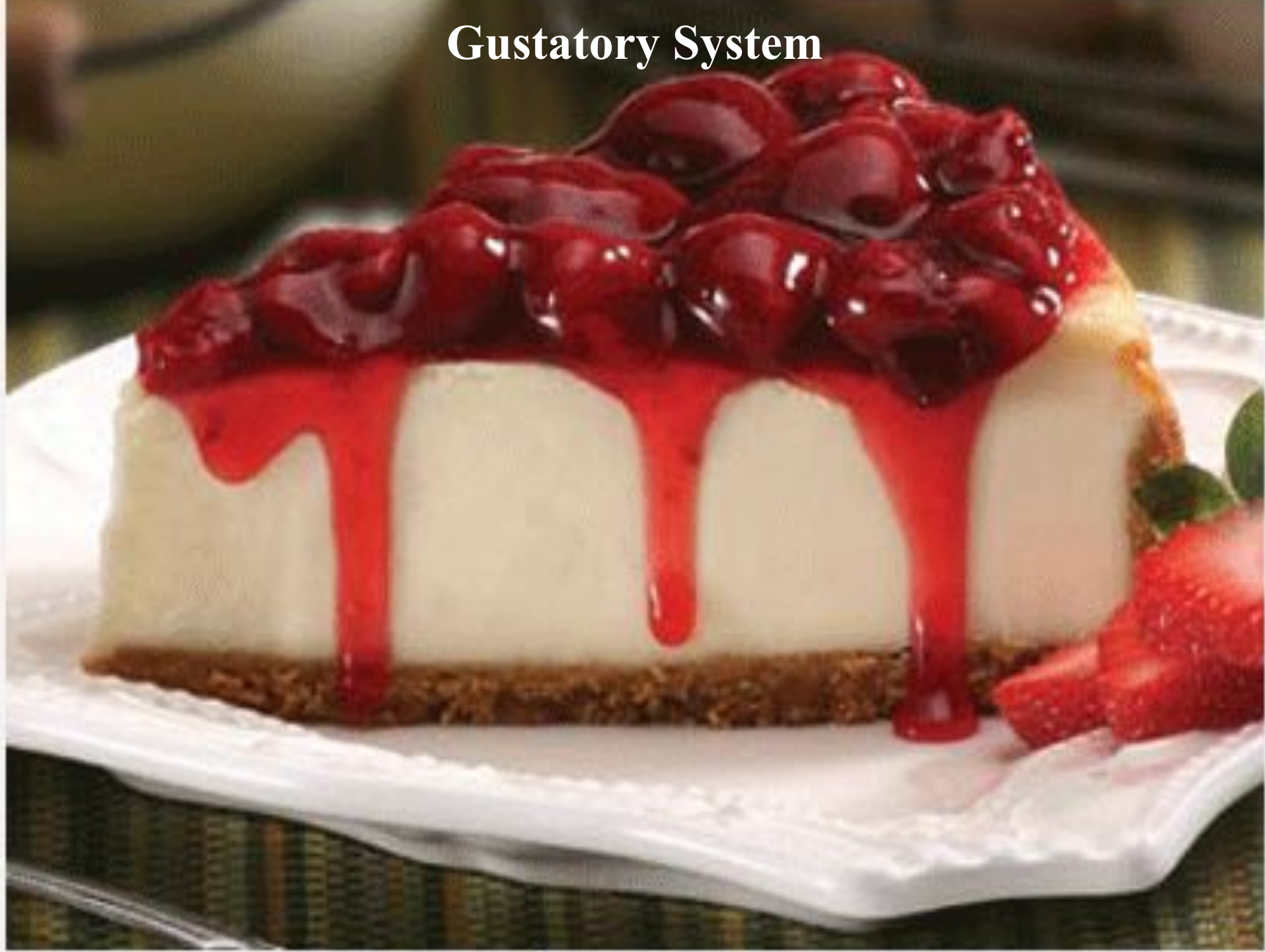
Causes of Bilateral Anosmia

- ENT causes: common cold, atrophic rhinitis.
- Heredofamilial.
- Hysterical.
- Excessive smoking.
- Use of cocaine.

Causes of Parosmia (Smell Hallucination) and Olfactory Agnosia

- Temporal epilepsy.
- Temporal lobe SOL.
- Intracranial aneurysm and AVM.
- Psychogenic

Gustatory System



II. The Sense of Taste “Gustatory System”

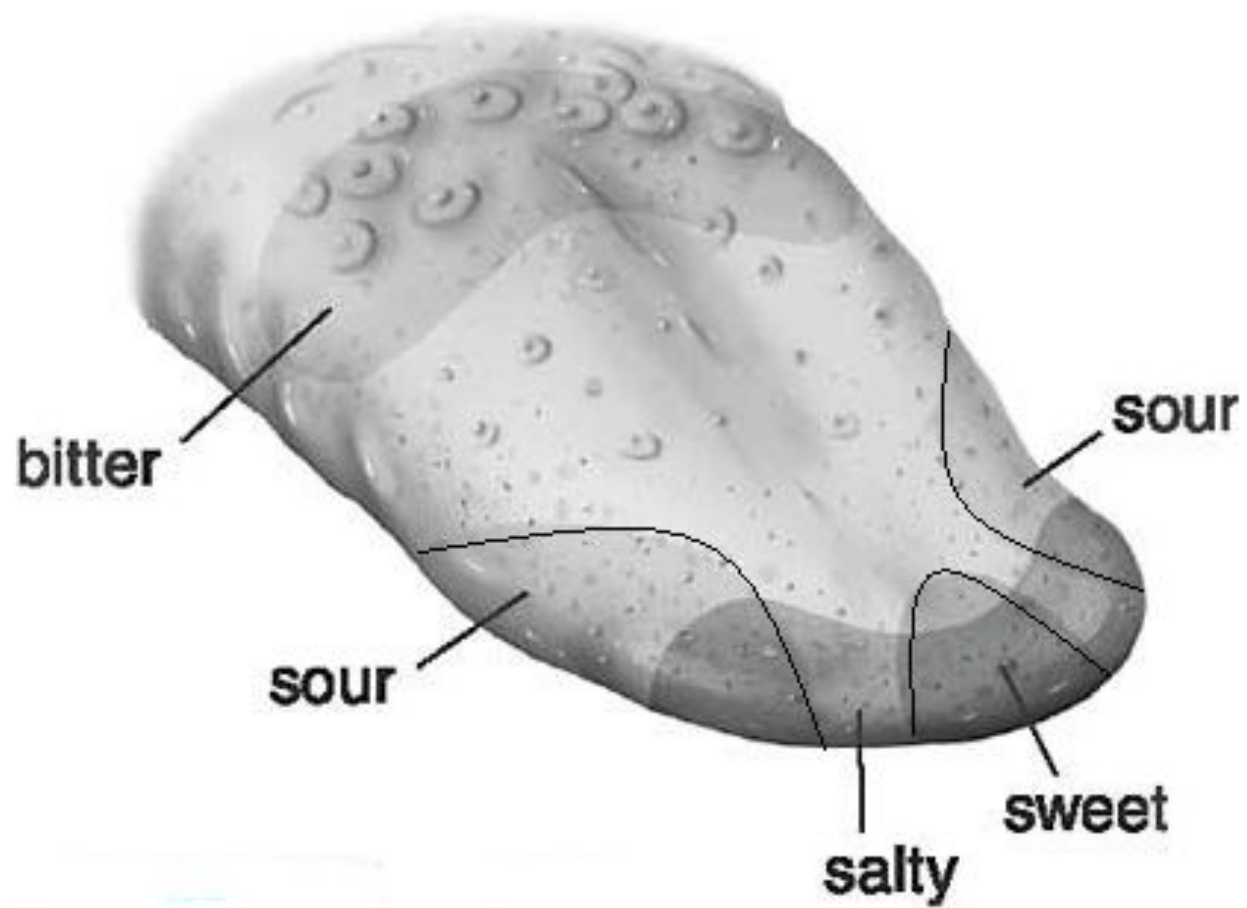
- The taste stimuli are detected by taste receptors within the tongue, palate, epiglottis and pharynx.
- **Functional Modality:** mediates the **special visceral afferent modality of taste Taste** via **the facial, glossopharyngeal and vagus nerves.**
- Mediates gustation, which, like smell, is **a chemical sense.**

The Sense of Taste

“Gustatory System”

Types of taste sensation:

1. **A sweet sensation:** the tip “apex” of the tongue is the area most sensitive to sweet stimuli.
2. **A bitter sensation:** is produced by alkaloids. The back of the tongue is the area most sensitive to bitter stimuli.
3. **A salty sensation:** the anterior half of each side of the tongue is the area most sensitive to salty stimuli.
4. **A sour sensation:** is produced by acids. The posterior half of each side of the tongue is the area most sensitive to sour stimuli.



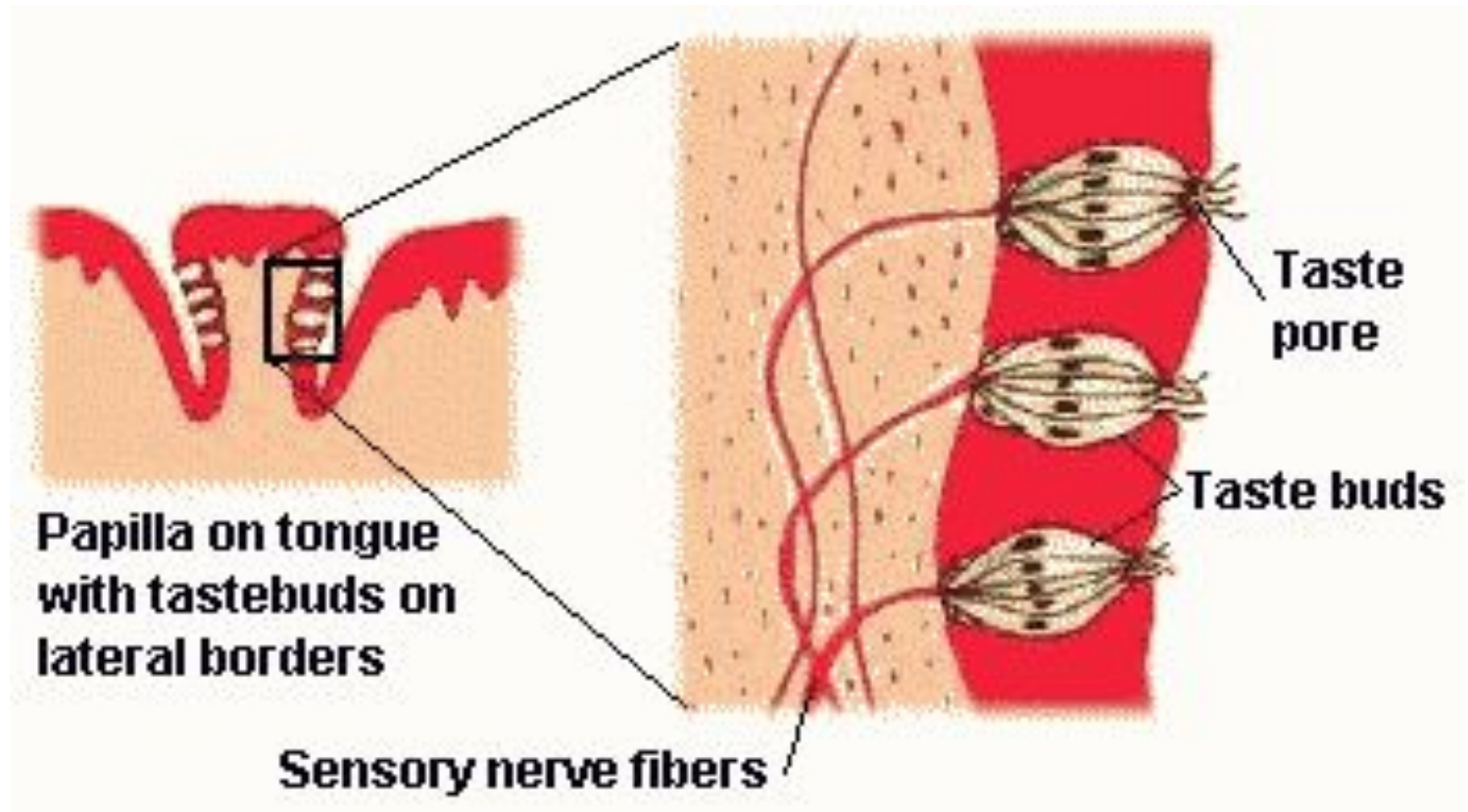
The Taste Buds

- ◆ **Taste Receptors:** taste cells (receptors) are located within **taste buds**, which are located within **tongue papillae (Tongue Papillae → Taste Buds → Taste Cells or Receptors)**.
- ◆ **Distribution of taste buds:** taste buds are located on the tongue papillae, hard and soft palate, epiglottis and pharynx.

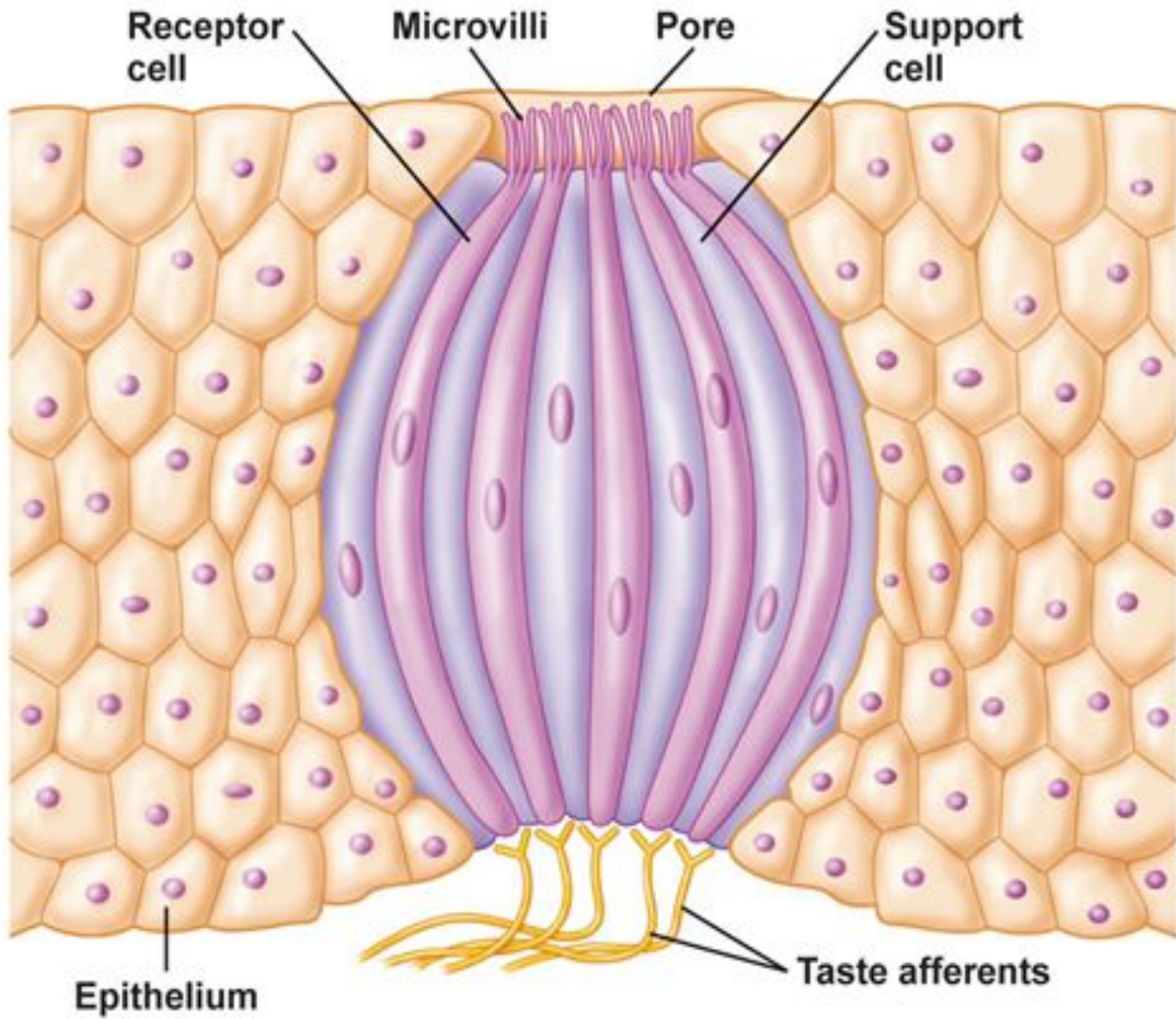
The Structure of Taste Buds

Each taste bud is consists of taste cells and numerous supporting cells:

- Taste pore.
- Taste microvilli.
- Taste (receptors) cells: each taste bud is consists of 40-60 taste cells
- Supportive cells.



Anatomy of Taste Buds



The Sense of Taste

✓ Specialization of taste buds:

- ❖ Each taste bud usually respond to only one of the four taste stimuli, when the taste substance is in **low concentration**.
- ❖ At **high concentration**, must buds respond to two or more of the four taste stimuli.

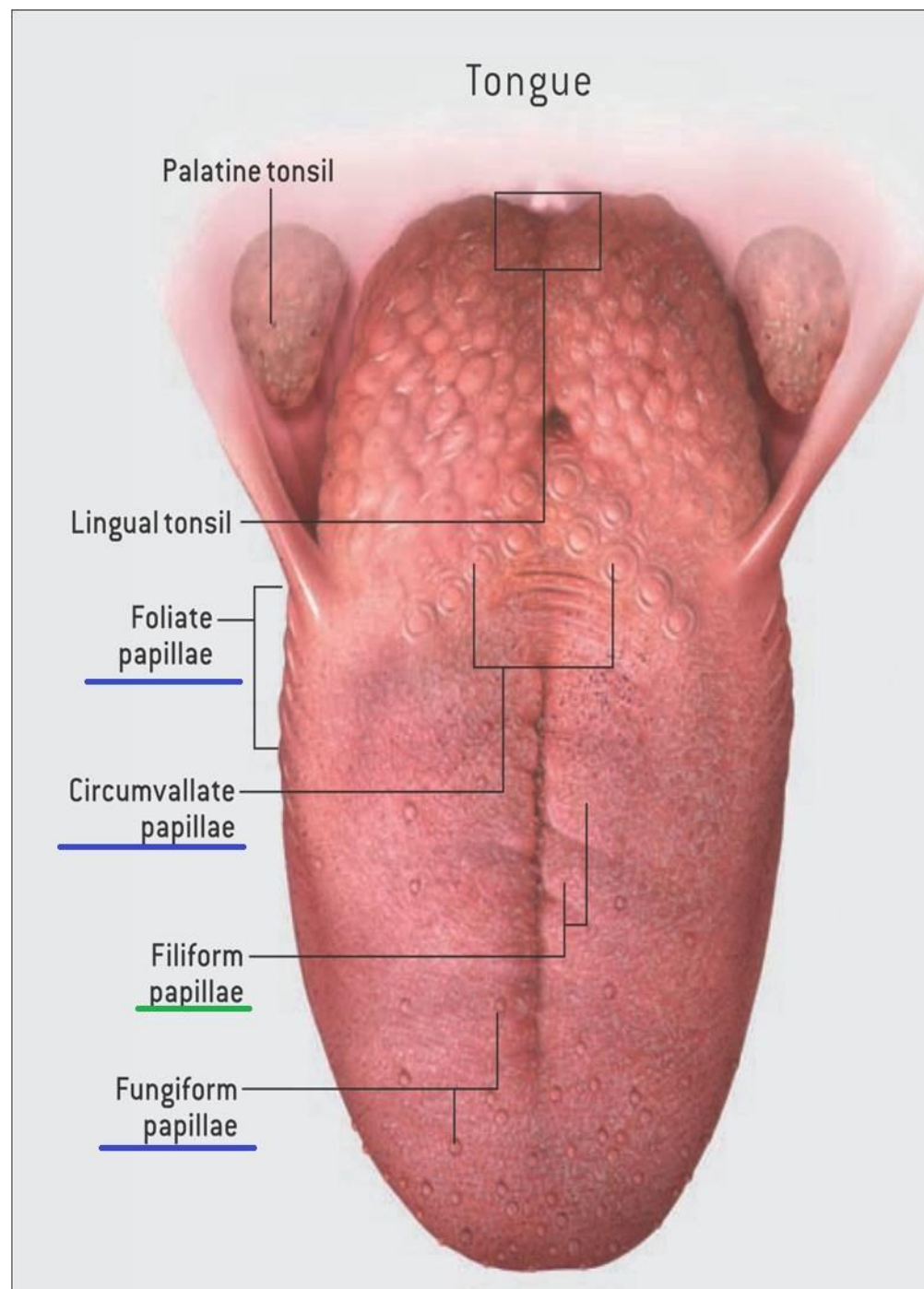
✓ Regeneration of taste buds:

Each taste cell has a life cycle of only a few days.

The Tongue Papillae

There are four types of papillae (three contain taste buds and one contains mechanical receptors):

1. **Fungiform papillae:** located in the anterior 2/3rd of the tongue. Each papillae has 8 – 10 taste buds.
2. **Circumvallate papillae:** located in the posterior part of the tongue. Each papillae has approximately 200 taste buds.
3. **Foliate papillae:** located on the lateral border of the tongue anterior to the circumvallate papillae. Has numerous taste buds.
4. **Filiform papillae (Mechanical):** are not taste structures. They may play a role in breaking up food particles.



The Anterior Two-thirds of the Tongue

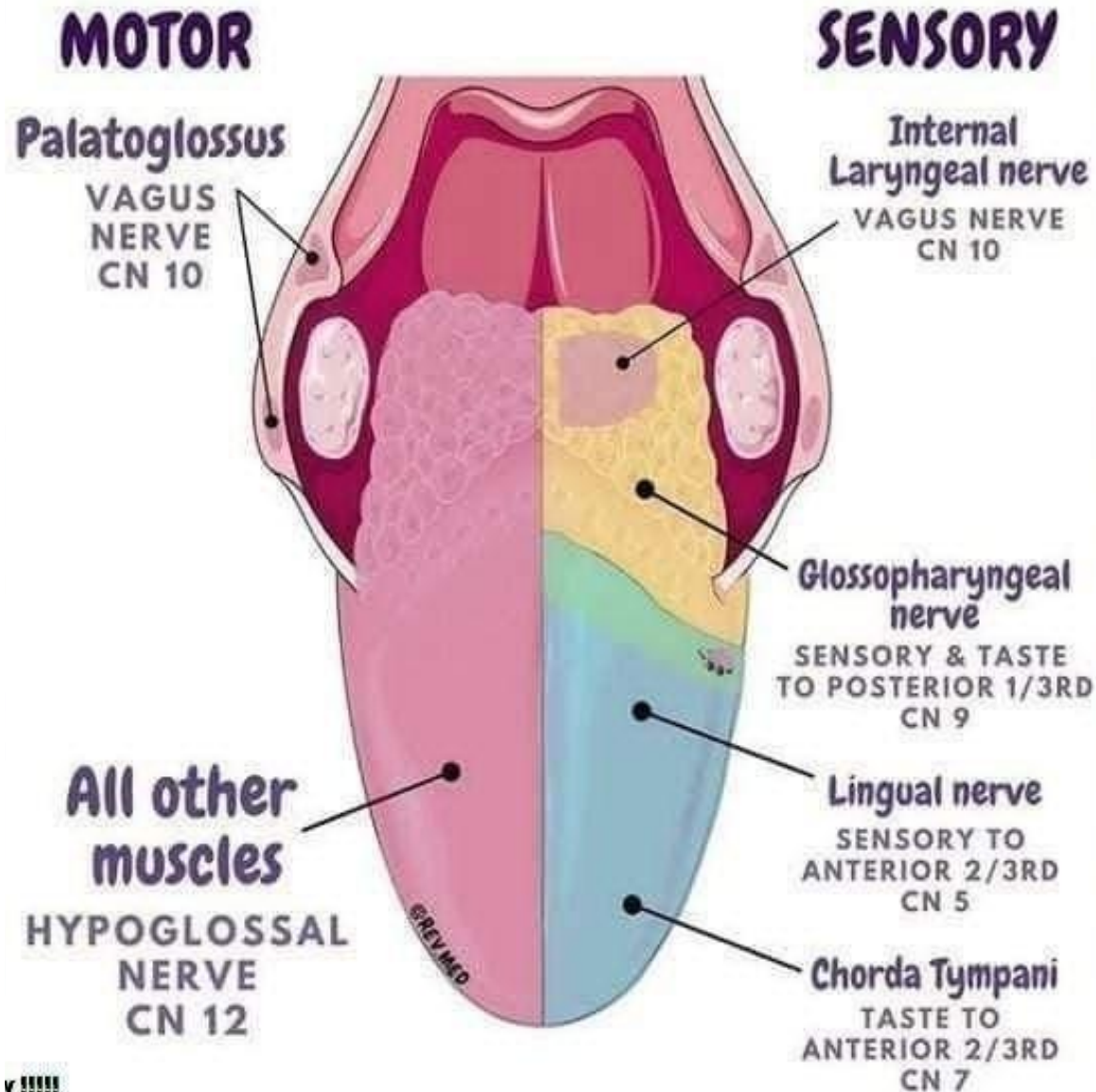
- Has **fungiform papillae**.
- Detects **salty and sweet** sensations.
- Is innervated by **CN VII (chorda tympani)**.

The Posterior One-third of the Tongue

- Has **circumvallate and foliate papillae**.
- Detects **sour and bitter** sensations.
- Is innervated by **CN IX (glossopharyngeal)**.
- The epiglottis are innervated by **CN X**.

The Tongue

INNERVATION



Mechanism of Stimulation of Taste Receptor

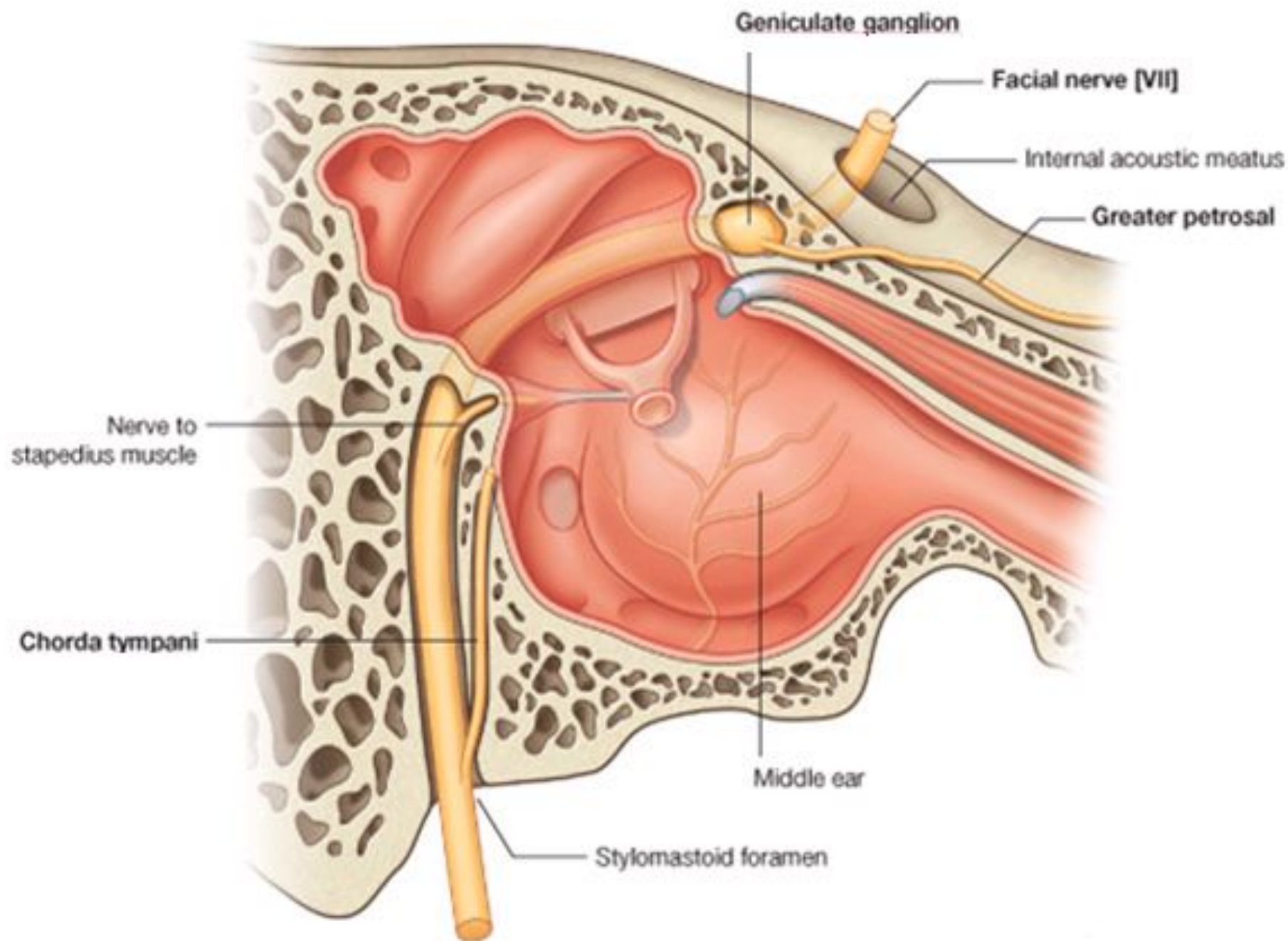
1. **Sweet-tasting substances:** by opening of Na^+ channels and closing of K^+ channels.
2. **Bitter-tasting substance:** by increasing intracellular Ca^{++} levels, which leads to the release of synaptic transmitter and activation of the taste nerve fiber.
3. **Salty-tasting substance:** by opening of Na^+ channels.
4. **Sour-tasting substance:** by increasing intracellular H^+ ion concentration, which blocks K^+ channels.

Pathway of Taste Sensation

- **The Taste Receptors:** are chemoreceptors (taste buds) in the papillae.
- The taste buds contain 40-60 receptor cells and numerous supportive cells.
- Innervated by taste sensory fibers of CN VII, CN IX, and CN X.

I. **First Neuron:** cells in **the sensory ganglia** (Geniculate ganglion of CN VII, inferior ganglion “Petrosal ganglion” of CN IX and inferior ganglion “Nodose ganglion” of CN X) → The central process of these ganglia enter the medulla oblongata to the rostral part of **Solitary nucleus**.

- **Facial Nerve:** receive taste sensation from the anterior 2/3 of the tongue.
- **Glossopharyngeal Nerve:** receive taste sensation from the posterior 1/3 of the tongue.
- **Vagus Nerve:** receive taste sensation from the epiglottis.

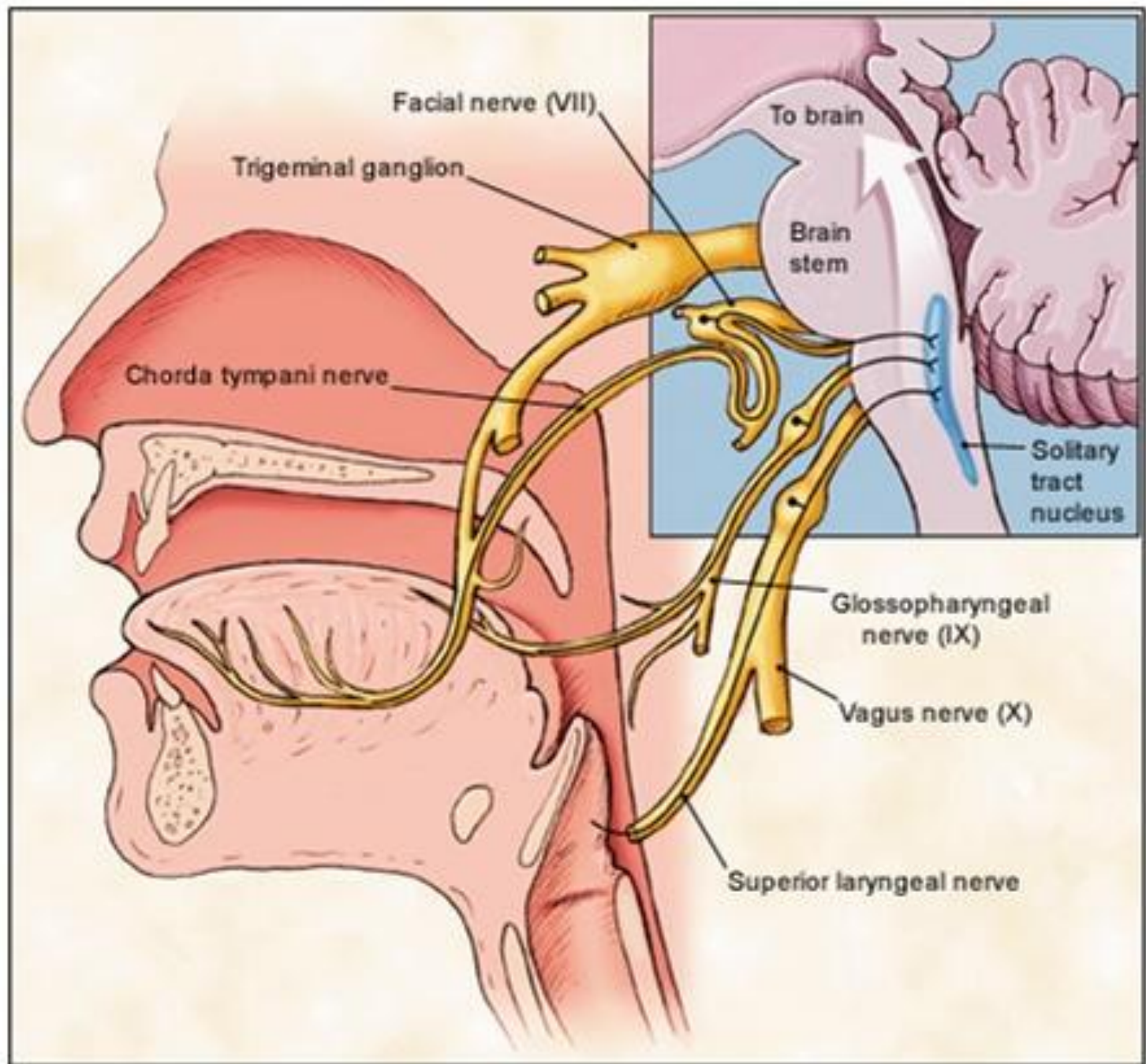


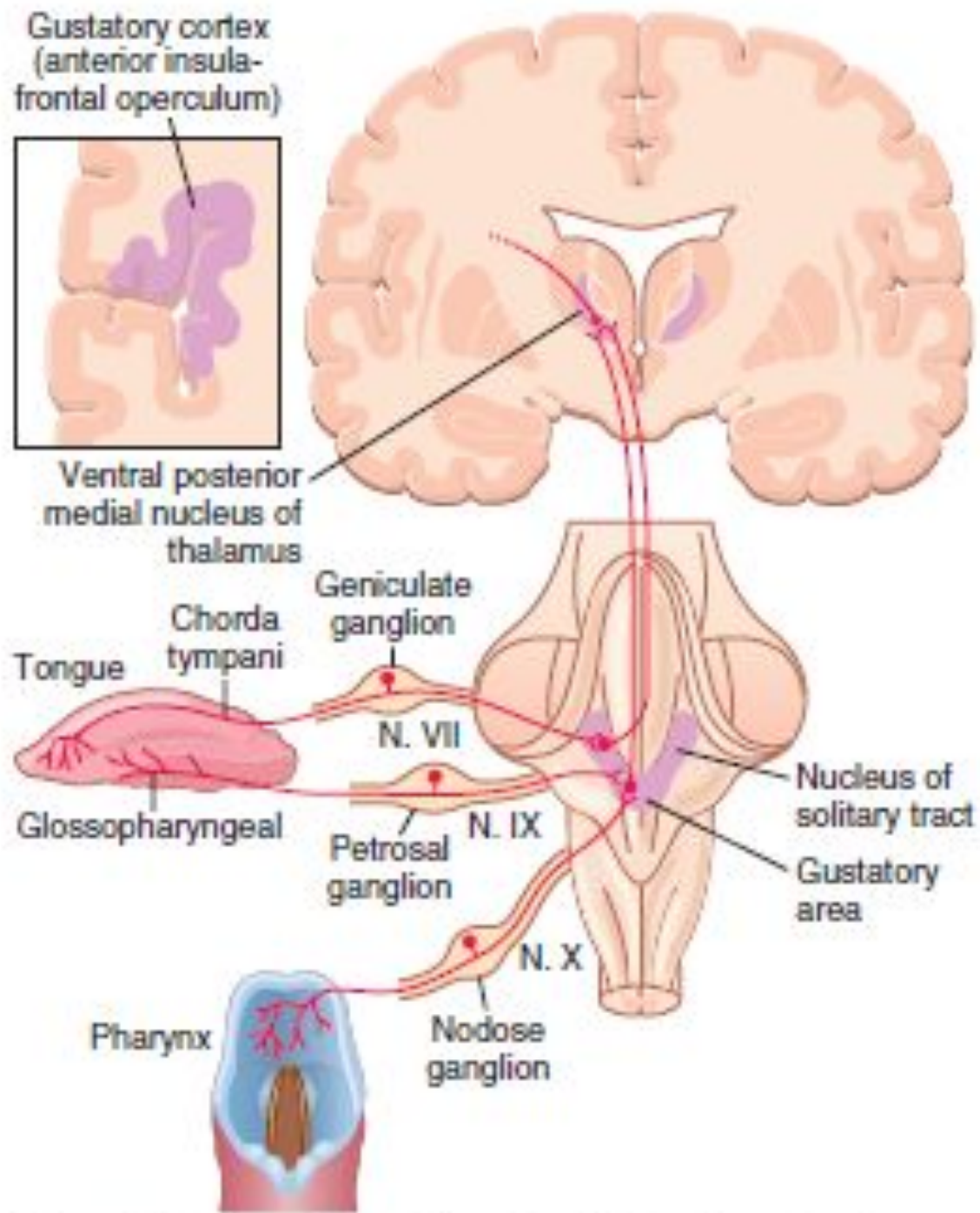
2. Second Neuron (Solitary Nucleus):

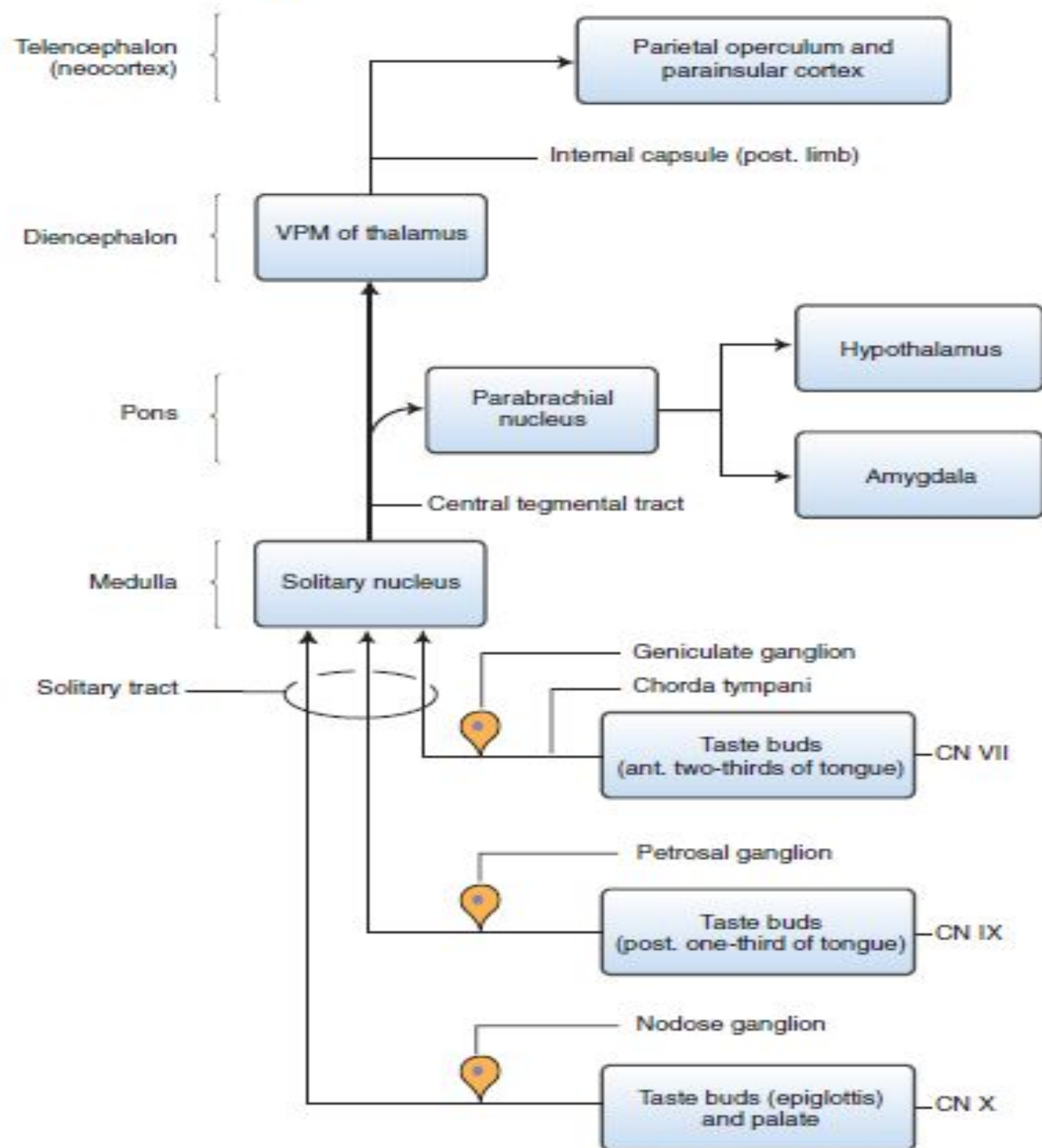
- Axons of the rostral part solitary nucleus ascend in the ipsilateral **central tegmental tract** to end in the VPM nucleus of thalamus.
- **Parabrachial nucleus of the pons:** receives taste input from the solitary nucleus and projects taste input to the **hypothalamus and amygdaloid body**.

3. Third Neuron (VPM Nucleus of Thalamus):

- Fibers run in the sensory radiation which passes in the posterior limb of the internal capsule and projects to the gustatory cortex of the parietal and frontal operculum (area 43) and insular cortex.







Taste Innervation

Part	CN	Branch	Ganglion	Foramen
Anterior 2/3 tongue	VII	Chorda tympani (via lingual)	Geniculate	Internal acoustic meatus
Soft palate	VII	GSPN	Geniculate/otic	Internal acoustic meatus
Posterior 2/3 tongue	IX	Lingual-tonsillar branch	Petrosal	Jugular foramen
Epiglottis	X	Laryngeal branch	Nodose	Jugular foramen

Clinical Correlation

- **Ageusia:** gustatory anesthesia or lack of sense of taste.
- Most frequently associated with peripheral lesions of facial nerve (Bell's palsy and disease of the middle ear) due to **chorda tympani nerve lesion.**



Thank You