

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.
 proprioception [deep sensation, visceral sensation], touch sensation
 the somatic :- reach to the spinal cord by the P.R.G. post. root ganglion

2. **Special senses:** reaching the CNS through specialized cranial nerves:
 reach to the spinal cord by specialize cranial nerve

- a. Sense of the vision. *special somatic*
- b. Sense of the hearing and equilibrium.
- c. Sense of the smell. *special visceral [chemical sensation]*
- d. Sense of the taste. *by glossopharyngeal, facial, vagus..*

3. **Visceral sensation:** including all sensations from the internal viscera and reaching the CNS through the autonomic nerves.
 organ *by*

4. **Organic sensations:** e.g. hunger, thirst and sexual sensations.
 ↳ somatic *by the hypothalamus..*

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. [superficial deep sensation]
2. **Special Somatic Afferent (SSA): afferent nerves of the special senses**, (fibers include the optic nerve and the vestibulocochlear nerve). [vision and hearing]
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. → sensation from the internal organs
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). → taste and smell

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 ^{SVA} 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.

↳ lead to pain when we smell it
by the branches of trigeminal nerve.

(ant. ethmoidal N. / nasociliary N.)

- The olfactory pathway has **no precortical relay** in the thalamus.
→ doesn't relay in the thalamus but send the signals to the temporal lobe. then 2ry projection to thalamus, hypothalamus, Brain stem
superior and inferior salivary nucleus
Salivation من الغدة اللعابية
- Projects to the thalamus **"Dorsomedial Nucleus"**, hypothalamus, amygdaloid body, and hippocampal formation.
لكن في الذاكرة
بمركز الذاكرة
temporal lobe

* hypothalamus → hypothalamic spinal tract. [Sacral part of parasympathetic]
 → vagus nerve [dorsal motor nucleus]
 → sup., inf. salivary nuclei in Brain stem [saliva.]
GIT

Smell...

The Olfactory Nerve (CN I)

First cranial nerve

□ **Olfactory Nerve:** (Latin for "to

smell").

↳ 20 filament on each side to cribriform Plate of ethmoid bone then to olfactory group → olf. Bulb. → olf tract

□ **Function:** Special visceral afferent nerve (smell).

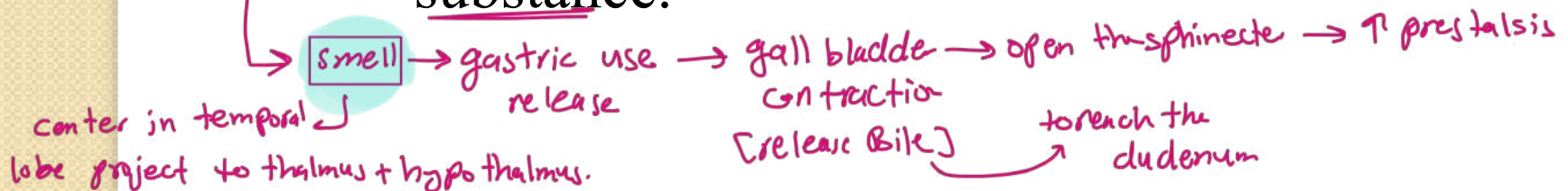
□ **Olfactory tract** located in the anterior cranial fossa and attached to the inferior surface of the frontal lobe.



The Sense of Smell

^{important}
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 is essential for gastrointestinal functions.
3. It is necessary for avoiding dangerous liquids or substance.



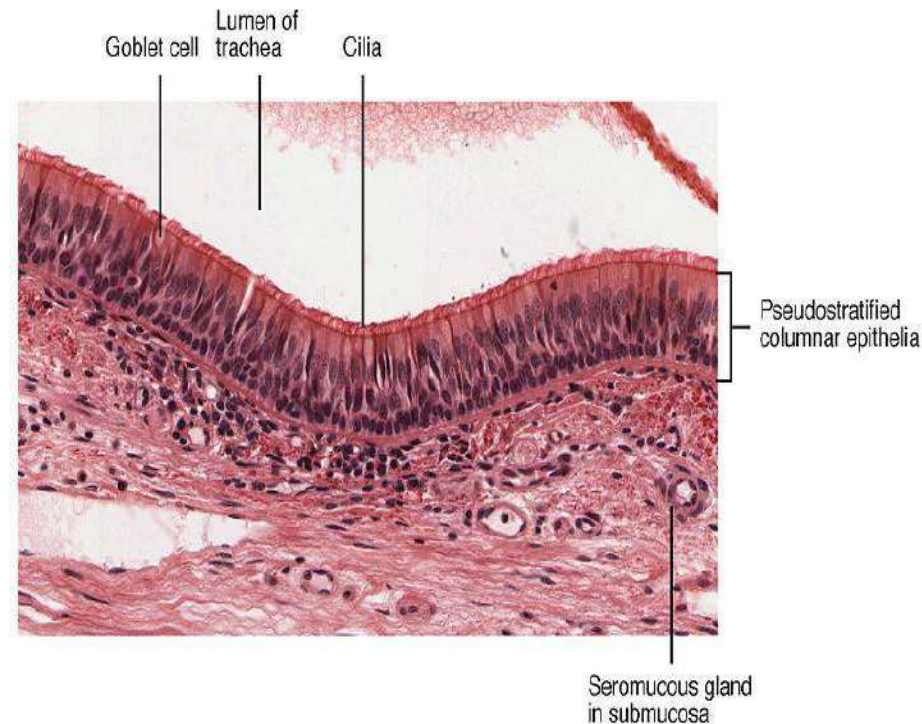
Properties of Olfactory Receptors

1. **Sensitivity:** the olfactory receptors are chemoreceptors.
2. **Discrimination of odorants:** the olfactory system can discriminate about 10,000 odors.
↳ 10000 odor عذرات
↳ odor intensity عذرة
3. **Discrimination of odorants intensity.**
4. **Adaptation:** the olfactory receptors and smell center are adapt rapidly with continuous exposure to an odorant.
↳ due to fatigue of Na^+ channels → depolarization → ↓ discharge of impulse → adaptation

العودة إلى الحالة

Nasal Epithelium

- Stratified squamous (ciliated).
- 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

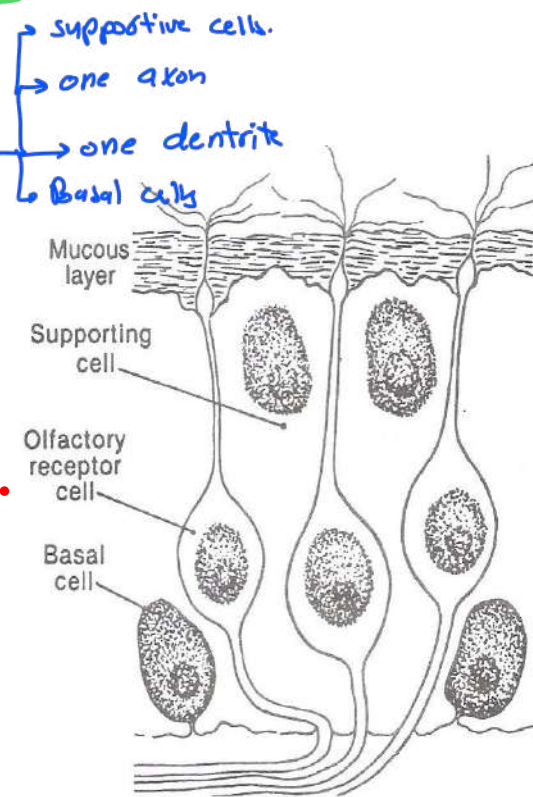
- ◆ **Three components:** Epithelium, basement membrane, lamina propria.

- ◆ **Cell Types:**

- **Olfactory receptor cells are bipolar neurons.** *send afferent nerve [olf. nerve]*
↳ in sup. nasal cavity

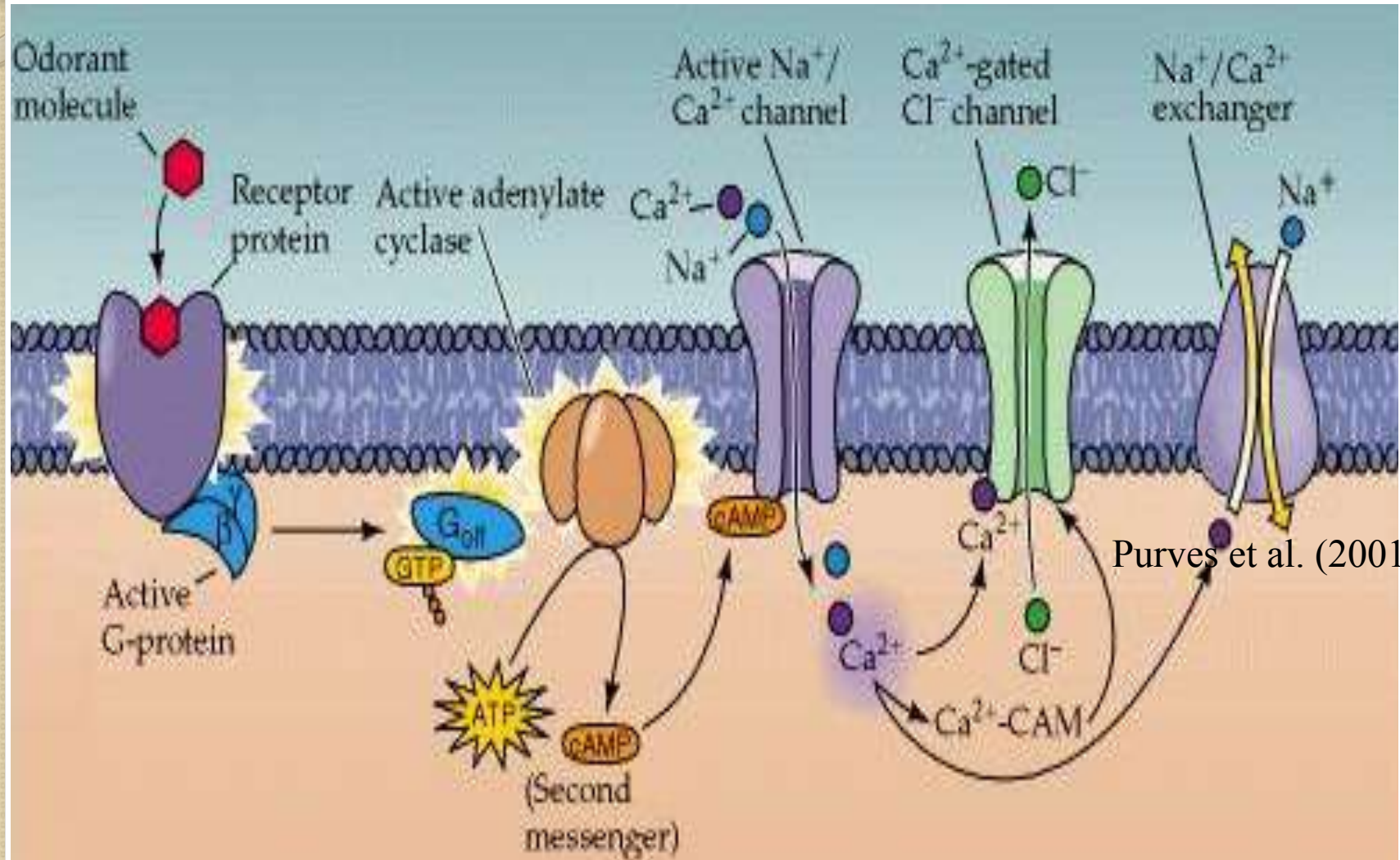
- Bowman's glands "Nasal glands".
- Olfactory ensheathing cells
- **Sustentacular cells "Supportive Cells".**
- **Basal cells.**
- Microvillar cells "another class of supporting cells".

- ◆ **Replacement of receptor cells (about 60 days).**
epith of nasal cavity



Olfactory Receptor Neurons

- Bipolar smell receptor neurons.

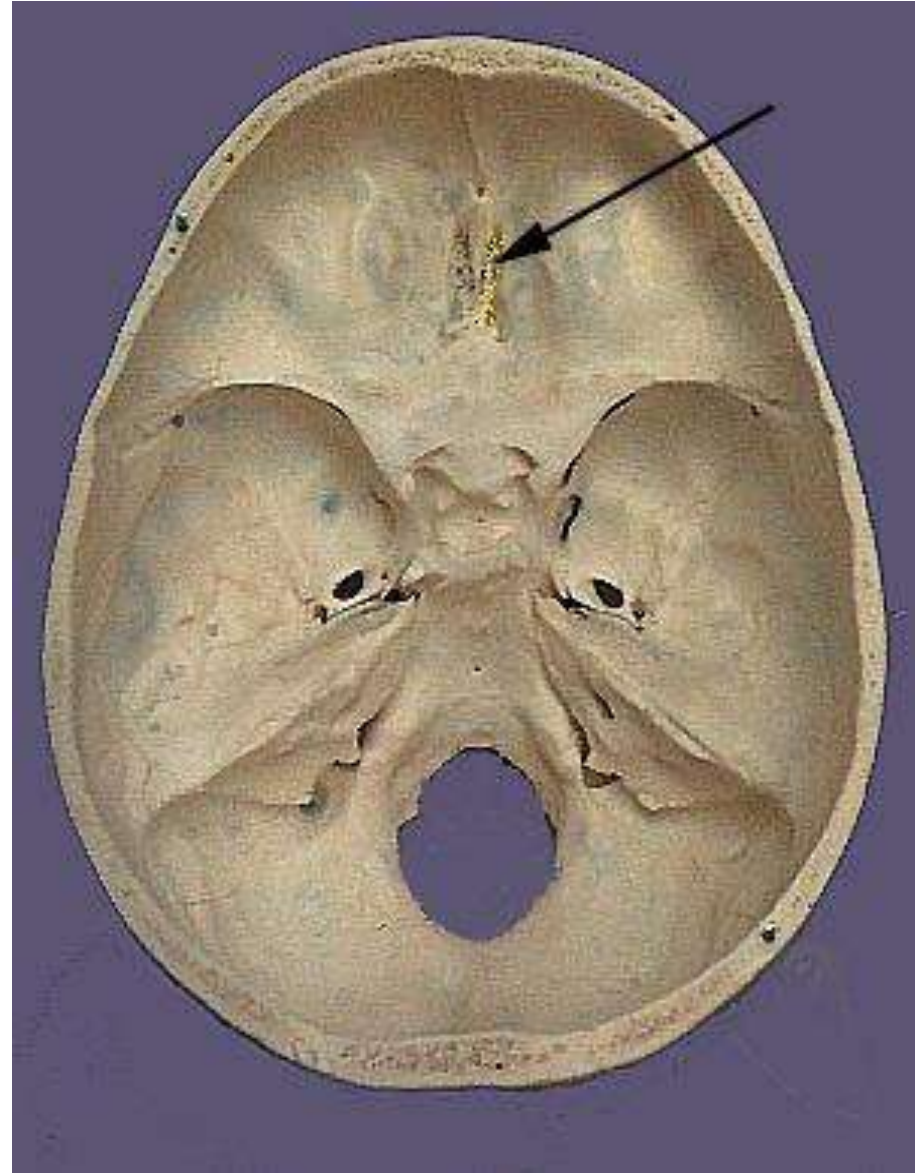


Cribriform Plate

olf. group ۱ و ۲ olf. nerve ۱ و ۲

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

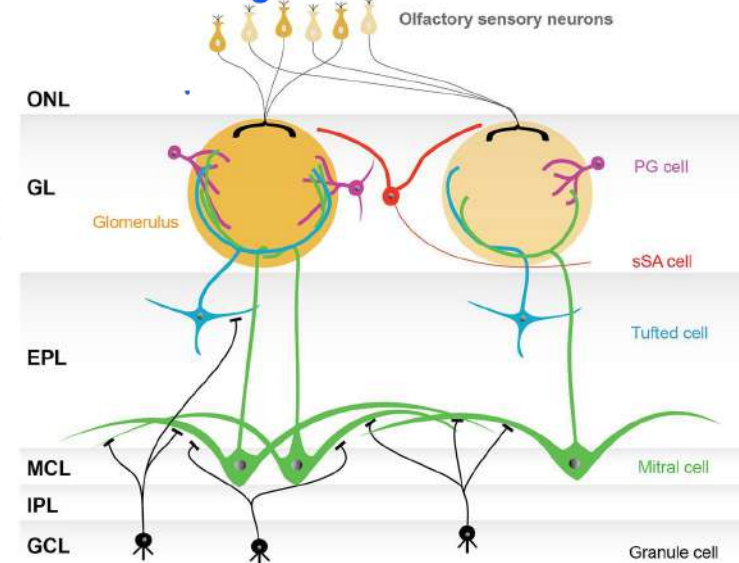
olfactory Bulb
↓
in the ant.
cranial fossa.



Olfactory Bulb → 6 layer.

- **Layer I**- Olfactory neuron layer "ONL"
- **Layer II**- Glomerular layer "GL" *the synaps of mitral cell*
- **Layer III**- External plexiform layer "EPL"
- **Layer IV**- Mitral cell layer "MCL" *2nd order neuron*
- **Layer V**- Internal plexiform layer "ICA"
- **Layer VI**- Granule cell layer "GCL"

to make synaps with the dendrite of 2nd order neuron by the olf. glomeruli:



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.

* odor [chemical substance] join to the septum forming odorant binding protein

↑ partial depolarization. ↓

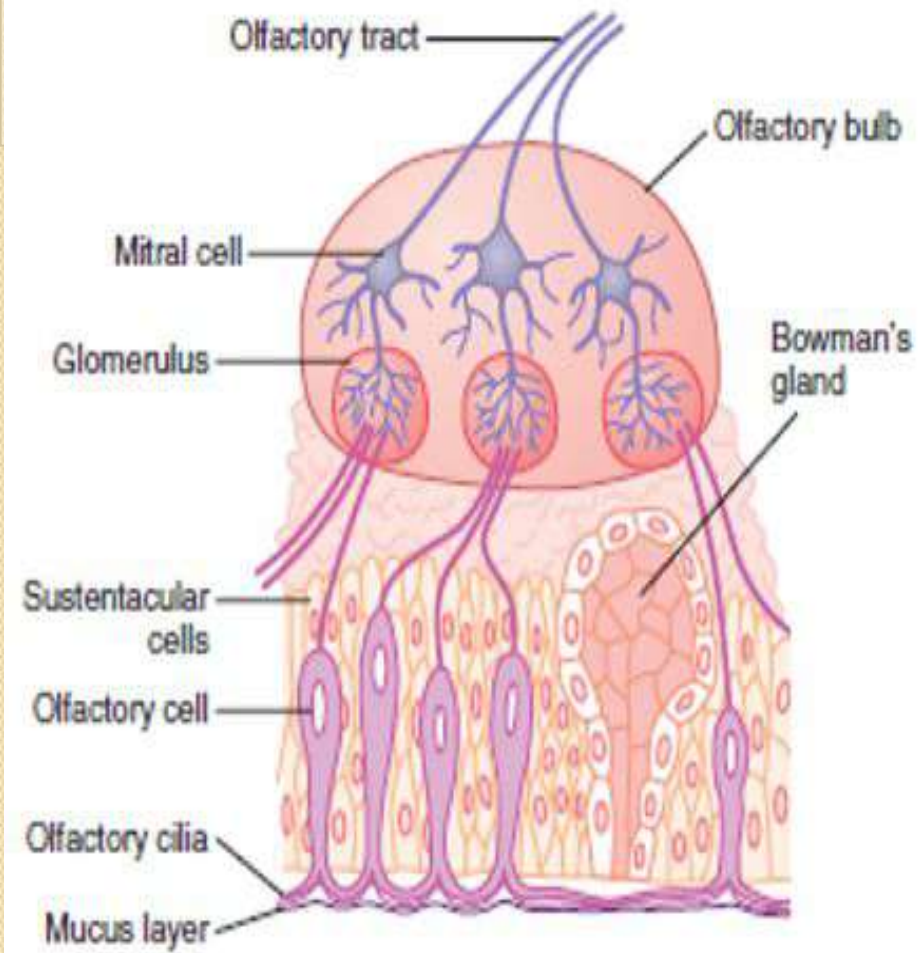
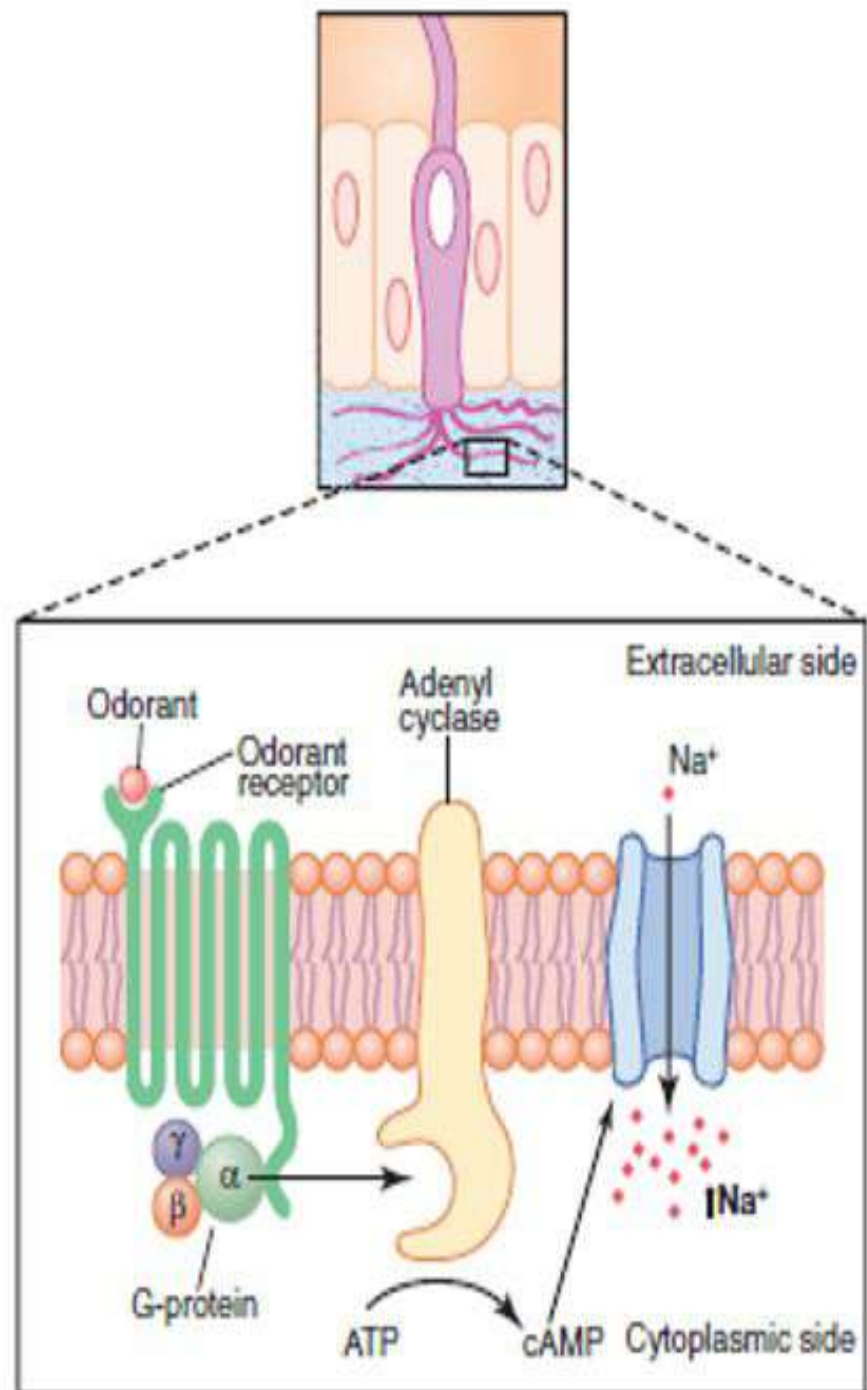
smell pathway at the level of receptor

* odorant sub. pass to sup. nasal cavity via olf. epithelium which has Bipolar smell receptor → Bind with the odor forming odor binding protein

open Na^+ channel ← stimulate adenylyl cyclase ← stimulate G protein

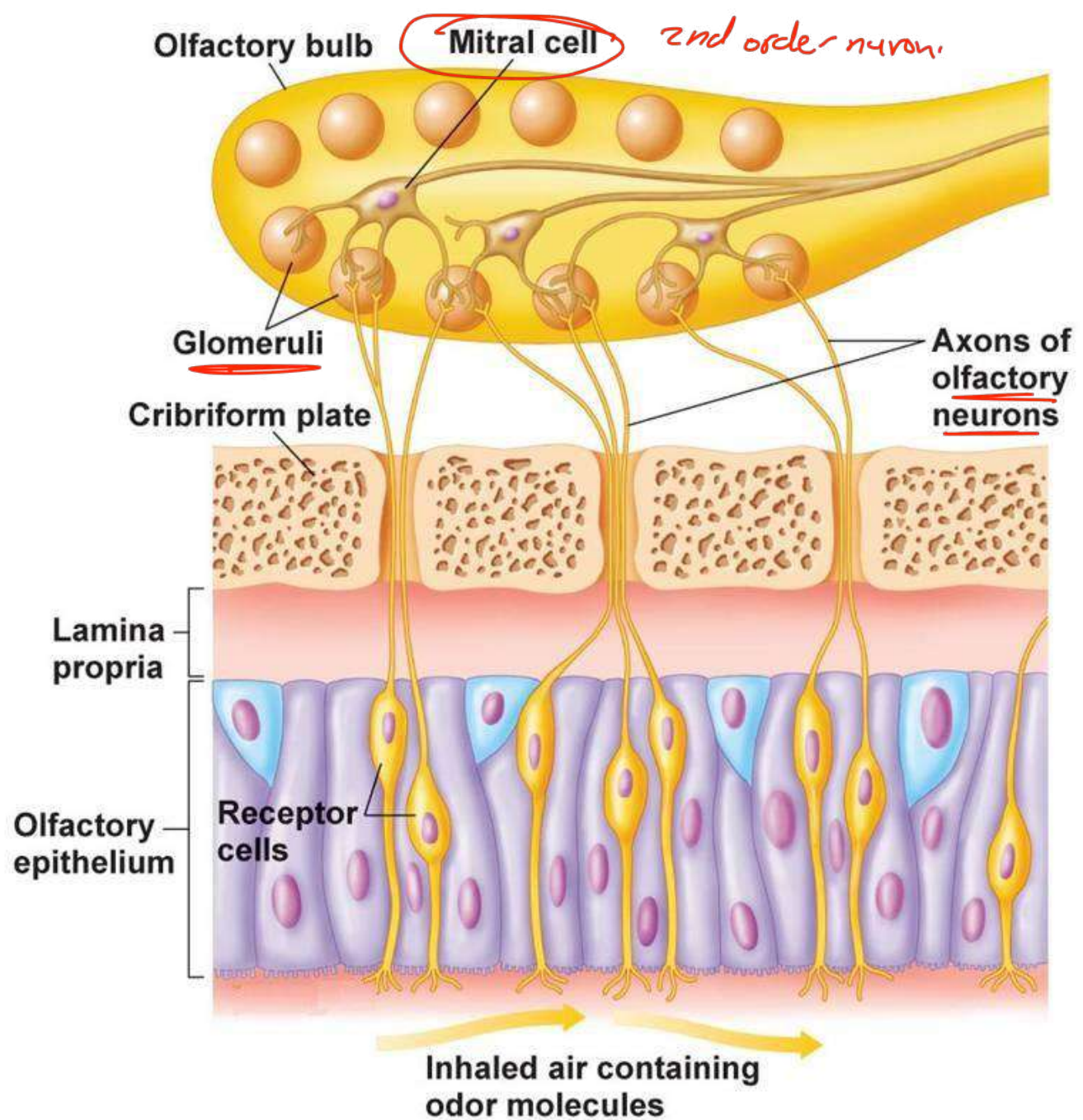
↳ lead to form R. AP and partial depolarization → deep depolarization → the signal reach to olf. nerve → 2nd order neuron ... [smell pathway]

- depolarization).** * theory of the adaptation: ←
 ← de polarization و fatigue to Na⁺ channel ←
 ← and G protein ←
 ② remodeling of R. ③ adaptation of small cortical center in the temporal lobe



Pathway of Smell Sensation

1. 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.
glomeruli [synaps]

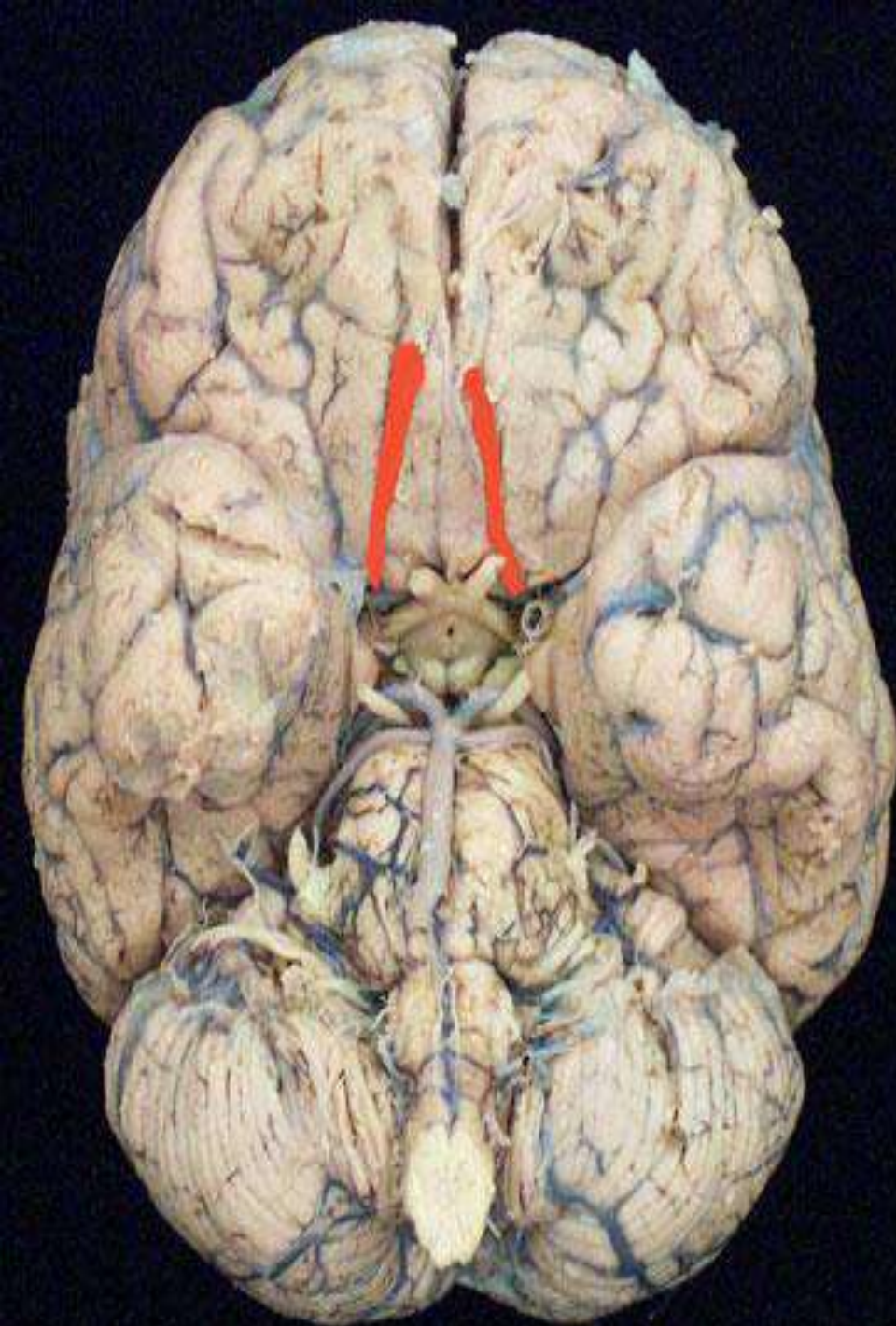
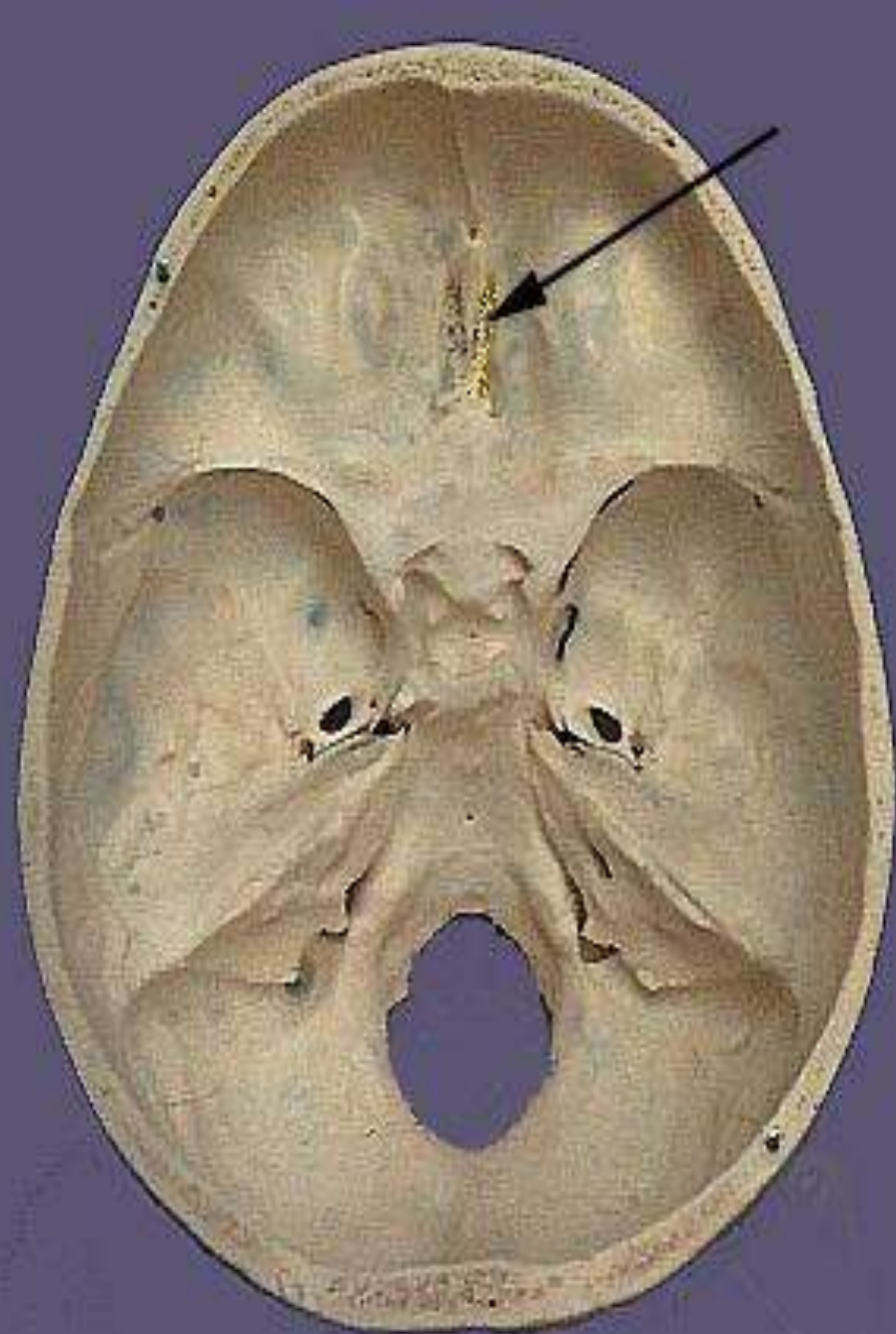


2. Second Neuron:

- 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.
to temporal lobe
give fiber to ant. commissure
- Some fibers project collaterals directly via **lateral olfactory striae and anterior commissure to primary olfactory cortex**.
connect the 2, if hemisphere. cerebral
then to opposite temporal lobe
- Ends in the uncus, parahippocampal, subcallosal, paraterminal gyri and amygdaloid body in temporal lobe (parts of the limbic system).
opposite

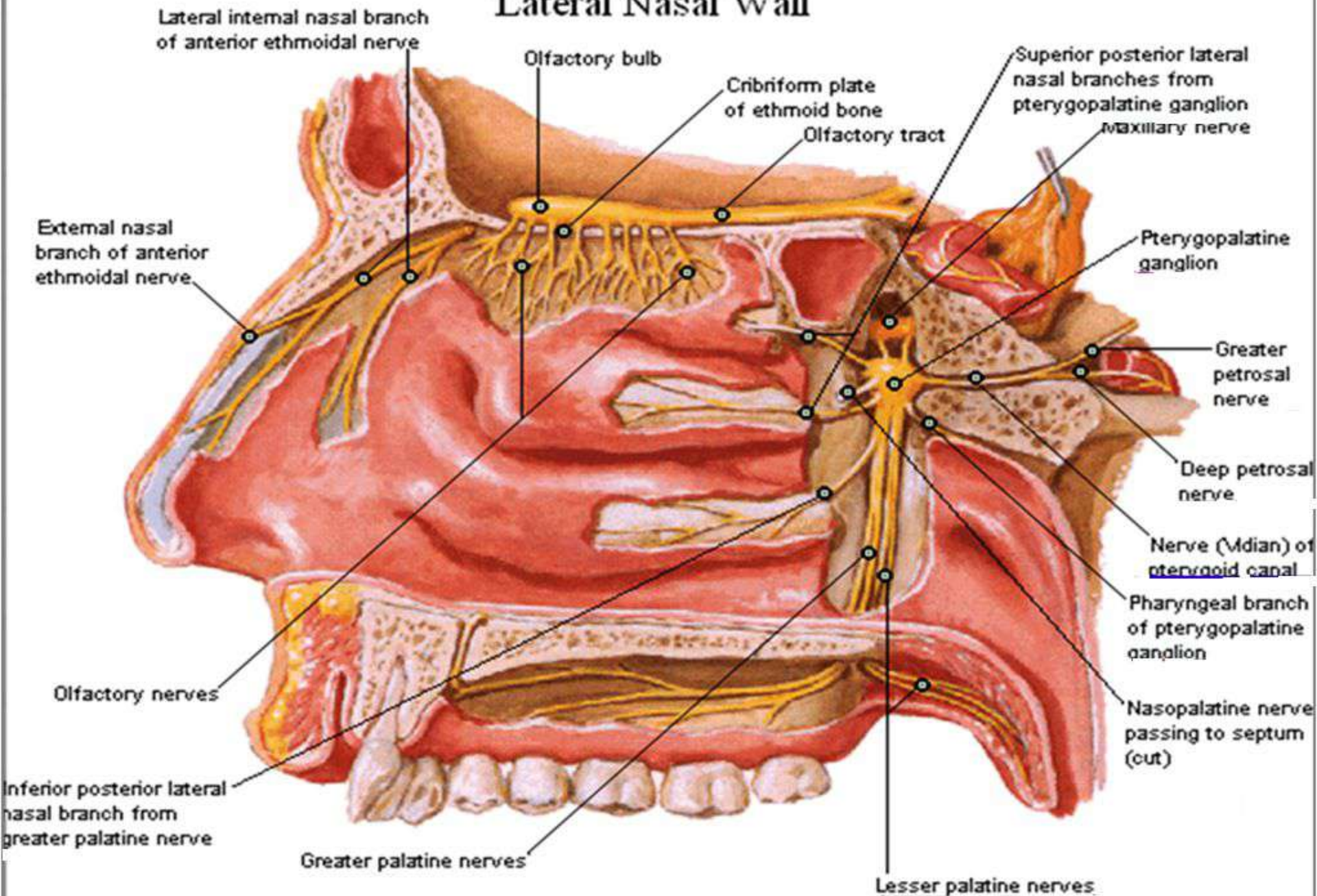
♦ **Note:** Unilateral lesion of temporal lobe does not cause anosmia as the sense of smell is bilaterally represented.

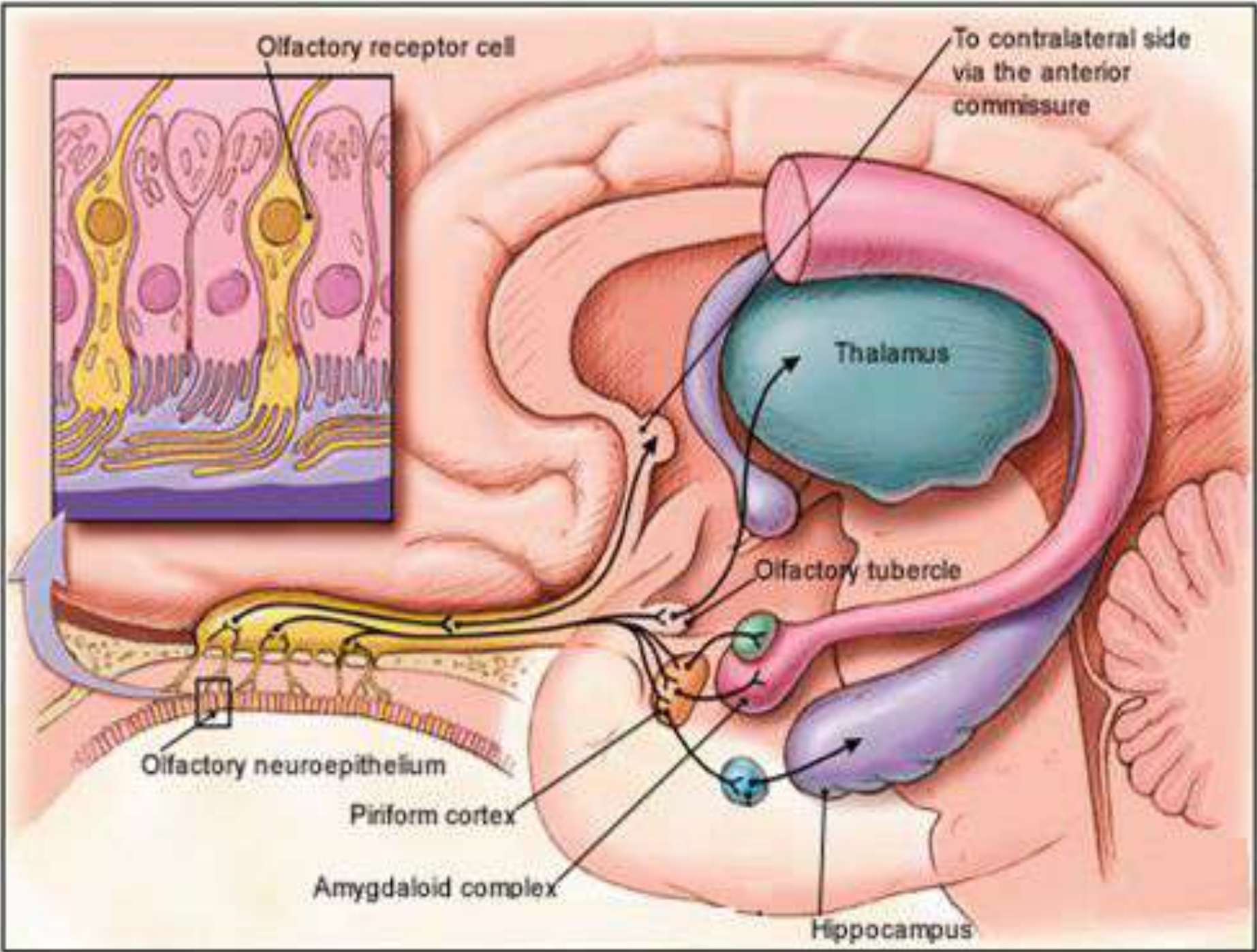
↳ sense of smell is Bilateral.



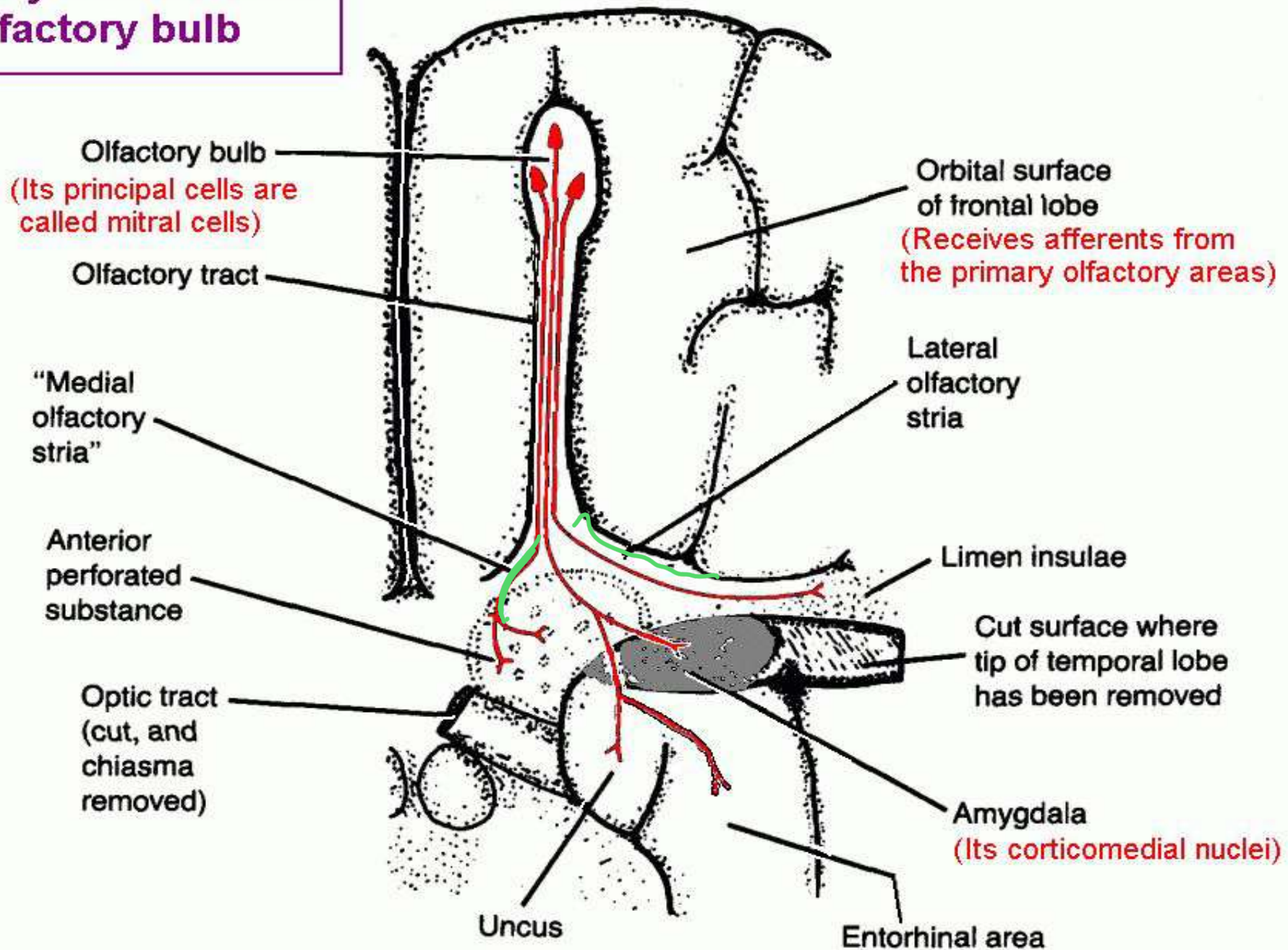
Nerves of Nasal Cavity

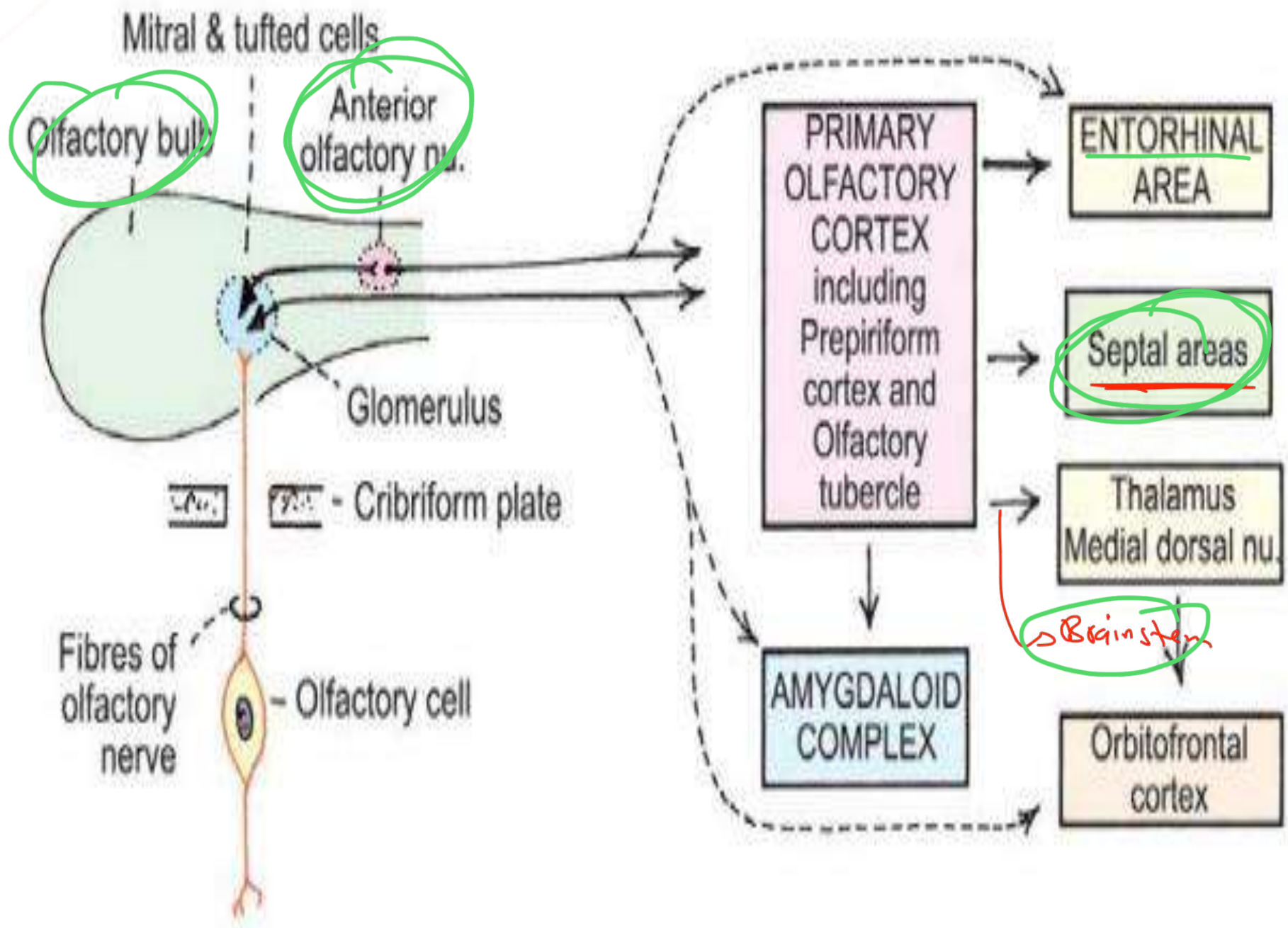
Lateral Nasal Wall



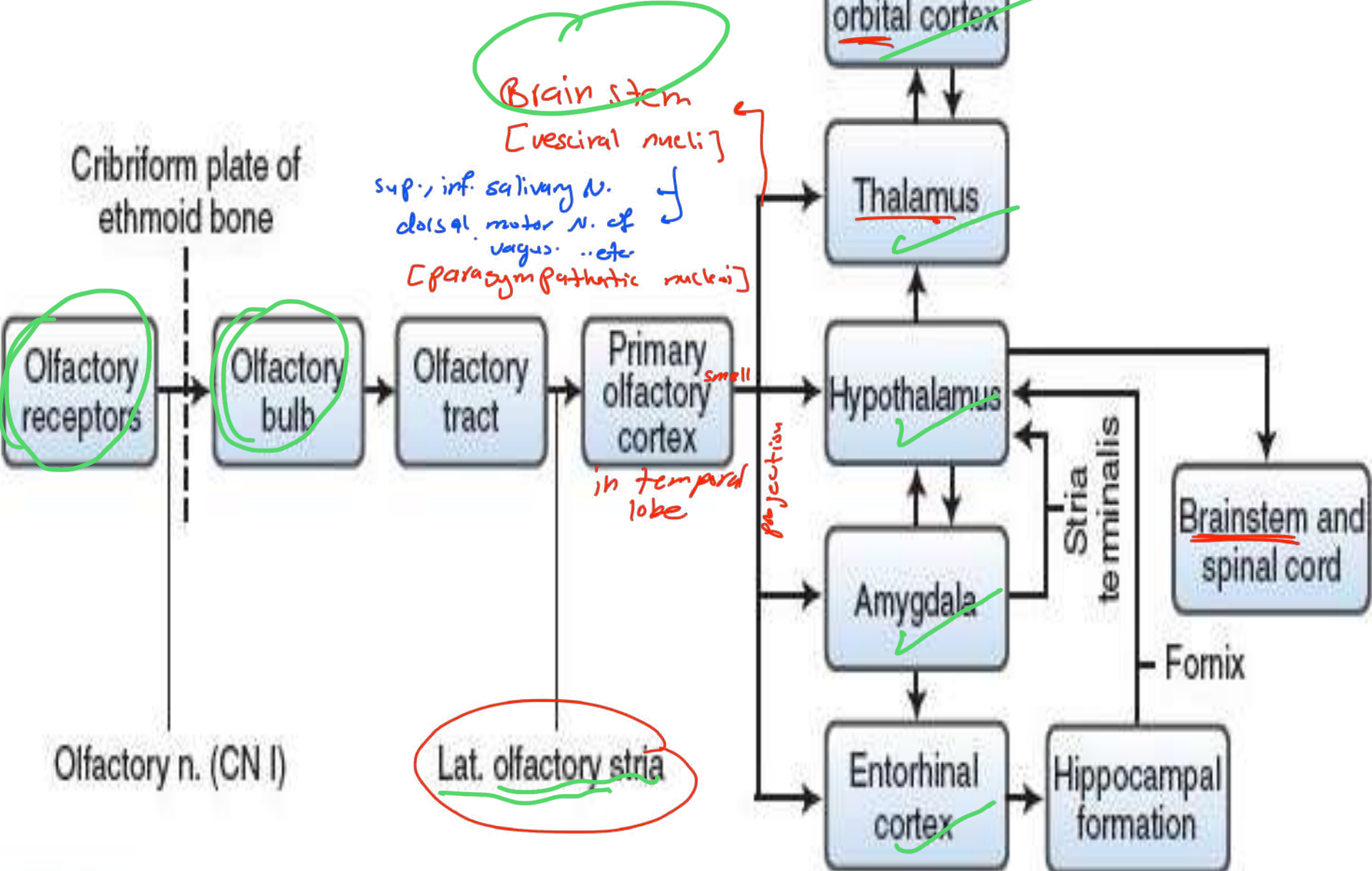


Projections of the olfactory bulb





* the largest commissure in the fibers is corpus callosum



Clinical Correlation

Lesion of the Smell Pathway

fracture of skull base + hematoma
[epidural, subdural] ↓
more dangerous [tumor in Ant. cranial fossa or olfactory groove] ← [تورم بيب]

1. Unilateral hyposmia or anosmia.

2. Bilateral hyposmia or anosmia. *due to commonal.*

3. Parosmia (Smell hallucination)

4. Cacosmia (bad smell in chronic sinusitis)
discharge او من قضاة القطن اذئف
التهنن سنيخج
Bad smell

5. Olfactory agnosia

عسك عيز الريحه.

Causes of Unilateral Anosmia

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

Brain injury

in Ex meningitis
↳ fever, headache

- Olfactory groove meningioma →

Foster Kennedy syndrome:

unilateral loss
of smell
tract

1. **Ipsilateral anosmia:** due to direct pressure on olfactory pathway.
affect the smell pathway [tract - bulb]
2. **Ipsilateral optic nerve atrophy:**
due to direct pressure on the optic nerve.
[↓ vision ipsilateral]
3. **Contralateral papilloedema:**
due to increase intracranial tension.
due to ↑ tumor size → ↑ ICP



* if the meningioma is large →
→ high degree of Foster
Bilateral papilloedema.

* we don't see the papilloedema
in the side of lesion due to
the atrophy so appear in
the normal side.

Causes of Bilateral Anosmia

- ENT causes: common cold, atrophic rhinitis.
- Heredofamilial. *وراثة*
- Hysterical. *psychogenic loss of smell*
- Excessive smoking. *the nicotine lead to Atrophic changes*
- Use of cocaine. *toxins to the Bipolar smell receptor lead to Atrophy in this R.*

Causes of Parosmia (Smell Hallucination) and Olfactory Agnosia

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

① • Psychogenic ex schizophrenia

Psychogenic
فقد استنشاق
فقد استنشاق
focal Brain damaged

→ space occipital lesion
!!

Gustatory System



II. The Sense of Taste

“Gustatory System”

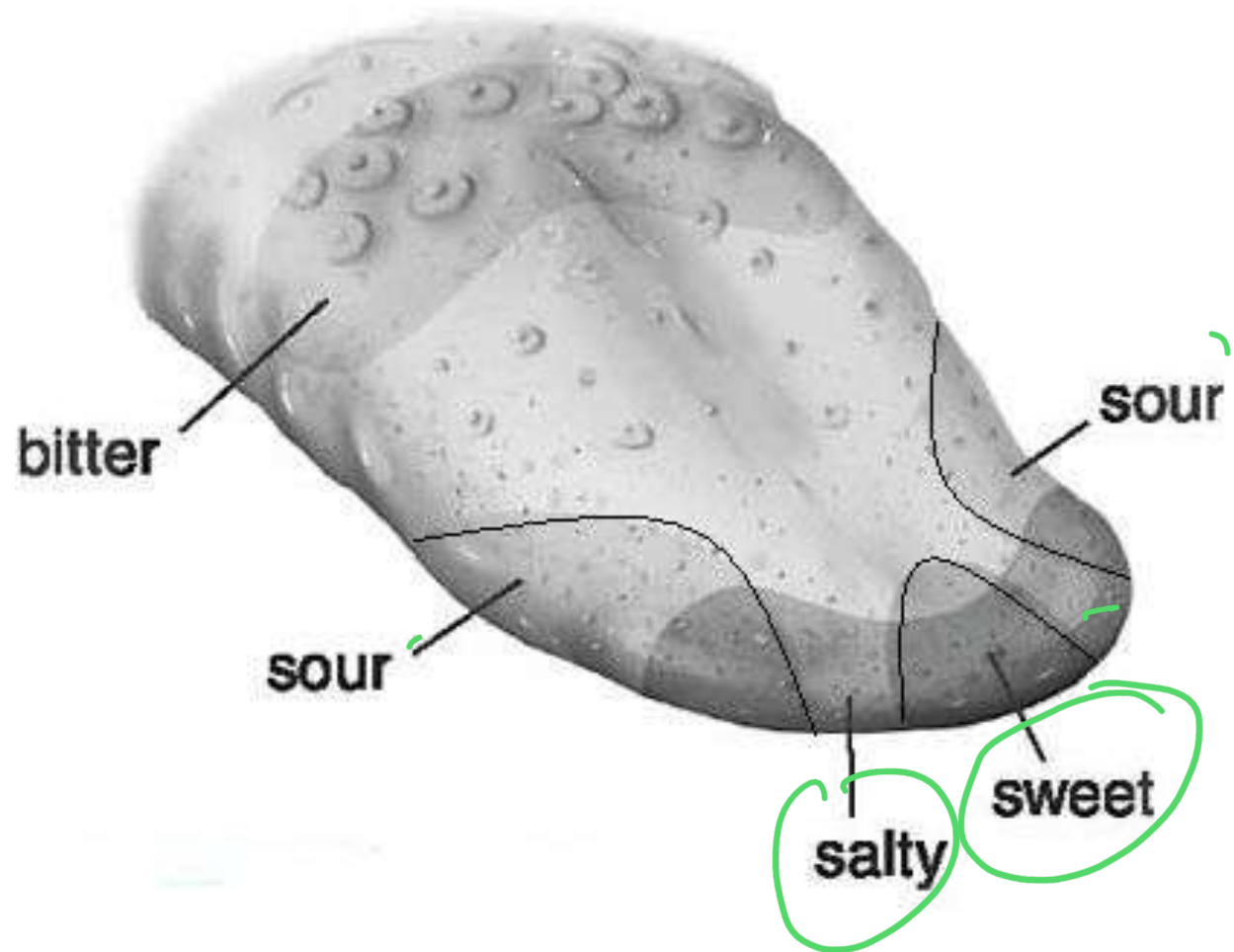
- The taste stimuli are detected by taste receptors within the tongue, palate, epiglottis and pharynx.
- **Functional Modality:** mediates the **special visceral afferent modality of taste** Taste via the facial, glossopharyngeal and vagus nerves.
- Mediates gustation, which, like smell, is **a chemical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

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. *Lodrug - coffee* 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 *lateral, anterior..* is the area most sensitive to salty stimuli.
4. **A sour sensation:** is produced by acids. *lemon* The posterior half of each side of the tongue *lateral, posterior* is the area most sensitive to sour stimuli.



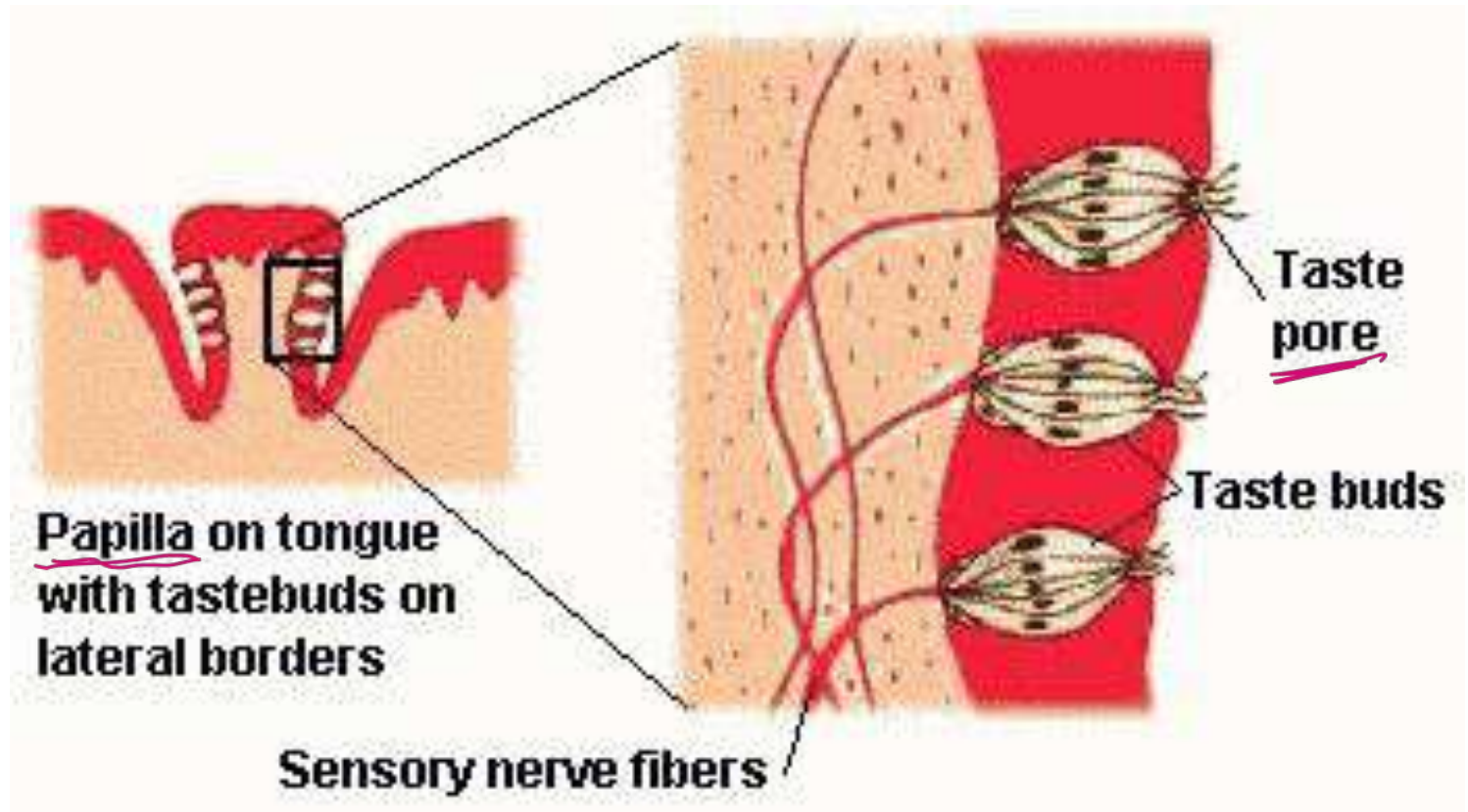
The Taste Buds

- ◆ **Taste Receptors:** taste cells (receptors) are located within ^{has 40-60 taste R.} taste buds, which are located within tongue papillae (Tongue Papillae → Taste Buds → Taste Cells or Receptors).
₄₀₋₆₀
- ◆ **Distribution of taste buds:** taste buds are located on the tongue papillae, hard and soft palate, epiglottis and pharynx.

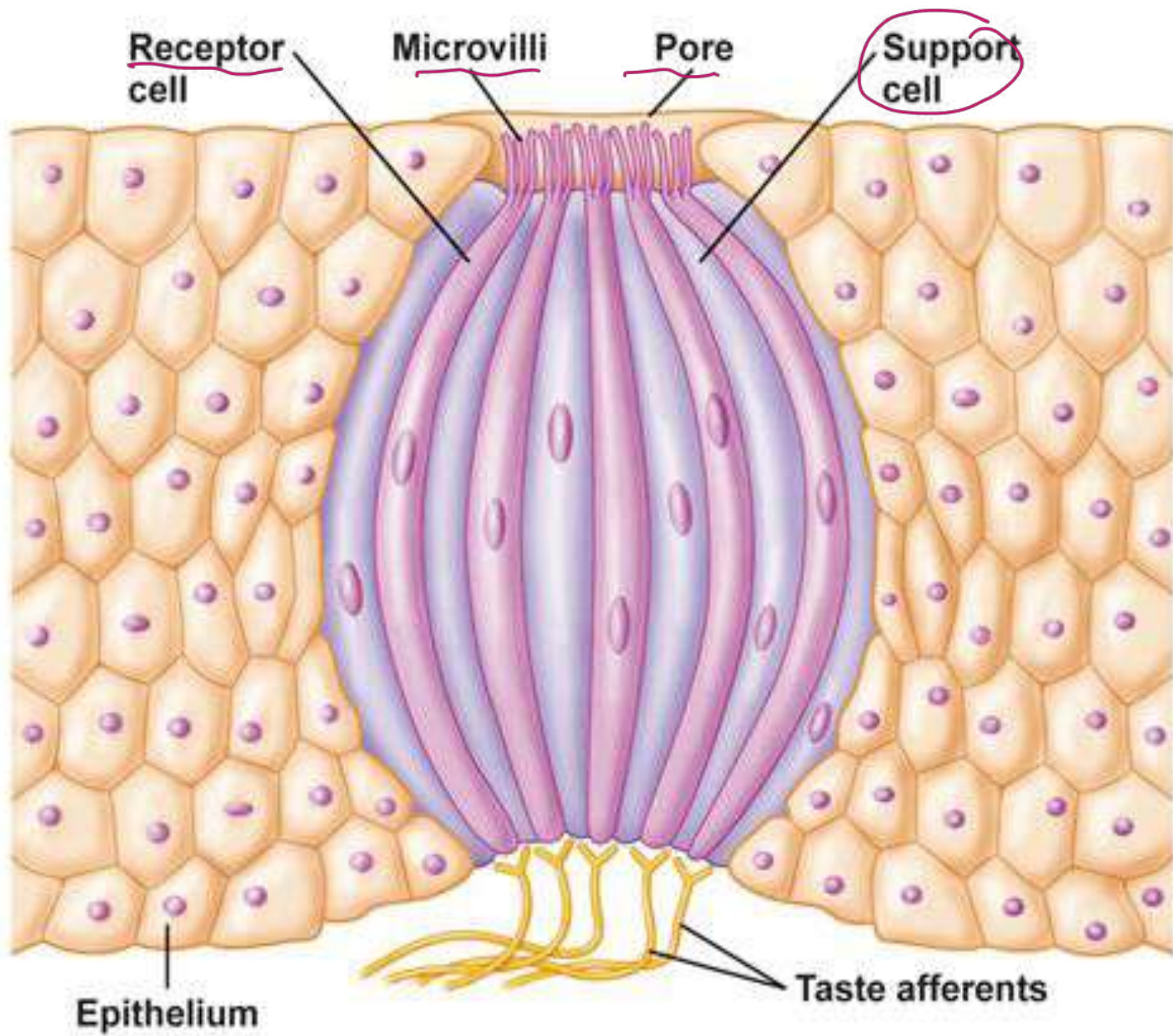
The Structure of Taste Buds

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
→ send to taste afferent fibers
└─┬─┘
Branches of the cranial nerve
7, 9, 10
- 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.

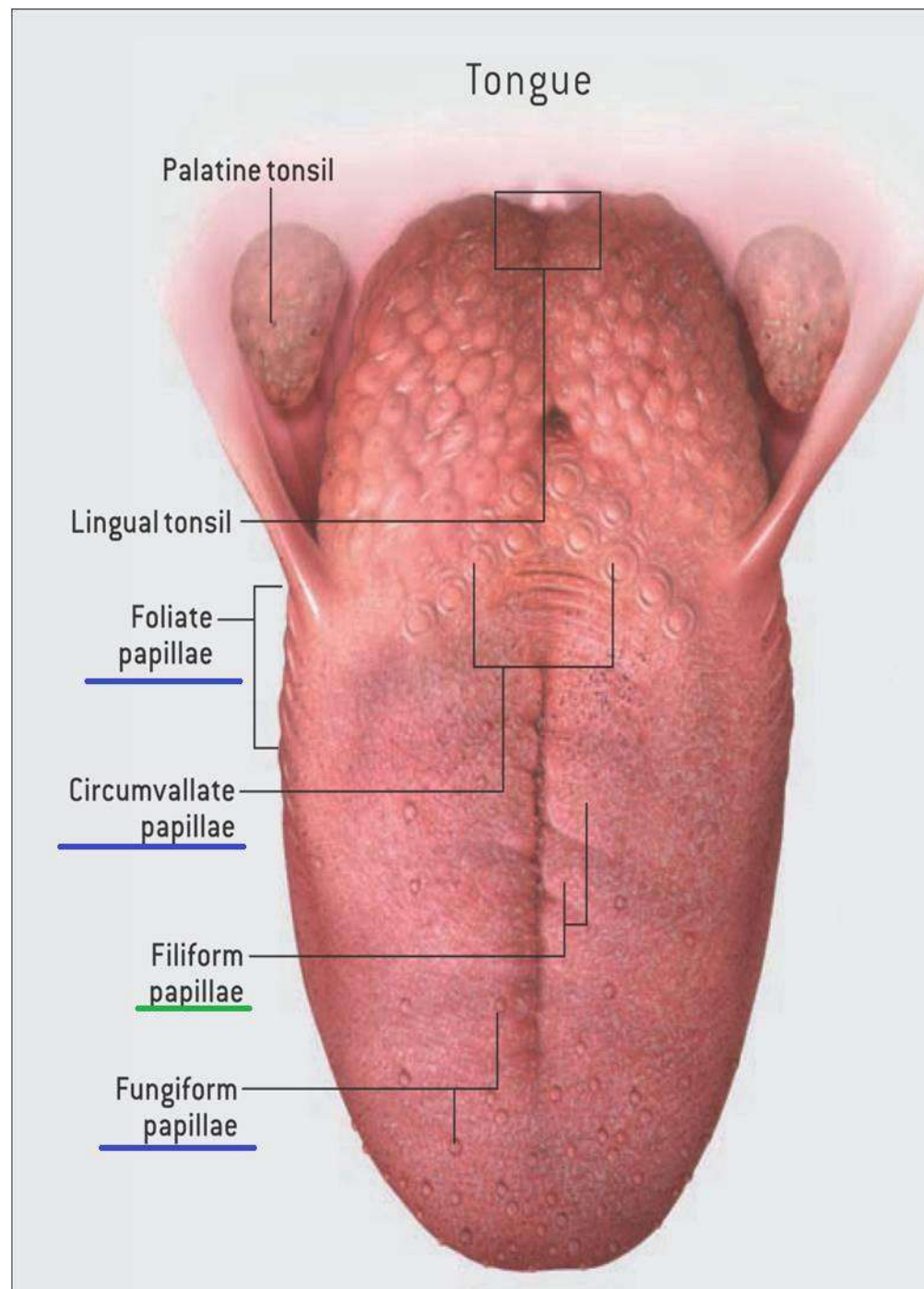
✓ Regeneration of taste buds:

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 $2/3^{\text{rd}}$ 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.
anterior to the circumvallate.



The Anterior Two-thirds of the Tongue

- Has **fungiform papillae**.

8-10 taste buds.

- Detects **salty and sweet** sensations.

- Is innervated by **CN VII (chorda tympani)**.

facial nerve
for taste sensation.

The Posterior One-third of the Tongue

- Has **circumvallate and foliate papillae**.

post side

lateral side

- Detects **sour and bitter** sensations.

- Is innervated by **CN IX (glossopharyngeal)**.

lingual Branch. Efferent

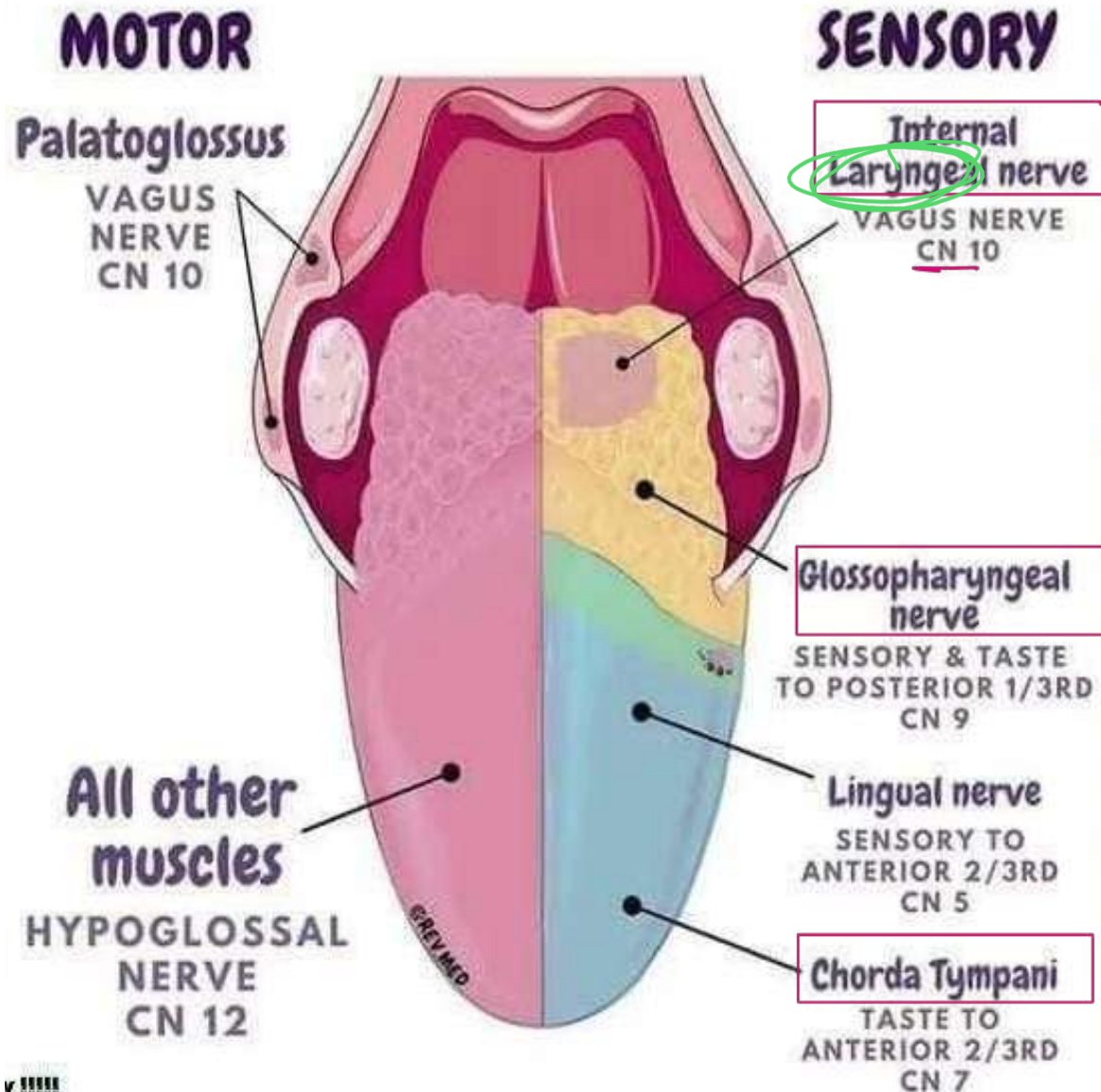
- The epiglottis are innervated by **CN X**.

efferent

internal laryngeal N Branch
of sup. laryngeal N. or
of vagus nerve.

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.

note الحنك باللسان

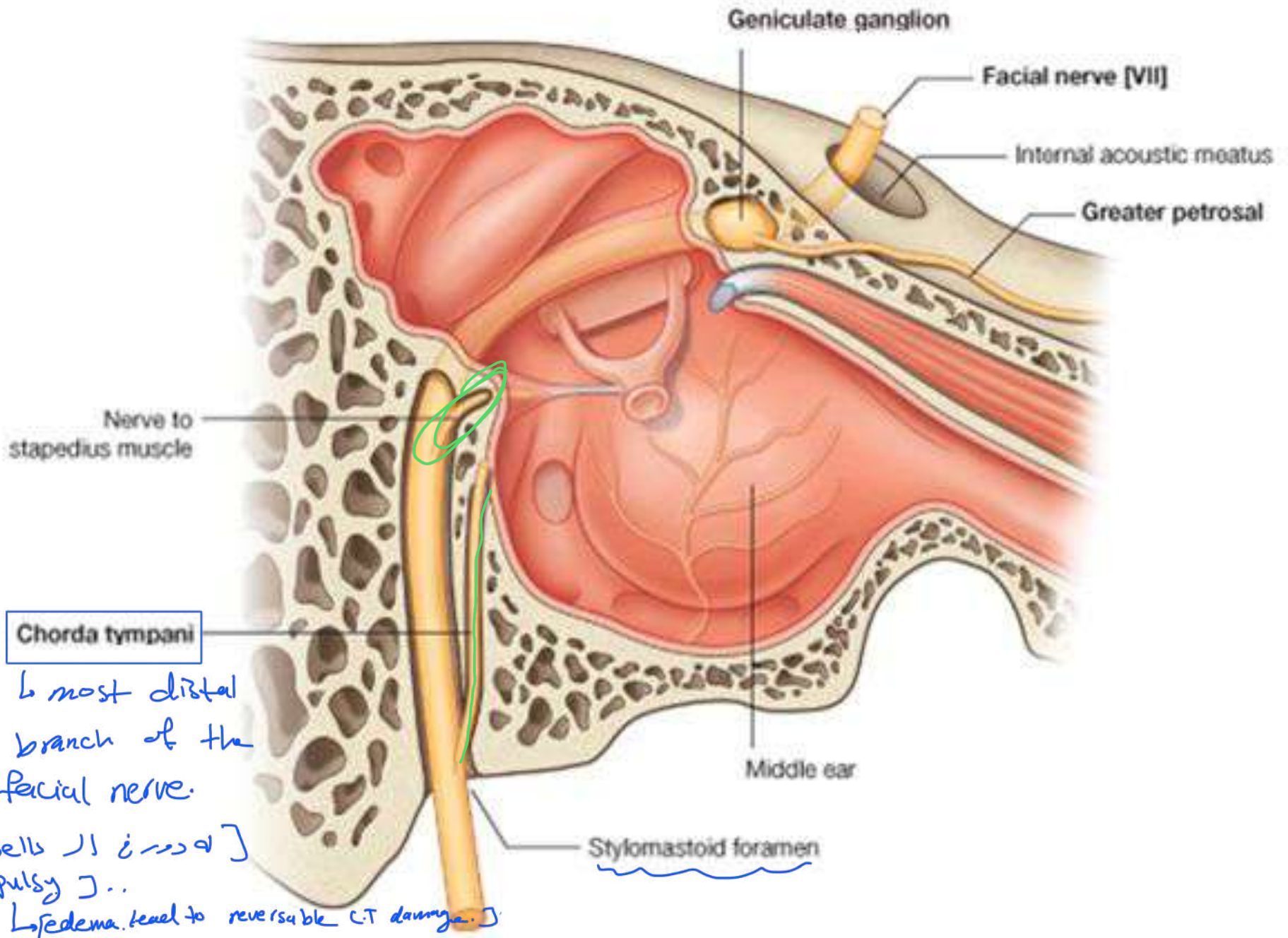
- I. **First Neuron:** cells in **the sensory ganglia** (**Geniculate ganglion** of **CN VII**, ^{to post. 1/3} **inferior ganglion “Petrosal ganglion”** of **CN IX** and **inferior ganglion “Nodose ganglion”** of **CN X**) → ^{to ant. 2/3}

The central process of these ganglia enter the medulla oblongata to the rostral part of **Solitary nucleus**.

the dendrite of the 1st order neuron - [branches of cranial nerve]

- ① Chorda tympani
- ② lingual
- ③ internal laryngeal

- **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.
- axon of 1st order neuron*



↳ most distal branch of the facial nerve.

Bells 11 i r s d]
pulsy]..

↳ [edema. lead to reversible C.T damage.]

2. Second Neuron (Solitary Nucleus):

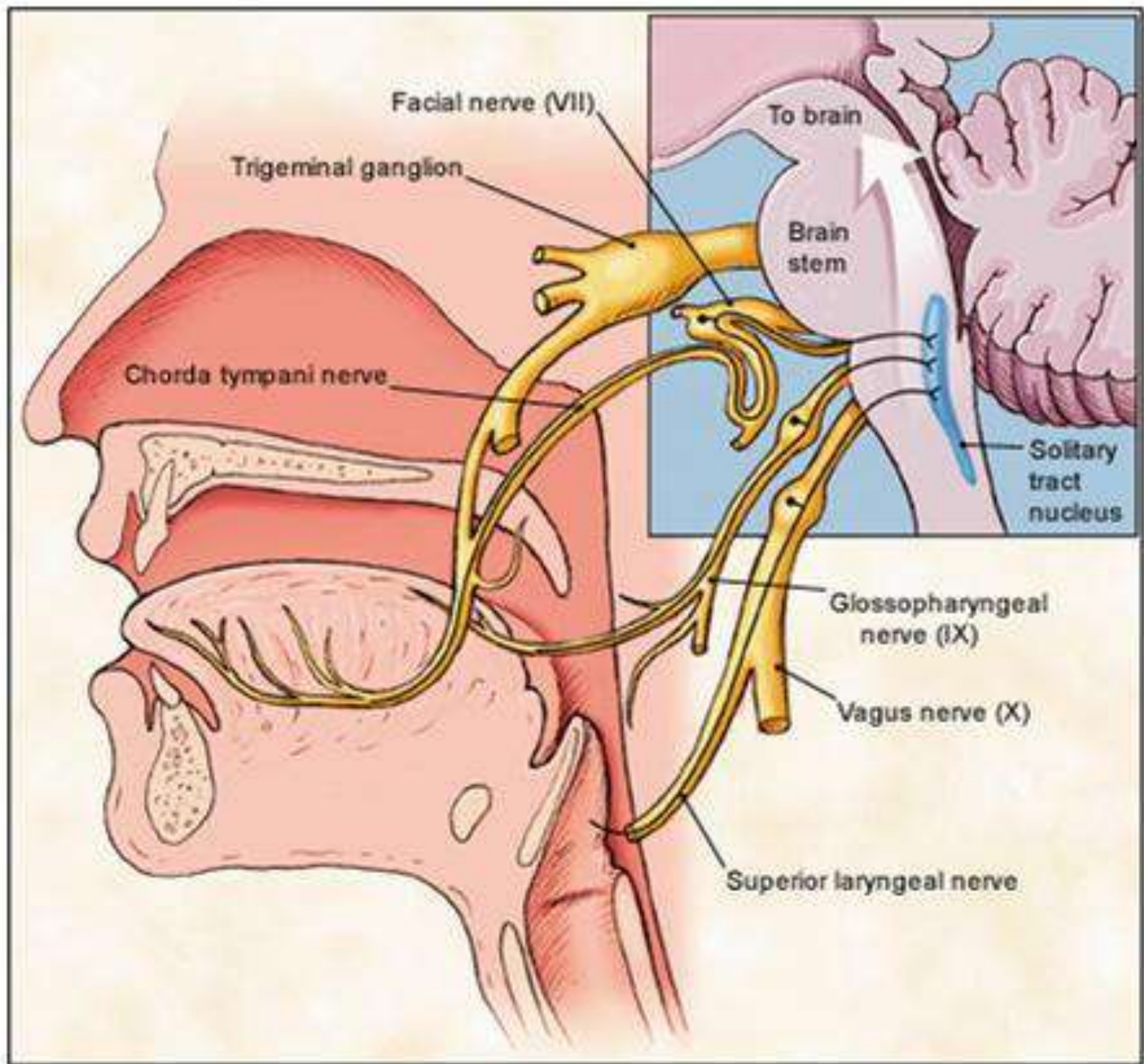
2nd order neuron

- Axons of the rostral part solitary nucleus ascend in the ipsilateral central tegmental tract ^{مخرج الحبل} to end in the VPM nucleus ^{ventro posterior medial 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):

3rd order neuron

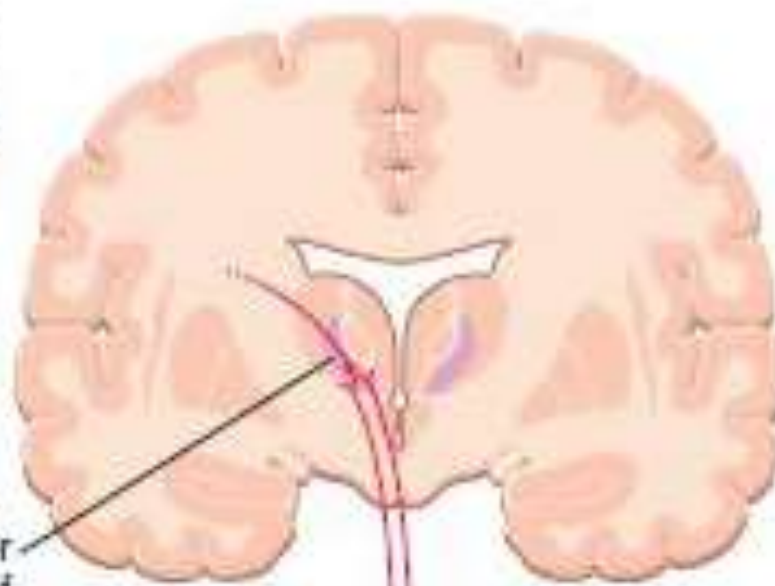
- Fibers run in the sensory radiation which passes in the posterior limb of the internal capsule and projects to the gustatory cortex of the parietal and frontal operculum (area 43) and insular cortex.

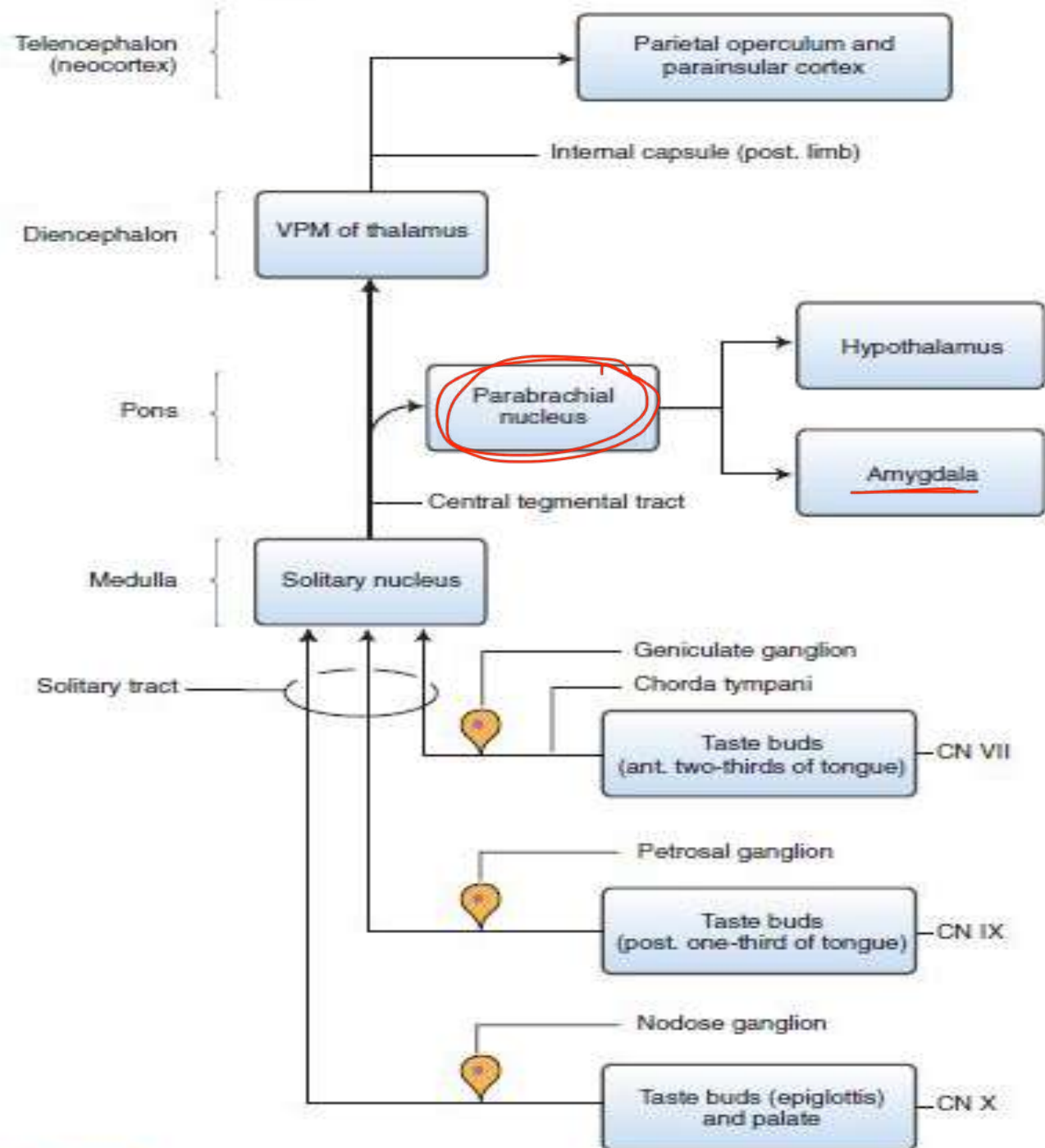


Gustatory cortex
(anterior insula-
frontal operculum)



Ventral posterior
medial nucleus of
thalamus





Taste Innervation

Part	CN	Branch	Ganglion	Foramen
Anterior 2/3 tongue	VII	<u>Chorda</u> tympani (via <u>lingual</u>)	Geniculate	Internal acoustic meatus
<u>Soft palate</u>	VII	<u>GSPN</u>	Geniculate/ etc	Internal acoustic meatus
<u>Posterior 1/3</u> <u>tongue</u>	IX	<u>Lingual-tonsill</u> ar branch	<u>Petrosal</u>	Jugular foramen
<u>Epiglottis</u>	X	<u>Laryngeal</u> branch	<u>Nodose</u>	Jugular foramen

Clinical Correlation

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



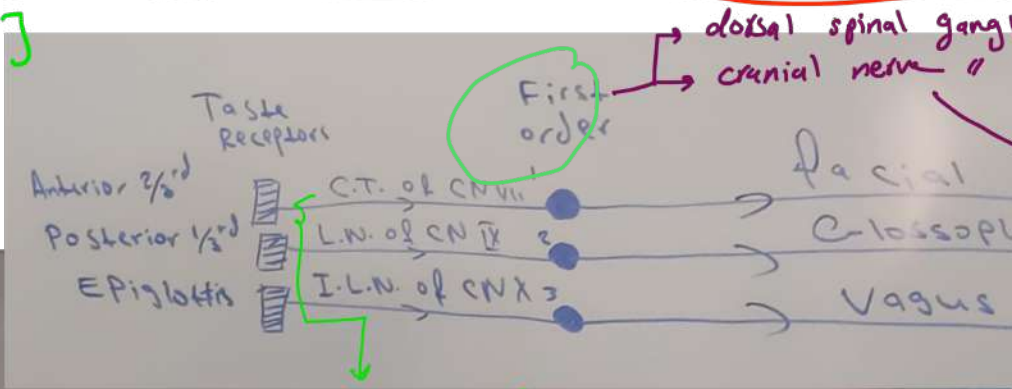
Thank You

* pathway of smell :- [slide 19]

first neuron order → in the epith. cell body [Bipolar smell cell]
 odor pass to nasal cavity by the dendrite reach to the cell body
 send the signal from first order neuron to 2nd order neuron. via axon of 1st order neuron
 → Filament of olfactory N.
 in the 4th layer [Mitral] ← mitral cell

olfactory Nc glomerular layer :- 2nd layer & 4th layer (2nd order neuron) 4th layer cell body in 4th layer begin of olfactory tract
 glomeruli [synaps between axon of 1st order neuron with the dendrite of 2nd order neuron]
 → pass in olf. groove in the cribriform plate of ethmoid bone
 axon of 2nd neuron.

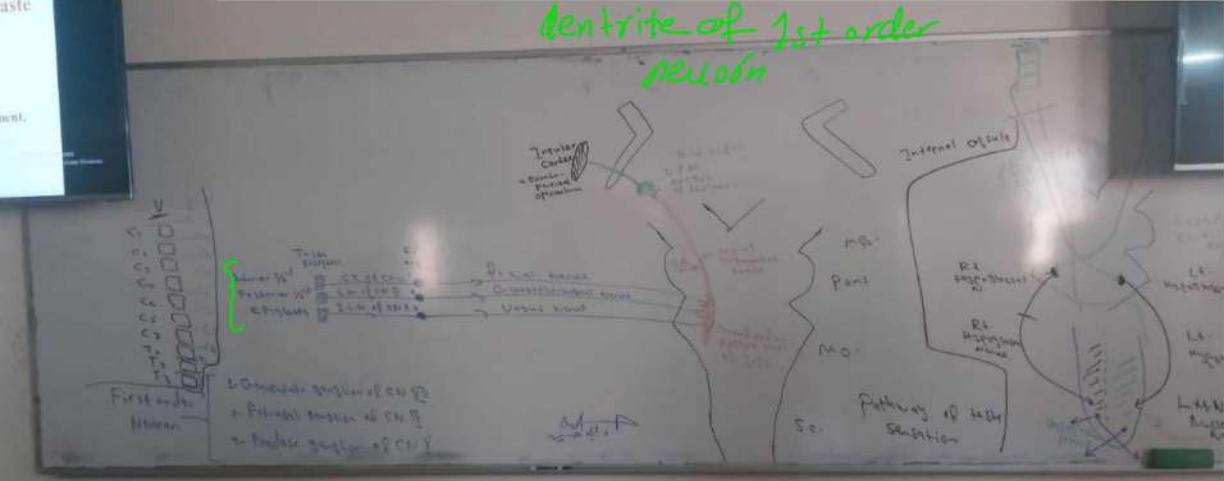
[slide 46]



- 1. Geniculate ganglion of CN VII (inferior of glossopharynx...)
- 2. Petrosal ganglion of CN IX (first neuron of taste from post 1/3 of tongue)
- 3. Nodose ganglion of CN X (inferior of vagus first neuron of taste from epiglottis)

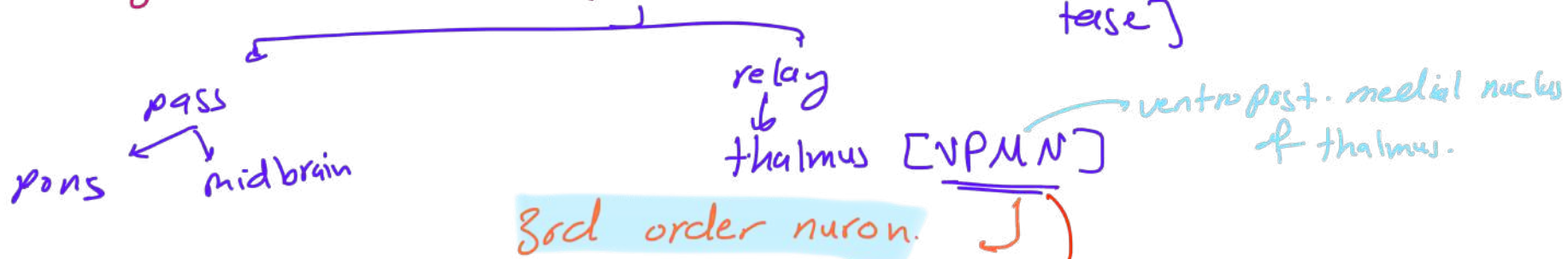
dendrite of 1st order neuron

* the signal begin from the R



* the 2nd order neuron → Solitary nucleus. response for the all taste and general sensation.

↳ emerge from central tegmentum tract. [axon of 2nd order neuron of taste]



the the signal emerge from the thalamus to the cortex
via thalamocortical pathway: pass to the post. leg of internal capsule. to reach the
insula and the fronto parietal operculum of the insula
↓
insula is part of the cortex

para brachial nucleus. → in the pons. → central tegmentum tract → thalamus → fibers →

↳ project some fiber to the amygdaloid nucleus and to the hypo thalamus
↳ part of BN
↳ part of diencephalon.