

Khalleedd  **Lecture:**

## **Chemical Sensations: Smell and Taste**

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# The Sensory System

The various sensations in the body include:

1. **Somatic sensation:** Afferent by somatic nerves from the skin and deep tissues (e.g. muscles, joints and bones), conducted to CNS through the somatic nerves. Like pain temperature cough and so on
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:** Afferent by autonomic nerves → 10973 including all sensations from the internal viscera and reaching the CNS through the autonomic nerves.
4. **Organic sensations:** In hypothalamus and diensephalen e.g. hunger, thirst and sexual sensations.

# Sensory Functional Modalities

Afferent

## 1. General Somatic Afferent (GSA): somatic sensory "afferent"

For touch pain proprioception temperature sensation

**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

For special sensation not related to GIT = hearing and vision

**senses**, (fibers include the optic nerve and the vestibulocochlear nerve).  
Vision Hearing

## 3. General Visceral Afferent (GVA): conduct sensory impulses

For sensory impulses of internal organs

**(usually pain or reflex sensations)** from the internal organs, glands, and blood vessels to the central nervous system.  
Like the stretched urinary bladder sensation  
Irritation from diseased or inflamed organ cause pain sensation in it

## 4. Special Visceral Afferent fibers (SVA): afferent fiber that develop

For special sensation related to GIT = smell and taste

**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).  
Smell Taste

Taste sensation by 3 cranial nerves: \*Facial nerve by chorda tympani for ant. 2/3 \* Lingual of glossopharyngeal for post. 1/3 \* Vagus give superior laryngeal and has external and internal branches the internal supplies the sensation above vocal cords and give a branch for taste sensation in epiglottis.

# 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.

*Optic nerve*

*Special somatic afferent*

II. Sense of the smell.

*Olfactory*

*Special visceral afferent*

III. Sense of the taste.

*3 cranial nerves: 7th 9th and 10th*

IV. Sense of the hearing and equilibrium.

*vestibulocochlear nerve*

# I. Sense of the Smell

- **Functional Modality:** mediates the **special visceral** The sensations related to gut like smell and taste **afferent modality of smell** via **the olfactory nerve**. Pass through Cribiform plate About 20 filaments of nerve in each side
- 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** Specially V1 and V2 **nerve**, which detects **noxious** Harmful or **painful stimuli**, such as **ammonia**. We know that branches of ophthalmic nerve V1 supplies nasal cavity so if we smell something harmful like ammonia olfactory nerve don't affected

- The olfactory pathway has <sup>Smell sensation</sup> **no precortical relay** in the thalamus. <sup>No 3rd order neuron</sup> → <sup>It relay directly in temporal lobe</sup>
- Projects to the thalamus <sup>A connection with</sup> **“Dorsomedial Nucleus”**, hypothalamus, amygdaloid body, and hippocampal formation.

<sup>It relay in 2nd motor neuron:</sup> **mitral cells** of olfactory pulp,  
<sup>it lies in olfactory tract and ascends to olfactory cortex</sup>

# The Olfactory Nerve (CN I)

*Smallest and shortest*

➤ **Olfactory Nerve:** (Latin for "to smell").

➤ **Function:** **Special visceral**  
*Sensory* **afferent nerve (smell).**

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



*Olfactory nerve → olfactory pulp → olfactory tract attached to inf. surface of the frontal lobe*

*And found on ant. cranial fossa so if any tumor or hematoma in the area will affect the sense of smell by affecting olfactory nerve. 8*

# 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.

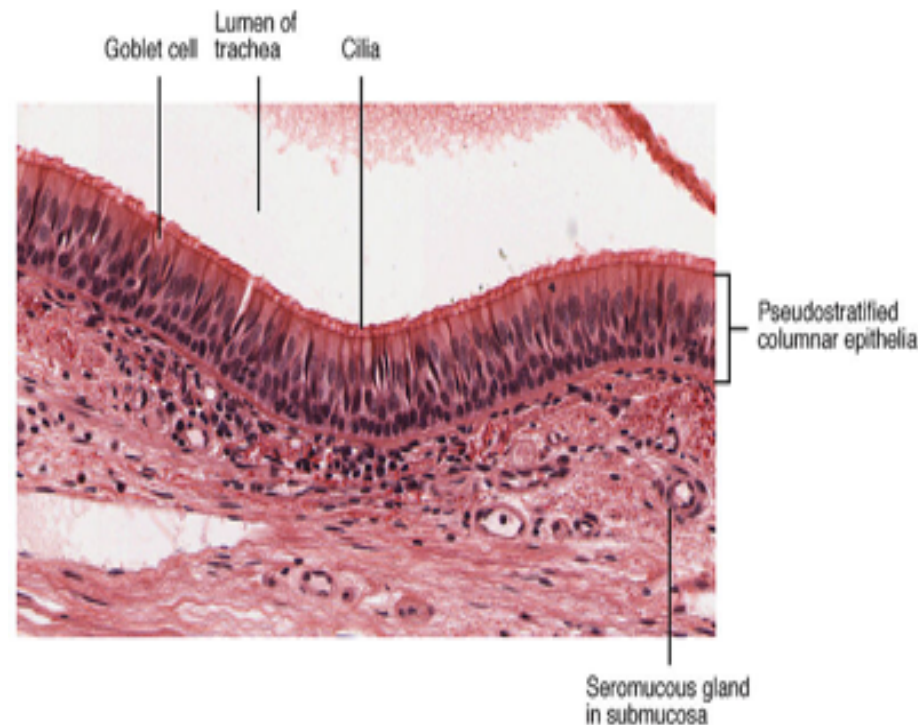
Saliva production by smell → signal goes to cortical center of the smell then give the thalamus and hypothalamus and insula then give order to superior and inferior salivary nuclei then they give order to salivary gland and give also dorsal motor nucleus of vagus nerve so increasing its effect so inc. Gastric juices and inc. Peristalsis movement

# Properties of Olfactory Receptors

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

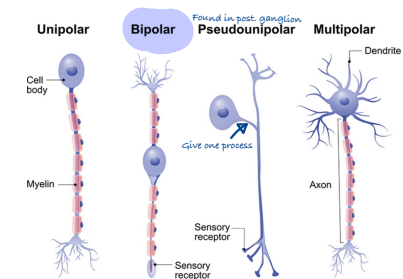
# Nasal Epithelium Pure Histology

- 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<sup>3</sup>



# Olfactory Epithelium

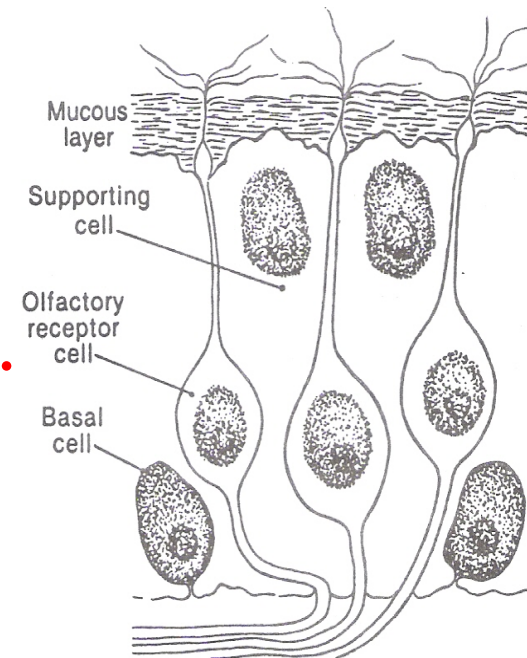
- ❖ **Three components:** Epithelium, basement membrane, lamina propria.



- ❖ **Cell Types:**

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

Type of neurons that has two extensions → one axon and one dendrite

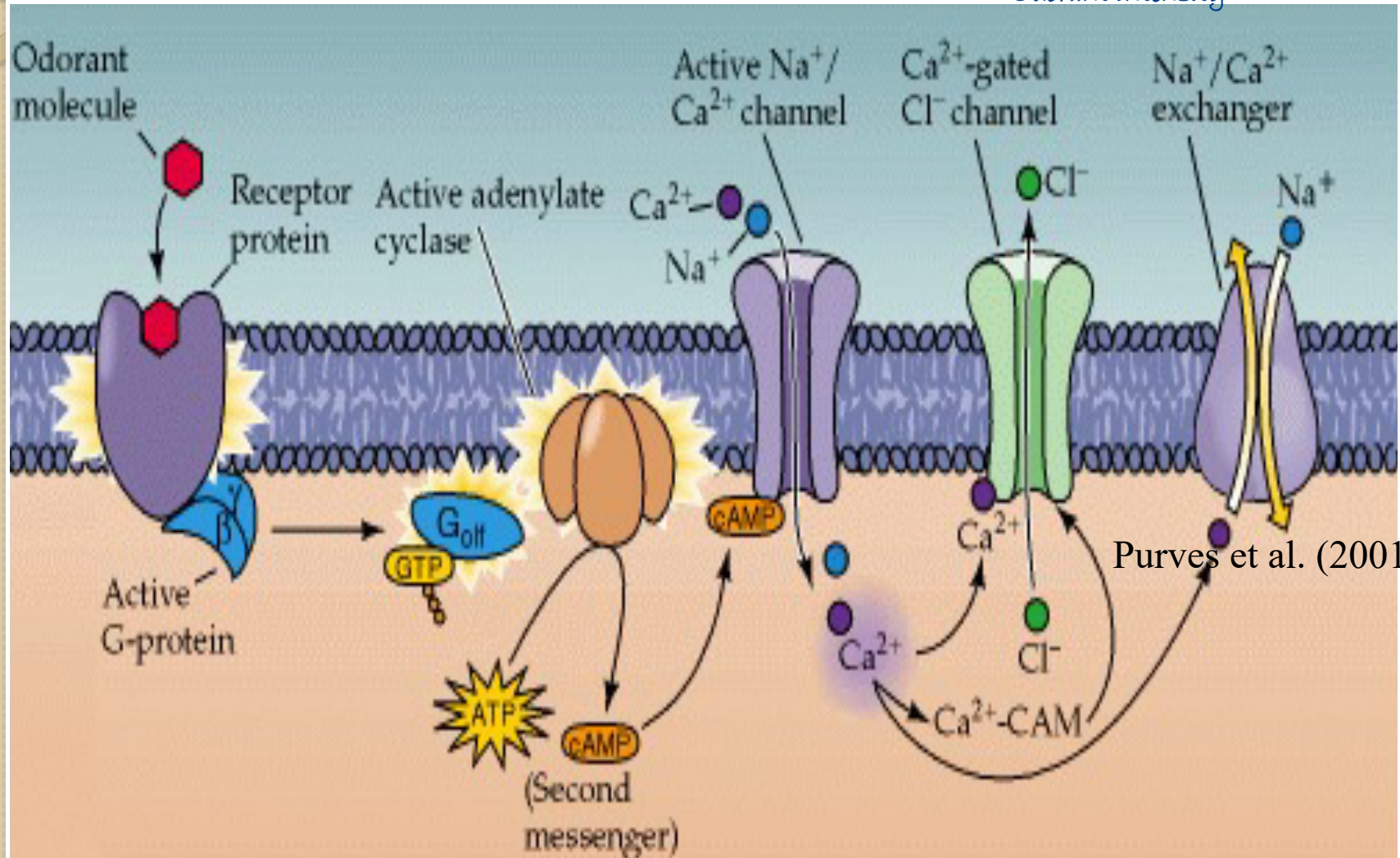


- ❖ **Replacement of receptor cells (about 60 days).** *Regeneration each 2 months*

# Olfactory Receptor Neurons

Na influx cause partial depolarization and the net result is discharge of impulse that depends on intensity of odorant

- **Bipolar** smell receptor neurons. Discharge of impulse depends upon:  
state of receptors  
Odorant intensity

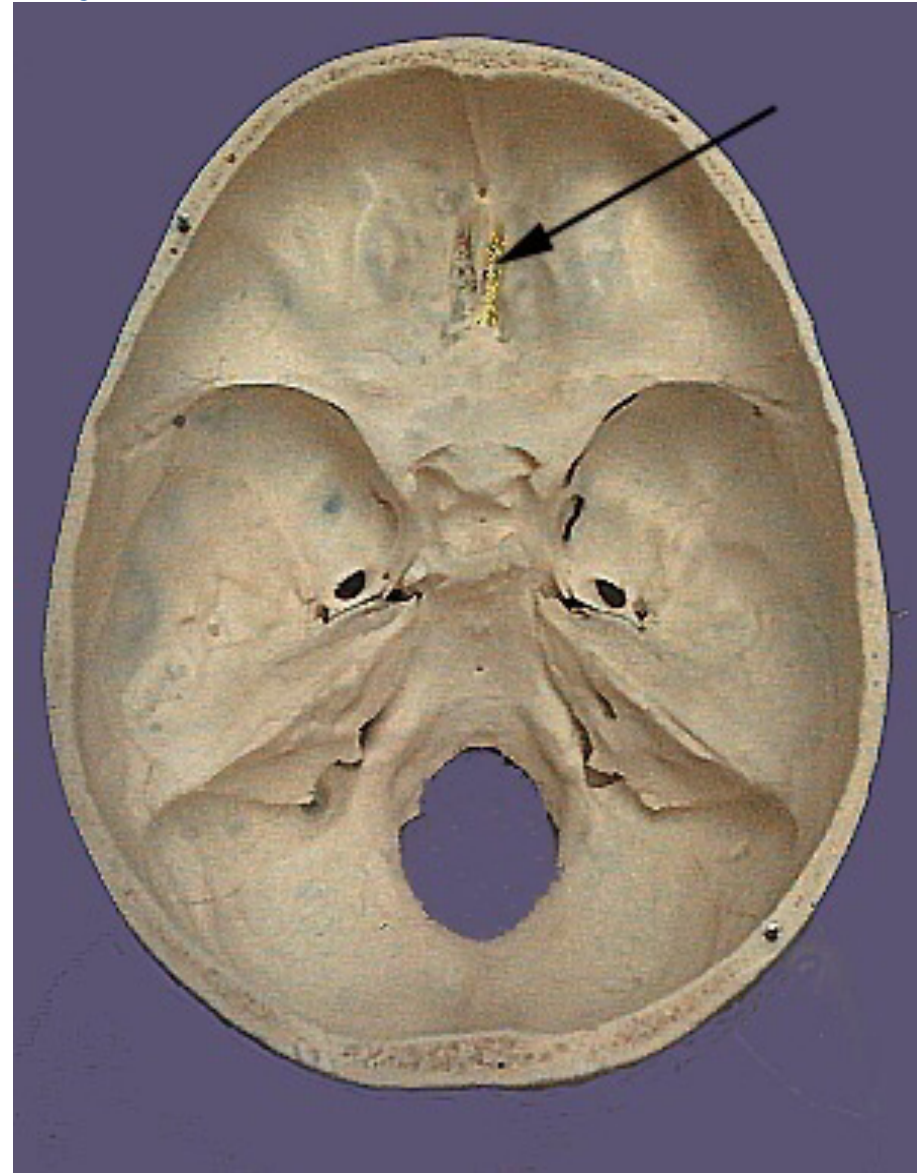


# Cribriform Plate

Where the filaments of olfactory nerve pass

About 20 groove each side

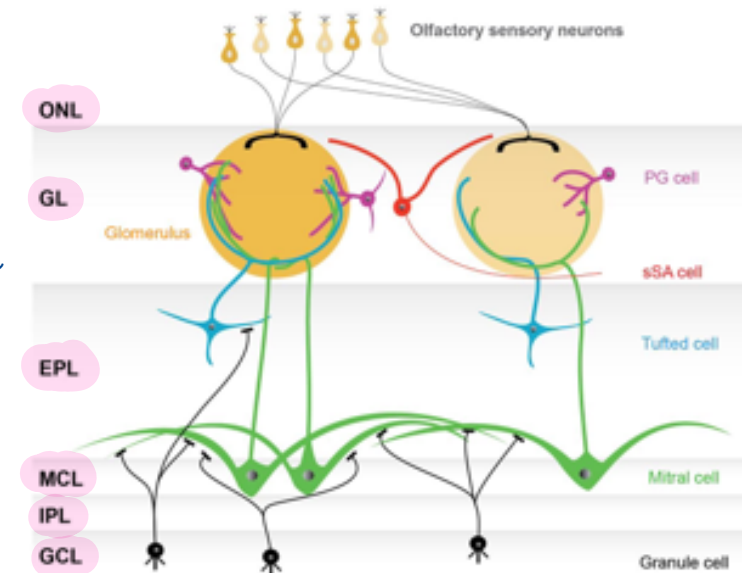
- Part of the ethmoid bone
- Fila olfactoria  
(unmyelinated axons) pass through perforations in cribriform plate.
- Pass from nasal cavity to the anterior cranial fossa floor.



# Olfactory Bulb

عبارة عن البصلة تاحث حاسة الشم

- **Layer I**- Olfactory neuron layer “ONL”
- **Layer II**- Glomerular layer  
“GL” *The site of synaps contact between axons of 1st order neuron and dendrites of 2nd order neuron*
- **Layer III**- External plexiform layer “EPL”
- **Layer IV**- Mitral cell layer  
“MCL” *Site of 2nd order neuron*
- **Layer V**- Internal plexiform layer I<sup>P</sup>A”
- **Layer VI**- Granule cell layer  
“GCL”



*Must be volatile*  
**Odorant-Binding Proteins**  
*Doesn't matter its type*

- These receptors are protrude through the membrane of nasal cavity.
- They bind to the odorants forming a complex, which  
*Then after activation it make action potential*  
*Then discharge of the impulse*  
generate the receptor potential.

# Stimulation of the Olfactory Cells

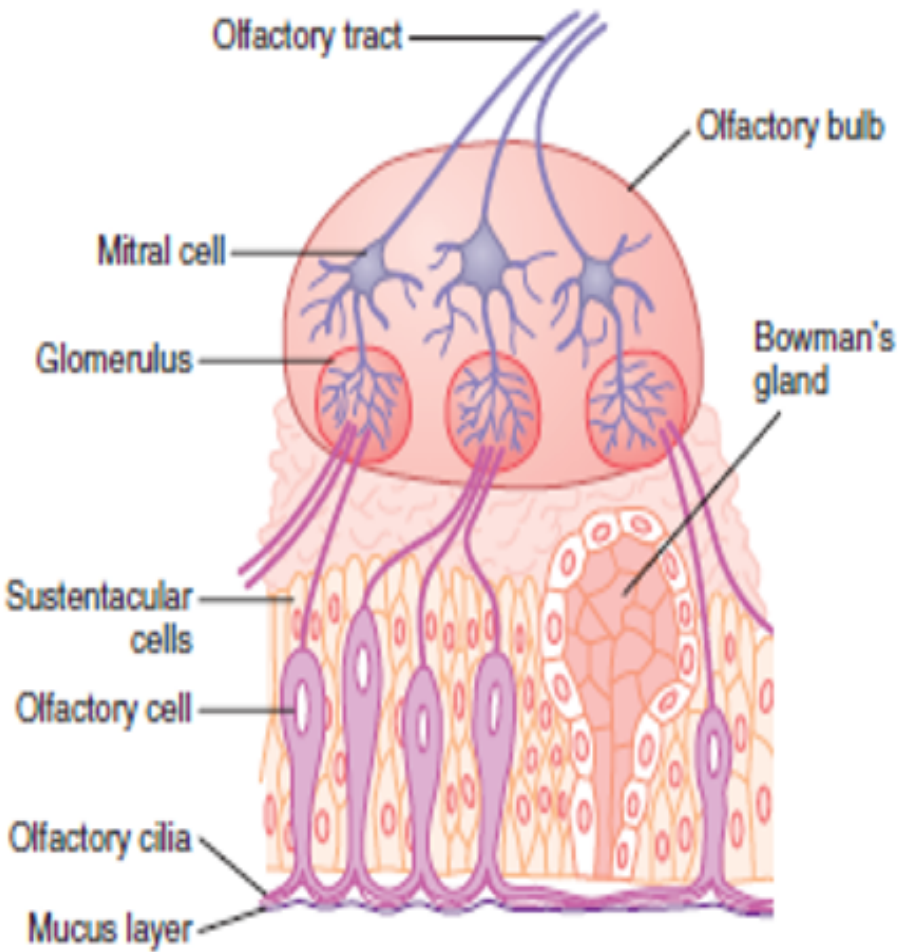
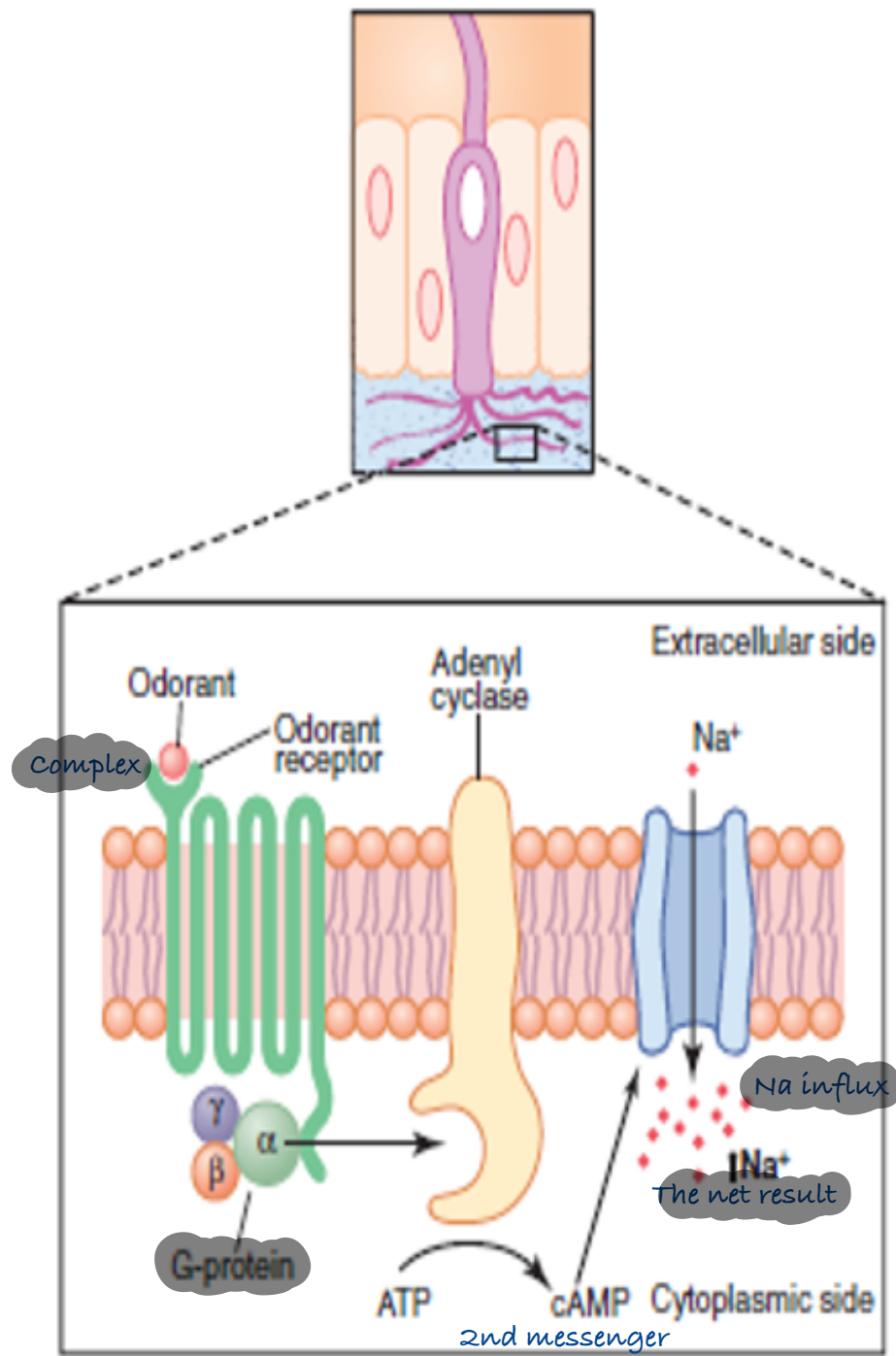
Odorant bind to receptor protein and make the complex then it activate G protein and the net result after that it cause the partial depolarization.

- 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<sup>+</sup> channels** → Na<sup>+</sup> entry will generate receptor action potential in the receptor cells (**partial depolarization**).

Achieved by Na channel activation and Na influx

The adaptation process happened when the odorant substance is found in huge quantity the receptors for this odorant face fatigueability state » يعني الصوديوم بطل يفوت بنفس الكمية الي كان يفوتها لانه الرسيبتورز وكاتهم أصيبوا بالتعب

بما إنه قل دخول الصوديوم يعني قل شغل قنوات الصوديوم حقل كنتيجة لكل الاشياء discharge  
of impulse ف يقل التركيز الرائحة، وبهيك بيصير adaptation

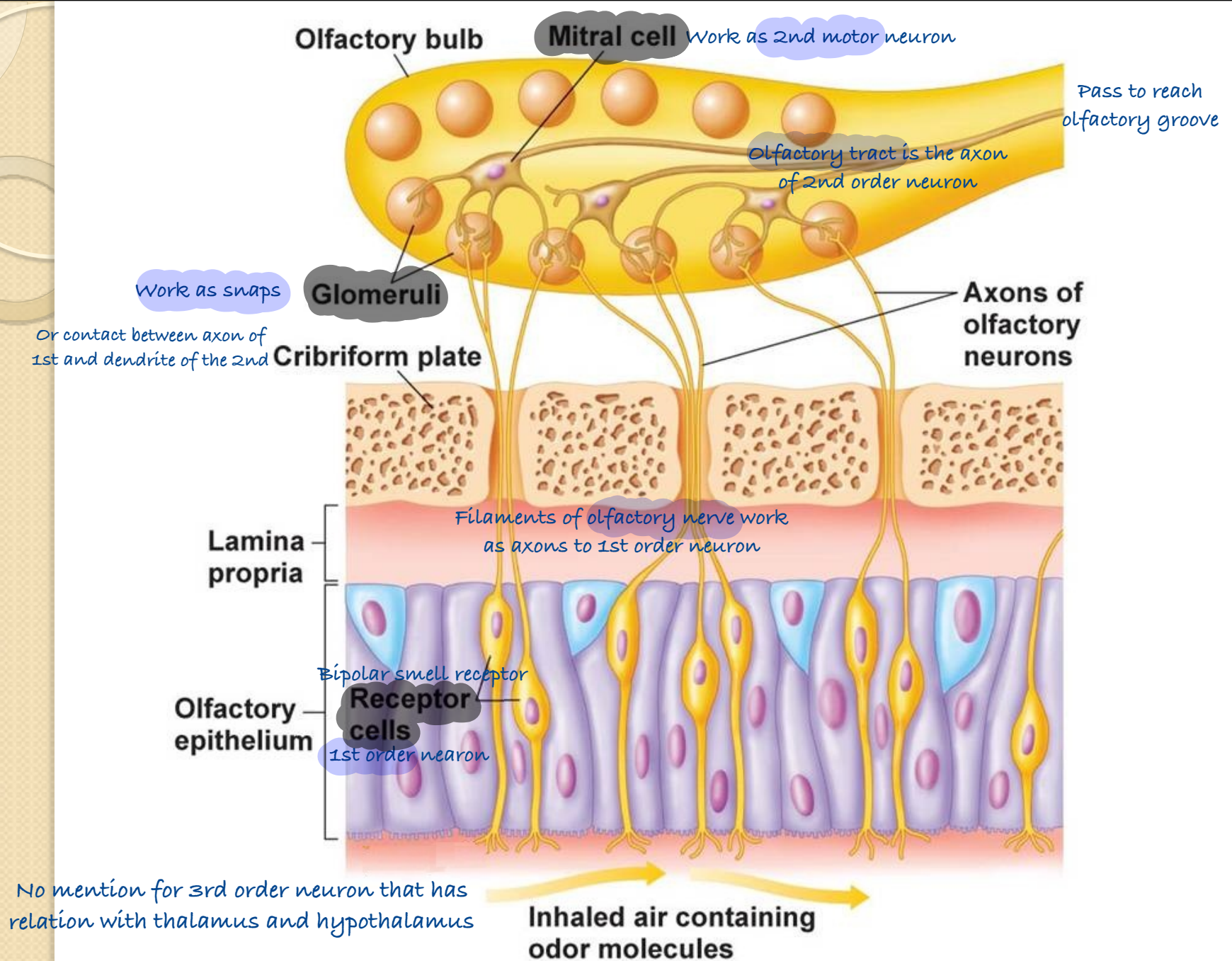


# Pathway of Smell Sensation

## 1. First Neuron: <sup>1st order neuron</sup> **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.**

Pass the signal from 1st order to the 2nd order  
Goes to 2 the 2nd order neuron  
(mitral cells)



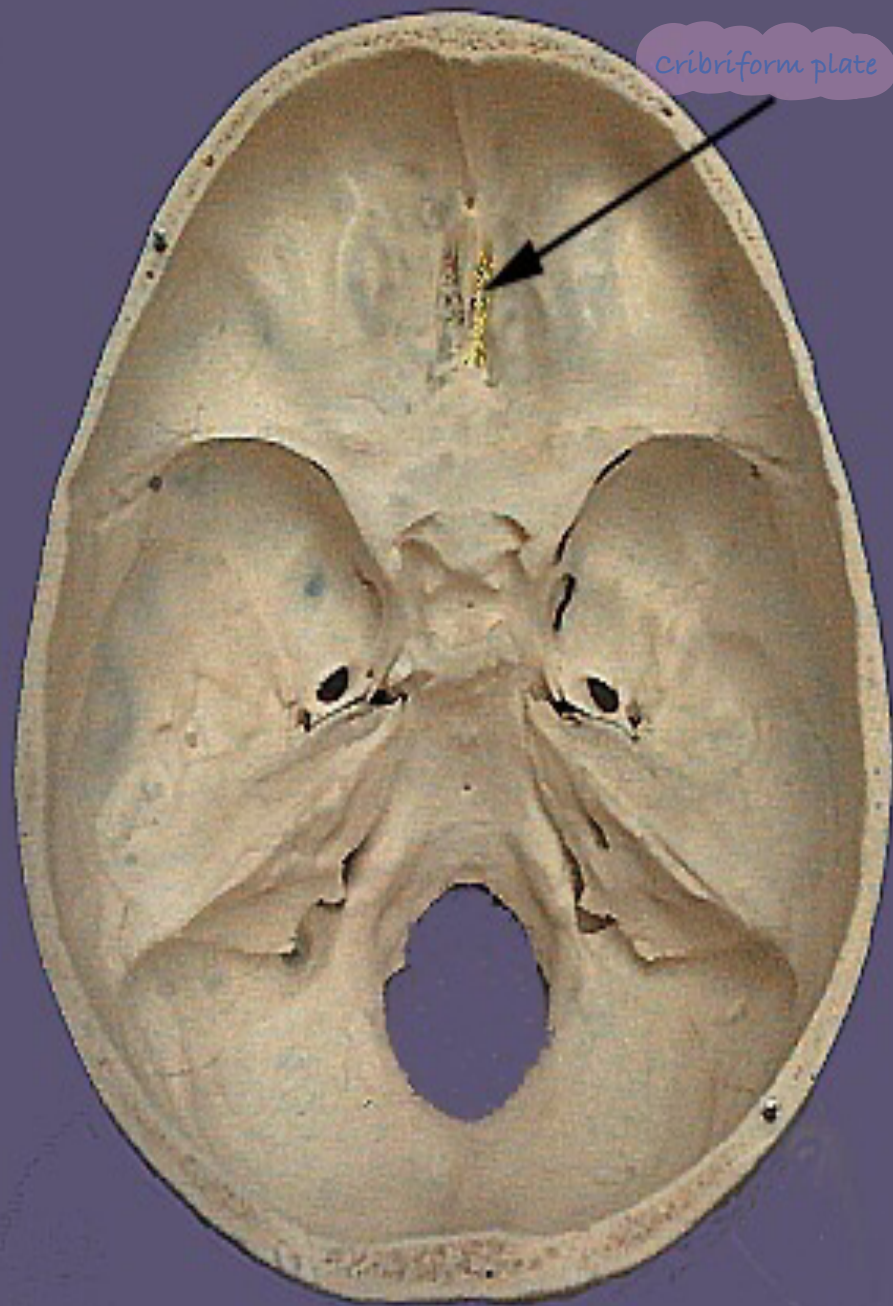
## 2. Second Neuron:

- The olfactory nerve fibers <sup>Axons of 1st neuron</sup> synapse with the dendrites of the **mitral and tufted cells (second order neuron)** of olfactory bulb called **olfactory glomeruli** <sup>Work as axons of 2nd order neuron</sup> → olfactory tract → passes along the **olfactory groove**.
- The olfactory tract <sup>2 parts</sup> → 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** <sup>To ipsilateral temporal lobe</sup>.
- Ends in the **uncus, parahippocampal, subcallosal, paraterminal gyri and amygdaloid body in temporal lobe** <sup>These fibers reach Limbic system</sup> <sup>Responsible for behavioral and emotional responses</sup> (parts of the limbic system).

So we should know the smell sensation work through afferent fibers to both sides of the temporal lobe of brain

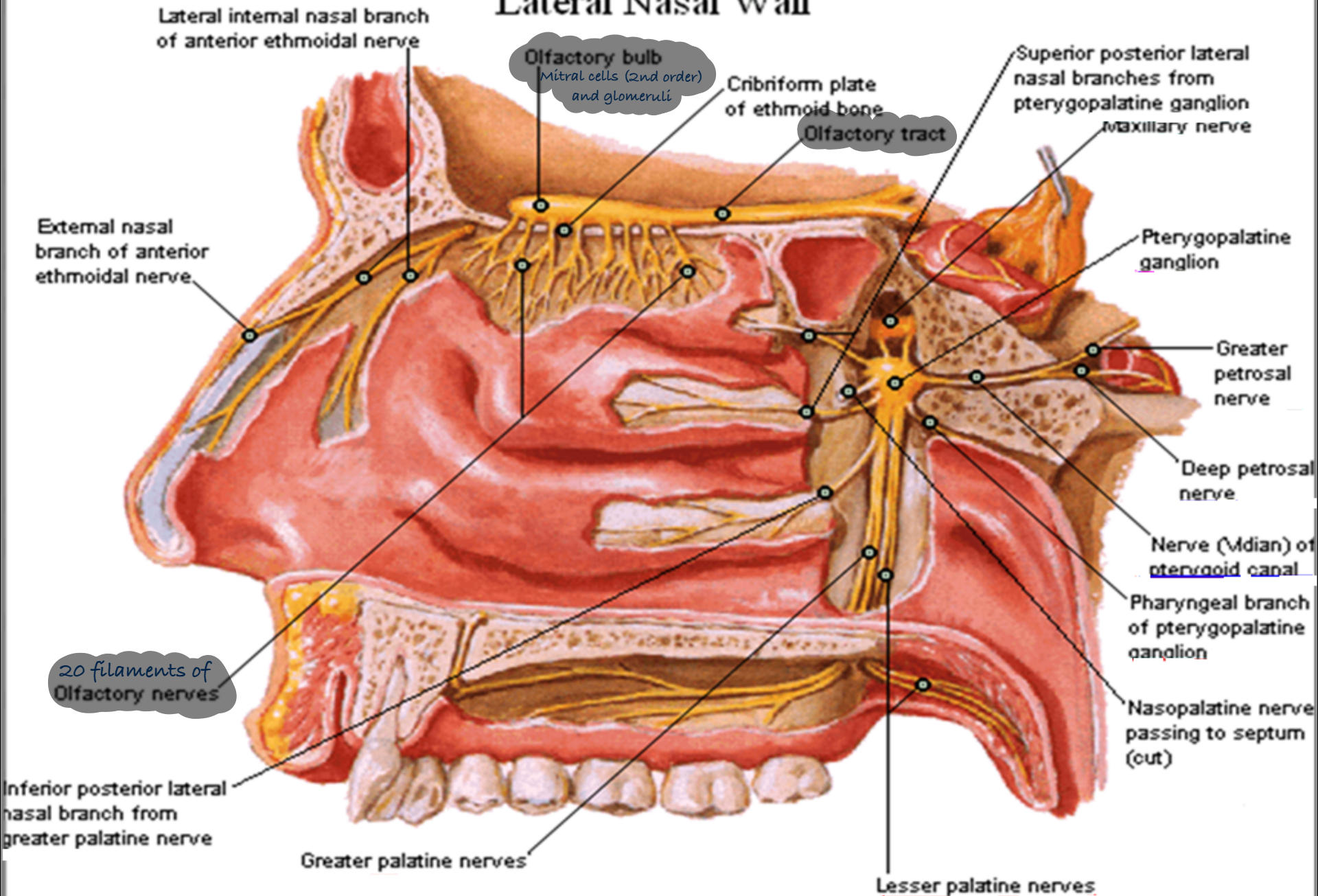
So  
❖ **Note:** <sup>Cause of the corresponding from the contralateral side</sup> **Unilateral lesion of temporal lobe does not cause anosmia as the sense of smell is bilaterally represented.**

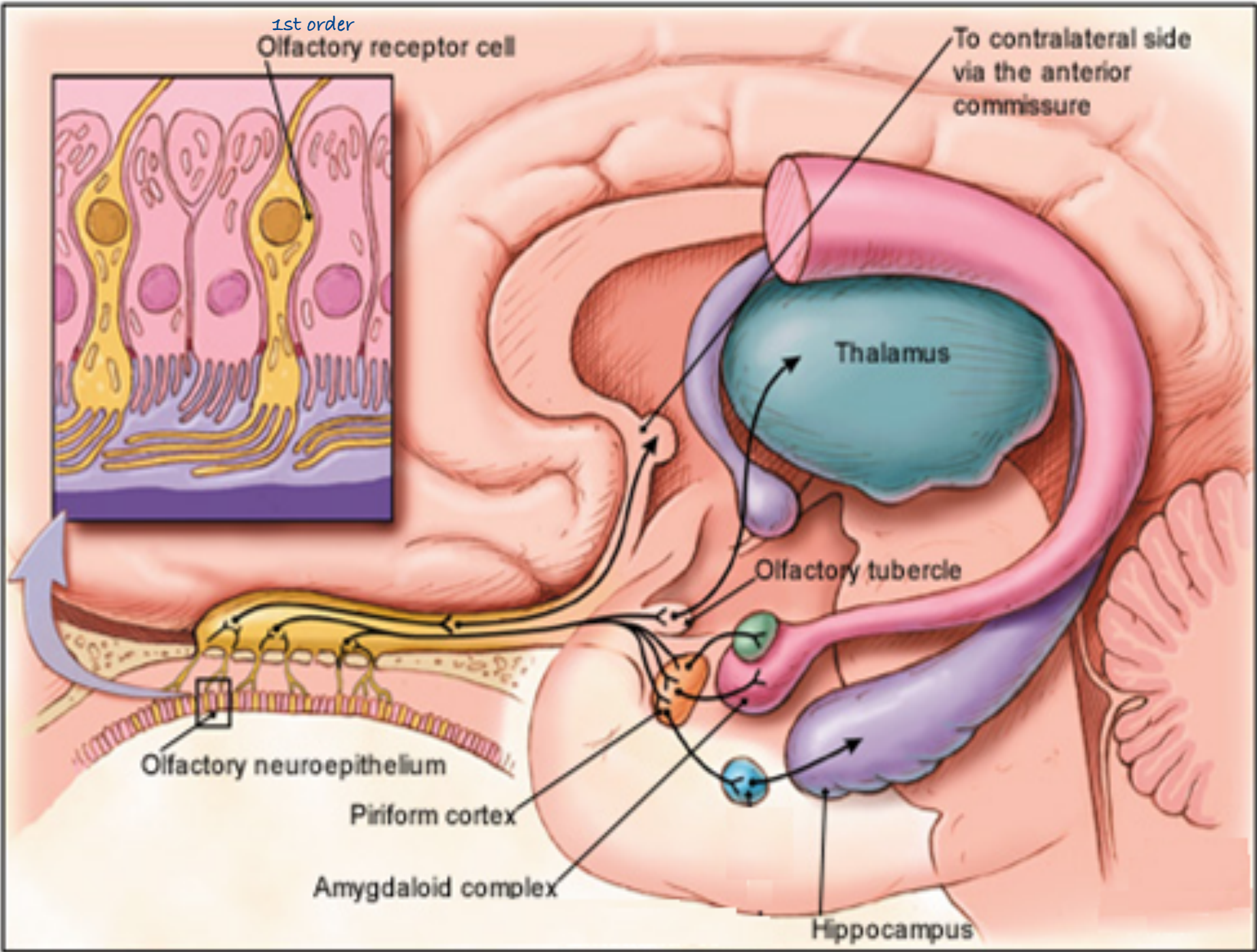
<sup>Partial or complete loss of smell</sup>



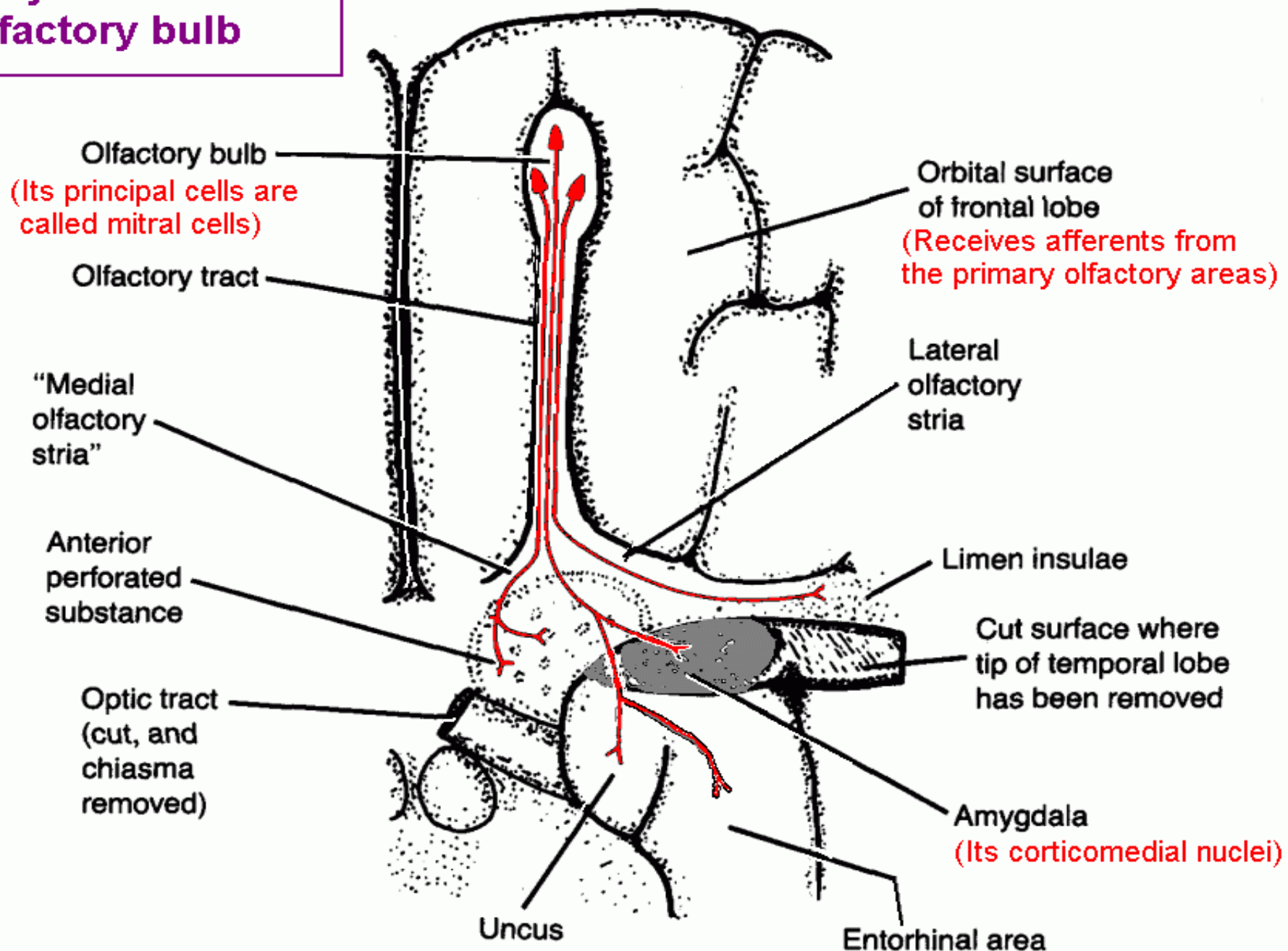
# Nerves of Nasal Cavity

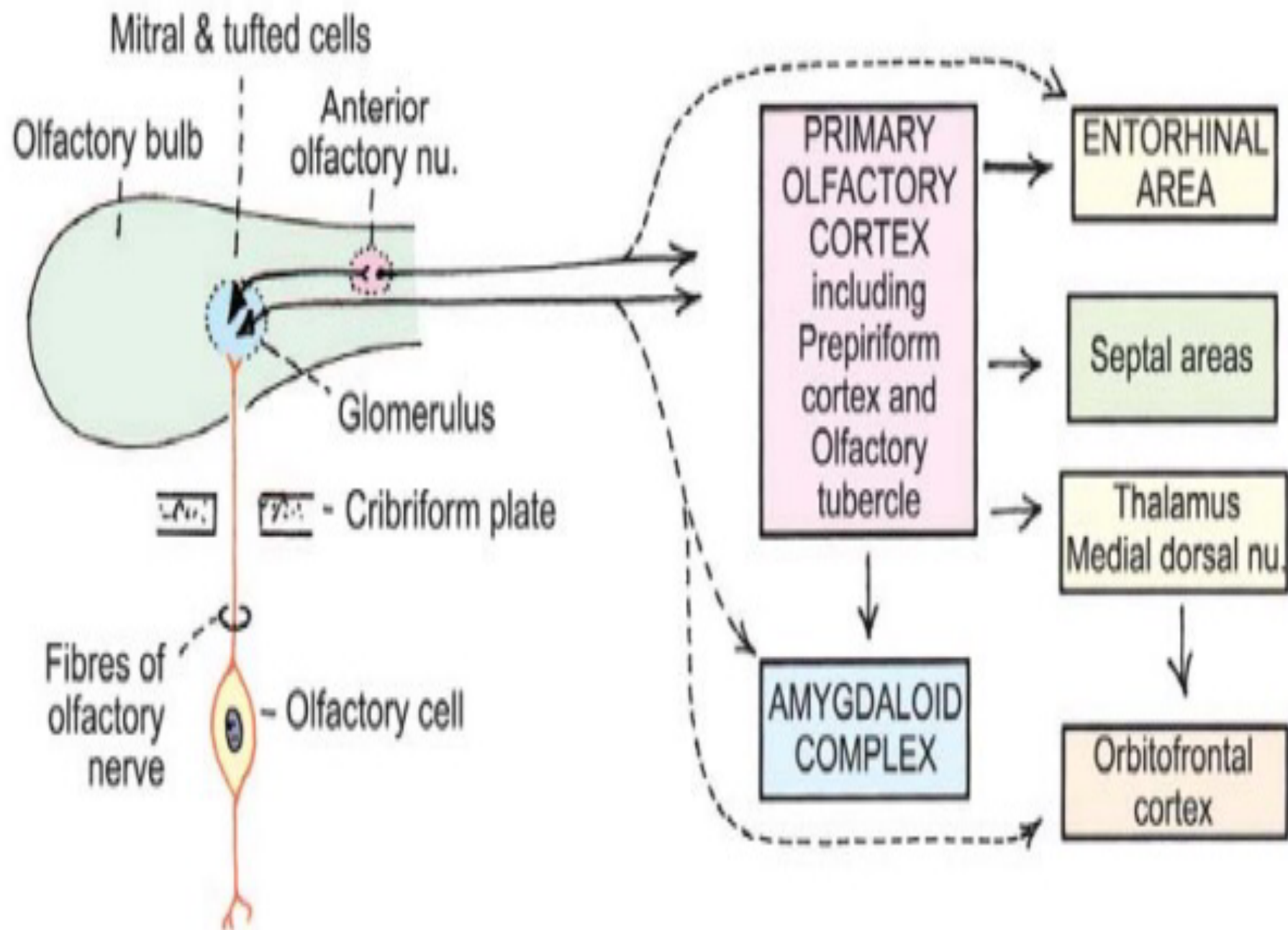
## Lateral Nasal Wall

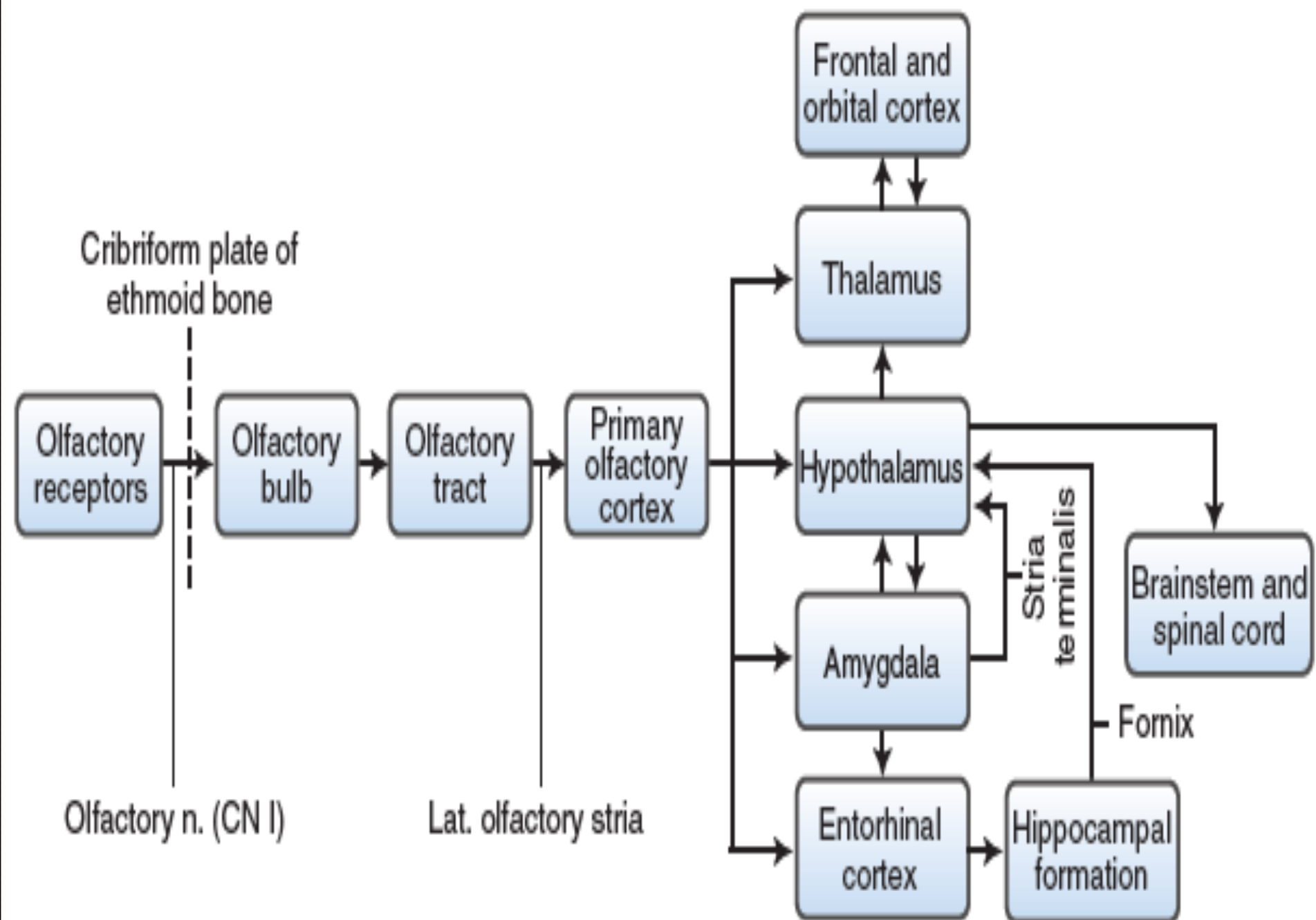




## Projections of the olfactory bulb







# Clinical Correlation

## Lesion of the Smell Pathway

unilateral is more dangerous than bilateral  
cause it may be tumor or hematoma or things like that  
while bilateral causes like common cold

1. Unilateral hyposmia or anosmia.
2. Bilateral hyposmia or anosmia.
3. Parosmia (Smell hallucination)  
*Distorted sense of smell*
4. Cacosmia (bad smell in chronic sinusitis)  
*it discharge pus*
5. Olfactory agnosia  
*unable to recognize certain smells or types  
of odors that you previously recognized*

# Causes of Unilateral Anosmia

- **Traumatic:** skull base fracture
- **Inflammatory:** <sup>Focal</sup> basal meningitis, abscess.
- **Neoplastic:**

- Olfactory groove meningioma →

Meningitis can cause both  
(uni and bi) lateral

Triad symptoms **Foster Kennedy syndrome:**

1. **Ipsilateral anosmia:** due to <sup>Tract or pulp</sup> pressure on olfactory pathway.
2. **Ipsilateral optic nerve atrophy:** <sup>Loss of vision</sup> due to direct pressure on the optic nerve.
3. **Contralateral papilloedema:** <sup>Means that disk swelling is 2ndry 2 inc. ICP</sup> due to increase intracranial tension. <sup>Optic disc swelling</sup>

We say that if unilateral lesion of temporal lobe cant cause anosmia bc cause of the contralateral corresponding but if the main pathway affected it will cause anosmia



Rounded tumor

Why it is not ipsilateral papilloedema  
As a result to optic disc atrophy it has pale  
colour and it will appear at the intact disk

# Causes of Bilateral Anosmia

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

# Causes of Parosmia (Smell Hallucination) and Olfactory Agnosia

Its not ischemic it is irritatory caused by anything

The difference between ischemic changes (destruction) and irritatory causes, that the 1st can't affect the smell function because it take from contralateral side while the 2nd overlap with smell hallucination

- Temporal epilepsy.
- Temporal lobe SOL. *Space occupying lesion*
- Intracranial aneurysm and AVM. *Artery-venous malformation*
- Psychogenic

It may be a result of schizophrenia (مرض انفصام الشخصية) so we diagnose it by diagnosis of exclusion by brain imaging and exclusion to SOL

# Gustatory System



Cranial nerves responsible for taste sensation  
Facial for ant. 2/3  
Glossopharyngeal for post. 1/3  
Vagus for epiglottis

## 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 <sup>Related to gut</sup> **special visceral** <sup>Sensation</sup> **afferent modality of taste Taste** via the **facial, glossopharyngeal and vagus nerves.**
- Mediates gustation, which, like smell, is **a chemical sense.**

Facial through chorda tympani nerve  
Glossopharyngeal through lingual branch nerve  
vagal through superior laryngeal nerve divided to 2 parts  
external for cricothyroid muscle and internal branch sensory

# The Sense of Taste

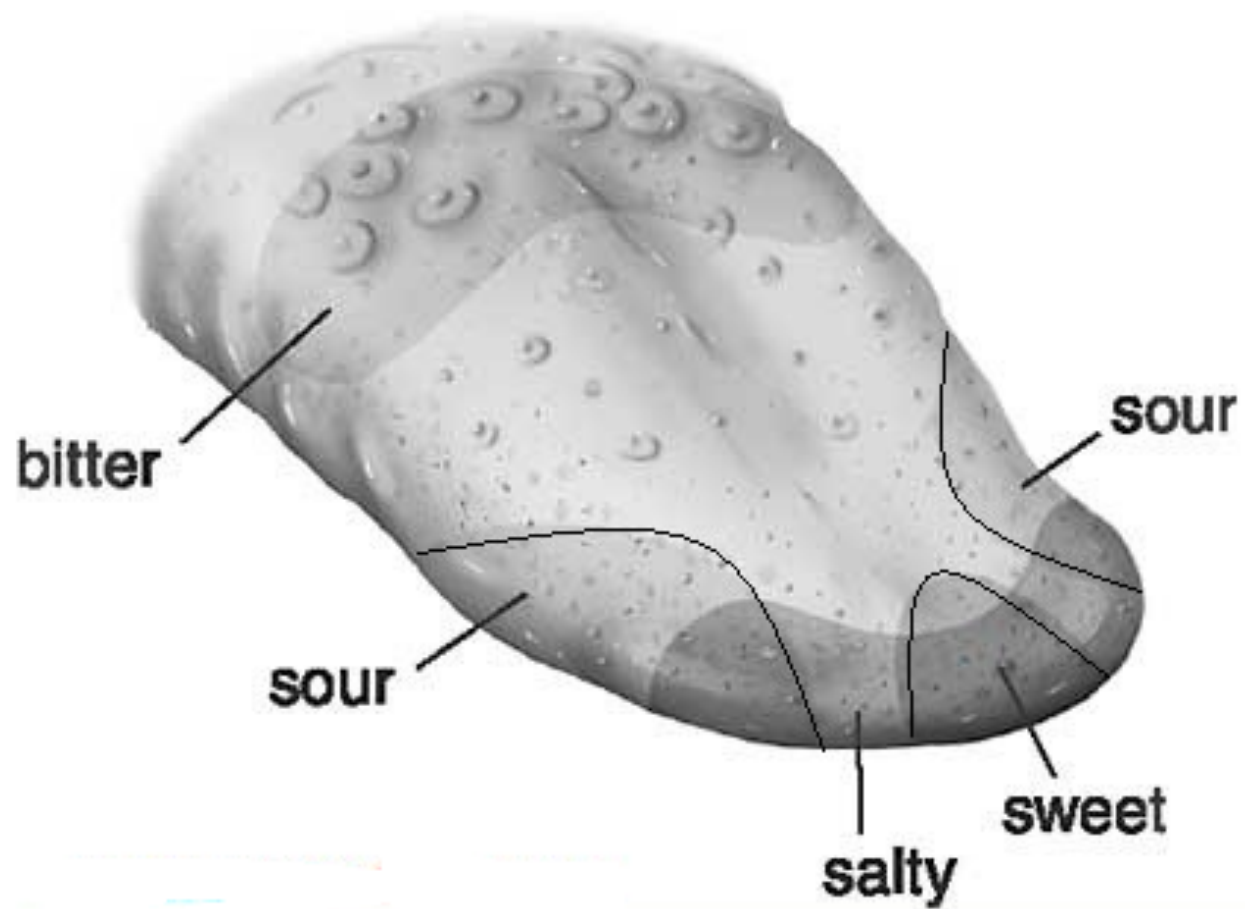
## “Gustatory System”

### 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.

هذه التقسيمات لا تعني ان الاشياء مقصورة على هذه المناطق بل العكس الـ receptors موجود في كل مكان  
باللسان بس الفكرة انهم يهتمون بكل نوعية منهم في مكان ف حسيت هذه  
يعني لو حطيت اشي مالاح راس اللسان خذوقه ولو لخطيت قد ما يرك خذوق بس الكلام الي قبل  
اعرف انه تجمعات للرسيبتز باكثر كثافة ممكنة



# The Taste Buds

Types of taste papillae: foliate circumvallate *fungiform*

Taste buds found on the lateral side of it



- ❖ **Taste Receptors:** taste cells (receptors) are located within **taste buds**, which are located within **tongue papillae (Tongue Papillae → Taste Buds → Taste Cells or Receptors)**.  
*40-60 receptor in each taste bud*
- ❖ **Distribution of taste buds:** taste buds are located on the *Mainly* tongue papillae, hard and soft palate, epiglottis and pharynx.

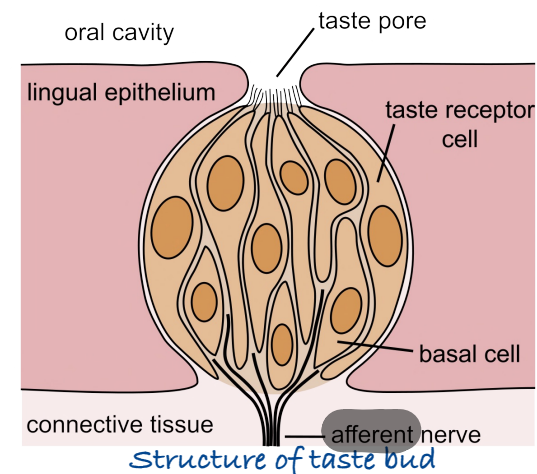
# The Structure of Taste Buds

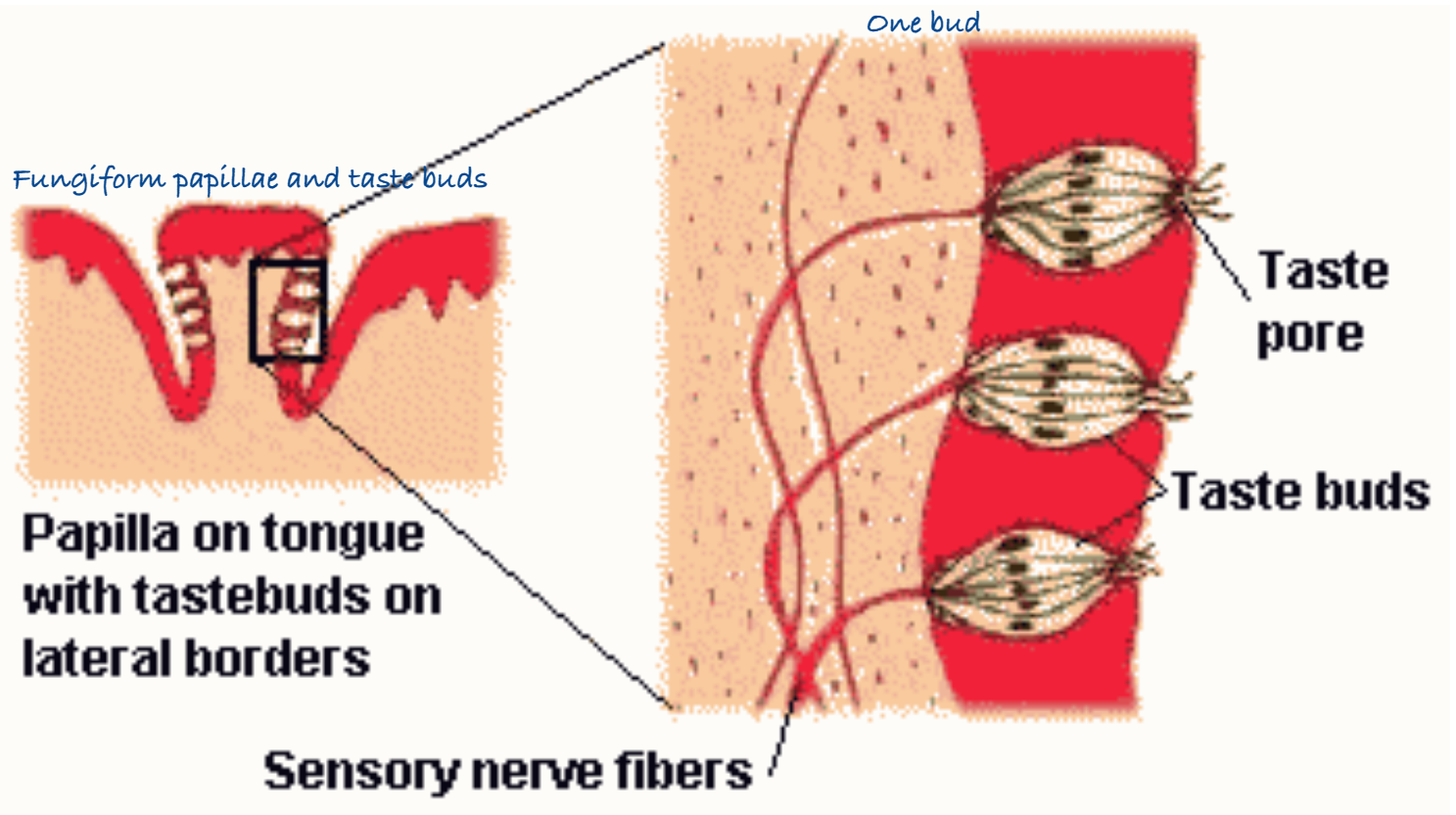
*Onion like structure*

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

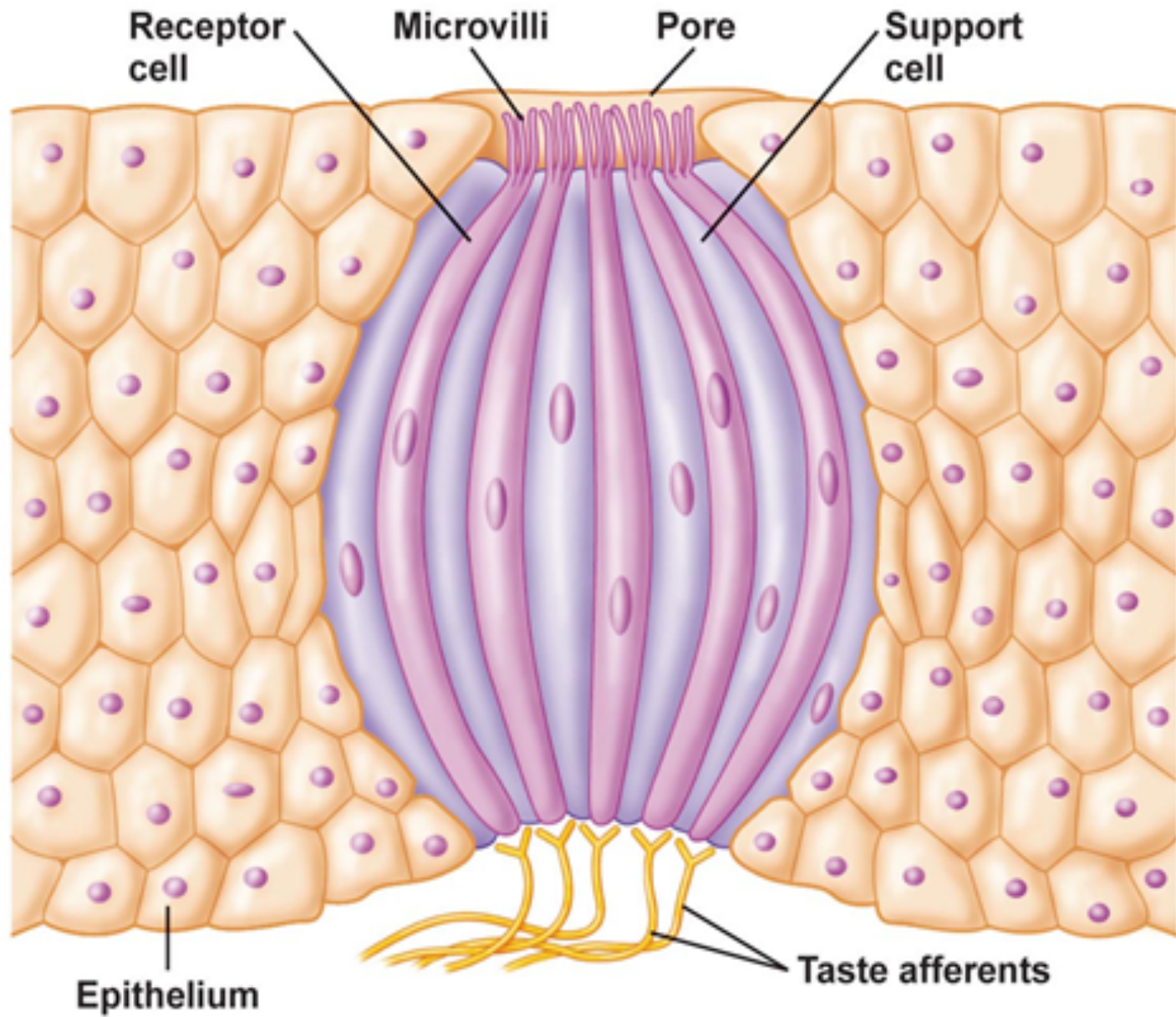
- Taste pore.
- Taste microvilli.
- Taste (receptors) cells: each taste bud is consists of 40-60 taste cells
- Supportive cells.  
*Basal cells*

Afferent fibers may be chorda tympani or lingual branch of glossopharyngeal or internal laryngeal of superior laryngeal nerve





## Anatomy of Taste Buds



# The Sense of Taste

## ✓ Specialization of taste buds:

❖ Each taste bud usually respond to only one of the

*Sweet bitter salty and sour* four taste stimuli, when the taste substance is in

**low concentration.**

*10L water with 20g salt Diluted liquid*

*Anterolateral will taste the salt*

❖ At **high concentration**, must buds respond to two

*1L water with 100g salt Concentrated liquid*

or more of the four taste stimuli.

*All receptors will taste the salt*

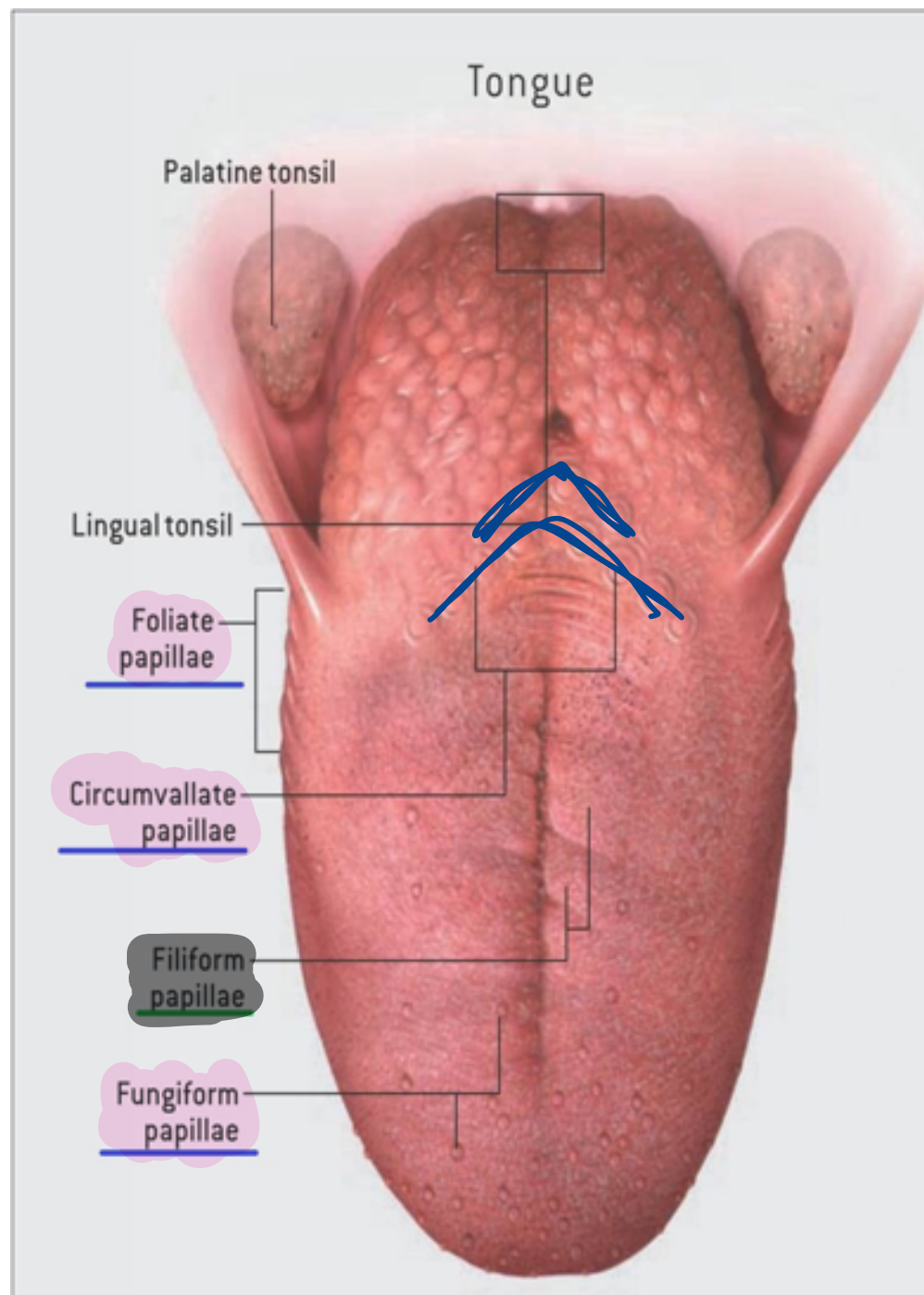
## ✓ Regeneration of taste buds:

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<sup>rd</sup> 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.  
على شكل رقم ٨
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 <sup>Anterolateral</sup> **salty** and <sup>Tip</sup> **sweet** sensations.
- Is innervated by **CN VII** (<sup>Branch of facial</sup> **chorda tympani**).

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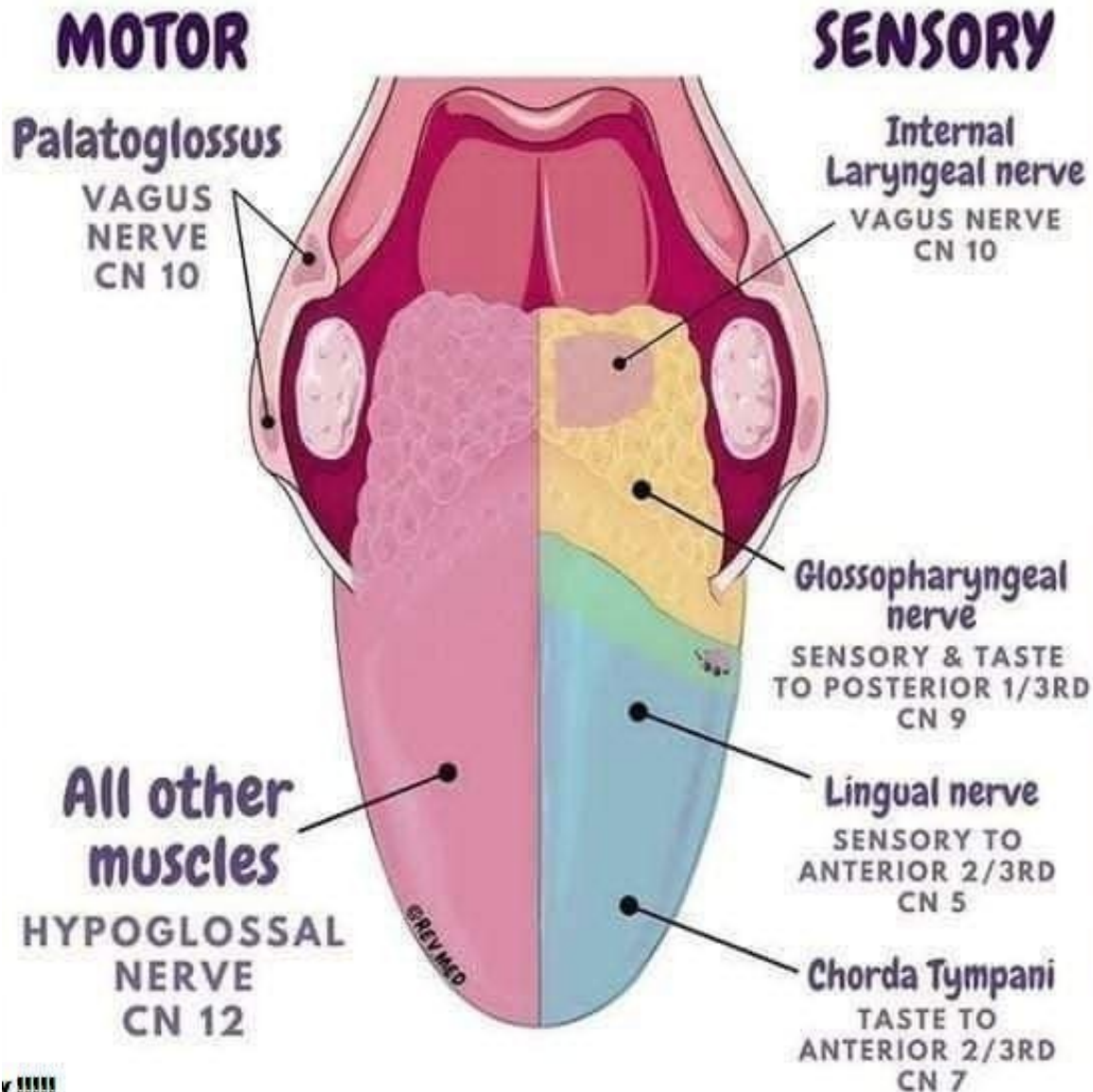
*Solitary nucleus* in medial oblongata is responsible for taste sensation for the ant. 2/3 of the tongue and share the 3 cranial nerves: 7th 9th 10th

## The Posterior One-third of the Tongue

- Has **circumvallate** and **foliate papillae**.
- Detects <sup>circumvallate</sup> **sour** and <sup>foliate</sup> **bitter** sensations. <sup>In high concentration may sense sweet and salty</sup>
- Is innervated by **CN IX** (**glossopharyngeal**). <sup>Lingual branch</sup>
- The **epiglottis** are innervated by **CN X**. <sup>vagus</sup>  
<sup>Internal laryngeal branch of superior laryngeal nerve</sup>

# The Tongue

## INNERVATION



# Mechanism of Stimulation of Taste Receptor

It differs according to stimulus

1. **Sweet-tasting substances:** by opening of  $\text{Na}^+$  channels and closing of  $\text{K}^+$  channels.
2. **Bitter-tasting substance:** by increasing intracellular  $\text{Ca}^{++}$  levels, which leads to the release of synaptic transmitter and activation of the taste nerve fiber.
3. **Salty-tasting substance:** by opening of  $\text{Na}^+$  channels. Without closure of  $\text{K}^+$
4. **Sour-tasting substance:** by increasing intracellular  $\text{H}^+$  ion concentration, which blocks  $\text{K}^+$  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.

# Pathway of Taste Sensation

Receptors → dendrites → cell body ganglia of nerves → axon (CN itself) → nucleus → cortex of brain

Receptors of:-  
Ant. 2/3  
Post. 1/3  
Epiglottis

Signal transport through dendrite  
Ant. 2/3 → chorda tympani of 7th CN  
Post. 1/3 → lingual n. of 9th CN  
Epiglottis → internal laryngeal branch  
of sup. Laryngeal of 10th CN

1st order neuron is ganglia of cranial nerves:-  
Chorda tympani → geniculate G  
Lingual branch → petrosal G = inf. G  
Sup. Laryngeal branch of vagal → nodosal G

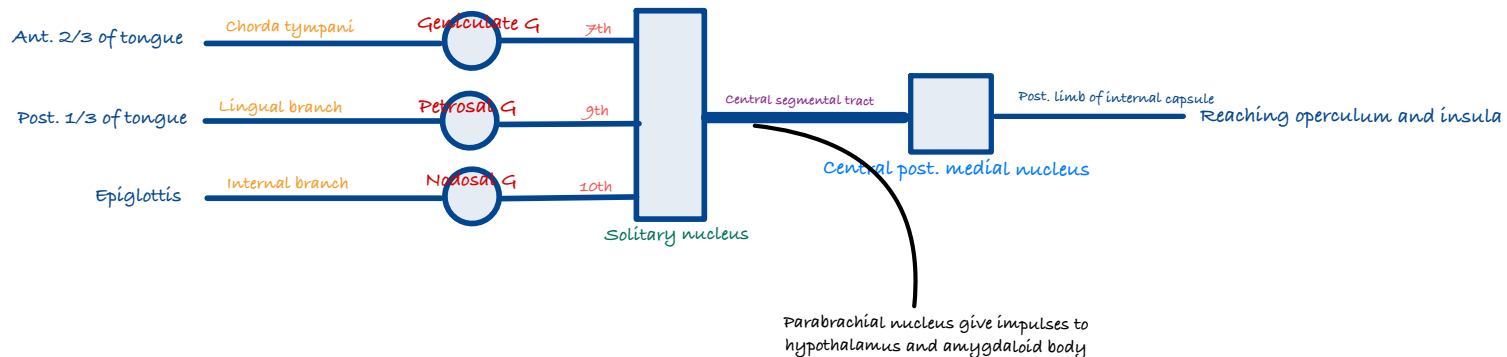
Axons:-  
Facial nerve  
Glossopharyngeal nerve  
Vagal nerve

2nd order neuron is solitary nucleus:-  
For the 3 parts

It will transmit the signal to the thalamus to work as 3rd  
order neuron and that's achieved through:-  
Central segmental tract (ipsilateral) without crossing  
CST gives parabrachial nucleus in pons

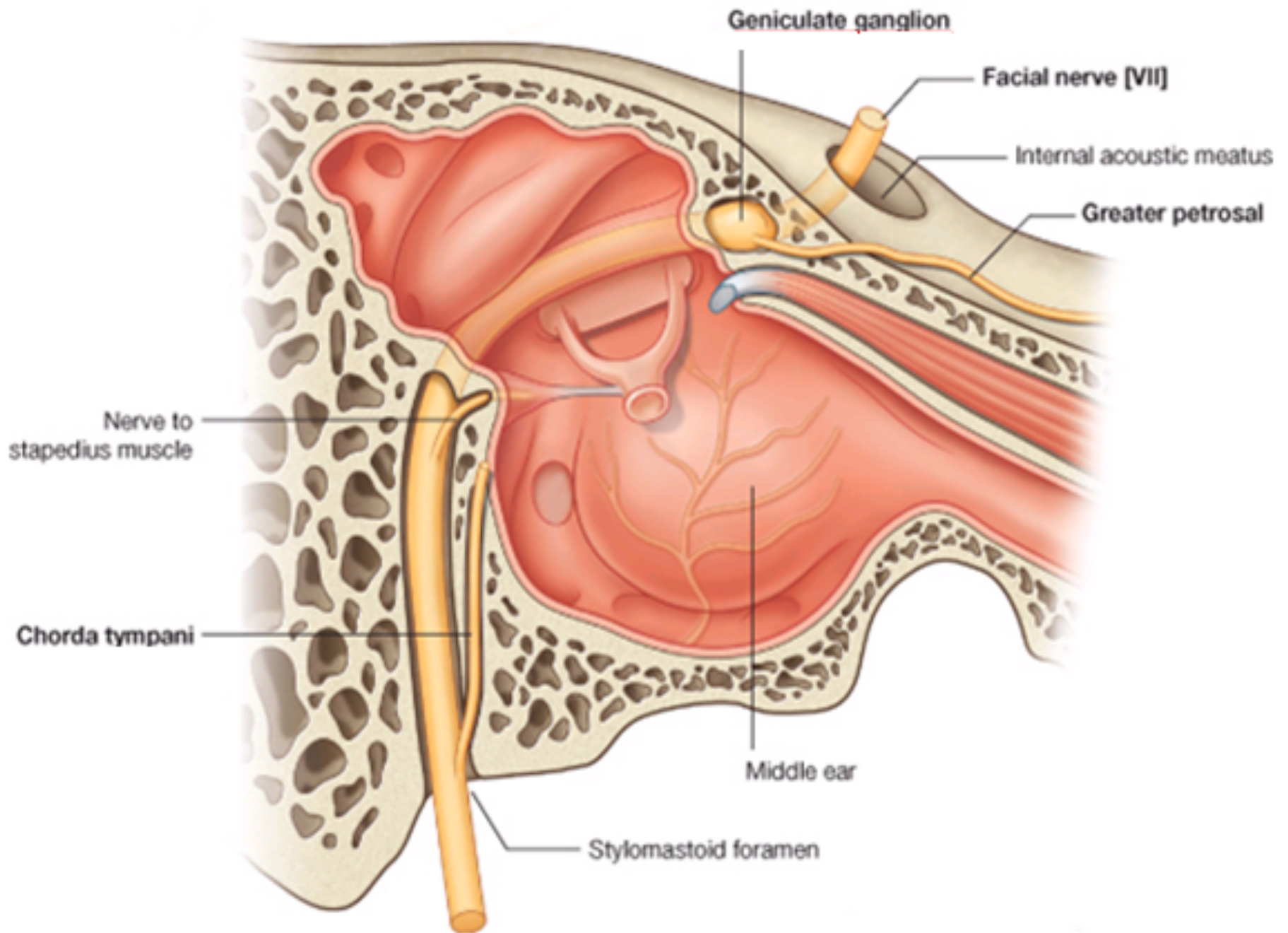
3rd order neuron VPM Ventral  
post. medial nucleus of  
thalamus

The signal pass through post. limb of internal  
capsule to reach the insula and operculum → the part  
of cortex that cover the insula



1. **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 Chorda tympani 2/3 of the tongue.
- **Glossopharyngeal Nerve:** receive taste sensation from the Lingual branch posterior 1/3 of the tongue.
- **Vagus Nerve:** receive taste sensation from the epiglottis. Internal laryngeal branch of sup. Laryngeal nerve of vagus

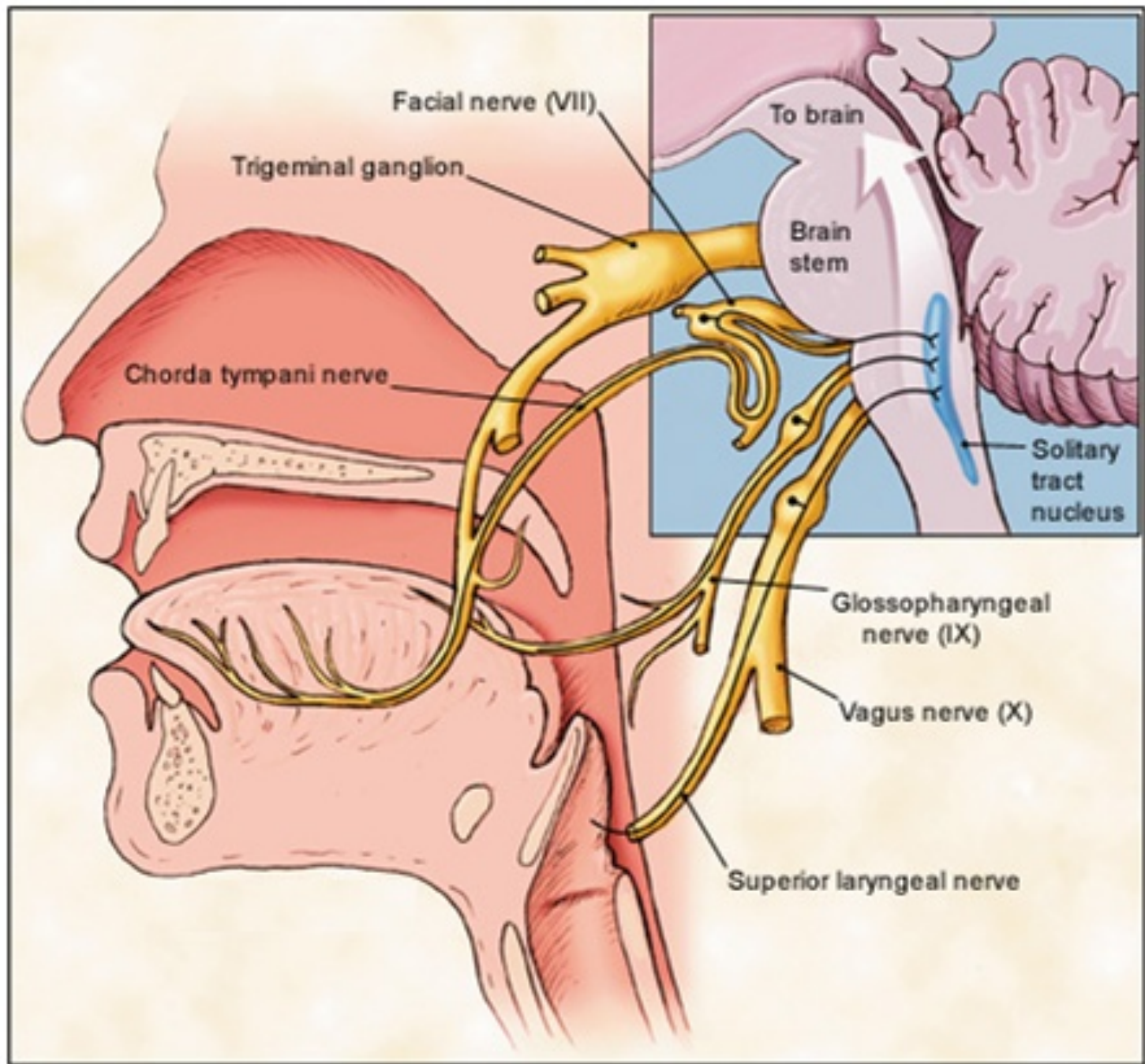


## 2. Second Neuron (Solitary Nucleus):

- 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):

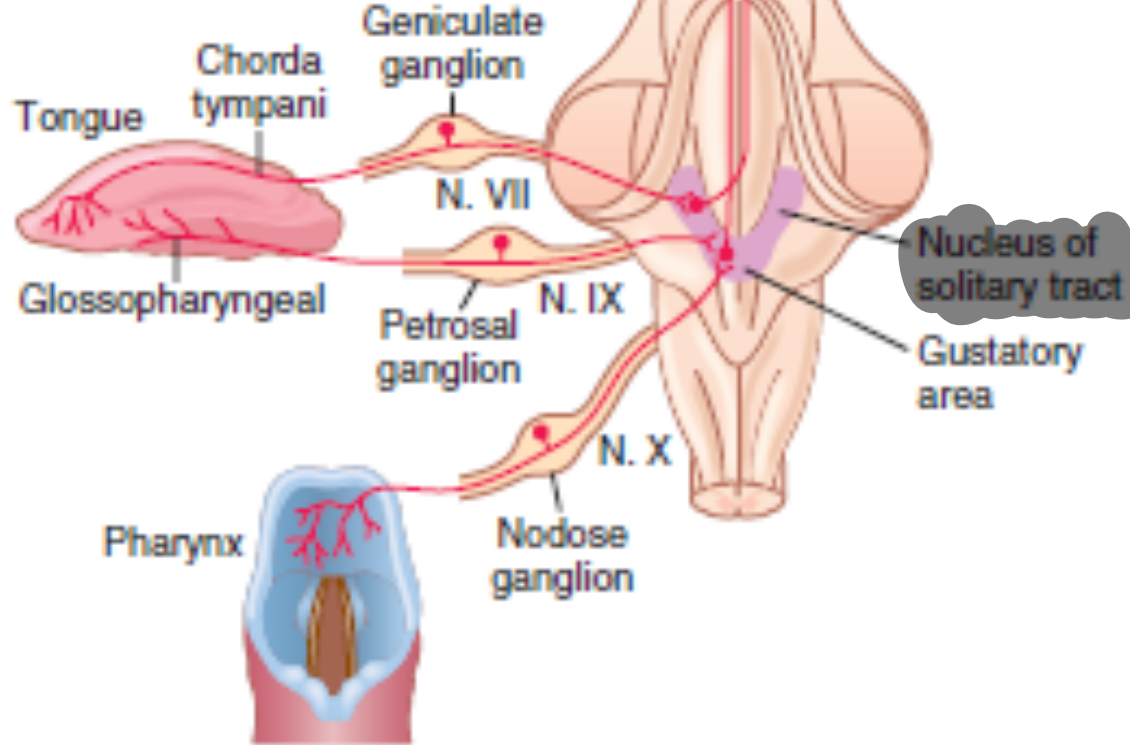
- Fibers run in the sensory radiation which passes in the posterior limb of the internal capsule and projects to the gustatory cortex of the parietal and frontal operculum (area 43) and insular cortex.

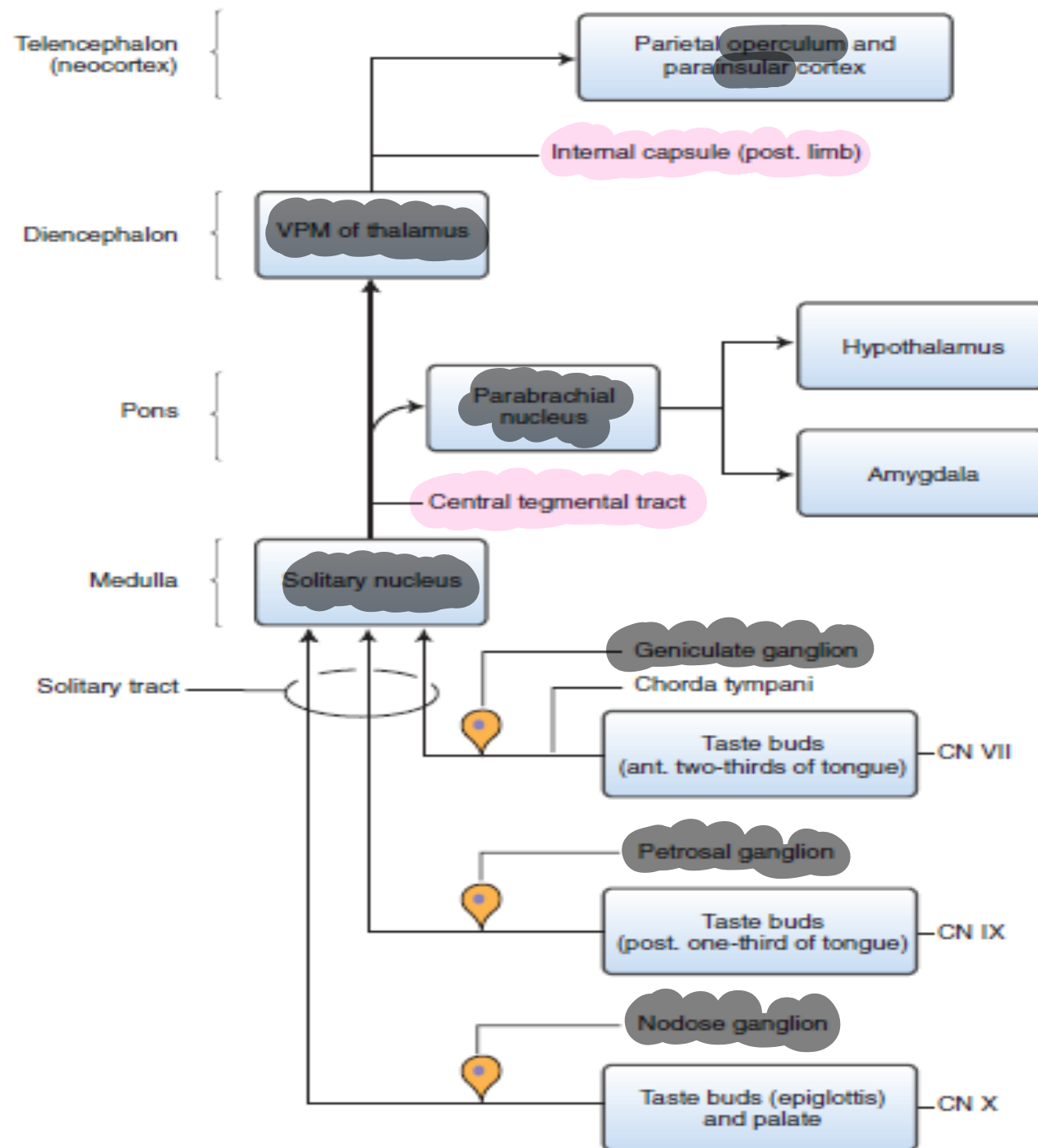


Gustatory cortex  
(anterior insula-  
frontal operculum)



Ventral posterior  
medial nucleus of  
thalamus





# Taste Innervation

| Part                                     | CN                                    | Branch                             | Ganglion<br><small>1st order nucleus</small> | Foramen<br><small>In the same side<br/>without crossing</small> |
|------------------------------------------|---------------------------------------|------------------------------------|----------------------------------------------|-----------------------------------------------------------------|
| Anterior 2/3<br>tongue                   | VII<br><small>Facial</small>          | Chorda<br>tympani (via<br>lingual) | Geniculate                                   | Internal<br>acoustic<br>meatus                                  |
| Soft palate                              | VII                                   | GSPN                               | <small>Mainly</small><br>Geniculate/<br>otic | Internal<br>acoustic<br>meatus                                  |
| Posterior <sup>Third</sup> 1/3<br>tongue | IX<br><small>Glossopharyngeal</small> | Lingual-<br>tonsillar branch       | Petrosal<br><small>Inf. Ganglionic</small>   | Jugular<br>foramen                                              |
| Epiglottis                               | X<br><small>vagus</small>             | Laryngeal<br>branch                | Nodose                                       | Jugular<br>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.**

Bell's palsy

Idiopathic lower facial motor neuron due to inflammation of facial nerve at exit of stylomastoid foramen

Chorda tympani nerve is the most distal branch in stylomastoid foramen so if inflamed the chorda tympani nerve will affect and the taste sensation