Peripheral Nervous Syst. Module

Dr. Gamal Taha Abdelhady
Assistant Professor of Anatomy & Embryology

Smell & Taste

Smell & taste

- ***By the end of this session you should be able to:***

- Identify the components and the pathways both olfaction and taste take to reach their specific cortical areas

Olfaction

- The **olfactory nerve** is the first of the 12 cranial nerves and one of the few cranial nerves that carries **special sensory** information only. In this case, the olfactory nerve is responsible for our sense of **smell**

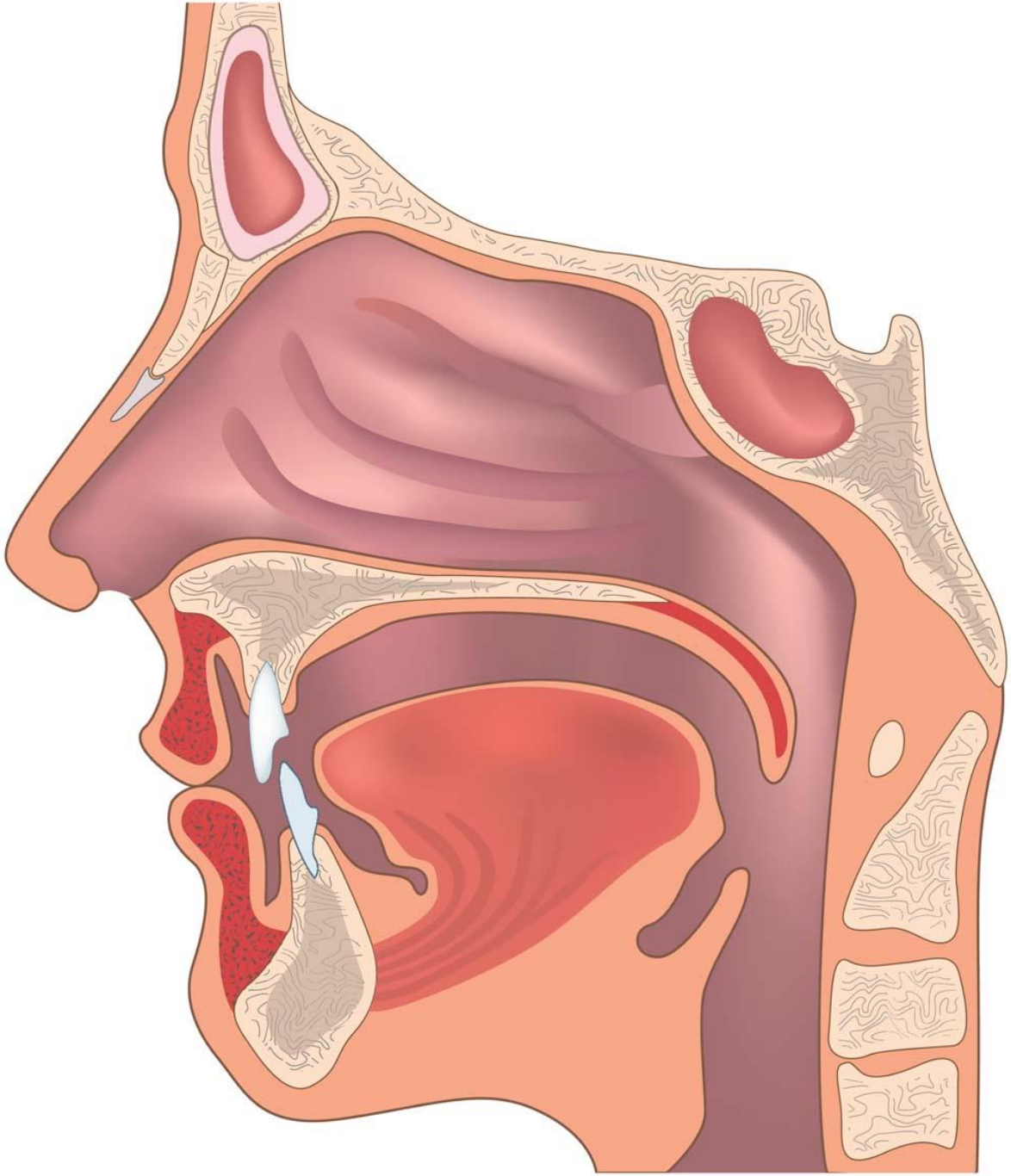
- Requires odorant's molecules reaching the olfactory mucosa at the top of the nasal cavity and a special type of nasal airflow

Olfactory Pathway Components

- Olfactory receptor cells
- Olfactory nerves
- Olfactory bulb
- Olfactory tract
- Olfactory striae
- Olfactory cortex
- Output targets of the olfactory cortex

Air Flow in the Nose

- 50% of the total airflow passes through the middle meatus
- 35 % of total airflow passes through the inferior meatus
- ***15% of total airflow passes through the olfactory region***



Nasal Mucosa

- ***Respiratory epithelium:***

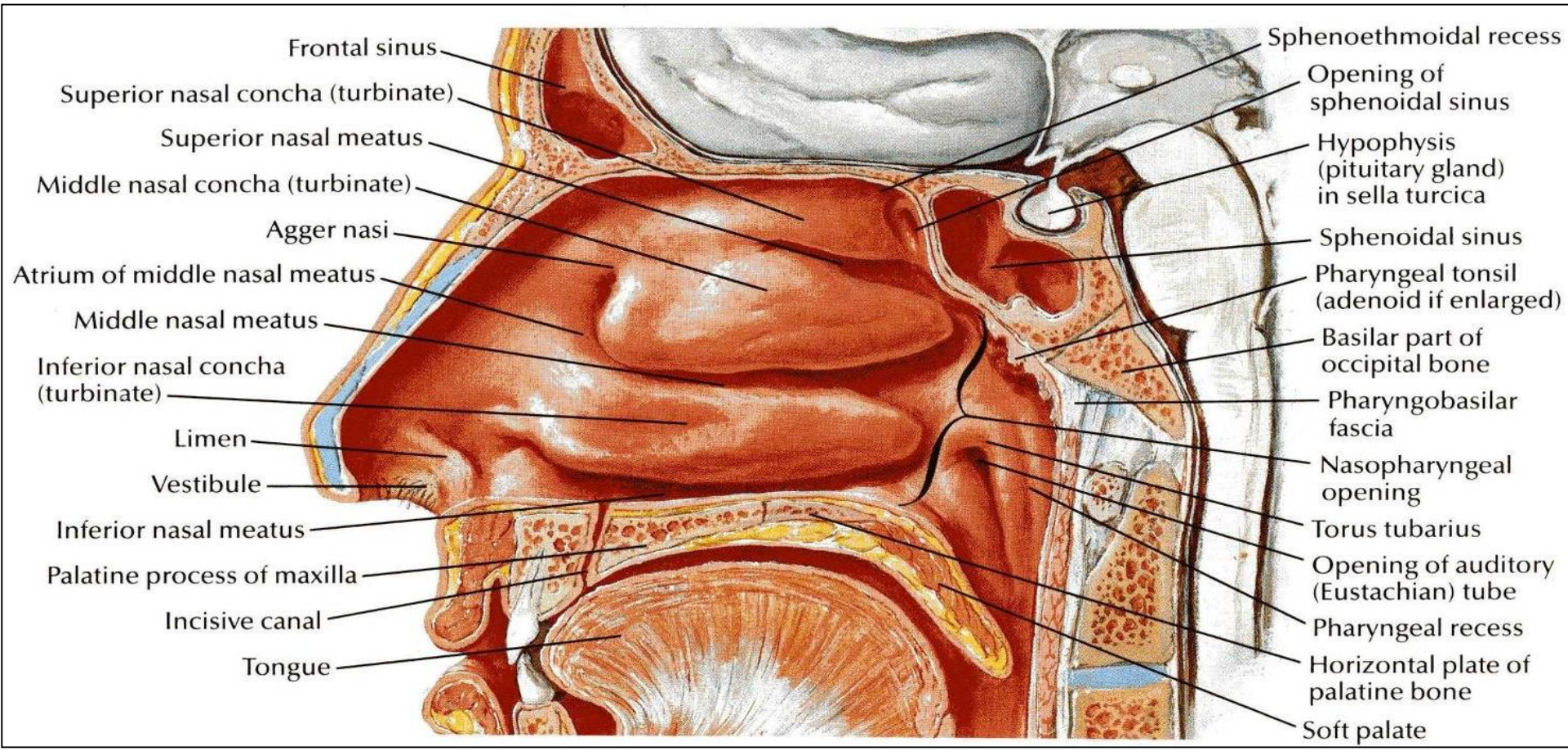
- It is thick, ciliated highly vascular and contains mucous glands & goblet cells

- It lines the lower part of the nasal cavity (from skin of vestibule to the superior concha).

- It functions to **moisten**, **clean** and **warm** the inspired air.

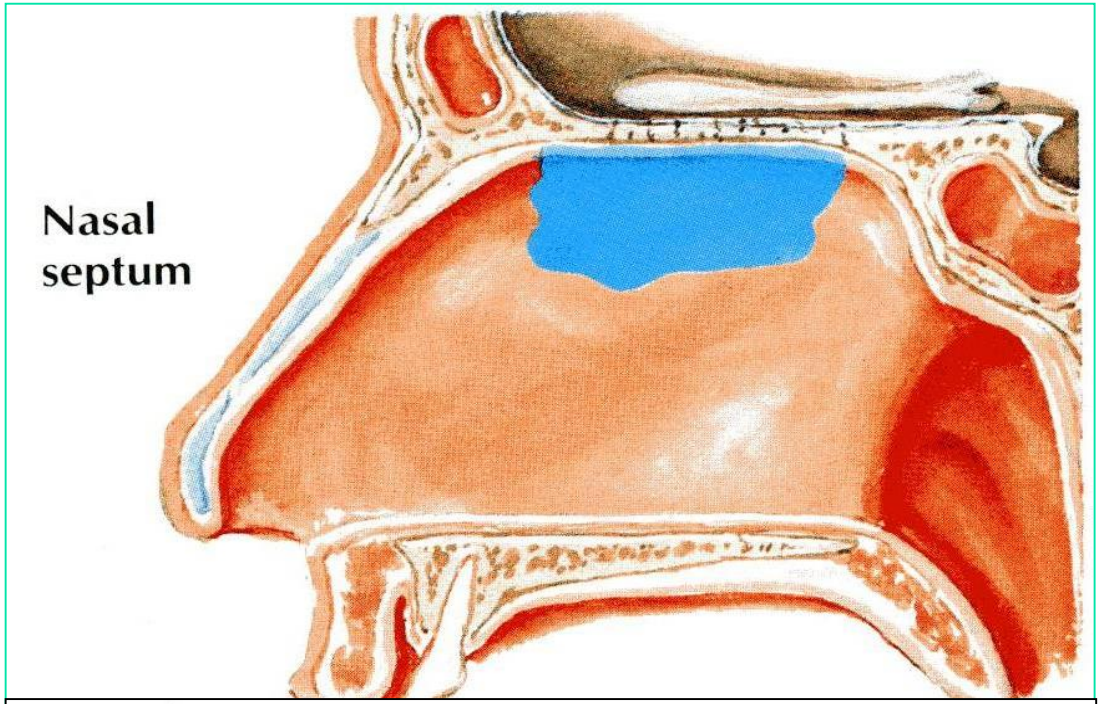
Nasal Mucosa

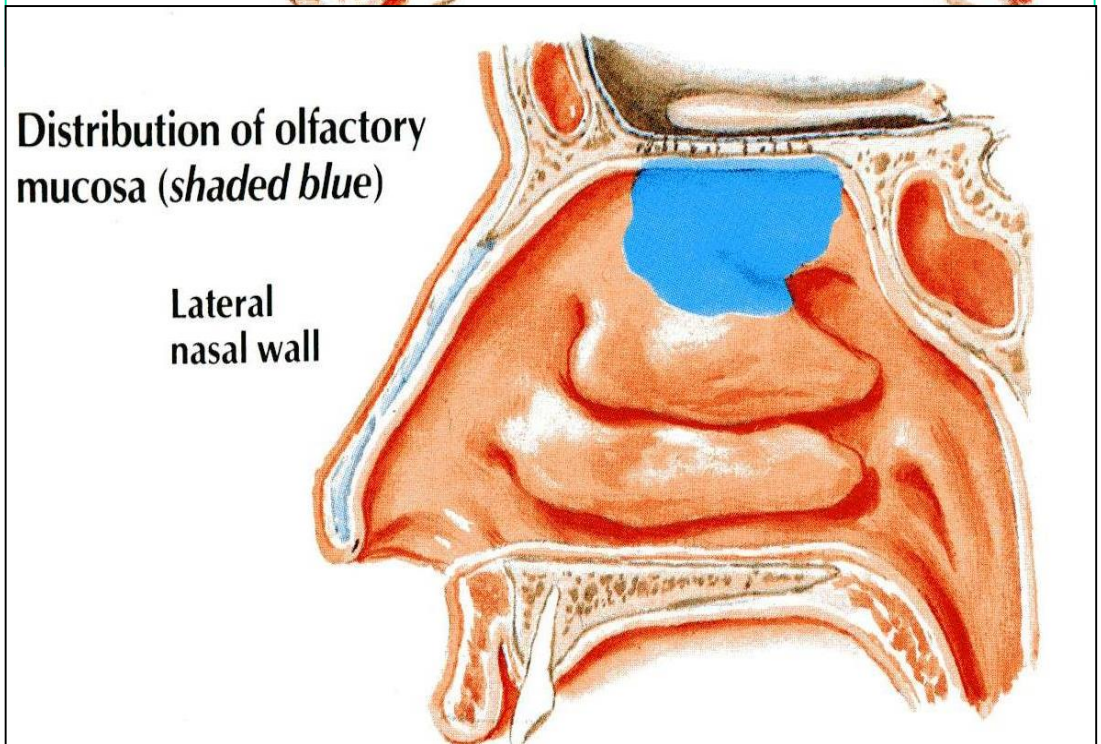
- The ***air is moistened by*** the secretion of numerous ***serous glands***.
- It is ***cleaned by*** the ***removal*** of the ***dust*** particles by the ***ciliary action*** of the ***columnar*** ciliated ***epithelium*** that covers the mucosa.
- The ***air*** is ***warmed*** by a submucous ***vascular plexus***.


Frontal sinus
Superior nasal concha (turbinate)
Superior nasal meatus
Middle nasal concha (turbinate)
Agger nasi
Atrium of middle nasal meatus
Middle nasal meatus
Inferior nasal concha (turbinate)
Limen
Vestibule
Inferior nasal meatus
Palatine process of maxilla
Incisive canal
Tongue
Sphenoethmoidal recess
Opening of sphenoidal sinus
Hypophysis (pituitary gland) in sella turcica
Sphenoidal sinus
Pharyngeal tonsil (adenoid if enlarged)
Basilar part of occipital bone
Pharyngobasilar fascia
Nasopharyngeal opening
Torus tubarius
Opening of auditory (Eustachian) tube
Pharyngeal recess
Horizontal plate of palatine bone
Soft palate

Nasal Mucosa

- ***Olfactory epithelium :***
- Delicate epithelium containing olfactory nerve cells (***1st order neuron cells***).
- It is present in the ***roof***, ***lateral wall*** and ***upper*** part of ***nasal cavity***.
- On the ***lateral wall***, it lines the ***upper surface of the superior concha*** and the ***sphenoethmoidal recess***.
- On the ***medial wall***, it lines the ***superior part of the nasal septum.***


Nasal
septum


Distribution of olfactory
mucosa (*shaded blue*)
Lateral
nasal wall

Olfactory Mucosa

- The **olfactory receptor cells** are ***bipolar***, meaning that they have two projections from their cell body.

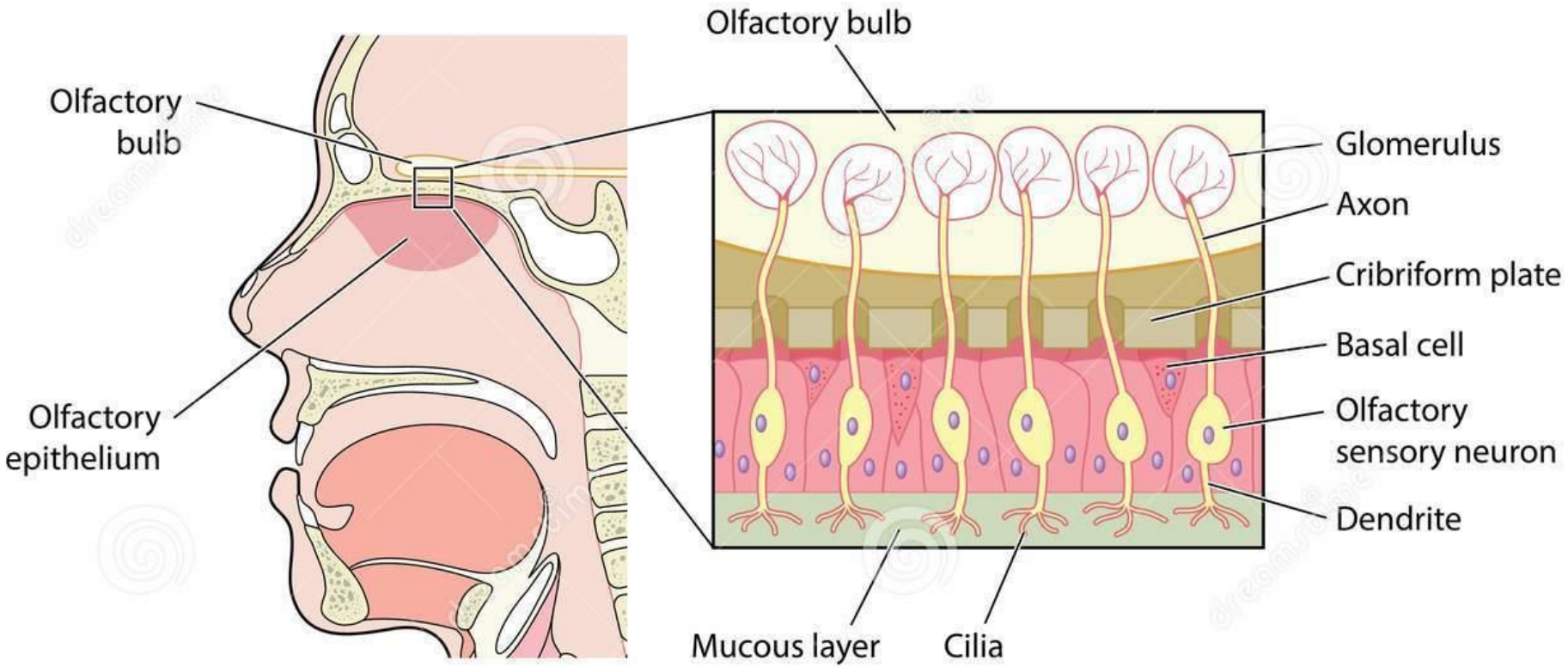
- One ***projection***, the ***dendrite***, extends to the ***surface*** of the ***olfactory epithelium***. Located on the dendrite's surface are 10-20 non motile **cilia** that extend into the fluid layer covering the epithelium in the nose.

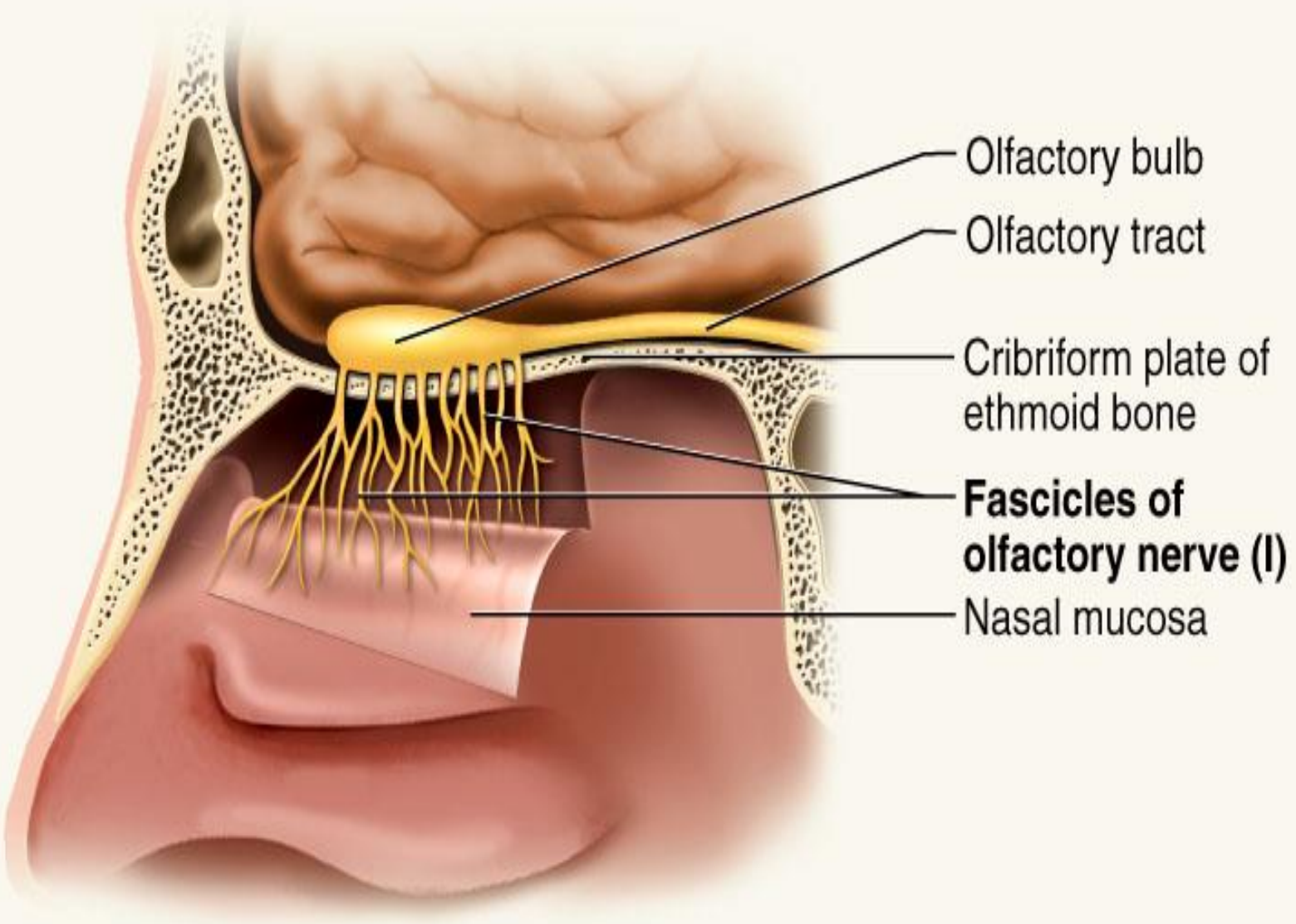
- The ***other projection*** from the receptor cell body is an ***unmyelinated axon*** relaying in the ***olfactory bulb***

Olfactory Mucosa

- Typically, an olfactory receptor cell lifespan is ***30-60 days***. The basal stem cells differentiate into/and replace damaged receptor cells.

- However, across a lifespan, ***not all receptors are replaced***, meaning that the sense of ***smell can diminish with age***.

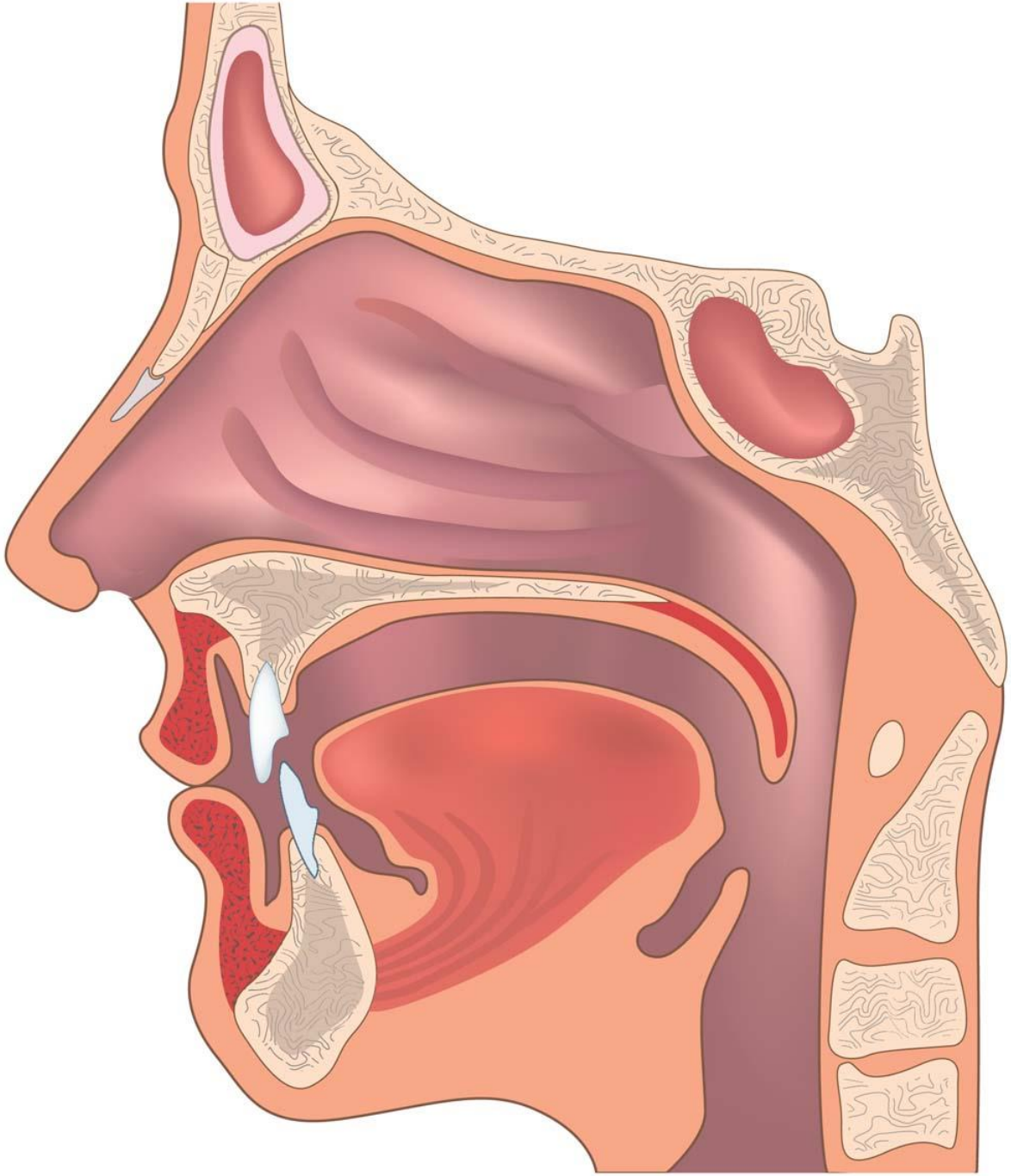

Olfactory bulb
Olfactory bulb
Olfactory epithelium
Glomerulus
Axon
Cribriform plate
Basal cell
Olfactory sensory neuron
Dendrite
Mucous layer
Cilia



Olfactory Nerve Stimulation

- ***Orthonasal flow:*** airflow toward the olfactory epithelium on inhalation from the anterior naris/nostriles

- ***Retronasal flow:*** during eating, stimulates olfactory receptors and contributes greatly to the flavor of food through the pharynx/nasopharynx



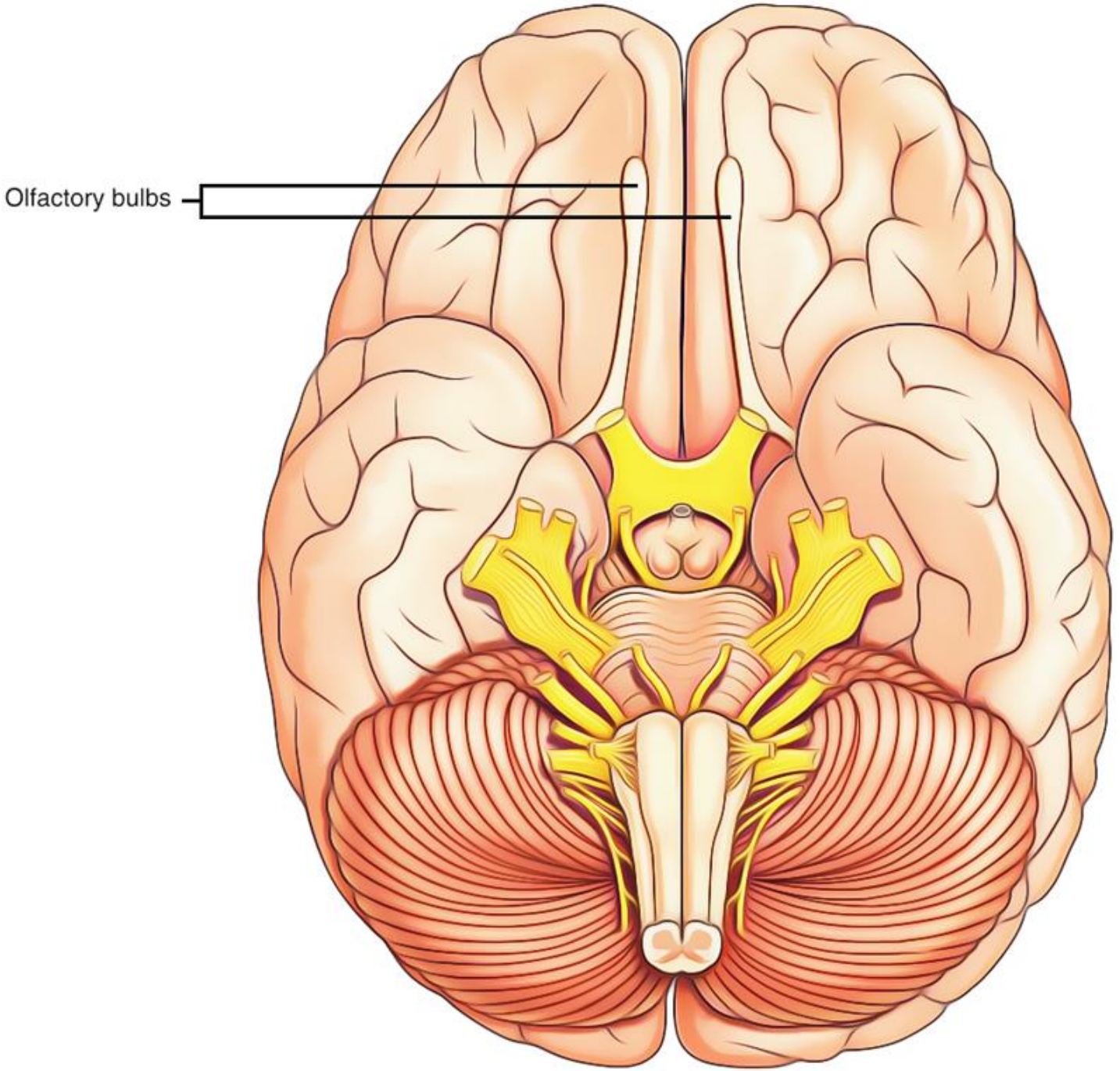
Olfactory Nerve

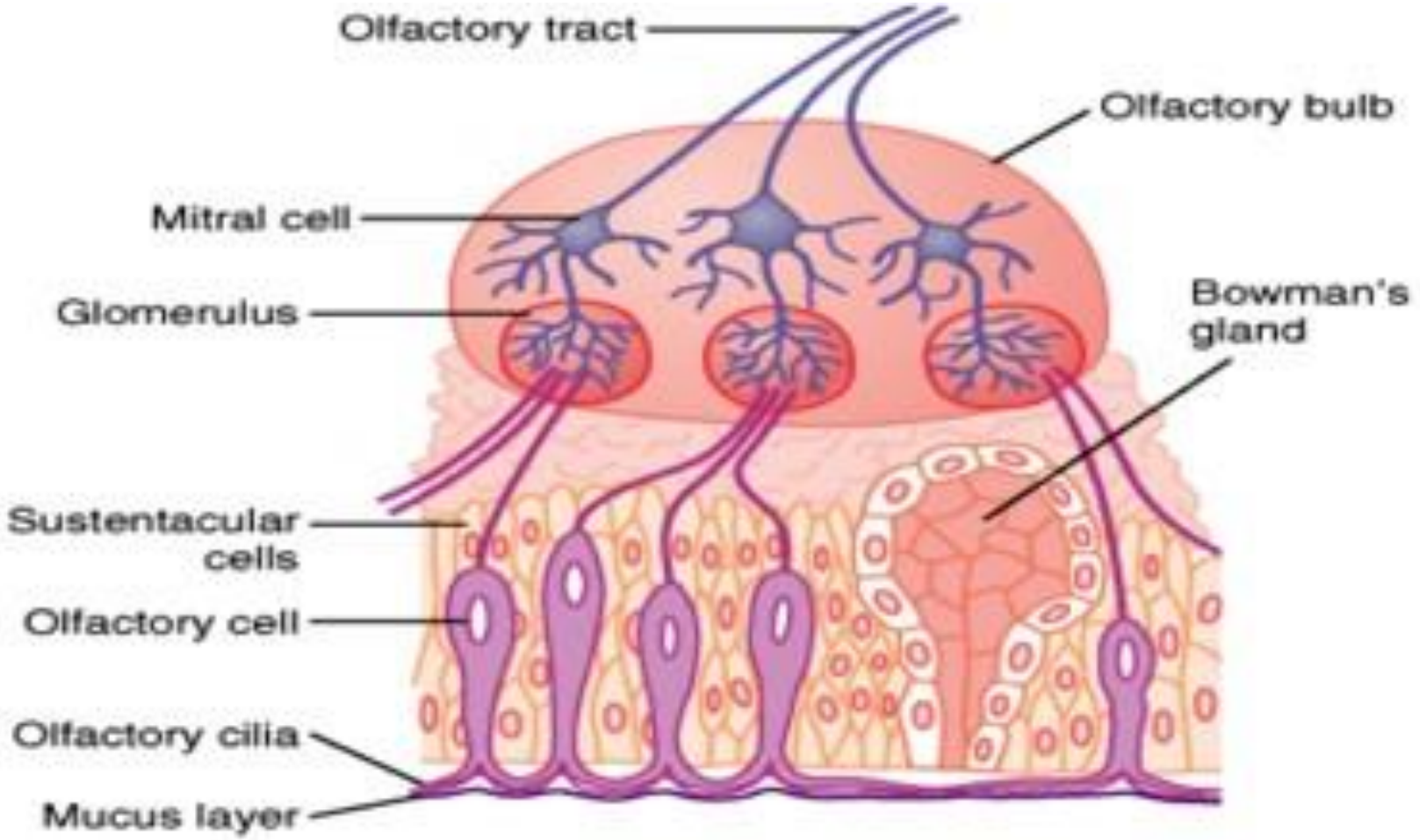
- Each receptor cell has an axon extending from its basal surface.
- As the axons project from the cell body, they combine with other receptor cell axons, making up bundles of nerve fibers/rootlets. All of these axonal bundles can collectively be thought of as the **olfactory nerve (CNI)**.
- These bundles of nerve fibers, surrounded by dura and arachnoid mater, then move superiorly as 15-20 rootlet by passing through the (holes) in the cribriform plate of the ethmoid bone.

Olfactory Bulb

- Each olfactory bulb (***right and left***) lies lateral to the crista galli and superior to the cribriform plate of the ethmoid bone, inside the cranial cavity.

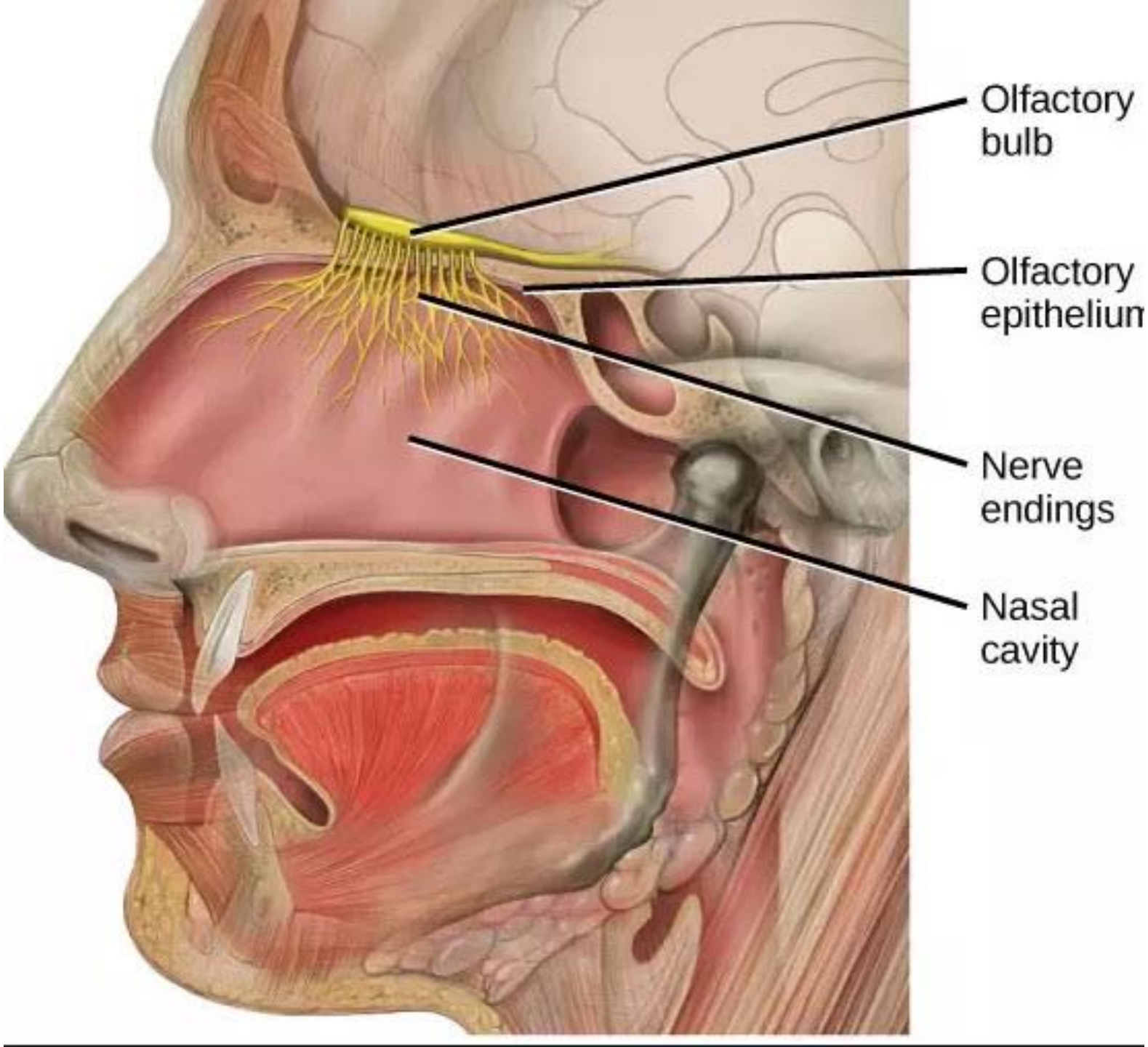
- Within the olfactory bulb are bundles of nerve fibers known as **glomeruli**; where *incoming receptor cell axons* make connections with the dendrites of ***mitral relay neurons (2nd order neuron cell)***

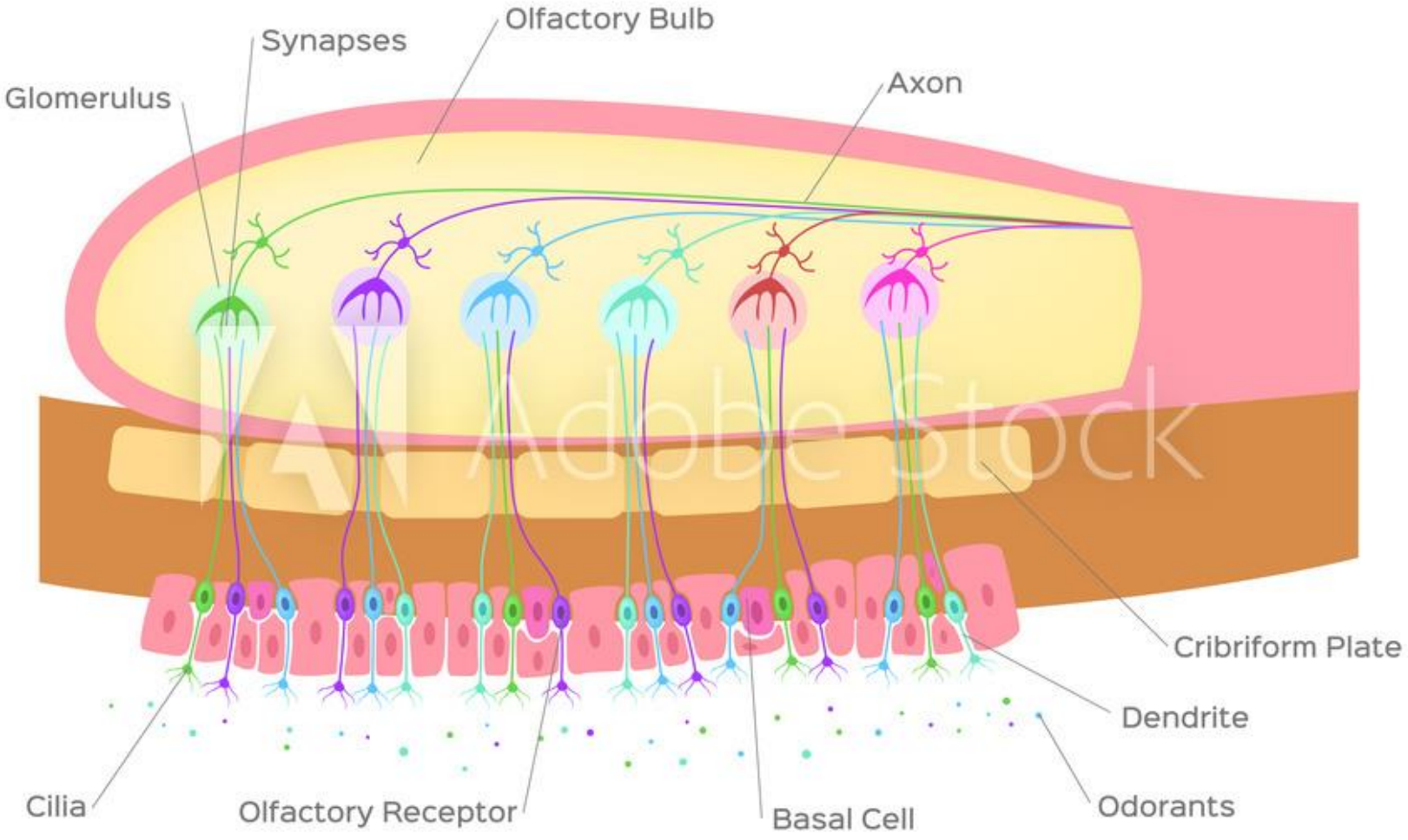

Olfactory bulbs


Olfactory tract
Olfactory bulb
Mitral cell
Glomerulus
Bowman's gland
Sustentacular cells
Olfactory cell
Olfactory cilia
Mucus layer

Olfactory Bulb

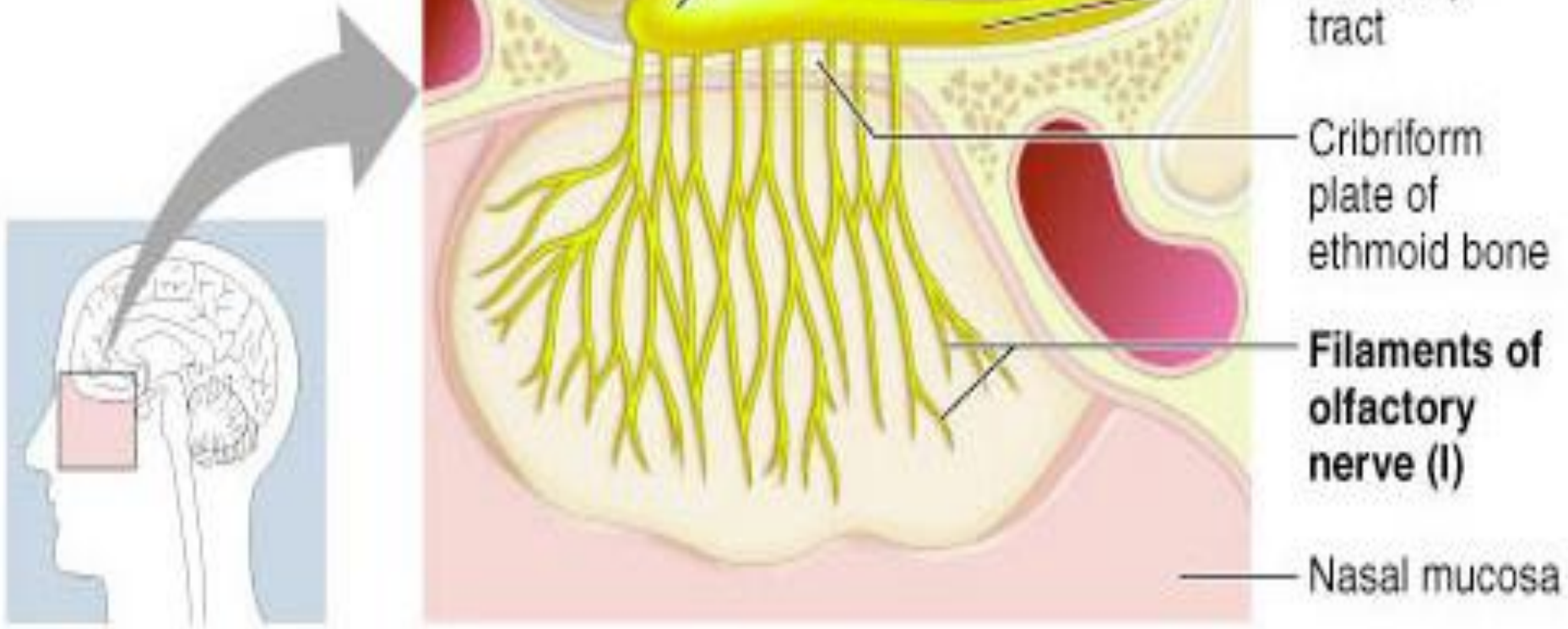
- **Ovoid structure possessing several types of nerve cells, the largest is the mitral cell.**
- **Highly organized**.
- ***Layers :***
  1. Glomerular layer
  2. External plexiform layer
  3. Mitral cell layer
  4. Internal plexiform layer
  5. Granular cell layer.


Olfactory bulb
Olfactory epithelium
Nerve endings
Nasal cavity


Olfactory Bulb
Synapses
Glomerulus
Axon
Cribriform Plate
Dendrite
Odorants
Basal Cell
Olfactory Receptor
Cilia

Olfactory Pathway

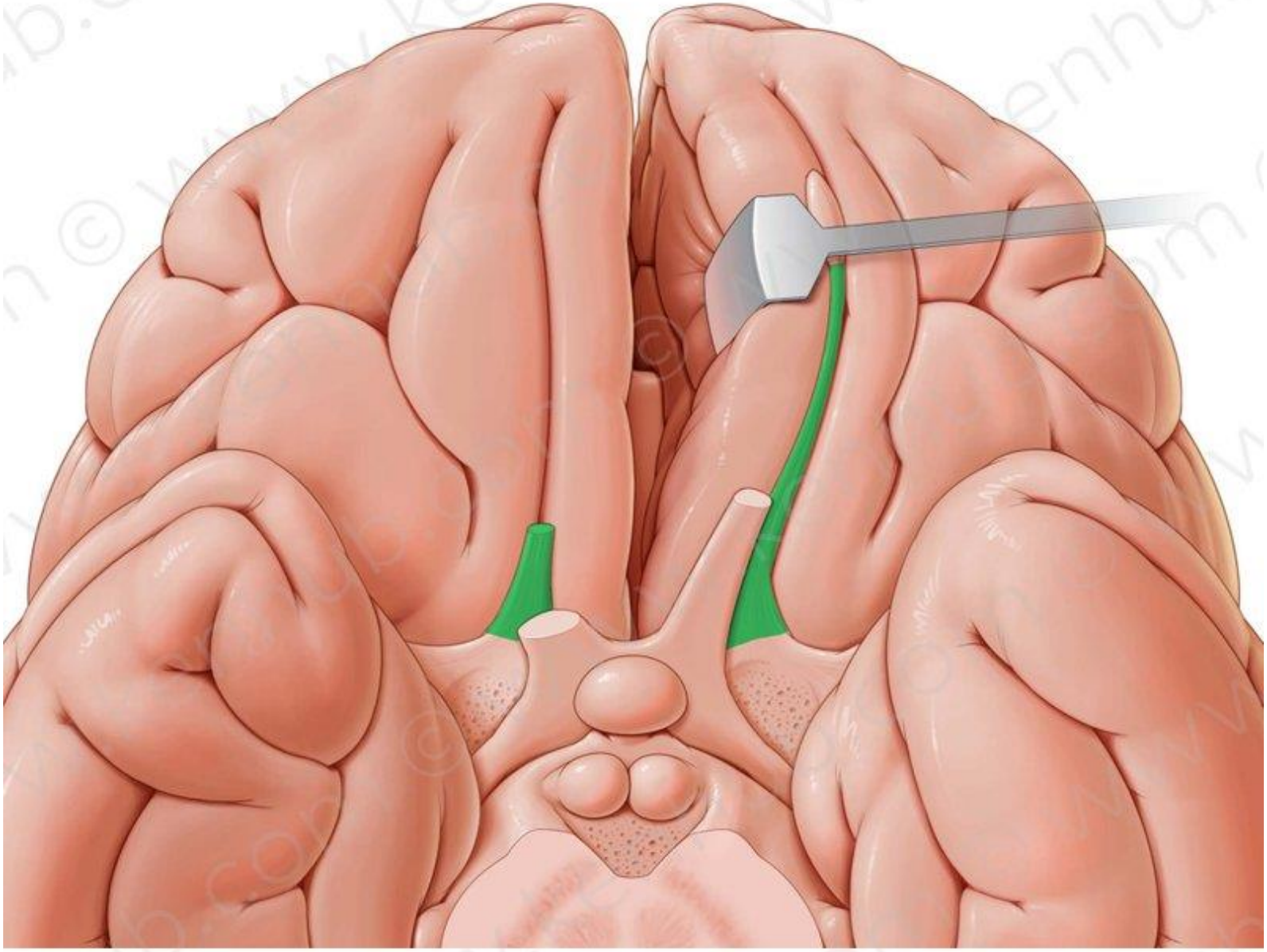
- *Preliminary processing of olfactory information* is within the olfactory bulb, which contains interneurons and large **Mitral cells** axons, from which, leaves the bulb as the olfactory tract.


Frontal lobe of cerebral hemisphere
Olfactory bulb
Olfactory tract
Cribriform plate of ethmoid bone
Filaments of olfactory nerve (I)
Nasal mucosa

Olfactory Tract and Stria

- Olfactory tract is made up of the axons of **mitral relay neurons** bound for the regions of the brain associated with the olfactory cortex. The tract passes posteriorly on the underside of the medial frontal lobe in a sulcus known as the **olfactory groove**.

- ***Olfactory Striae***
- In relation to the **optic chiasma**, the olfactory tract on both sides divides into ***medial*** and ***lateral*** **olfactory striae**.

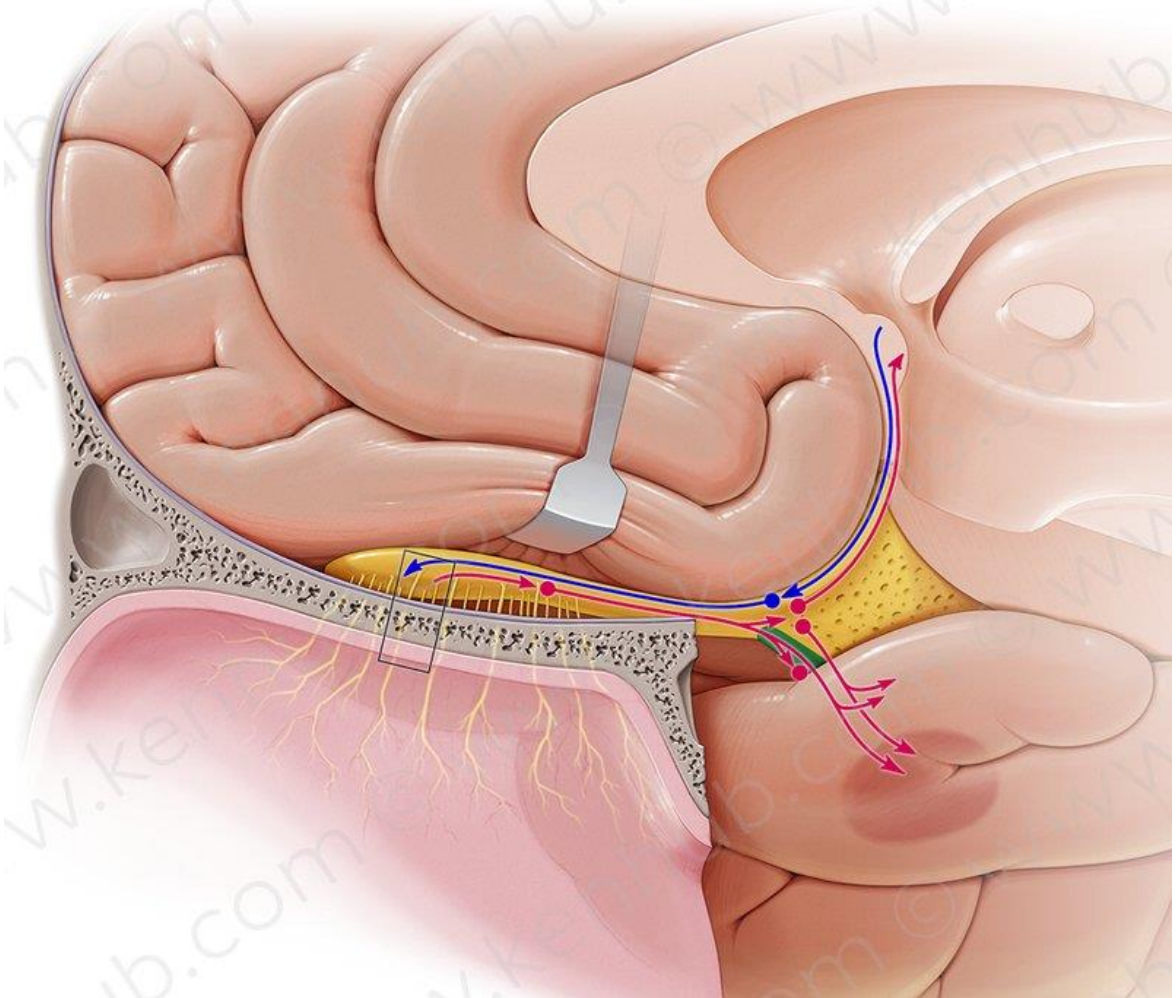


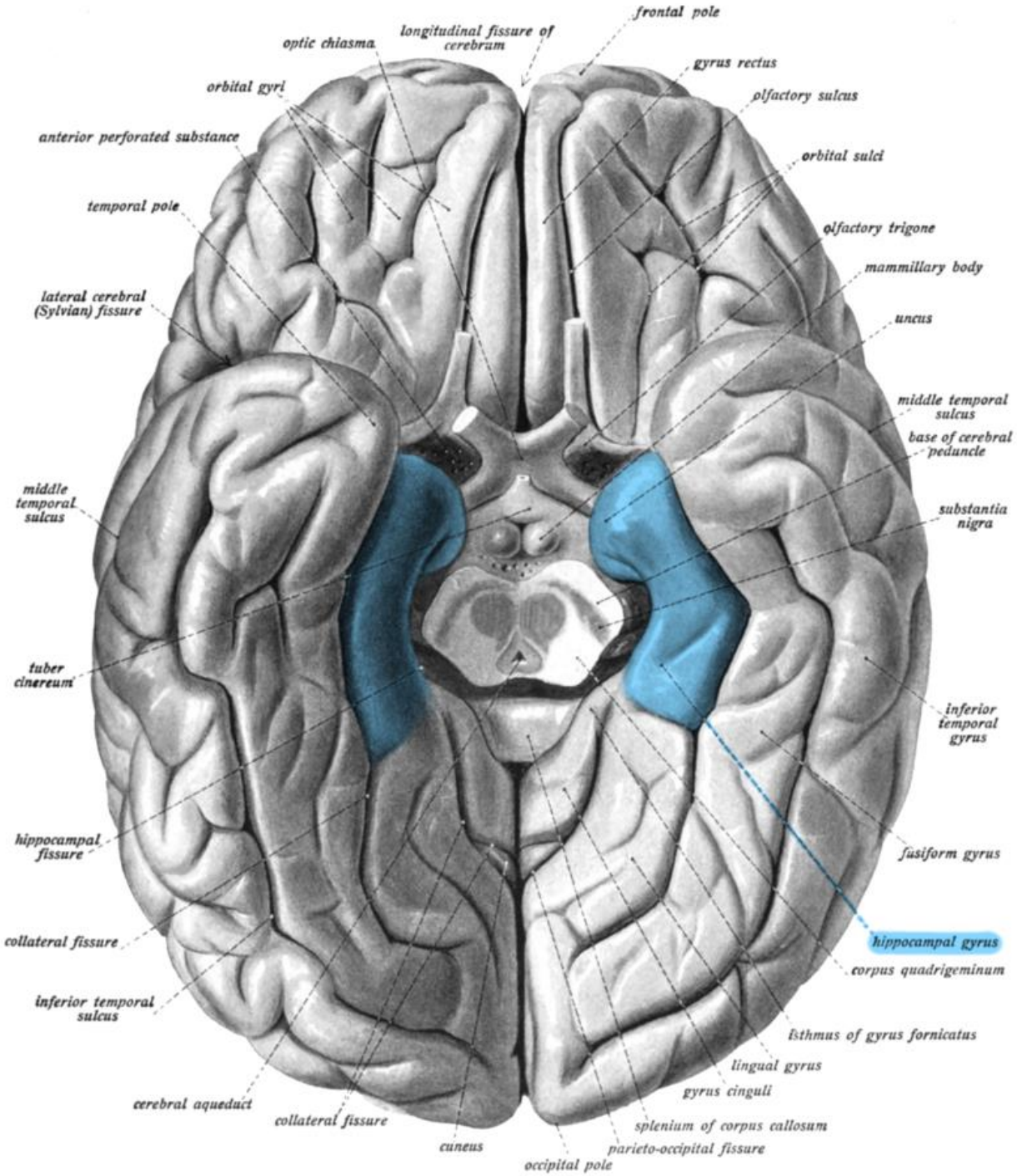
Olfactory Pathway

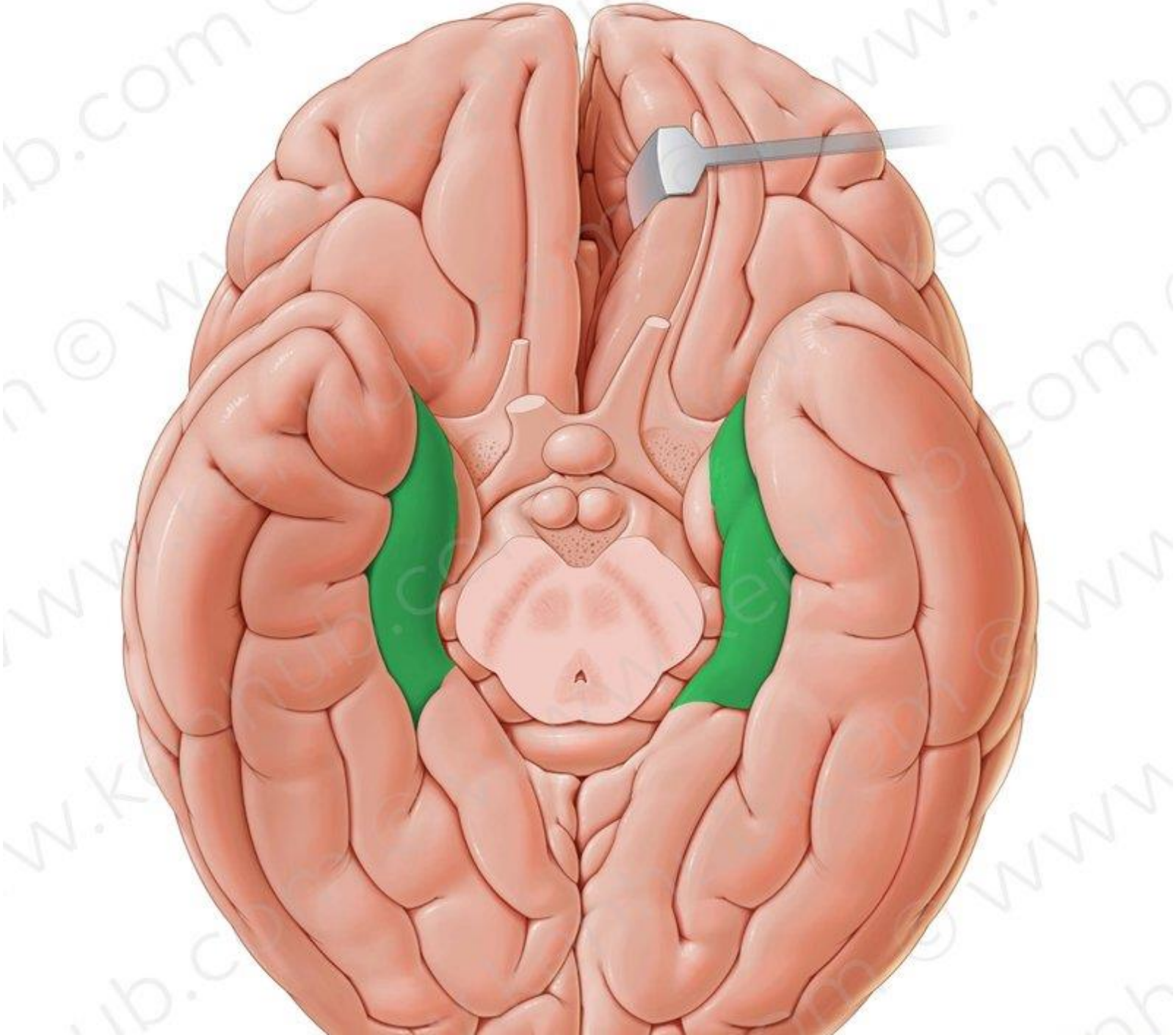
- ***Lateral root:***

- Carries olfactory fibers to **end in** cortex of the **Uncus** & adjacent part of **Hippocampal gyrus (center of smell)** ***ipsilateral side***

Lateral Olfactory Stria




frontal pole
longitudinal fissure of cerebrum
optic chiasma
gyrus rectus
orbital gyri
olfactory sulcus
anterior perforated substance
orbital sulci
temporal pole
olfactory trigone
mammillary body
lateral cerebral (Sylvian) fissure
uncus
middle temporal sulcus
base of cerebral peduncle
middle temporal sulcus
substantia nigra
tuber cinereum
inferior temporal gyrus
hippocampal fissure
fusiform gyrus
collateral fissure
hippocampal gyrus
corpus quadrigeminum
inferior temporal sulcus
isthmus of gyrus fornicatus
lingual gyrus
gyrus cinguli
cerebral aqueduct
collateral fissure
splenium of corpus callosum
cuneus
parieto-occipital fissure
occipital pole



Olfactory Pathway

- **Medial root :**

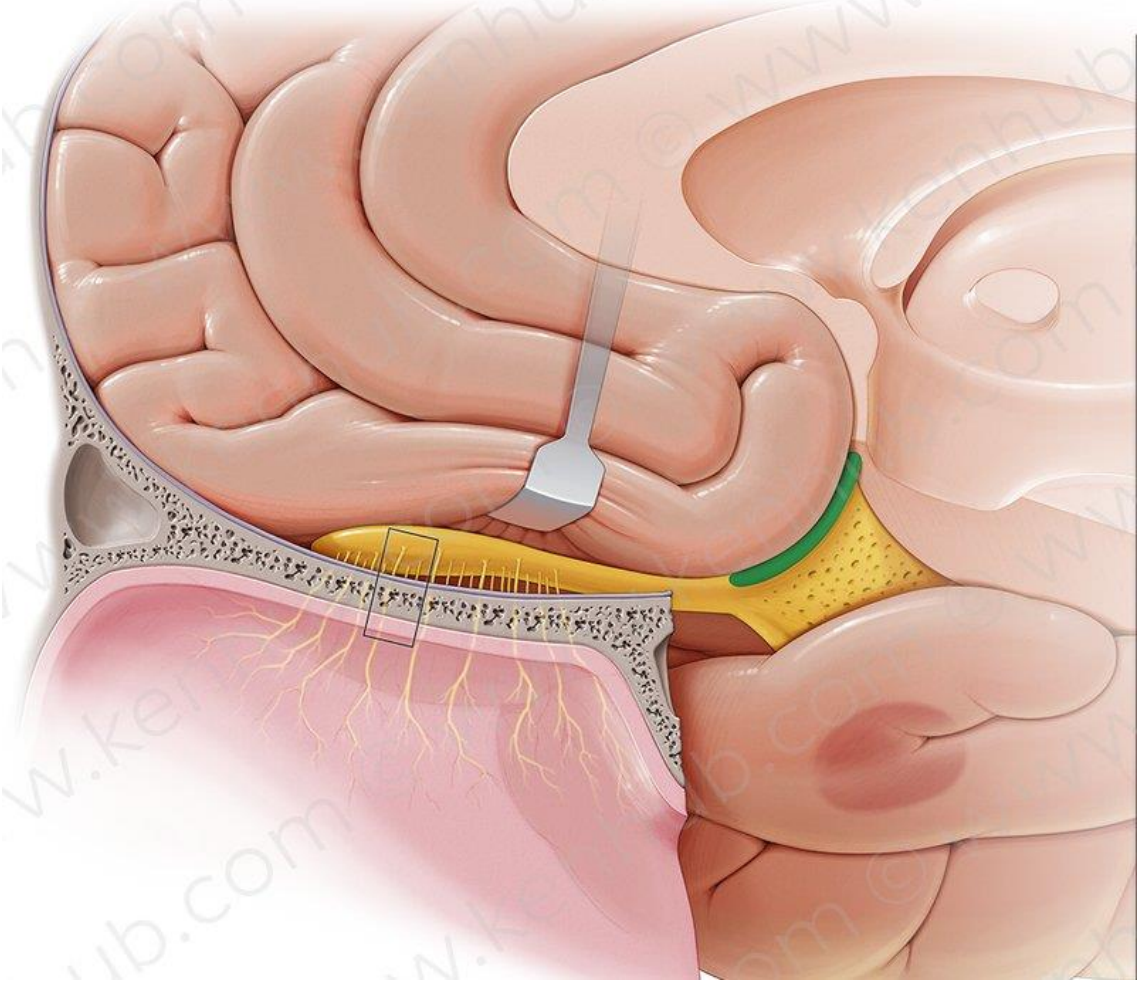
- ***Crosses midline*** through anterior commissure and joins the uncrossed lateral root of opposite side.

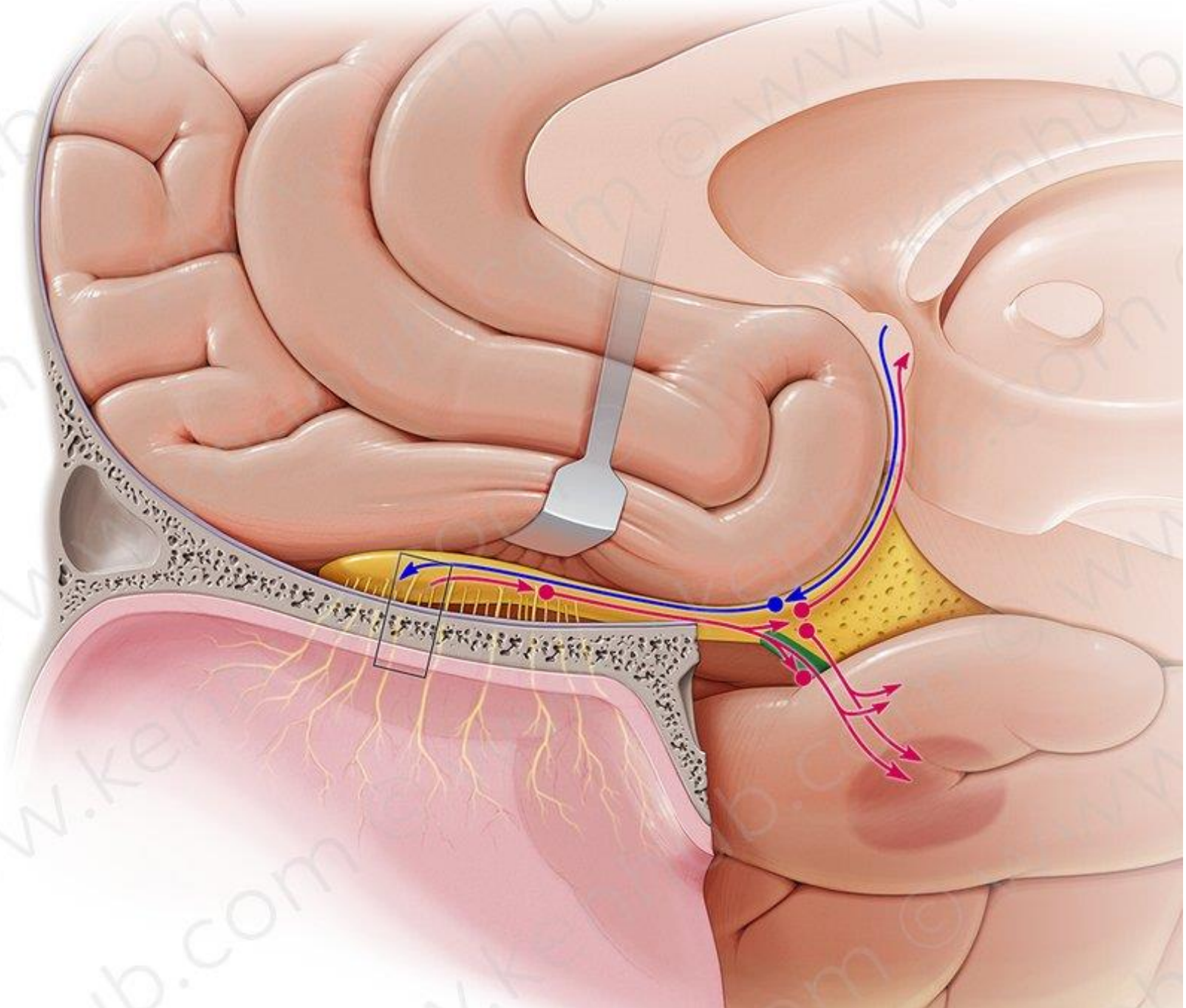
- It connects olfactory centers of 2 cerebral hemispheres.

- So each olfactory center receives smell sensation from both halves of nasal cavity.

- **NB: Olfactory pathway is the only sensory pathway which reaches the cerebral cortex without passing through the Thalamus (Old School Talk)**

Medial Olfactory Stria





Olfactory Cortex

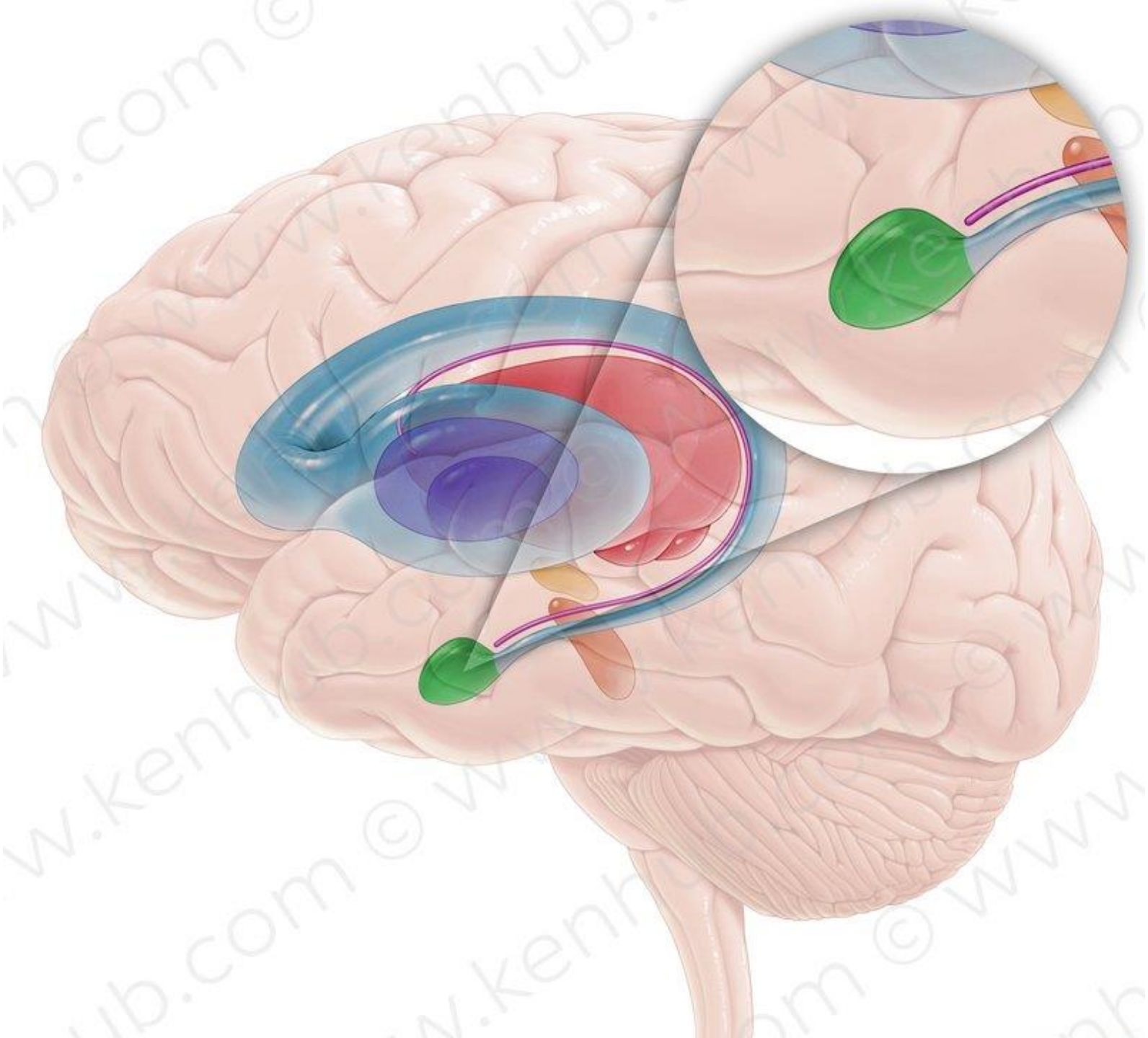
- This cortex is not a single structure, rather, it is defined as the combined areas of the cerebral cortex (***generally within the temporal lobe***) that receive input directly from the olfactory bulb. These regions include the:

- ***Piriform cortex:*** which is located below the lateral olfactory stria.

Olfactory Cortex

- ***Amygdala:*** which is located anterior to the temporal/inferior horn of the lateral ventricle, and is associated with the ***emotion of fear***.

- ***Entorhinal cortex:*** which is the anterior part of the parahippocampal gyrus, and is involved in the ***formation of memory***.



Olfactory Cortex

- Impulses are interpreted in olfactory cortex
  - Deep in temporal lobe and base of frontal lobe
- Some project into the limbic system and hypothalamus (***emotional and memory evoked responses***).
- The primary olfactory area has axons that extend to the orbit frontal area (frontal lobe), ***region for odor identification***

Sensory Adaptation

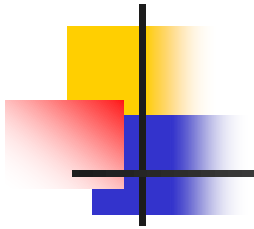
How long do you think sensory adaptation occurs for the sense of smell?


Do I smell
what?

Sensory Adaptation

Olfactory receptors undergo sensory adaptation **RAPIDLY**

- Sense of smell drops by up to 50% within 5 seconds after stimulation
- Within a minute the receptors may become insensitive to a given odor



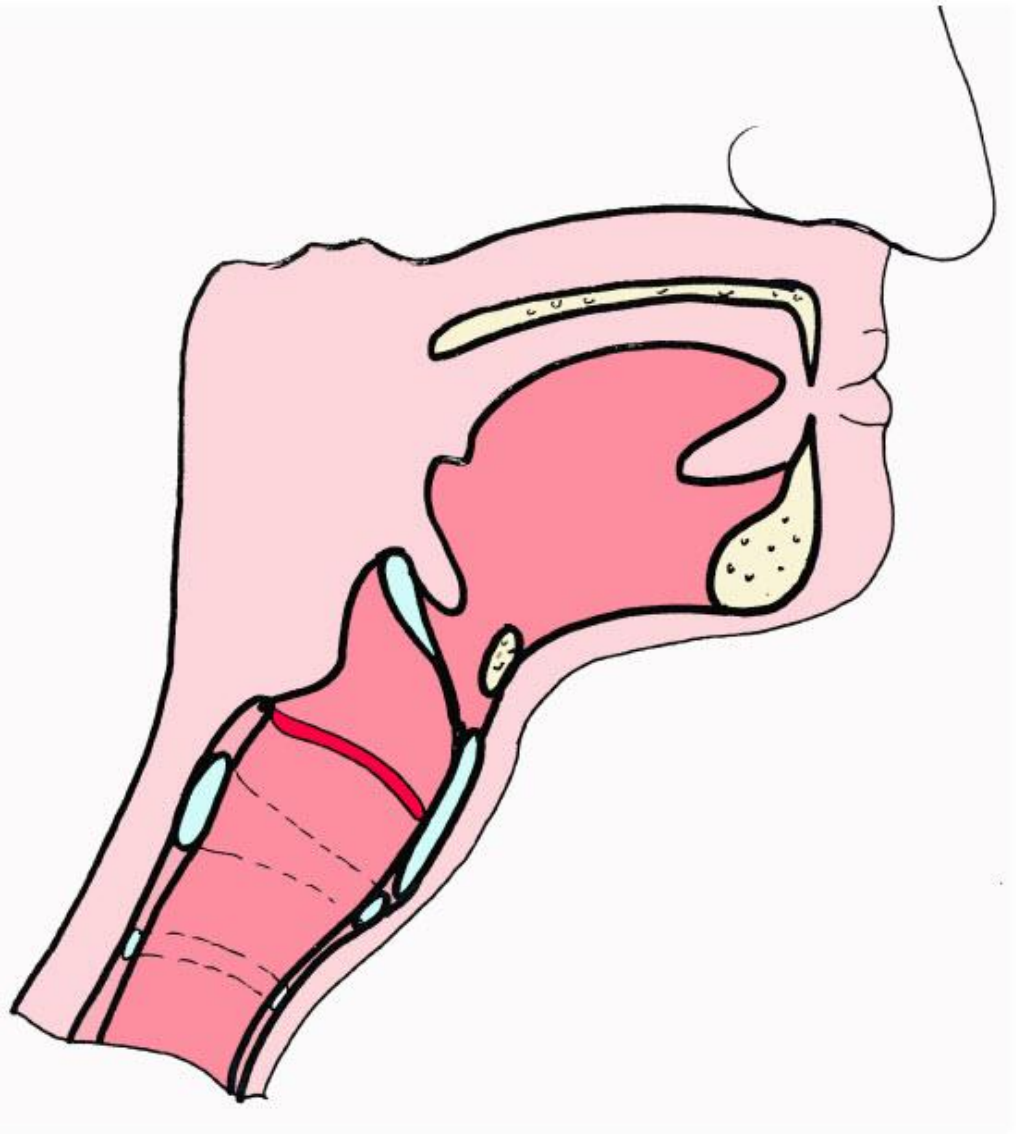
Gustatory Pathway

Taste Sensation - Gustation

- **Gustation is considered a primitive sense**
- **5** main 'tastes' **Sweet, Bitter, Umami** (savouryness), **Salt and Sour**
- **Others e.g.** carbonated + fattyness also likely exist (no consensus as to whether these are true 'primary' tastes)

Taste Sensation - Gustation

- **Taste serves as a protective/evolve promoting mechanism**
- ***Bitter/Sour*** foods may be ***toxic/unripe***
- ***Sweet*** foods are often energy ***rich***
- In utero babies 'drink' amniotic fluid = rich in glucose, fructose, fatty acids and amino acids
- Introduction of glucose into amniotic fluid triggers increased rate of fetus swallowing and movement while bitter solutions inhibit swallowing



Taste buds with taste cells = **chemosensors**

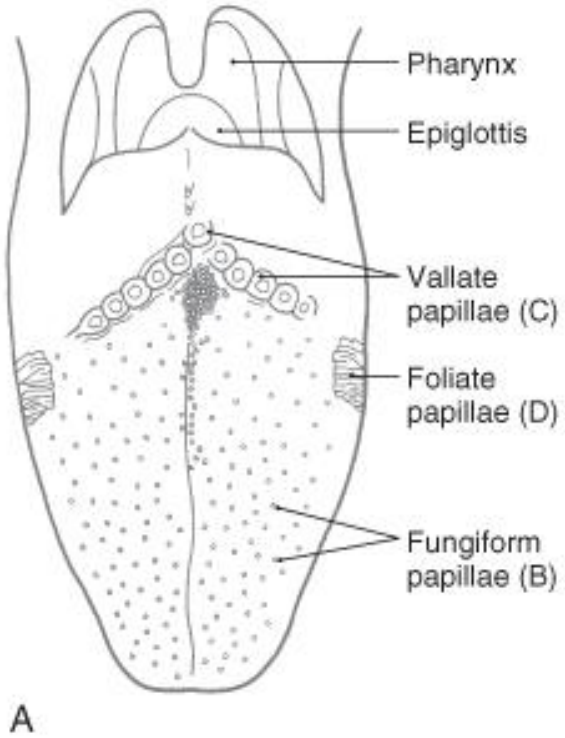
Highest concentration on tongue

Also present on:

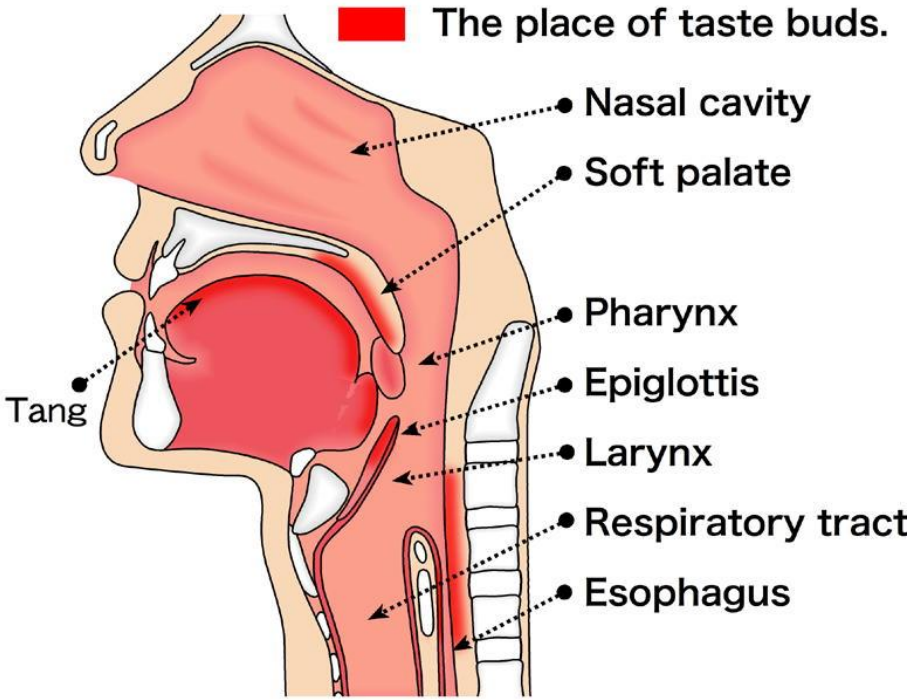
- Lips
- Inside wall of mouth
- Wall of pharynx/larynx/epiglottis
- Upper 1/3 oesophagus

Taste buds

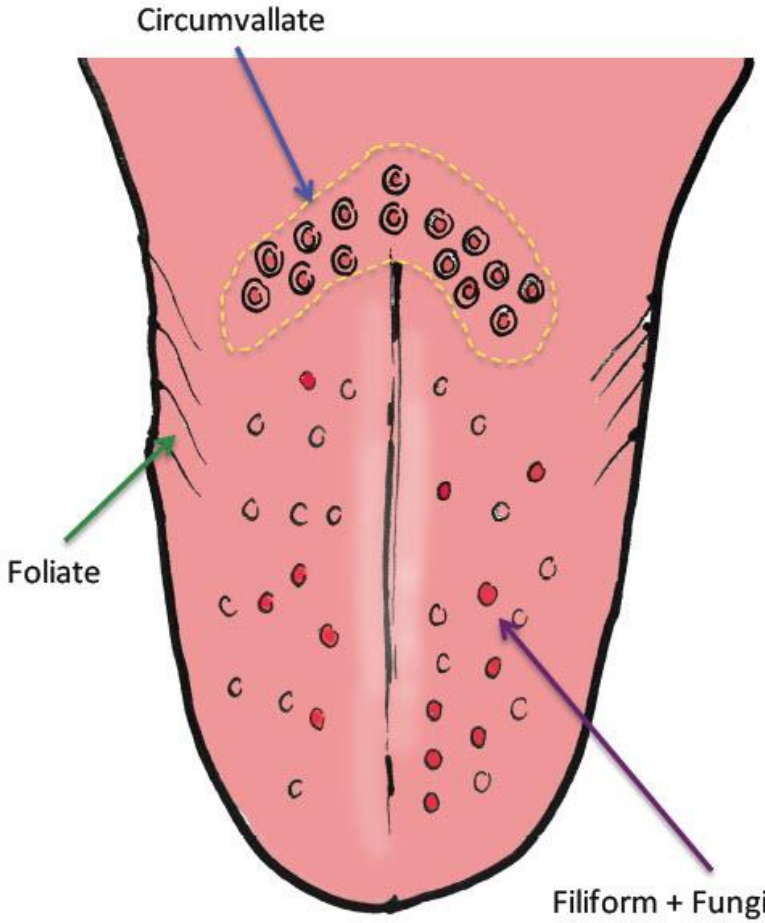
Lingual



Extra-lingual



Taste Buds



Every part of the tongue is sensitive to all five tastes

'Tongue map' depicting specific regions is a common misunderstanding

Bumps on tongue = papillae

Filiform papillae - detect texture
Fungiform, foliate + circumvallate - contain taste buds.

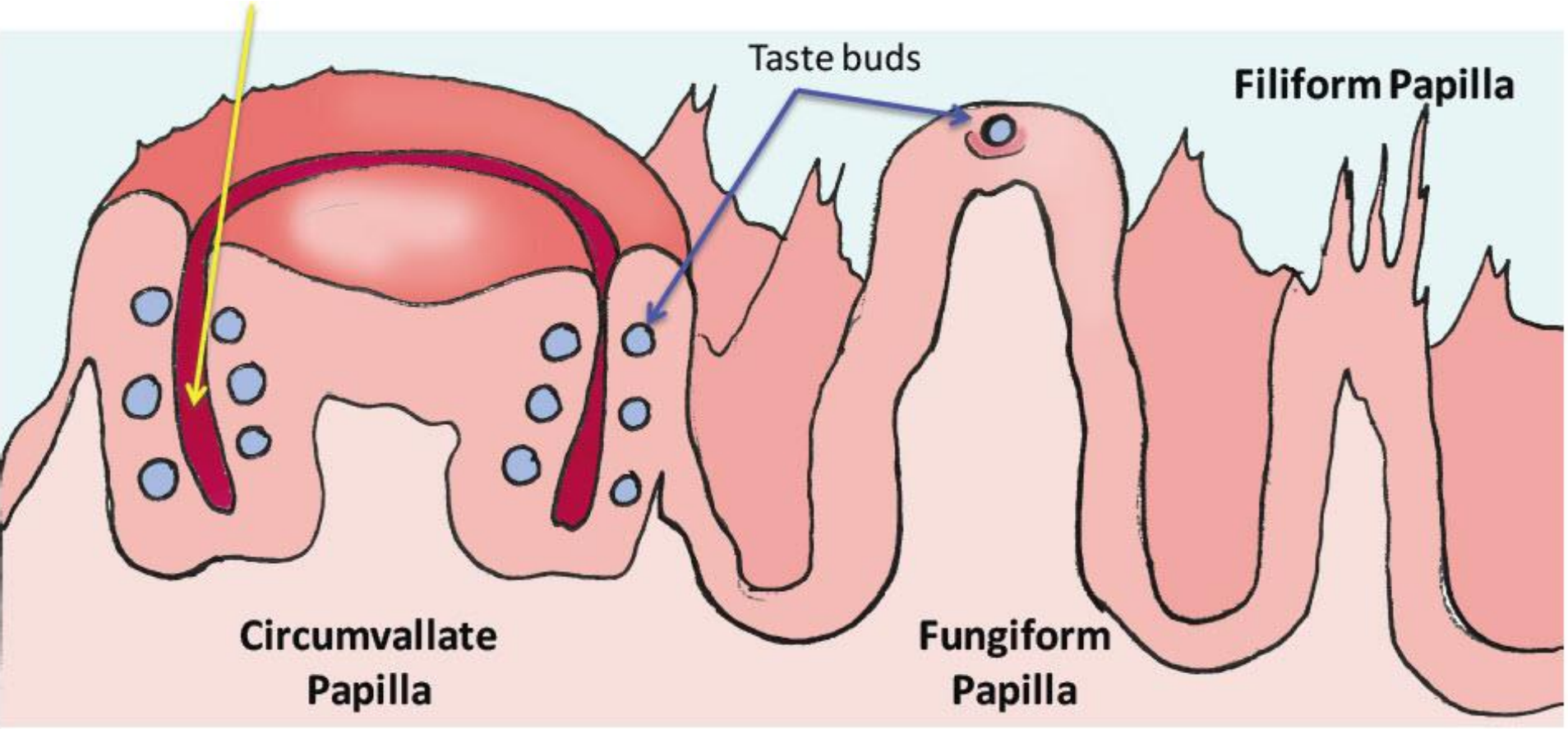
Circumvallate positioned in 'v-shape' **posteriorly**
Foliate at **sides**
Filiform and Fungiform **anteriorly**

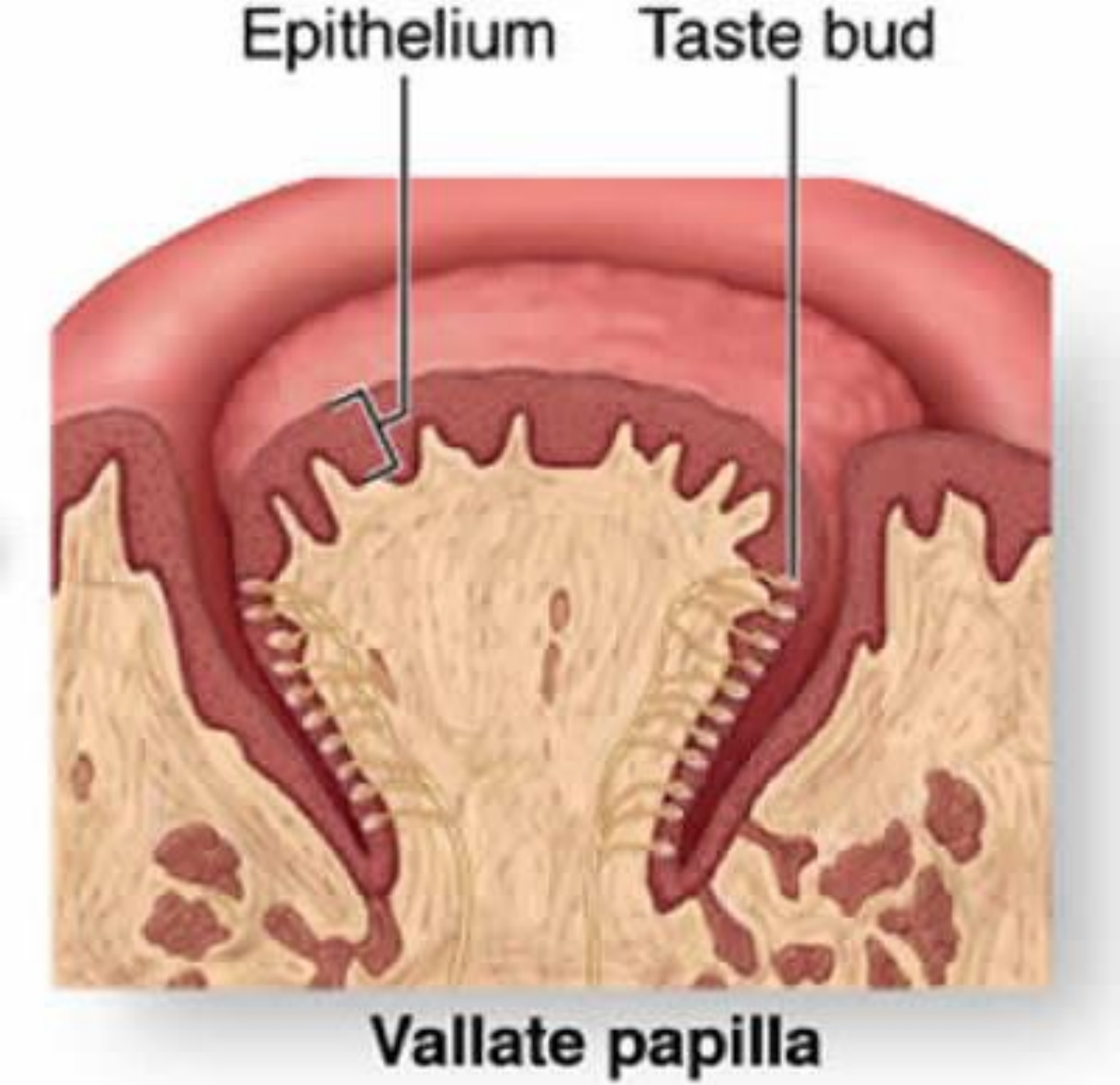
Taste buds

- ***Circumvallate papillae***

- These papillae lie in a ***V-shaped*** row immediately anterior to the ***sulcus terminalis***

- The shape of the papillae resembles a (***truncated cone***). The base that attaches onto the tongue is the narrower end and the broader apex is coated with stratified squamous epithelium.


Taste buds
Filiform Papilla
Circumvallate Papilla
Fungiform Papilla

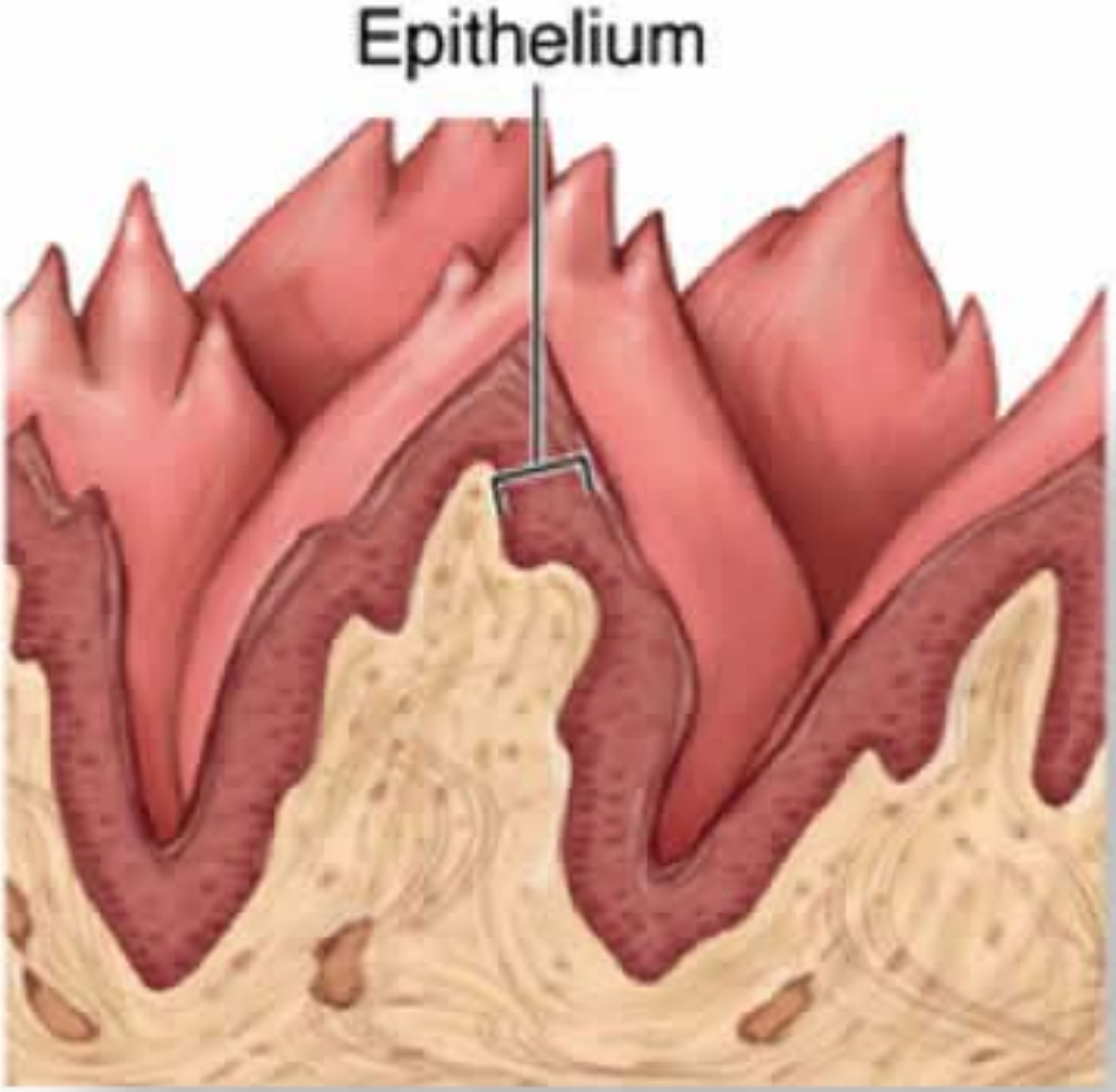

Epithelium
Taste bud
Vallate papilla

Taste buds

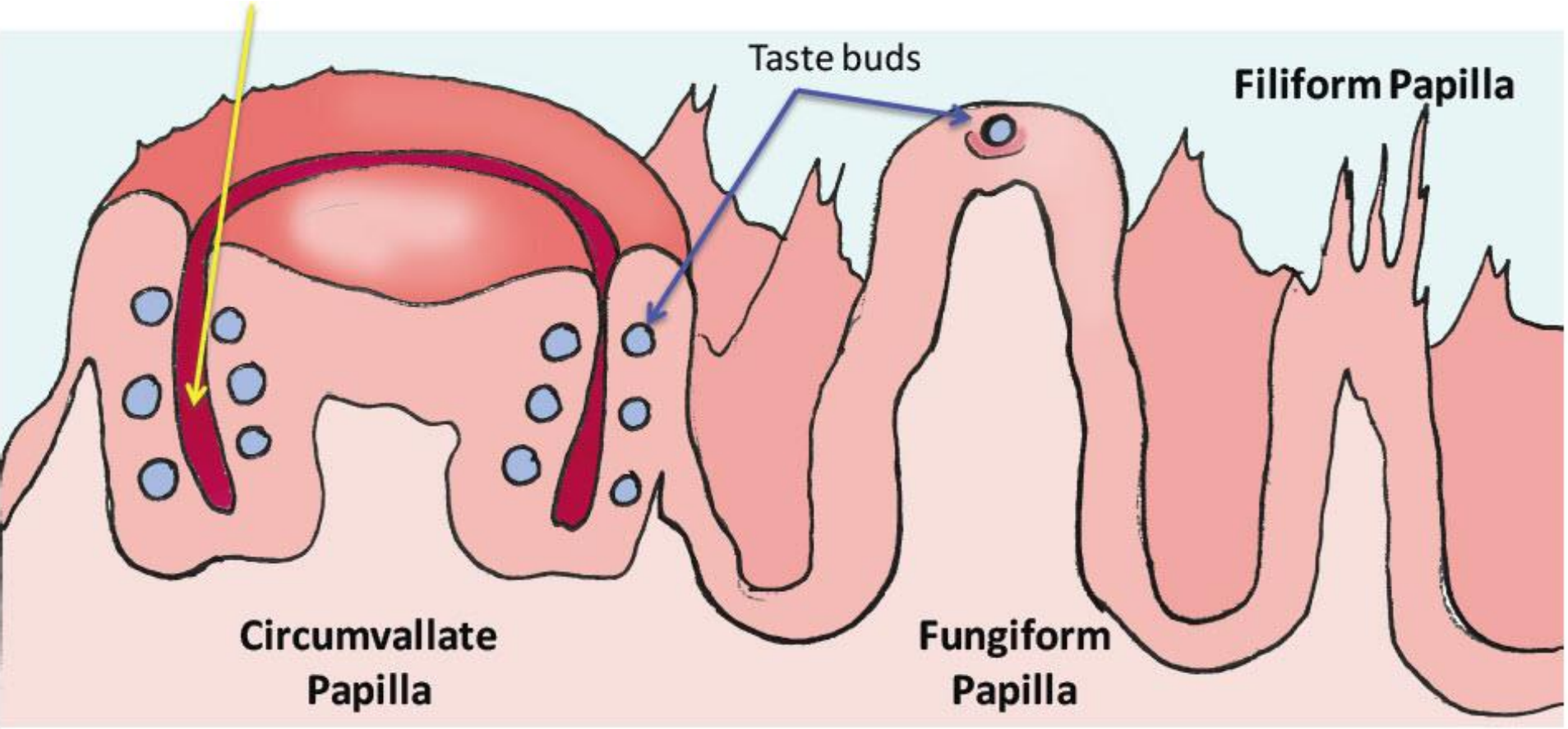
- ***Filiform Papillae***

- These are the commonest papillae on the tongue, and cover the majority of the anterior two thirds of the tongue.

- They are ***small and conical***, and ***do not contain taste buds***. They comprise a core of irregular connective tissue, which is covered by a keratinized epithelium featuring secondary processes, they are overlapped into a ***brush like dense layer of processes***. For proper food grip and handling in mouth



Filiform papilla

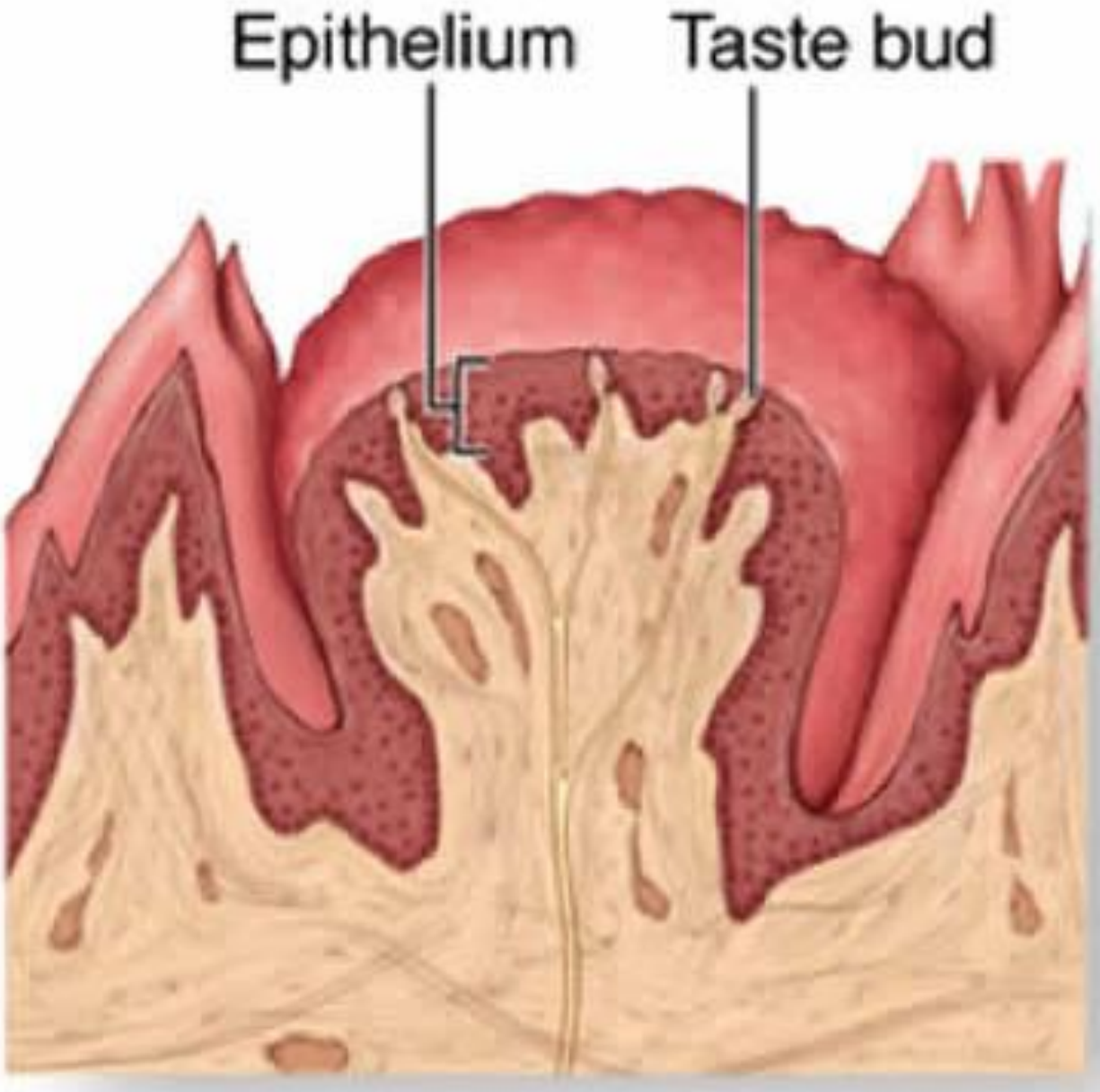

Taste buds
Filiform Papilla
Circumvallate Papilla
Fungiform Papilla

Taste buds

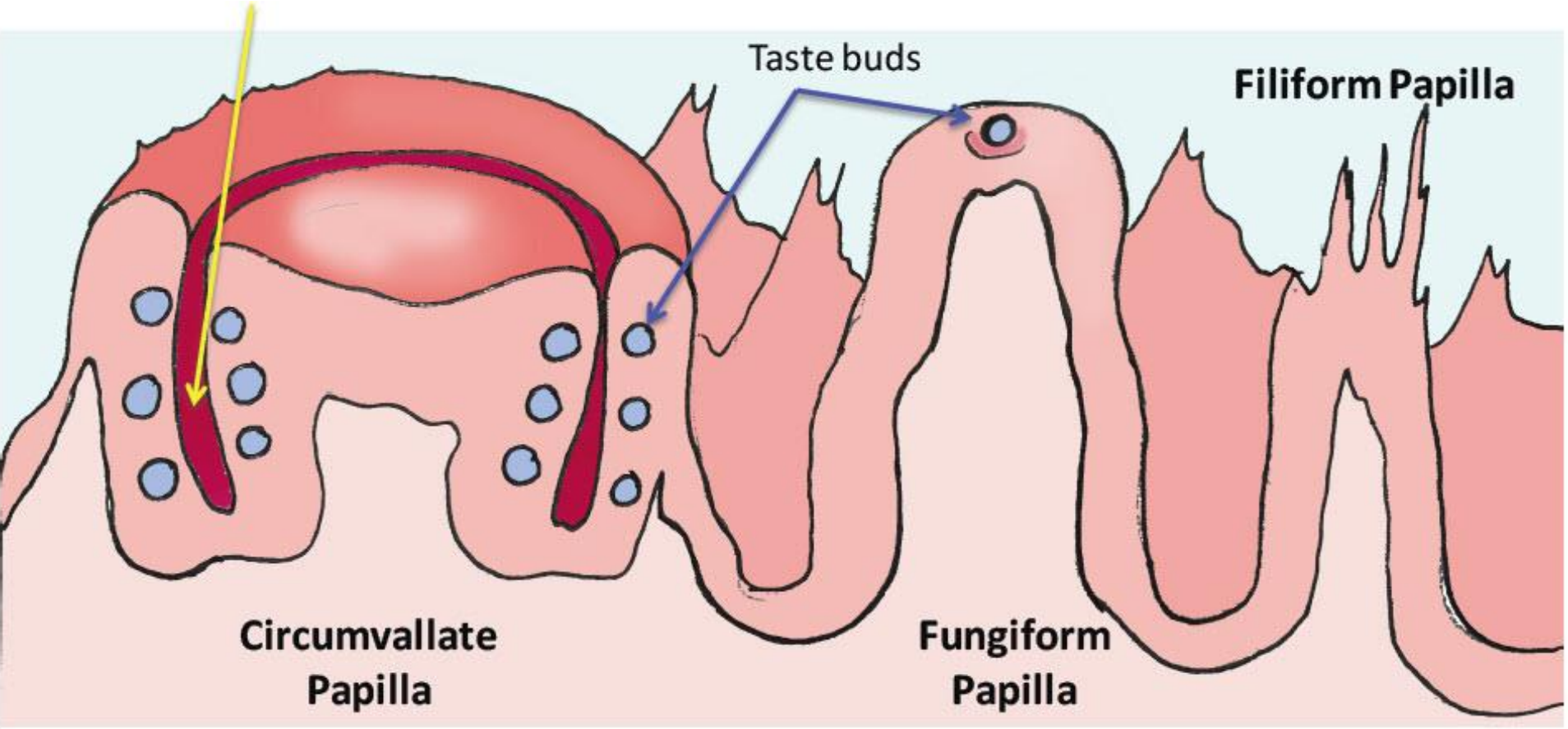
- ***Fungiform Papillae***

- These are named fungiform as they **resemble mushrooms**. Lying at their core is connective tissue.

- They are located on the superior surface of the tongue, and are dotted around the surface. Lying on them are ***numerous taste buds*** that are able to discern sweetness, sourness, saltiness, bitterness and umami.



Fungiform papilla

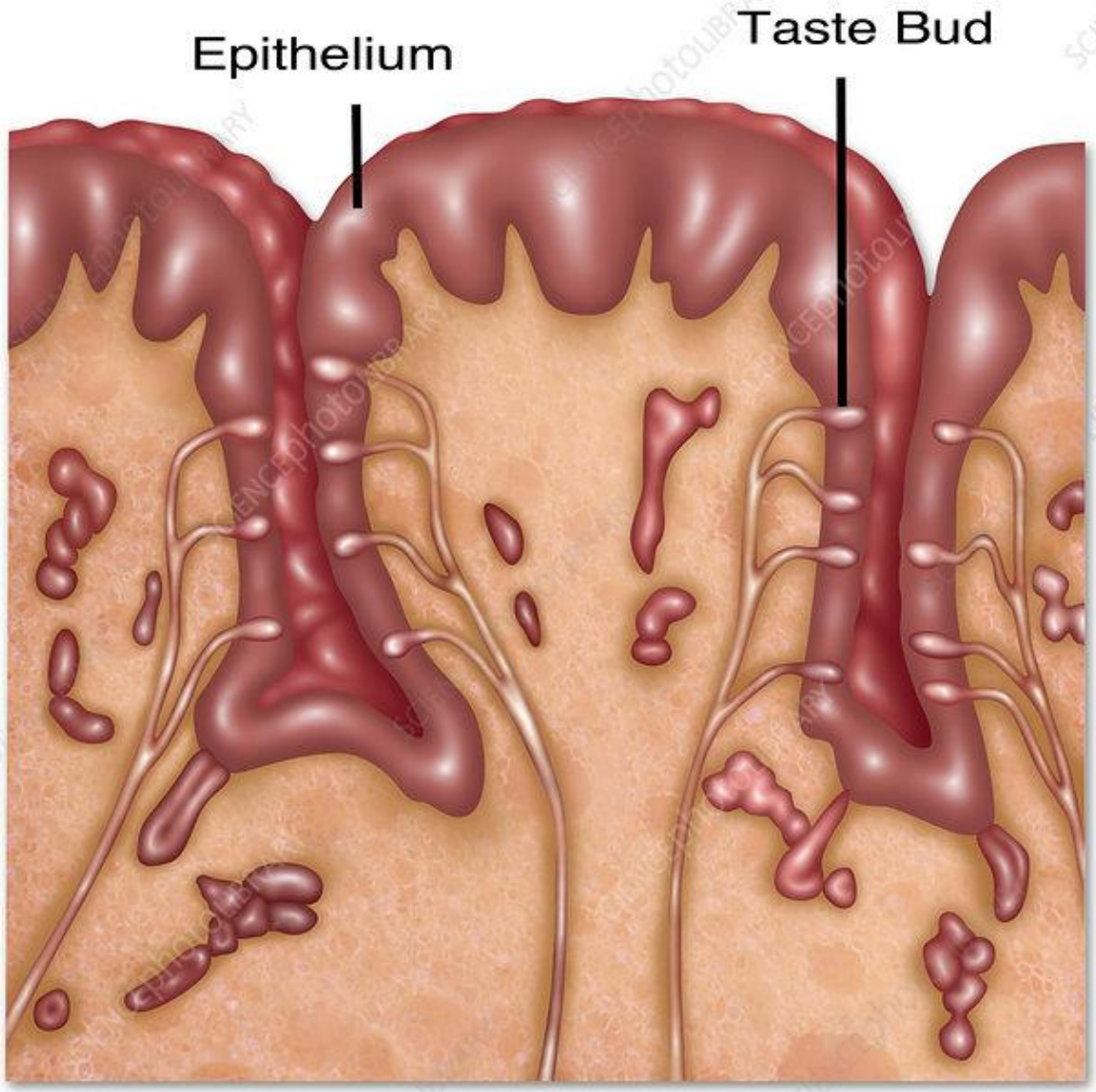

Taste buds
Filiform Papilla
Circumvallate Papilla
Fungiform Papilla

Taste buds

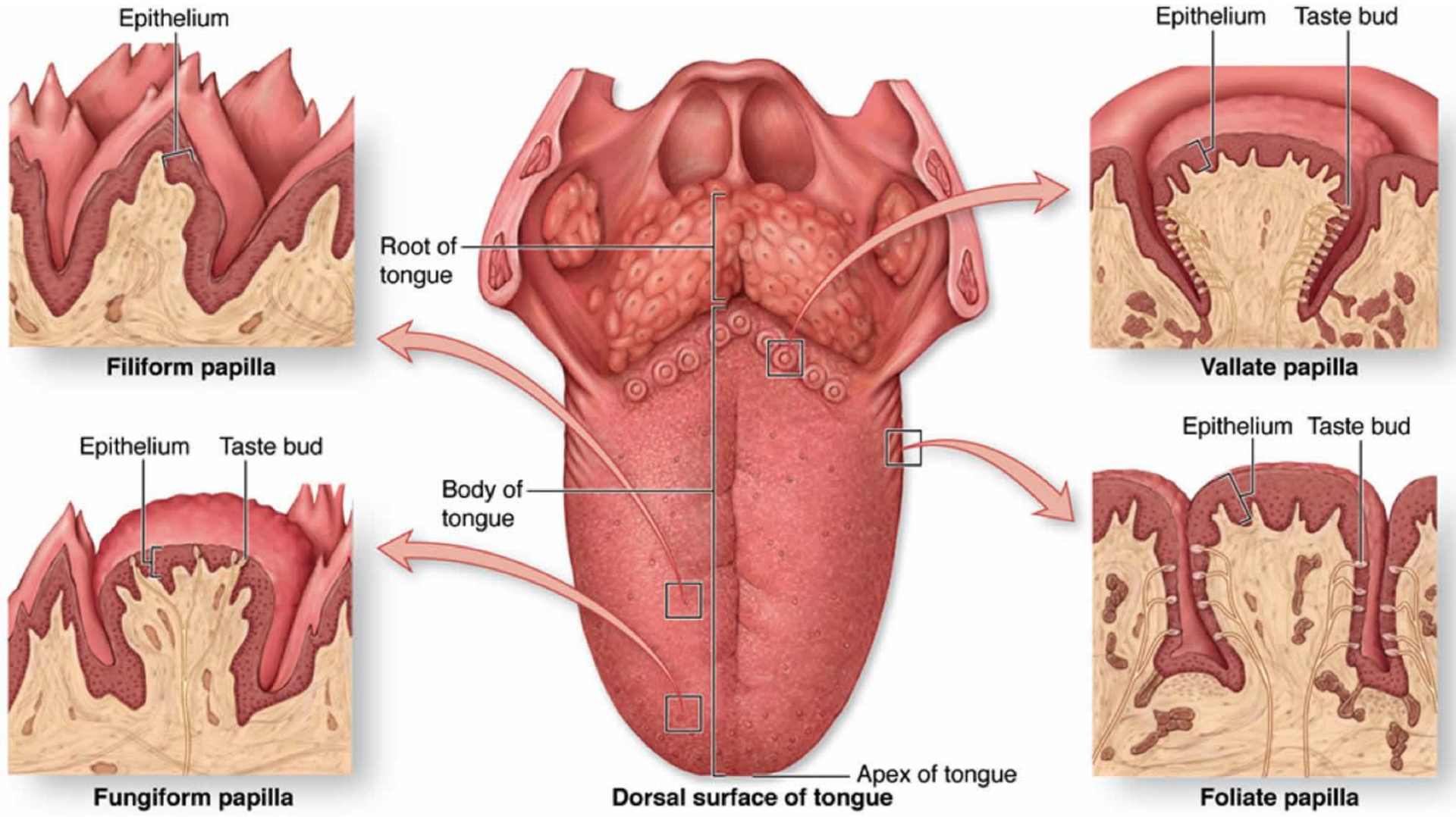
- ***Foliate Papillae***

- These are **vertical, relatively short** and lie on either side and back of the tongue.

- They can be located anterior to the palatoglossal arch. They are coated with non-keratinized epithelium and hence are softer than other papillae. They have ***numerous taste buds.***



Foliate Papilla


Epithelium
Filiform papilla
Epithelium
Taste bud
Vallate papilla
Root of tongue
Body of tongue
Epithelium
Taste bud
Fungiform papilla
Epithelium
Taste bud
Foliate papilla
Apex of tongue
Dorsal surface of tongue

Peripheral Taste Pathways

- ***Extra lingual taste buds: Mouth, palate and pharyngeal mucosa***

- Afferent fibers of first-order taste neurons travel in the ***facial*** (The ***greater superficial petrosal branch*** for the soft palate), ***glossopharyngeal*** (IX), and ***vagus*** (X) nerves for other oral/pharyngeal regions

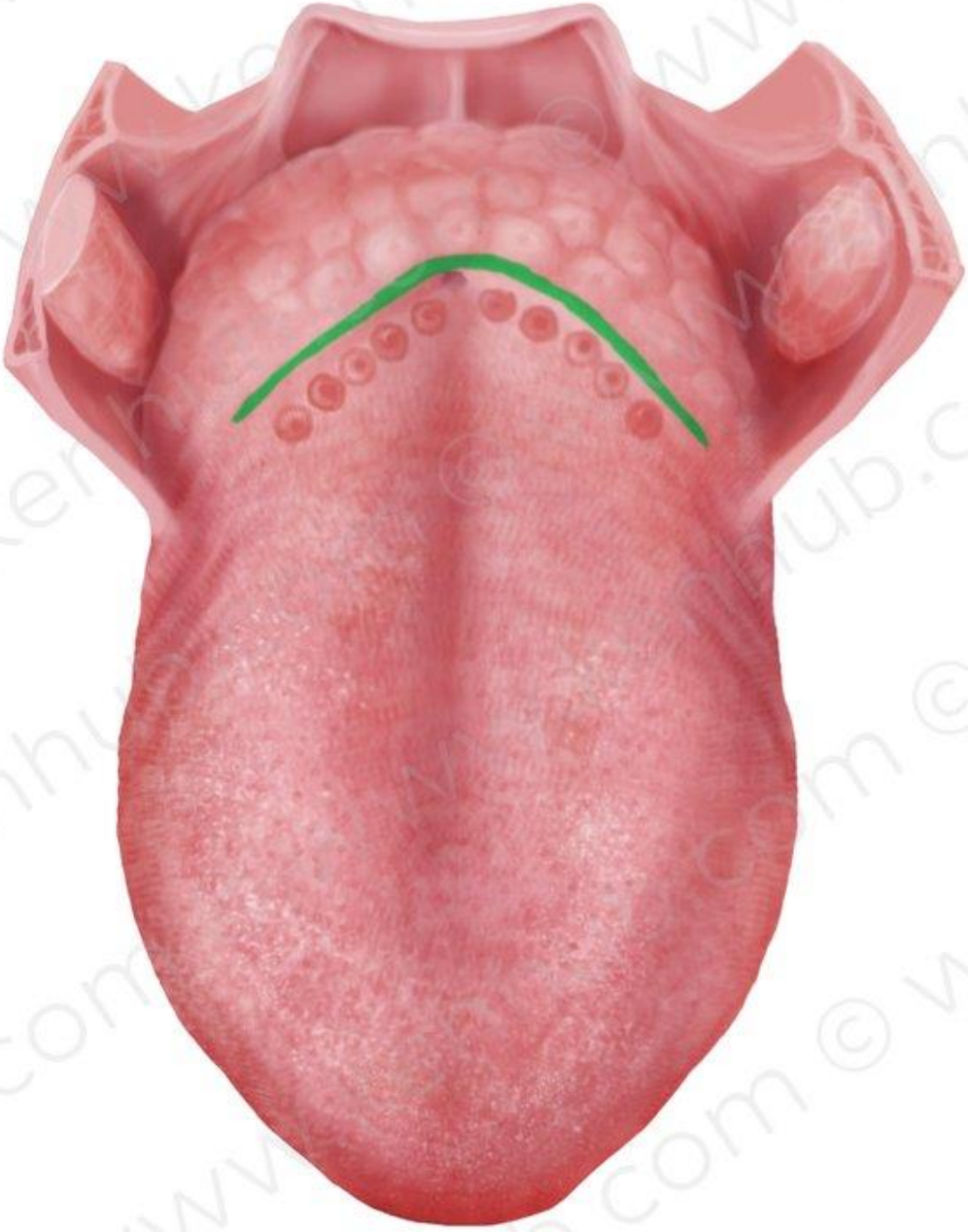
Peripheral Taste Pathways

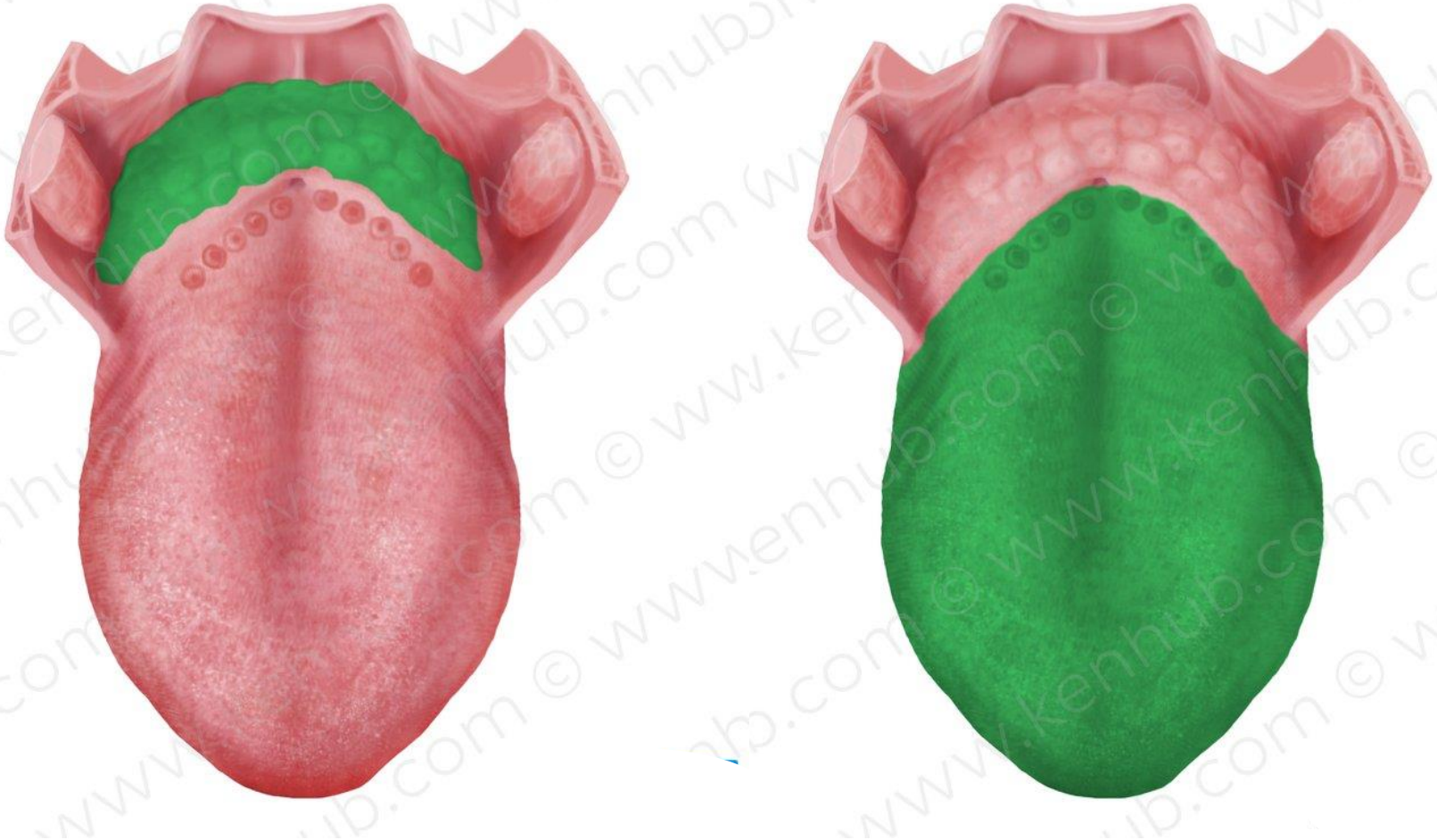
- ***Lingual:***

- Ant 2/3 tongue (in front of sulcus terminalis): ***chorda tympani branch of facial***

- Post 1/3 → ***lingual-tonsillar branch of the glossopharyngeal***

- Most posterior + epiglottis and esophagus → ***superior laryngeal*** branch of vagus





Peripheral Taste Pathways

- ***Facial nerve:***

- Sensation from ant. 2/3 tongue (chorda tympani) and soft palate (greater superficial petrosal) → cell bodies in the ***geniculate ganglion*** → central processes → ***intermediate nerve*** (part of facial) → brainstem at the pontomedullary junction → enter the ***solitary tract***, travel caudally, and terminate on the ***solitary nucleus***

Peripheral Taste Pathways

- ***Glossopharyngeal and Vagus Nerves:***

- Taste fibers in cranial nerves IX and X → ***inferior ganglia*** (***petrosal*** and ***nodose (inferior vagal ganglion)***, respectively) → enter the medulla, descend in the ***solitary tract*** → adjacent ***solitary nucleus***

Central Taste Pathways

- The ***solitary nucleus*** is the principal visceral afferent nucleus of the brainstem.

- Its ***rostral part*** (gustatory) *nucleus* (contains most of the second-order neurons in the taste pathway, Information from different areas of the tongue (***3 nerves***) convey to it

Central Taste Pathways

- Axons from second-order taste neurons in the gustatory nucleus ascend and terminate in the ***ventral posteromedial nucleus*** of the thalamus ***(VPM)*** → Axons from these neurons ***→ ipsilateral posterior limb of the internal capsule*** –> cortical taste areas

Cortical Taste Area

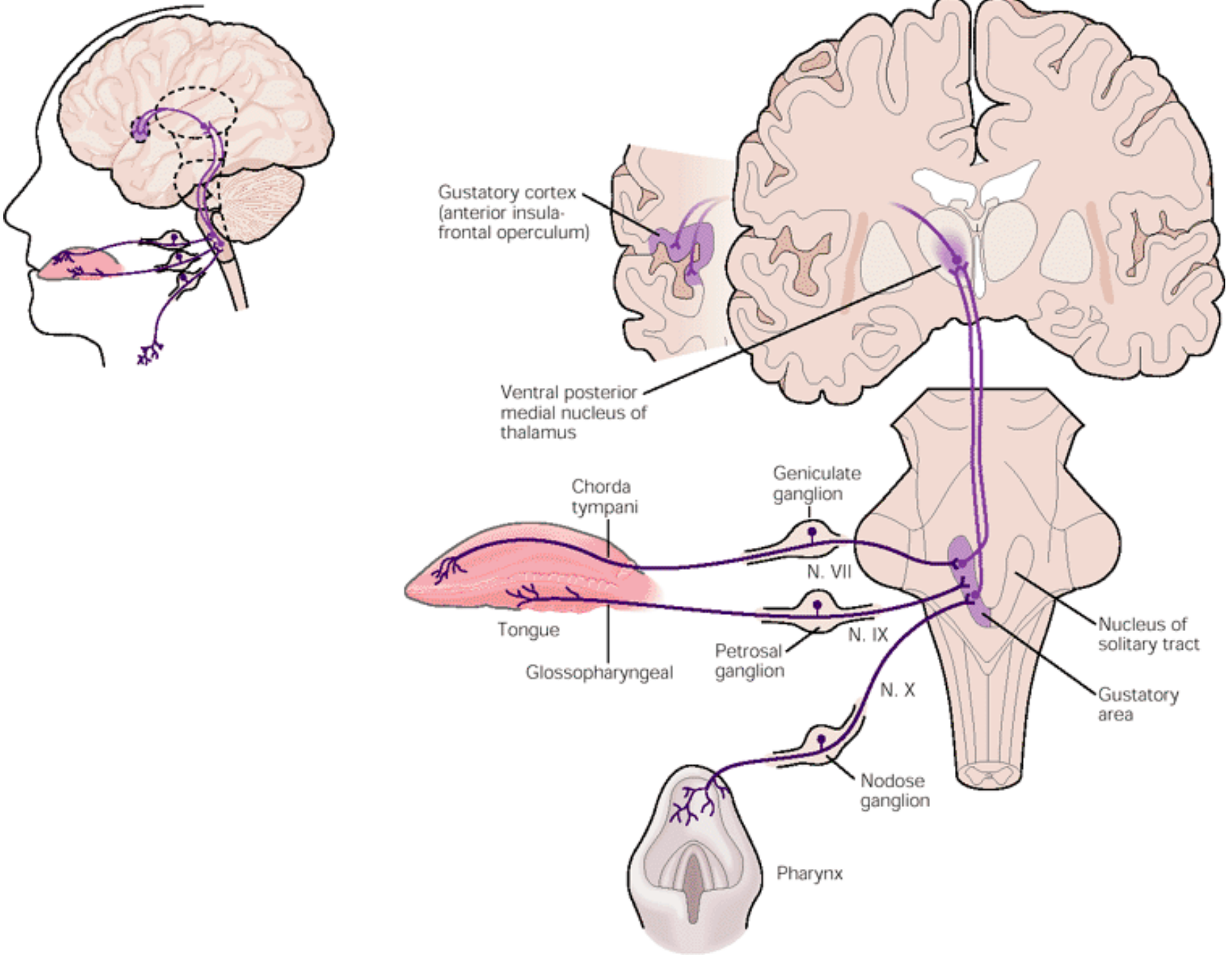
1. Inner portion of the *frontal operculum* overlying the insula
2. *Anterior insular cortex*
3. The rostral extension of *Brodmann area 3b* (postcentral gyrus)
4. Lateral convexity of the postcentral gyrus

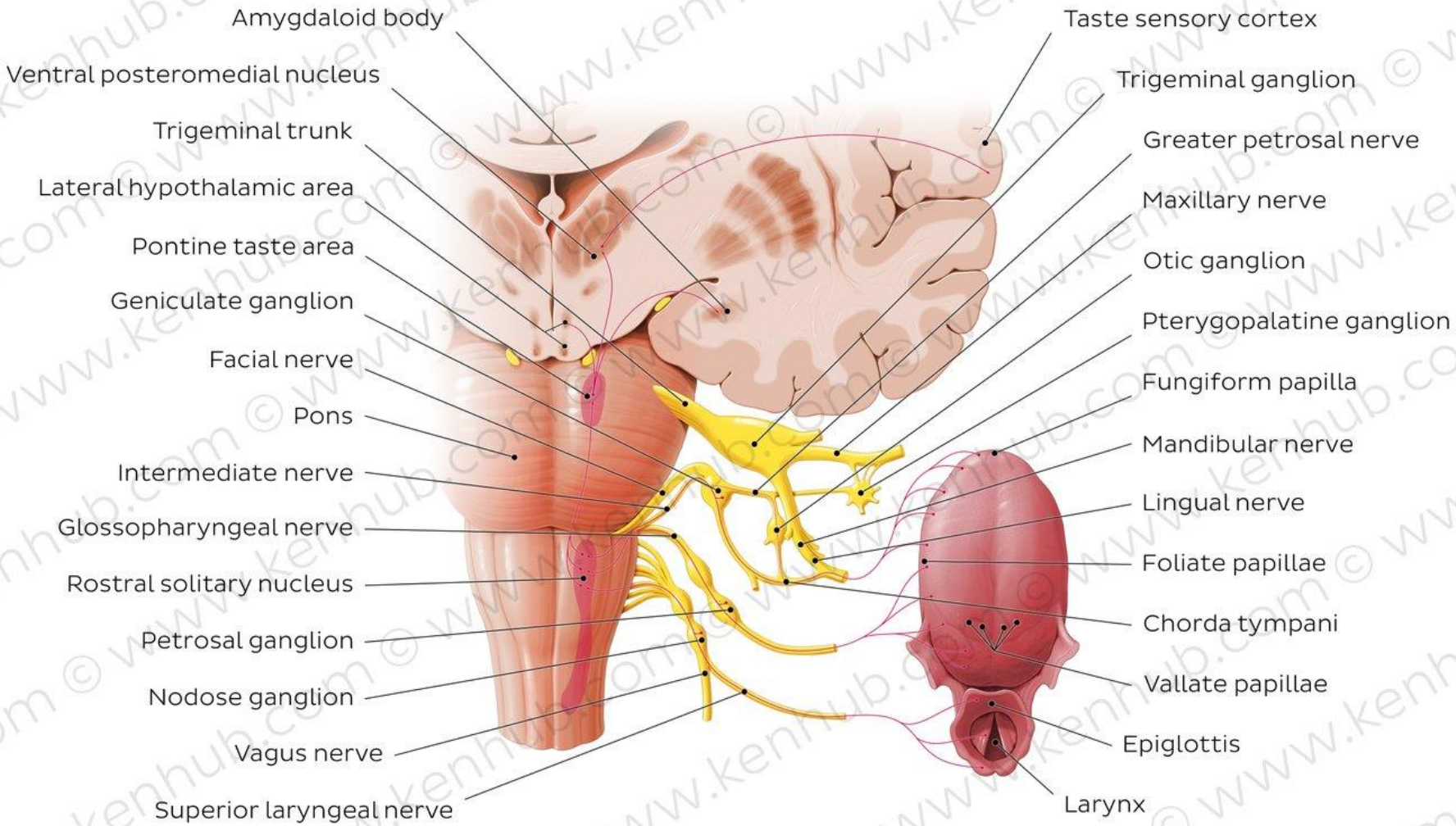
- ***In contrast to other sensory pathways, Taste is exclusively ipsilateral.***

Central Taste Pathways

- ***Lateral posterior orbitofrontal cortex*** → inputs from primary taste cortex and acts as a site of ***integration for taste, olfactory, and visual*** cues associated with the ingestion of foods, food reward & control of feeding.

- Taste information is also relayed from cells in the solitary nucleus into medullary reflex connections that ***influence salivary secretion, mimetic responses, and swallowing***.

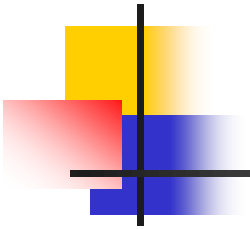

Gustatory cortex
(anterior insula-
frontal operculum)
Ventral posterior
medial nucleus of
thalamus
Chorda
tympani
Geniculate
ganglion
N. VII
Tongue
Glossopharyngeal
Petrosal
ganglion
N. IX
N. X
Nucleus of
solitary tract
Gustatory
area
Nodose
ganglion
Pharynx



- For further inquiries ***PLZ*** feel free to contact at any time through email

gamal.abdelhady@yu.edu.jo

gamaltaha@med.asu.edu.eg



Thank You