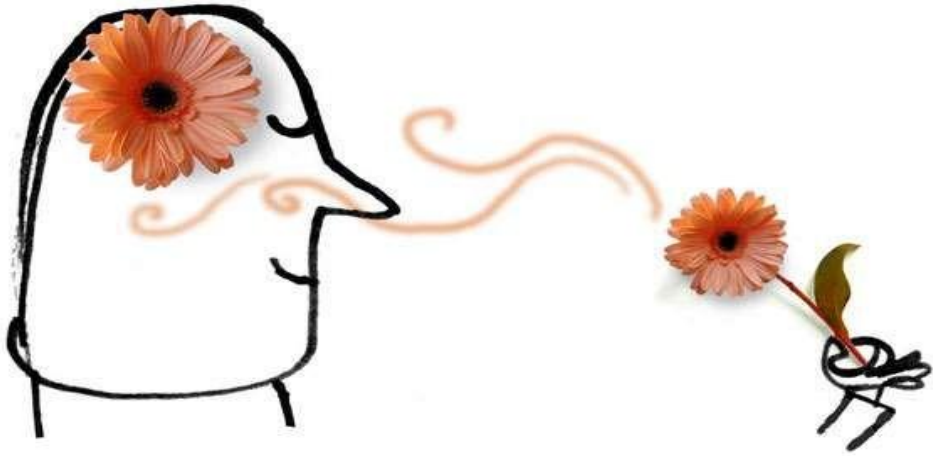


# PHYSIOLOGY OF SMELL



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# OBJECTIVES

- ❖ Site of olfaction.
- ❖ Olfactory pathway
- ❖ Physiology of olfaction
- ❖ Applied aspects.

# Sense of smell

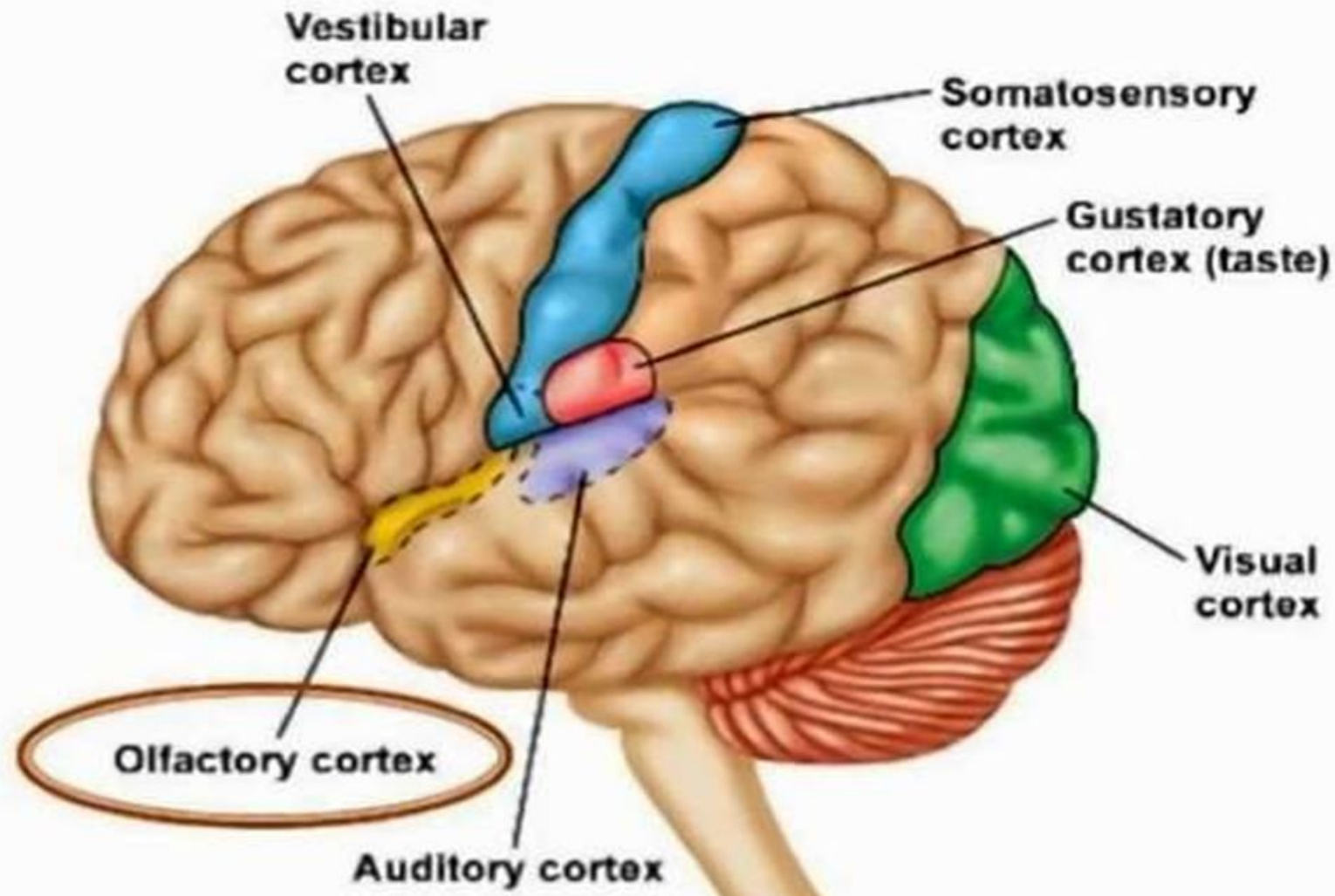
- Subjective phenomenon
- **Macrosmatic** - sense of smell well developed to give warning of environment. Eg. dogs
- **Microsmatics** – in humans less developed Eg. man



Four specialized neural systems within the left and right sides of the nose:

- (1)The main olfactory system (**cranial nerve I or CN 1**)
- (2)The accessory olfactory system (i.e. the **vomeronasal system**)
- (3)The trigeminal somatosensory system (**CN V**)
- (4)The nervus terminalis or terminal nerve.

# Physiology of Smell





# **SITE OF OLFACTION**

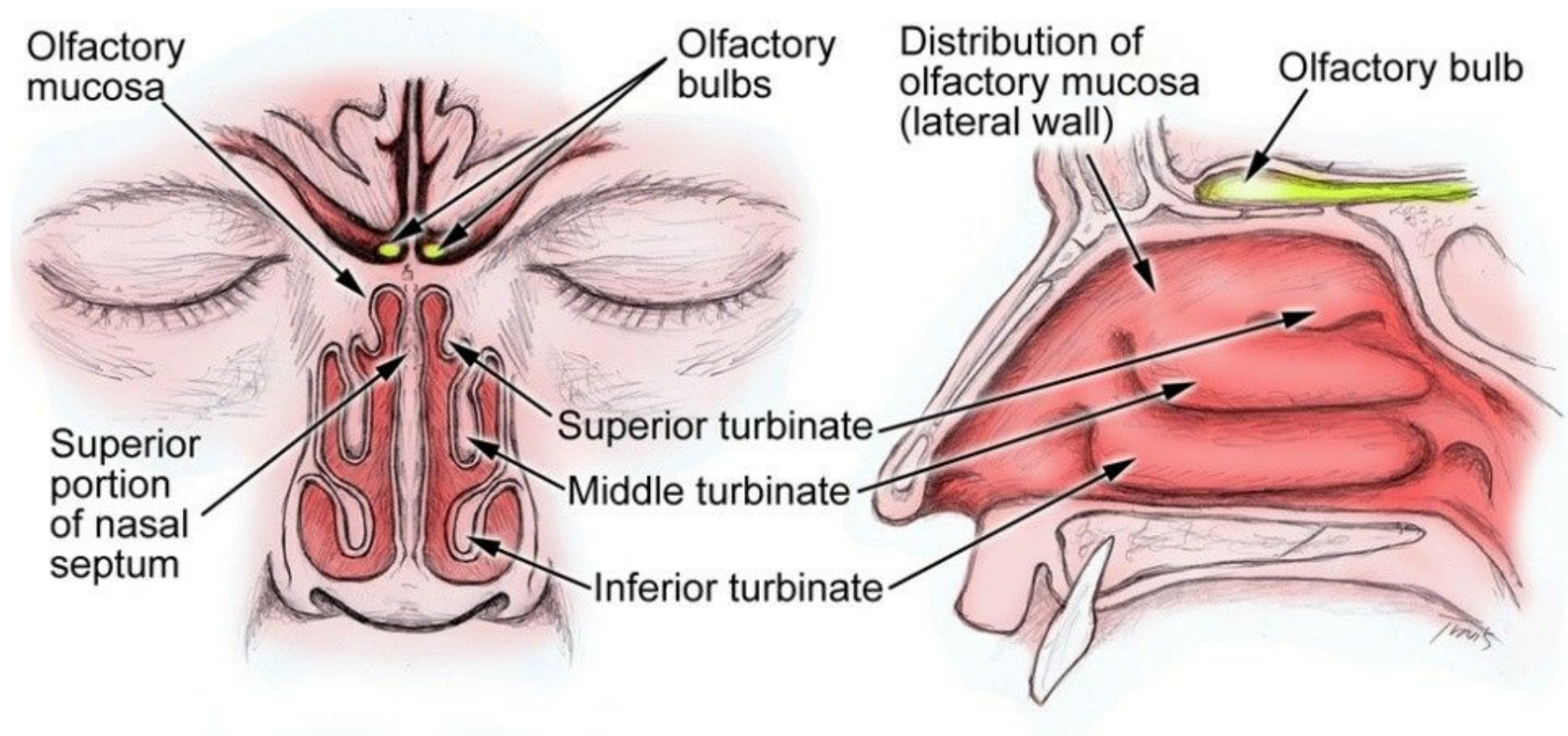
- Olfactory epithelium
- Vomeronasal organ
- Olfactory receptor cell

# OLFACTORY MEMBRANE

- lies in the **superior part of each nostril**
- In each nostril, the olfactory membrane has a surface area of about **2.4 square centimeters**.
- **Olfactory Cells** - The receptor cells for the smell sensation - bipolar nerve cells derived originally from the CNS, they lie in olfactory epithelium.
- about **100 million** of these cells in the olfactory epithelium interspersed among **sustentacular cells**
- Lies on the undersurface of the cribriform plate, the medial surface of superior turbinate, upper nasal septum, and a small amount on the medial surface of the middle turbinate

- 
- The **mucosal end** of the olfactory cell forms a knob
  - **cilia react to odors** in the air and stimulate the olfactory cells
  - Spaced among the olfactory cells - **Bowman's glands that secrete mucus** onto the surface of the olfactory membrane.
  - Olfactory cells are **constantly being replaced** with a half-time of a few weeks

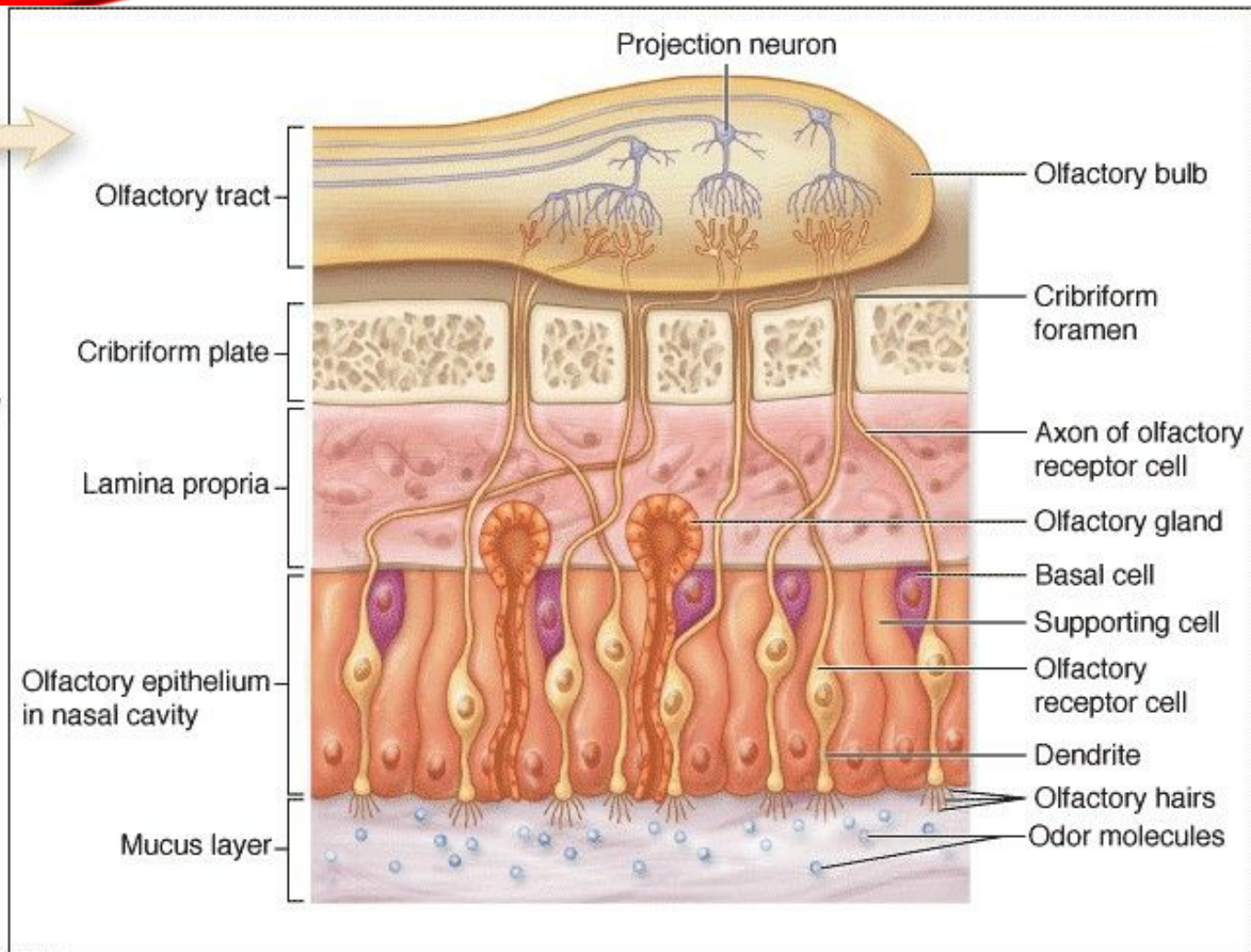
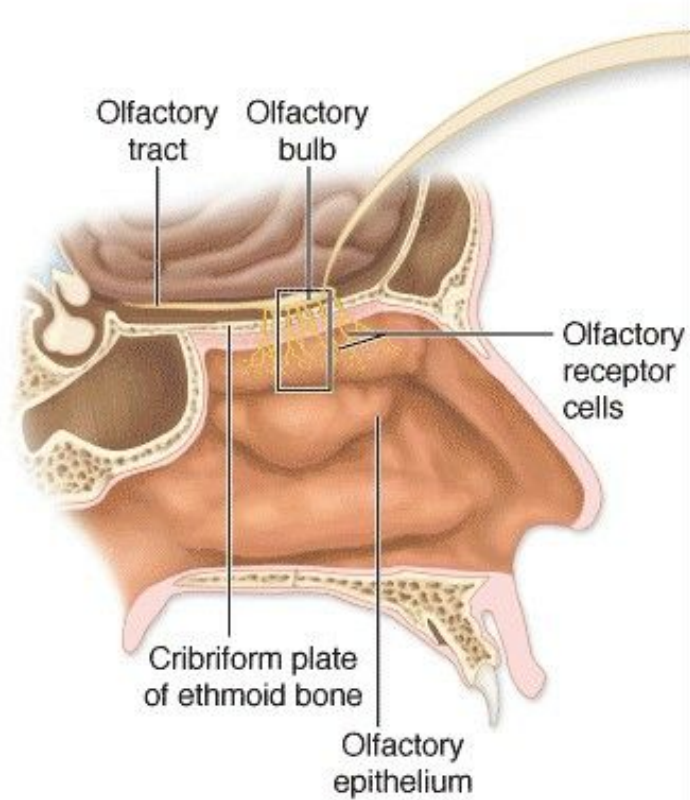
# OLFACTORY MUCOSA



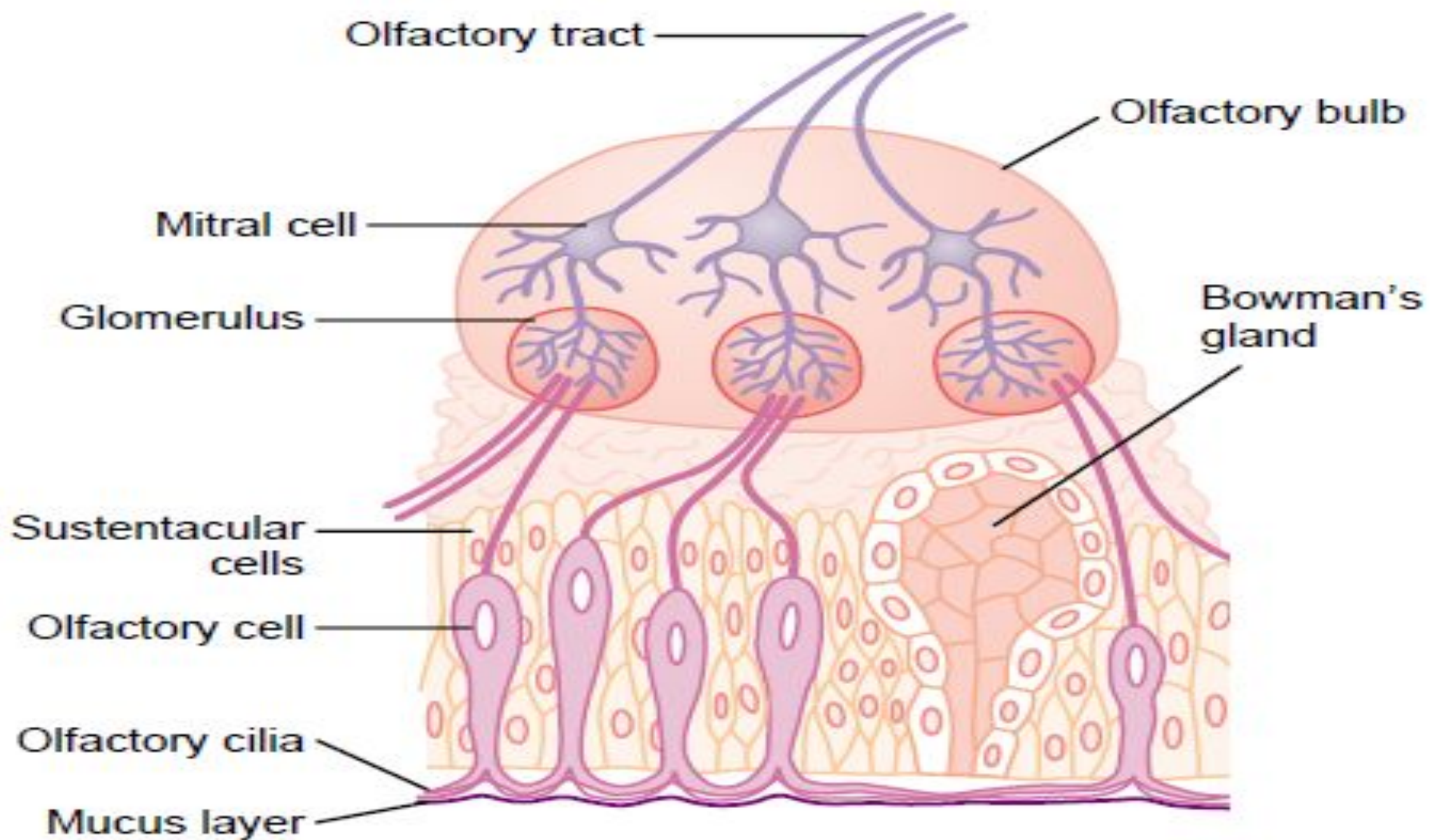


# NERVE SUPPLY OF OLFACTORY MUCOSA

- Olfactory mucosa innervated by **Olfactory nerves**
- General sensory - nerves supplying olfactory mucosa –**Trigeminal nerves**



a



# OLFACTORY BULB

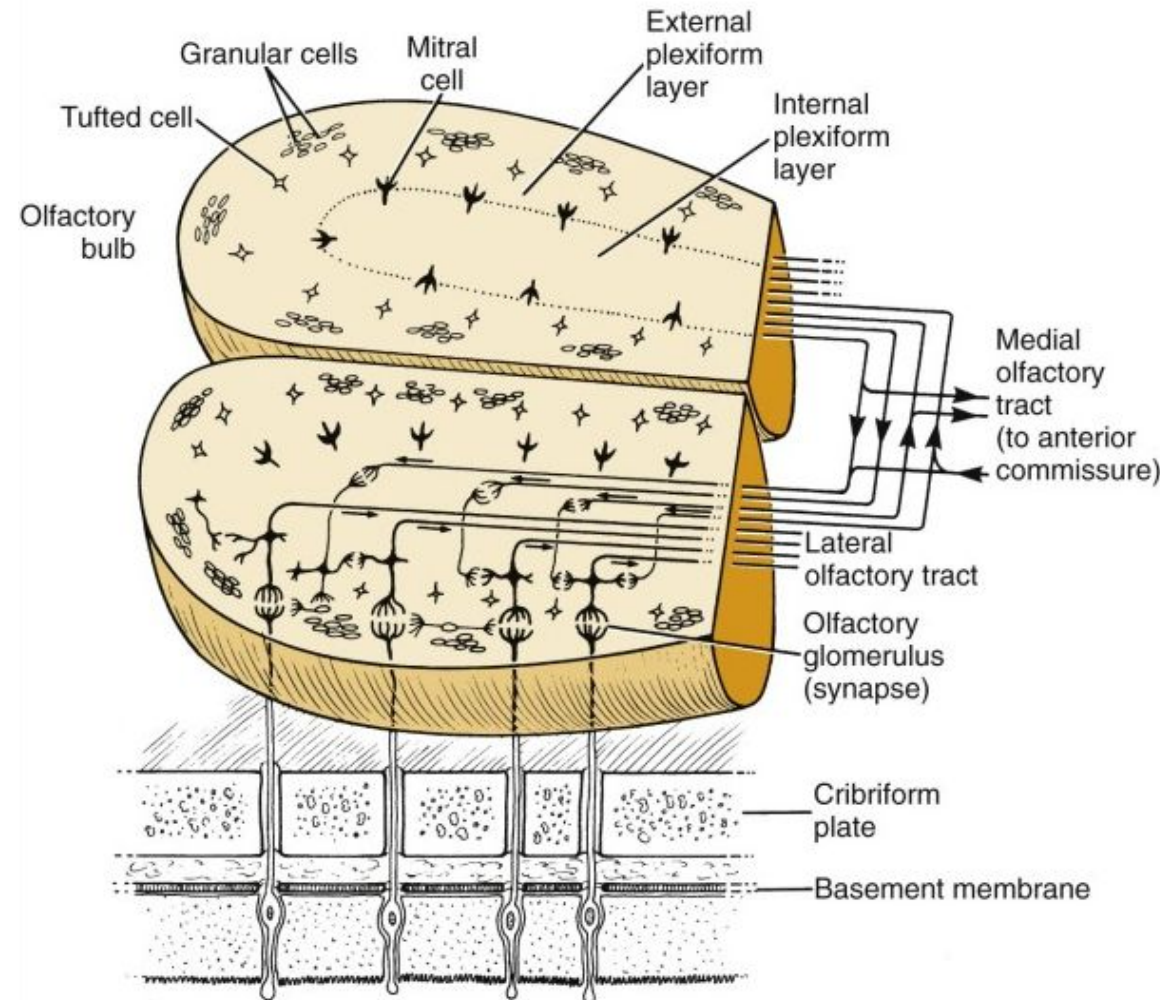
- located in the anterior cranial fossa.

It serves as the first relay station in the olfactory pathway

Contains many layers :

**a) Olfactory nerve layer** – bundles of unmyelinated axons of ORNs

**b) Glomerular layer** – olfactory glomeruli where incoming axons of ORNs synapse with second order neurons

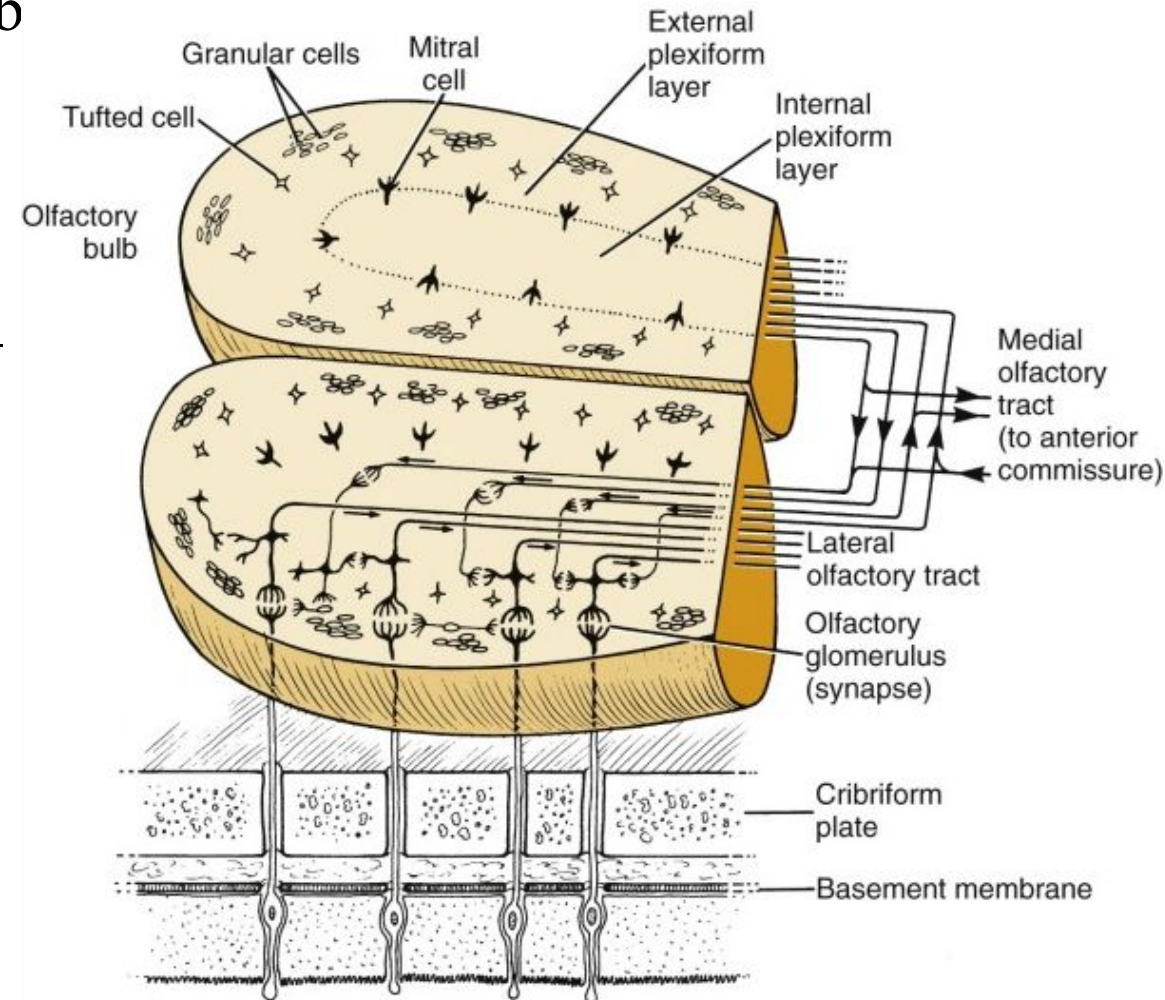


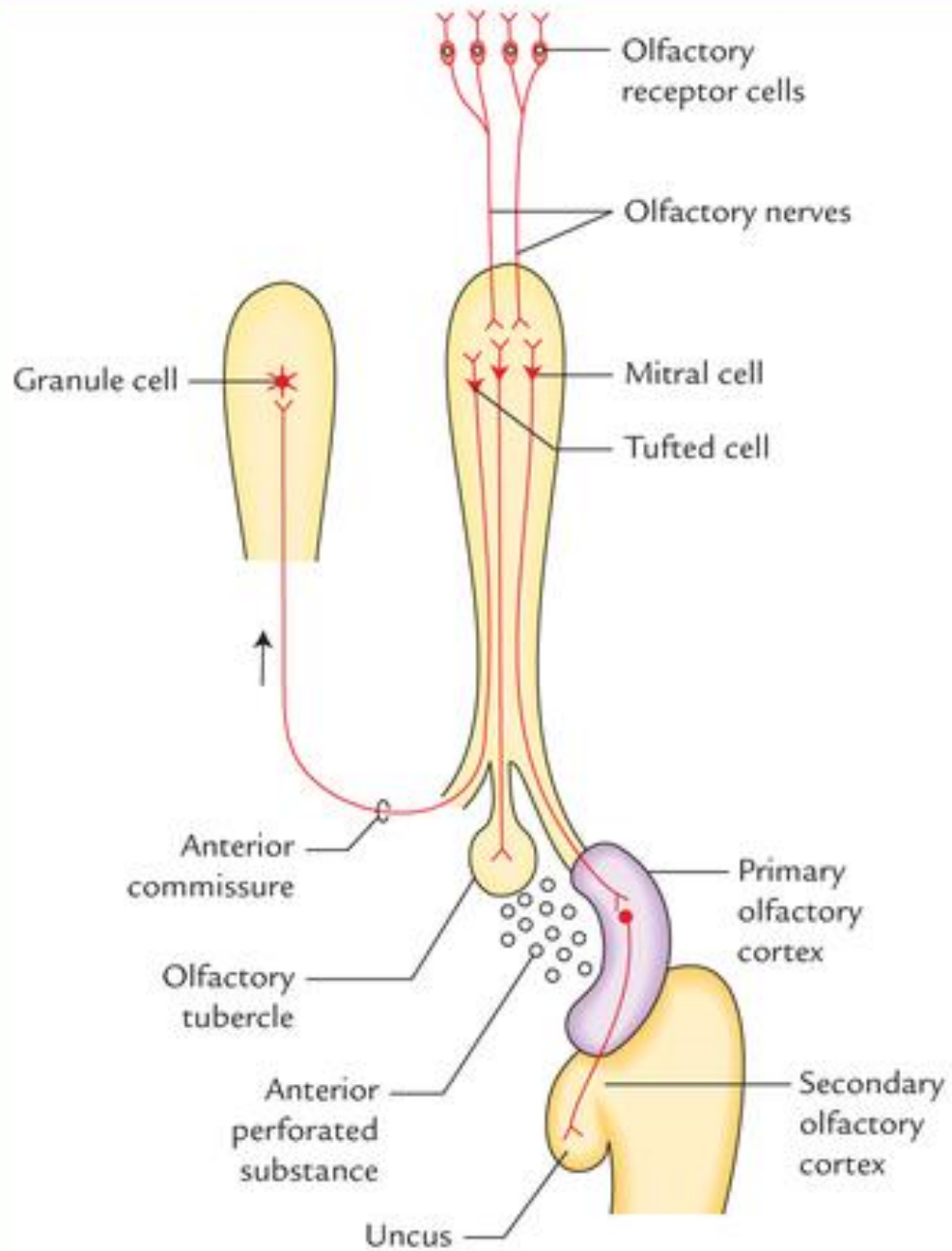
**c) External plexiform layer**— dense layer formed by dendrites of mitral, tufted and granule cells. Basal dendrites of principal cells synapse with peripheral dendrites of granule cells

**d) Mitral cell layer** — two types of principal cells — mitral and tufted

**e) Internal plexiform layer** — few short axons, numerous axons of principal cells and peripheral dendrites of granule cells

**f) Granule cell layer** — cell bodies of granule cells. Most numerous neurons in the olfactory bulb. No axons.





# ***OLFACTORY PATHWAY***

Olfactory nerve

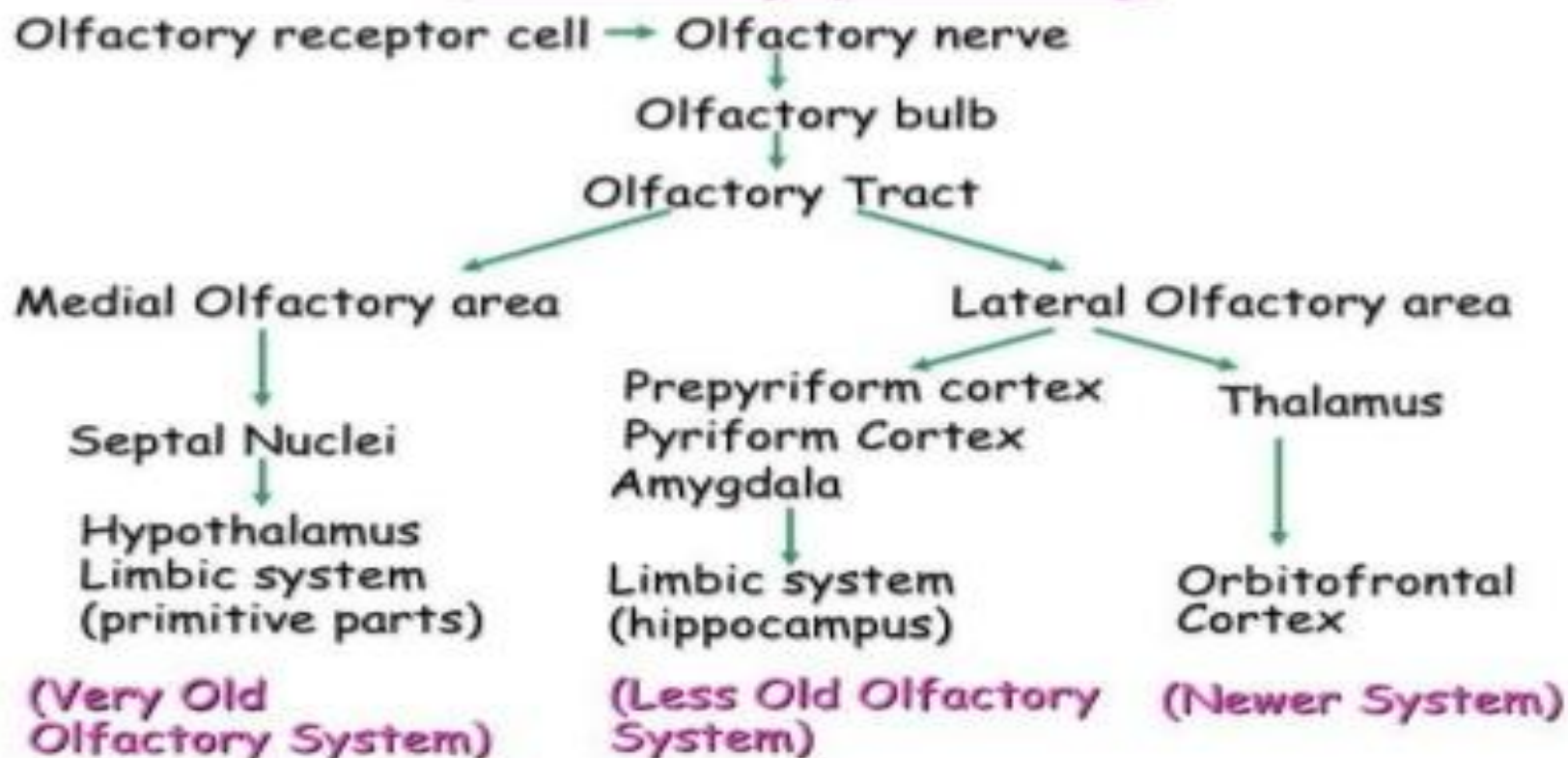
Olfactory bulb

Olfactory Glomeruli

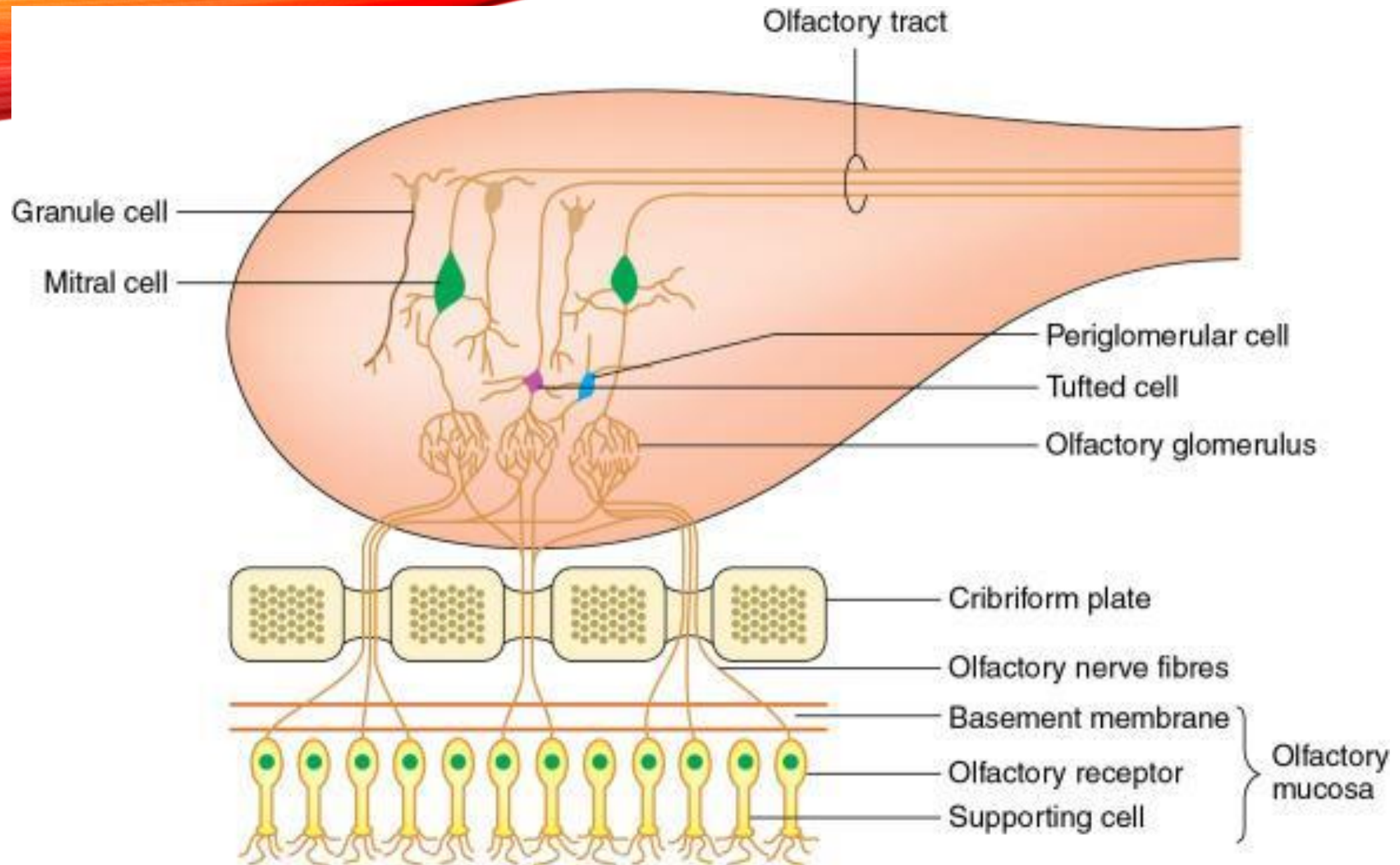
Olfactory tract

Olfactory areas(striae & cortex)

## Olfactory pathway



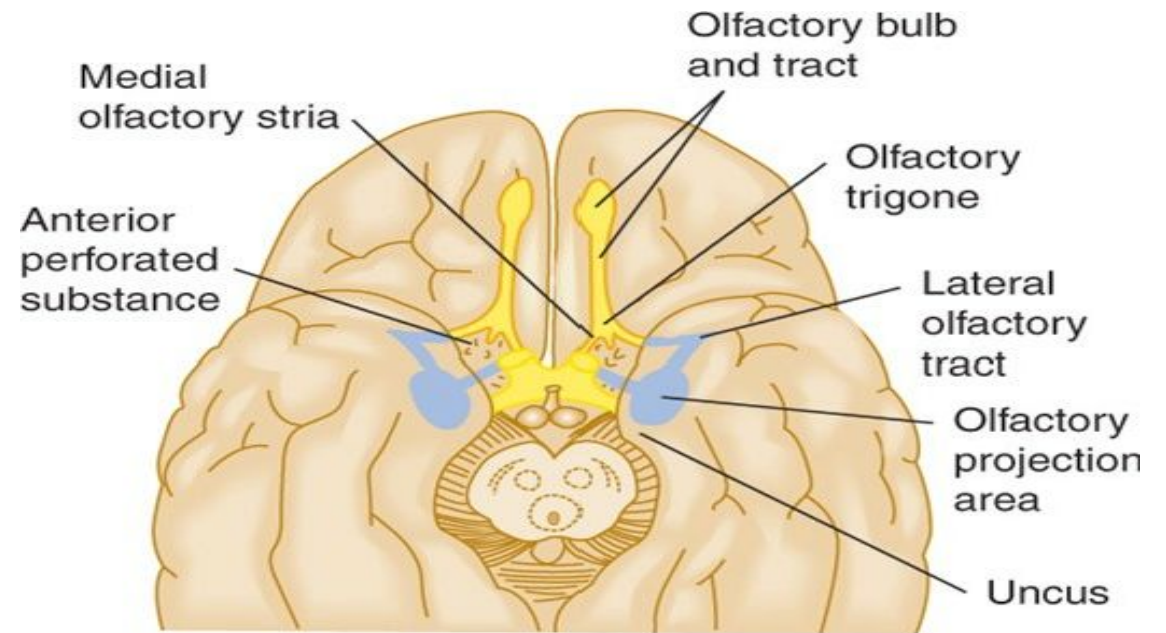
# OLFACTORY BULB



# OLFACTORY TRACT

❑ Lies in olfactory sulcus & proceeds backwards & divide into **lateral, medial & intermediate striae**.

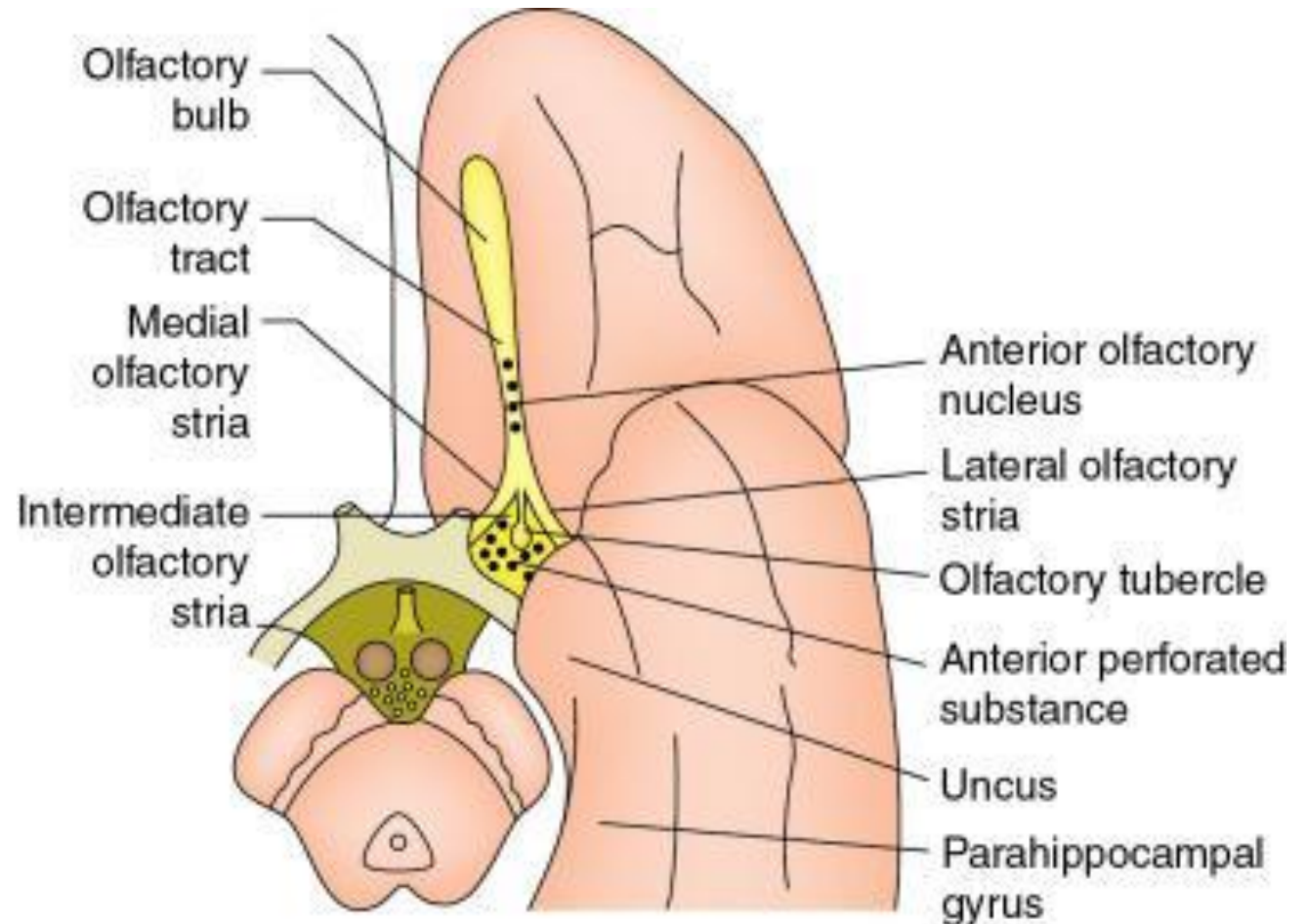
❑ **Olfactory trigone** – flattened part of olfactory tract.

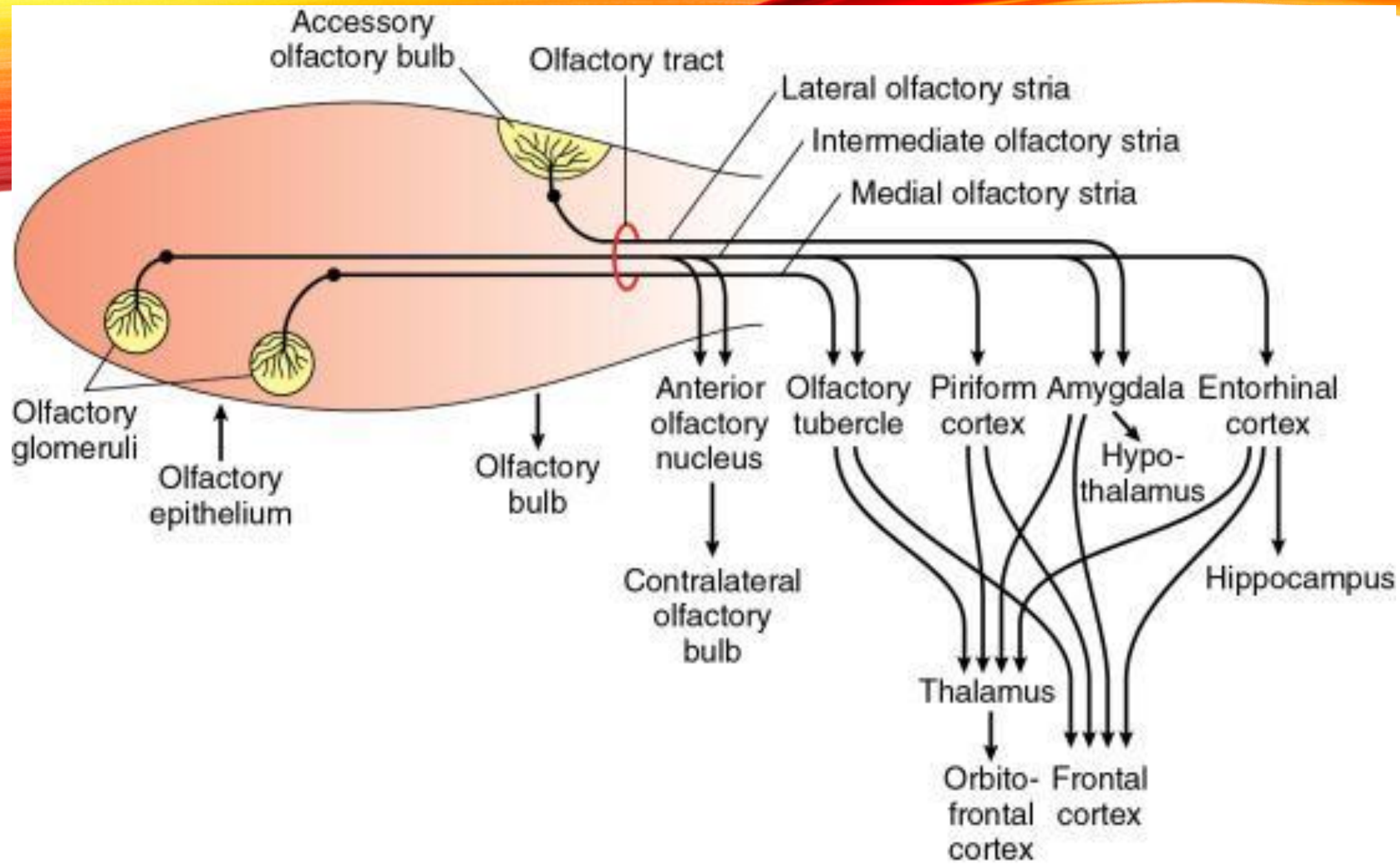


Source: Waxman SG: *Clinical Neuroanatomy: Twenty-Seventh Edition*:  
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# OLFACTORY STRIAE.

- **Lateral** – synapse in prim olfactory receiving area, includes prepiriform cortex.
- **Medial** – give projections to amygdaloid nucleus & cortex of basal brain.
- **Intermediate** – terminate in olfactory tubercle.

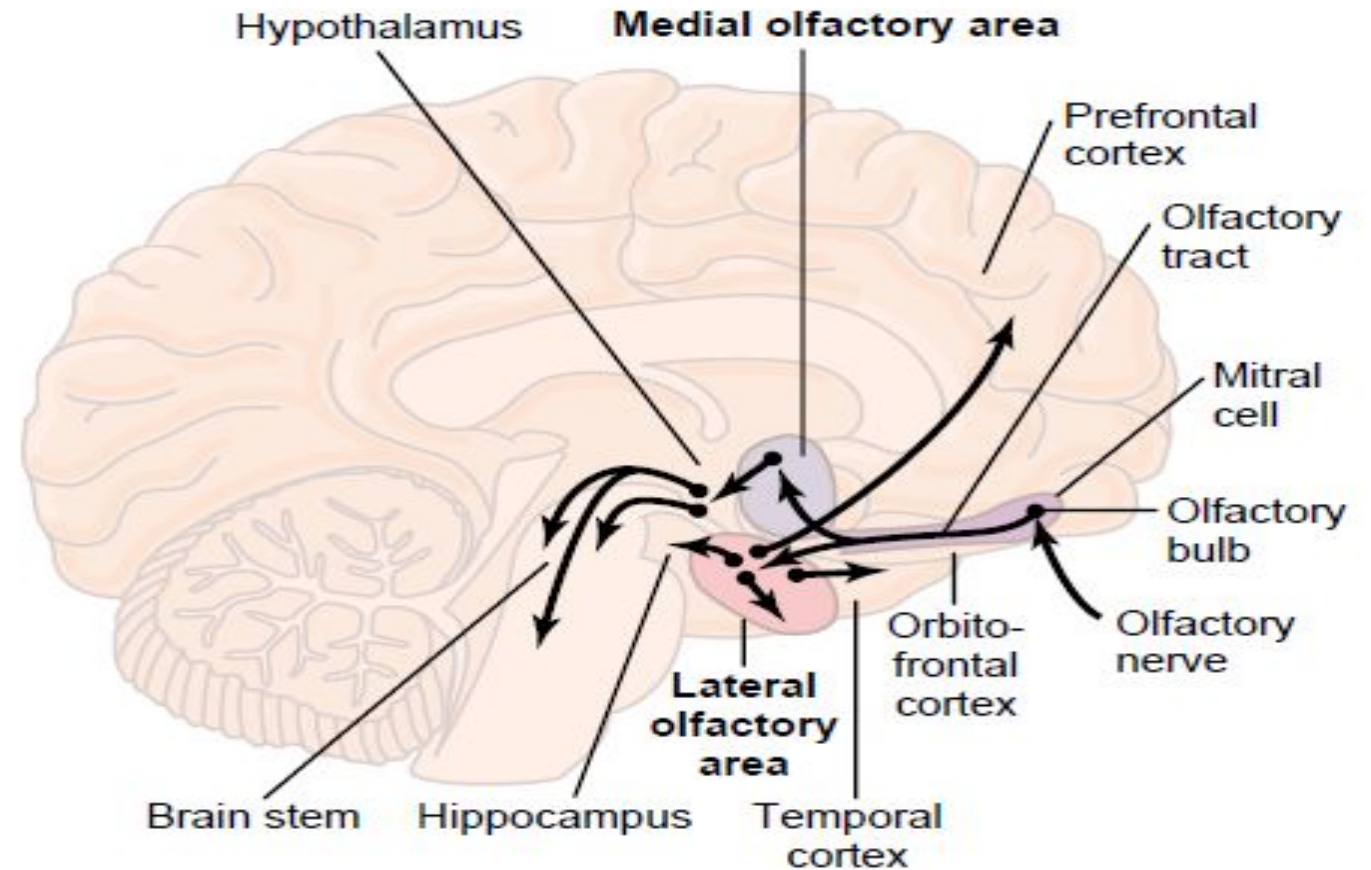




# OLFACTORY CORTEX

Includes Anterior olfactory nucleus, prepiriform cortex, olfactory tubercle & amygdala.

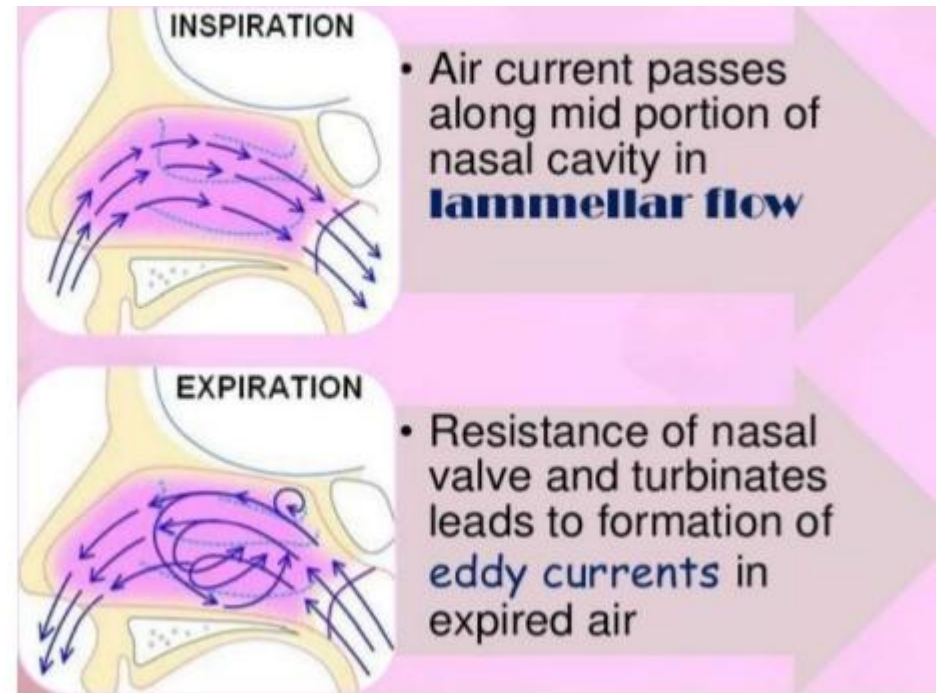
□ These are parts of **Limbic system.**



# PHYSIOLOGY OF OLFACTION

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- **Odoriferous stimuli** – enters the nasal cavity while breathing, then it reaches lower part of nasal cavity, & by eddy currents reaches olfactory mucosa.
- Odorant molecules **must dissolve** in mucus layer before receptors.



## EXCITATION OF OLFACTORY CELLS

- The portion of each olfactory cell that responds to the
- olfactory chemical stimuli is the **olfactory cilia**.
- The odorant substance, on coming in contact with the olfactory membrane surface, first **diffuses into the mucus** that covers the cilia.
- Then it binds with **receptor proteins** in the membrane
- of each cilium - **OBP**
- Receptor protein – G protein – cAMP pathway – opening of Na channels – action potential – exciting the olfactory neuron - **olfactory nerve** – CNS

## Mechanism of olfactory cell stimulation

Odourant + receptor protein



Activation of G protein



Activation of adenylate  
cyclase



ATP  $\rightarrow$  cAMP



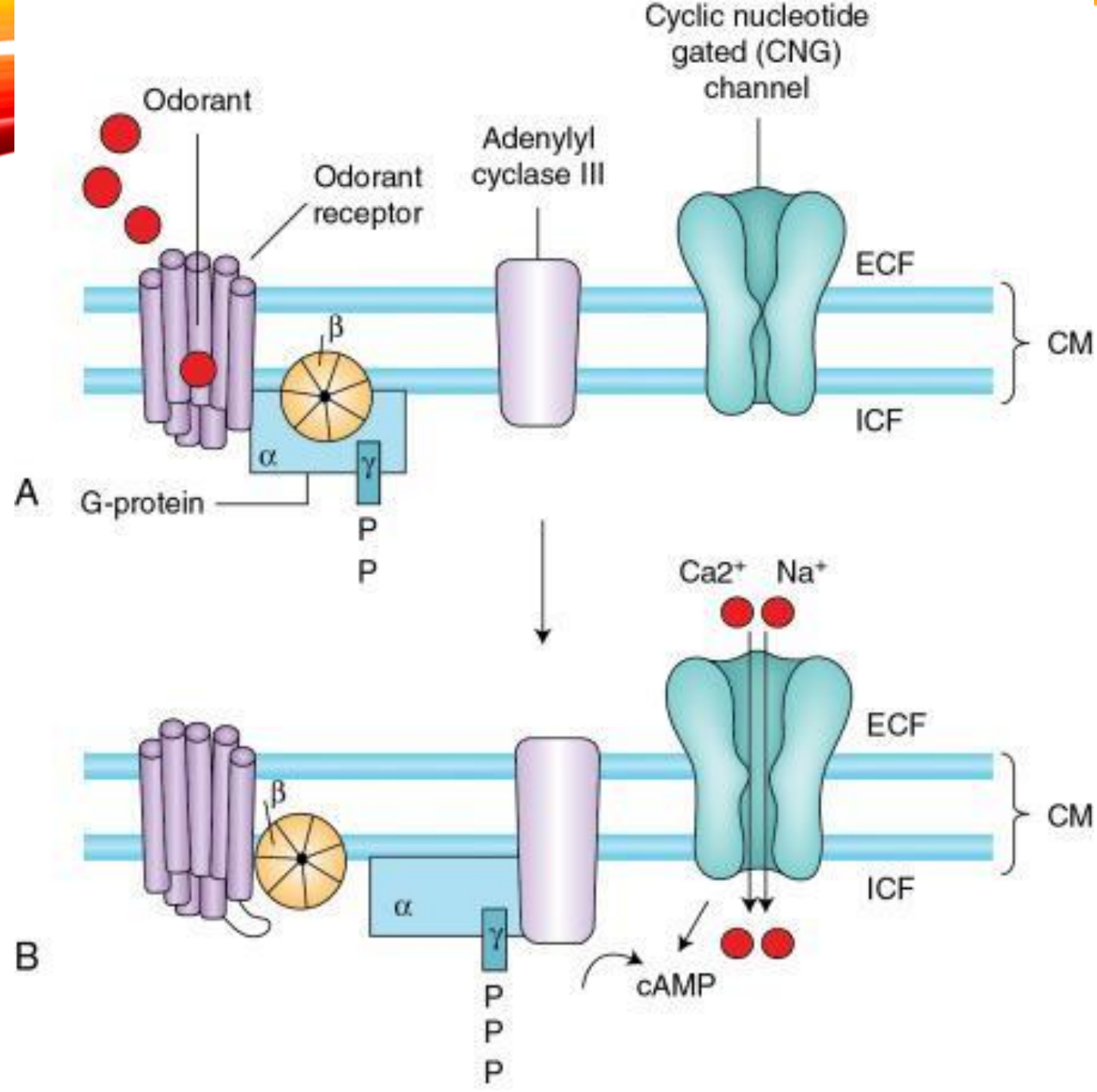
Opening of Na<sup>+</sup> channels

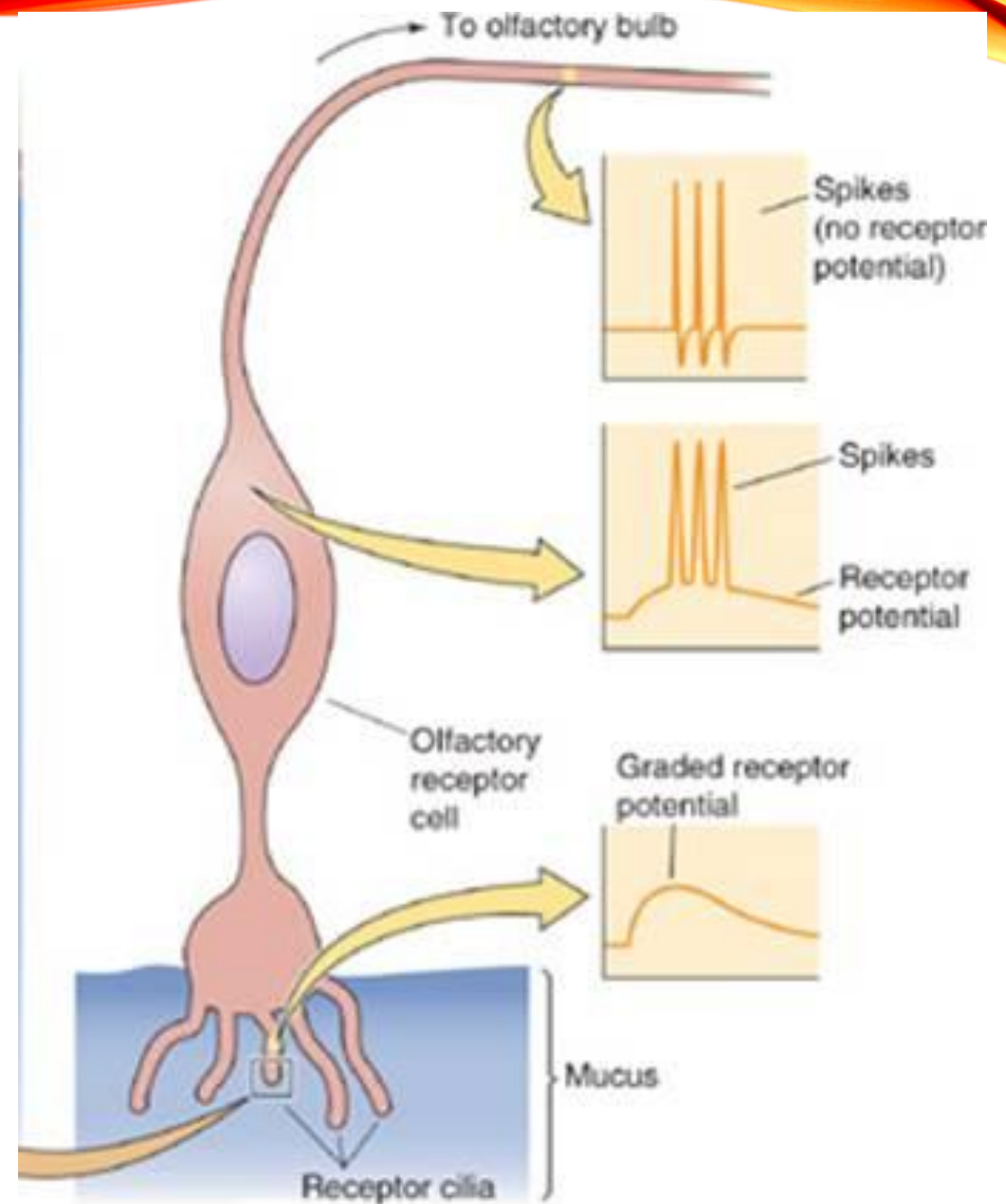
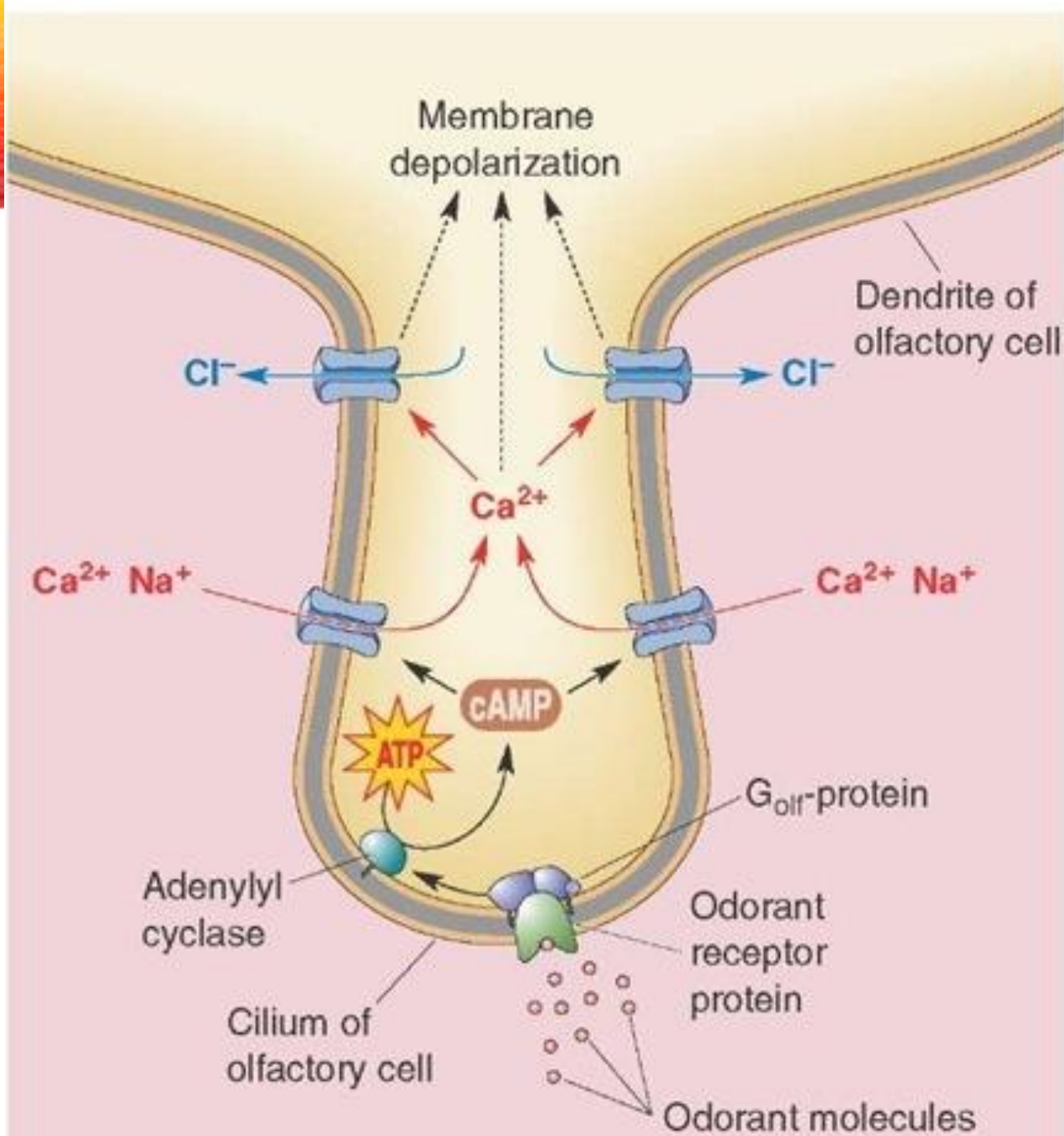


Na<sup>+</sup> influx



denaturation





# **SIGNAL TRANSDUCTION IN OLFACTORY CELL**

- **Depolarization receptor potential** –

- Intracellular rise in cAMP – influx of cations – depolarization.

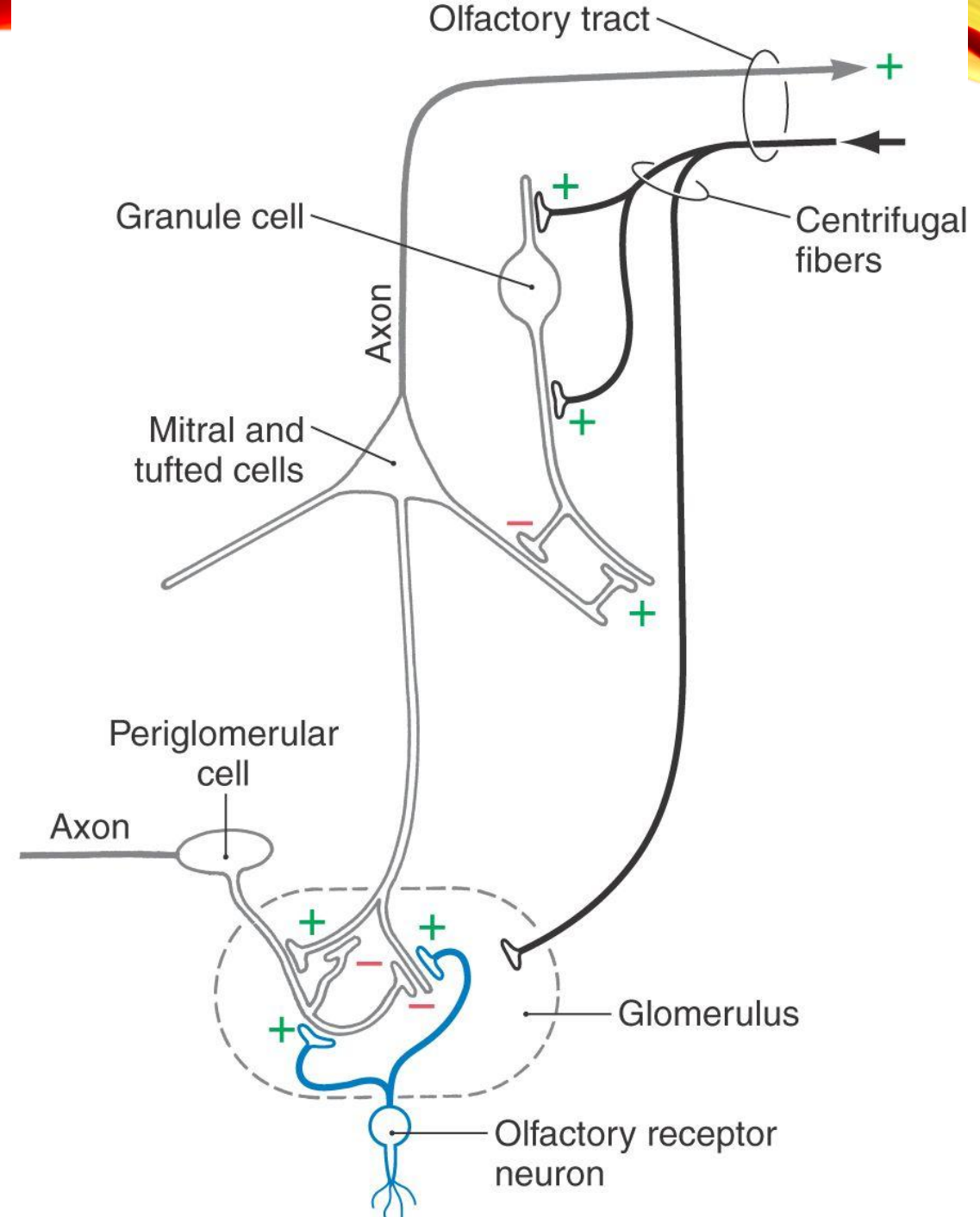
- **Action potentials** – in the sensory axons

- & transmission of signals to olfactory bulb.

- Even the most minute concentration of a specific odorant initiates a cascading effect

# PROCESSING OF OLFACTORY SENSATION IN THE OLFACTORY BULB

- Encoding occurs spatially in bulb.
- In olfactory glomerulus lateral inhibition by periglomerular cells & granule cells
- Further refinement done by impulses from olfactory areas of cortex, basal forebrain & midbrain.



## **Characteristic features of ODORANT MOLECULE.**

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□ To be effective odorant molecules must be

    Volatile

        Water soluble

            Lipid soluble.

□ 50 primary smell sensations

□ Can smell over 10000 different odorant molecules



## PRIMARY SMELL SENSATIONS

1. Camphoraceous

2. Musky

3. Floral

4. Pepperminty

5. Ethereal

6. Pungent

7. Putrid

## Olfactory thresholds and discrimination

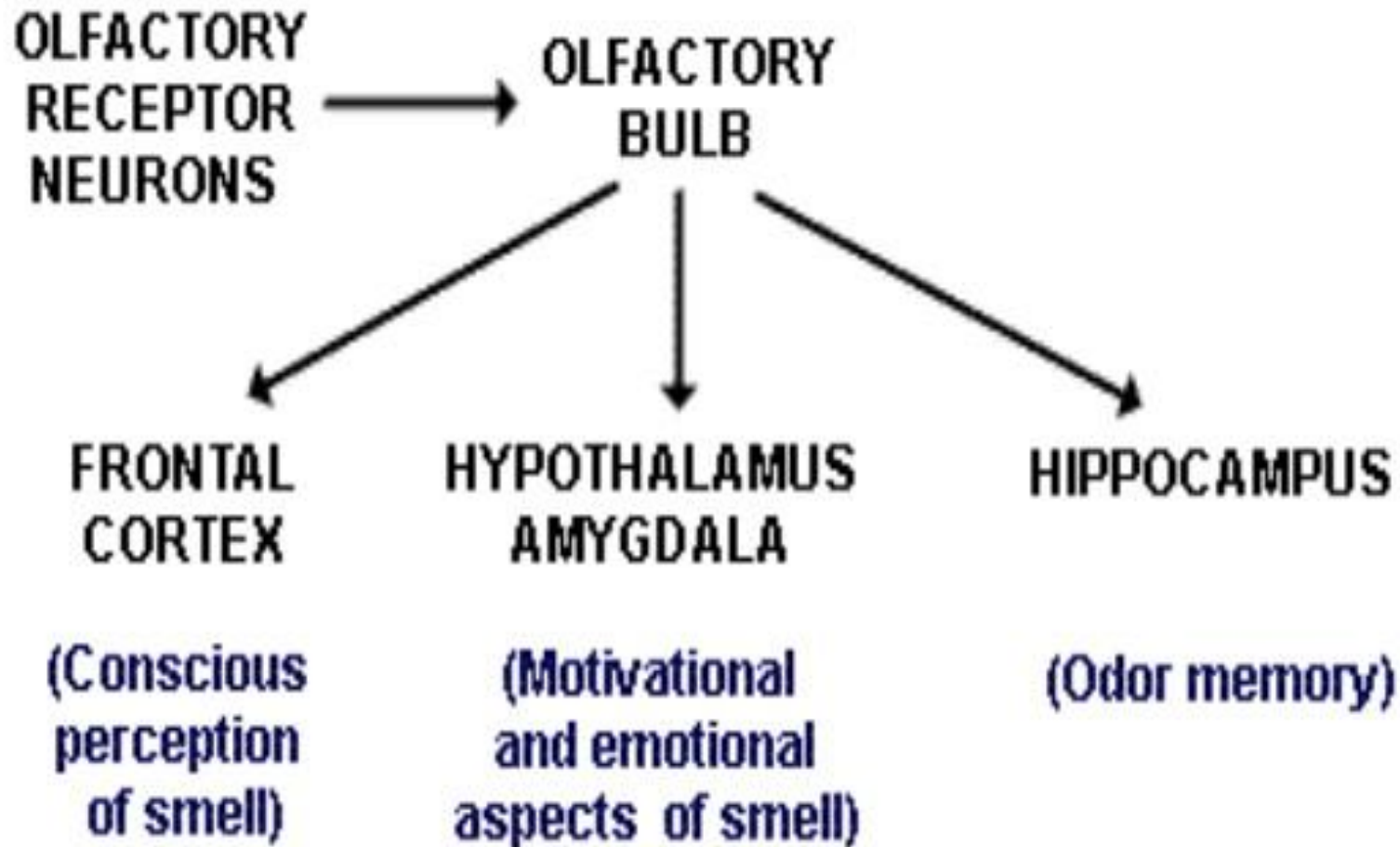
- Olfactory receptors respond only to substances in contact with olfactory epithelium and need to be dissolved in mucus
- Humans can recognize more than 10,000 different odors

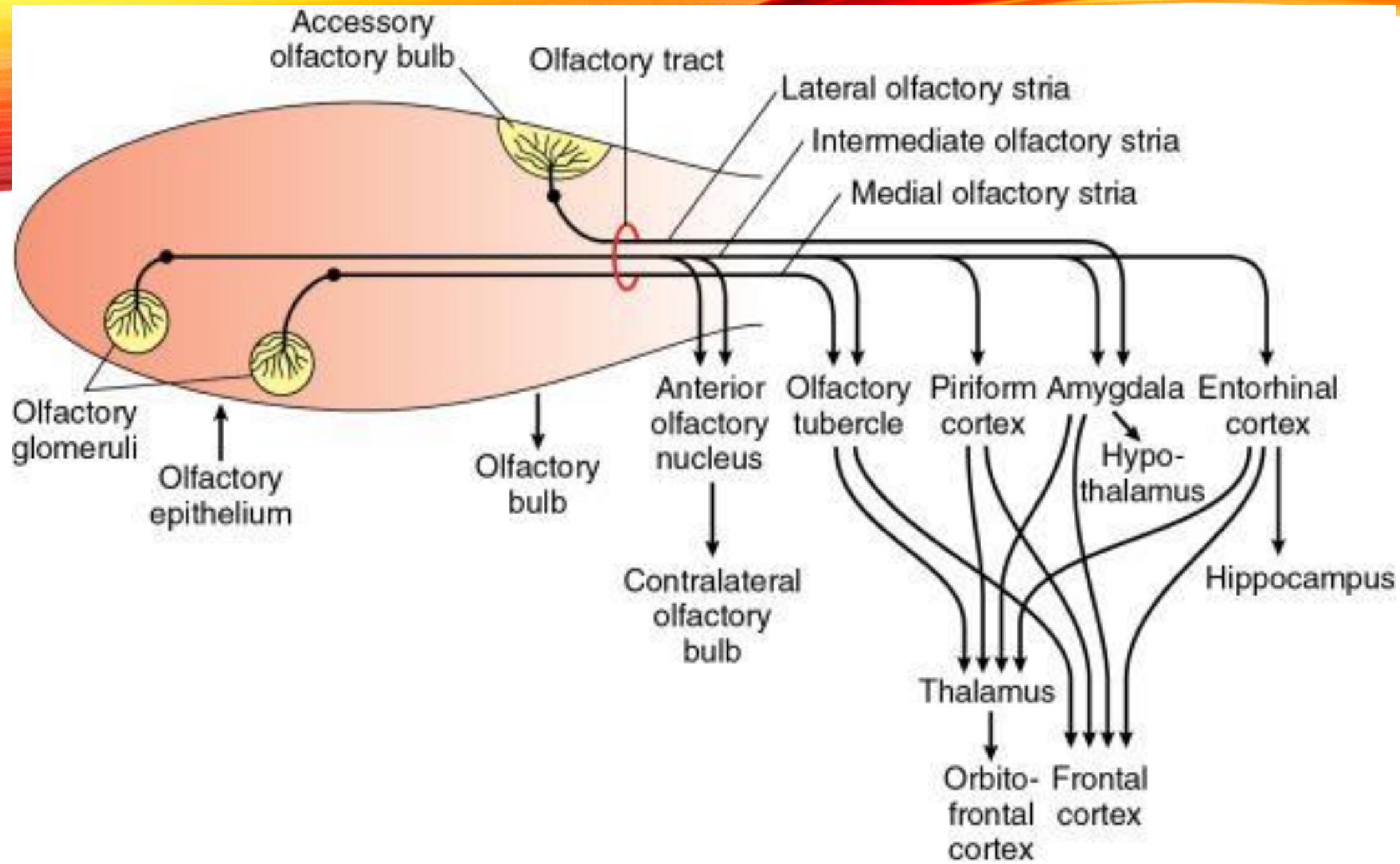
| Substance         | mg/L of Air |
|-------------------|-------------|
| Ethyl ether       | 5.83        |
| Chloroform        | 3.30        |
| Pyridine          | 0.03        |
| Oil of peppermint | 0.02        |
| Iodoform          | 0.02        |
| Butyric acid      | 0.009       |
| Propyl mercaptan  | 0.006       |

# ADAPTATION

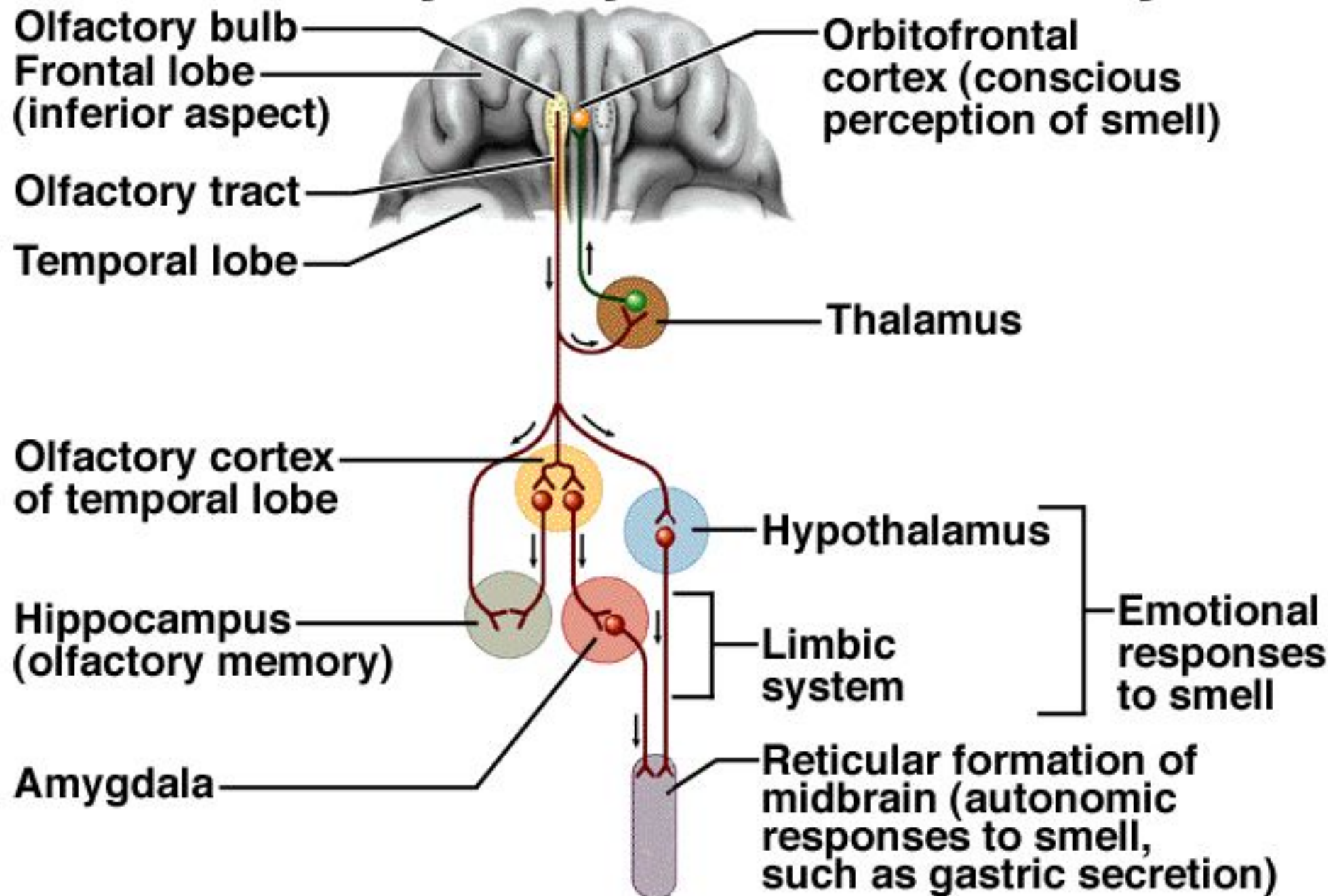
- The olfactory receptors adapt about **50 per cent in the first second** or so after stimulation
- Rapid adapting or Desensitization: - continuous exposure - ☐ decrease in percepton of odour ☐ ceases

# TRANSMISSION OF ODORANT INFORMATION TO THE OLFACTORY CORTEX AND NEO-CORTEX.





# Olfactory Projection Pathways



# APPLIED ASPECTS

- **Anosmia** - total loss of smell
- **Hyposmia** – decreased sensitivity of smell

## **Causes:**

nasal congestion

Injuries

Intracranial lesions .

Nasal obstructions

Atrophic rhinitis

Old age

Brain tumors

Alzheimers

Kallmann's syndrome – hyposmia with hypogonadism



**HYPEROSMIA**-Increased sensitivity to smell

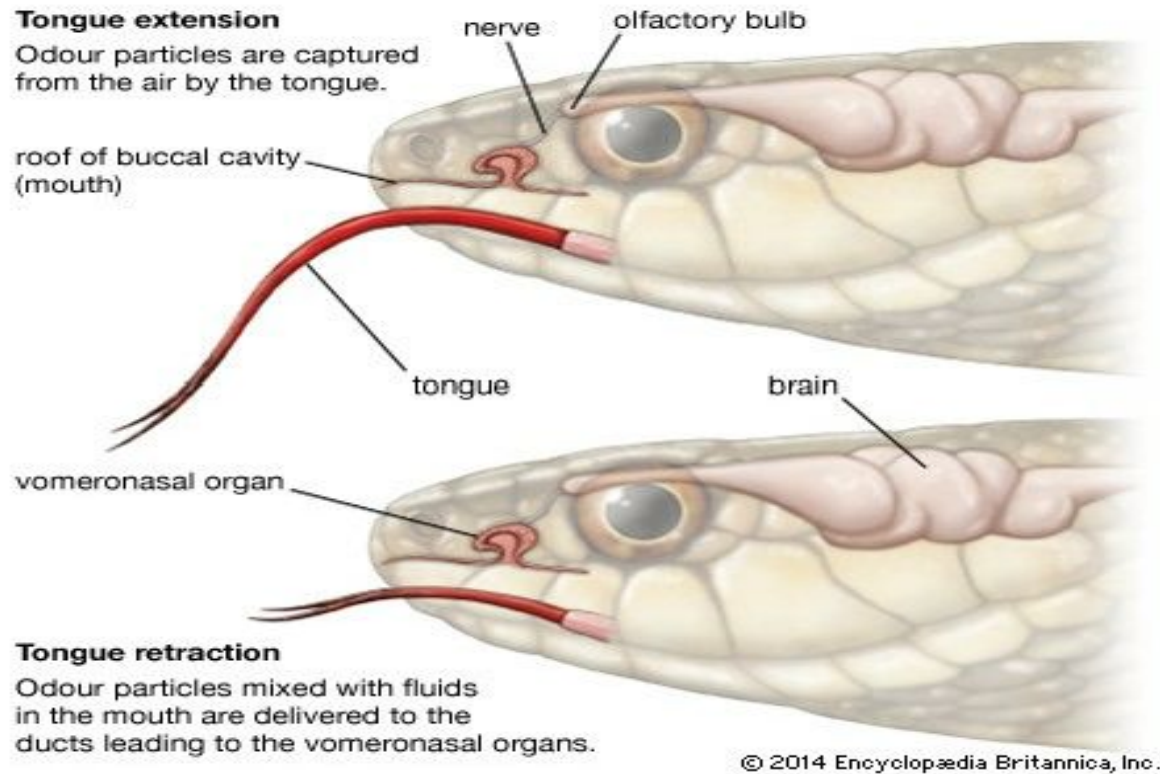
- Pregnancy

**DYSOSMIA/ PARAOSMIA**: distortion or  
perversion of smell

- sinusitis, damage to olfactory nerves

# VOMERONASAL ORGAN

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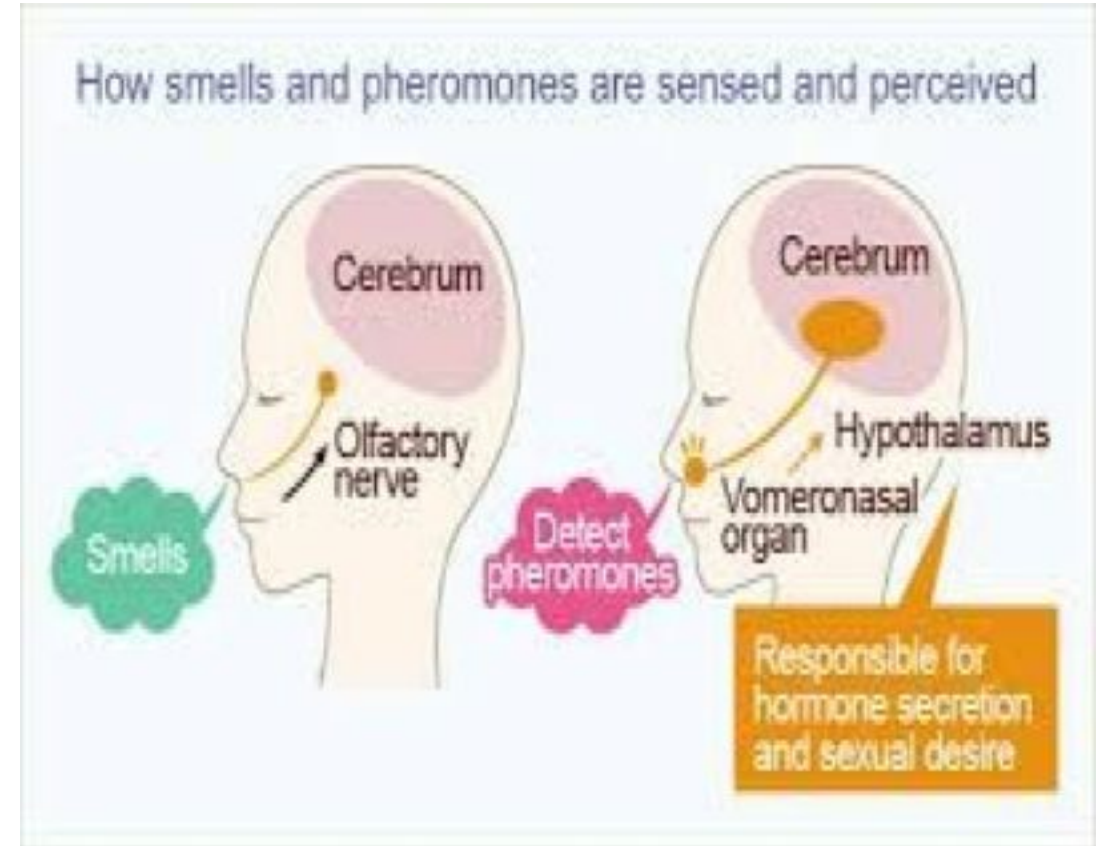


- Nerves project to accessory olfactory bulb & to **Amygdala & Hypothalamus** concerned with reproduction & eating behaviour.
- In humans its not well developed.

# PHEROMONES

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- Hormone like substances which emits specific odour & produce hormonal, behavioural & physiological changes in other animal.
- Usually cause of sex & released during mating only.





# THEORIES OF SMELL

- Shape theory
- Vibration theory
- Olfactory pigment theory
- Enzyme theory
- Penetrating & punctuating theory
- Odotope theory or Weak Shape theory



## **SHAPE THEORY**

A molecule's particular smell is due to a 'lock and key' mechanism by which a scent molecule fits into olfactory receptors

## **VIBRATION THEORY**

Randerbrock [1968] - olfactory receptors are peptide chains vibrating in alpha helix.

Odorant molecule forms a band with peptide chain modulating vibration.



## **OLFACTORY PIGMENT THEORY**

Rosenberg[1968] - odorant molecules form complex with certain olfactory pigment giving an increase electrical conductivity.

## **ENZYME THEORY**

Interaction of the odorant with a specific enzyme on the neuronal surface cause action potential due to catalytic properties of the enzyme or allosteric transition.

## **DAVIES PENETRATING THEORY**

Bulky and rigid odorant molecules penetrate olfactory nerve cell membrane, puncturing it and causing a temporary hole on the surface allowing ionic exchange and generation of action potential

## **ODOTOPE THEORY OR WEAK SHAPE THEORY**

A combination of activated receptors is responsible for any one smell  
Receptors in the odotope model recognize only small structural features on each molecule, and the brain is responsible for processing the combined signal into an interpreted smell.



**THANK  
YOU**