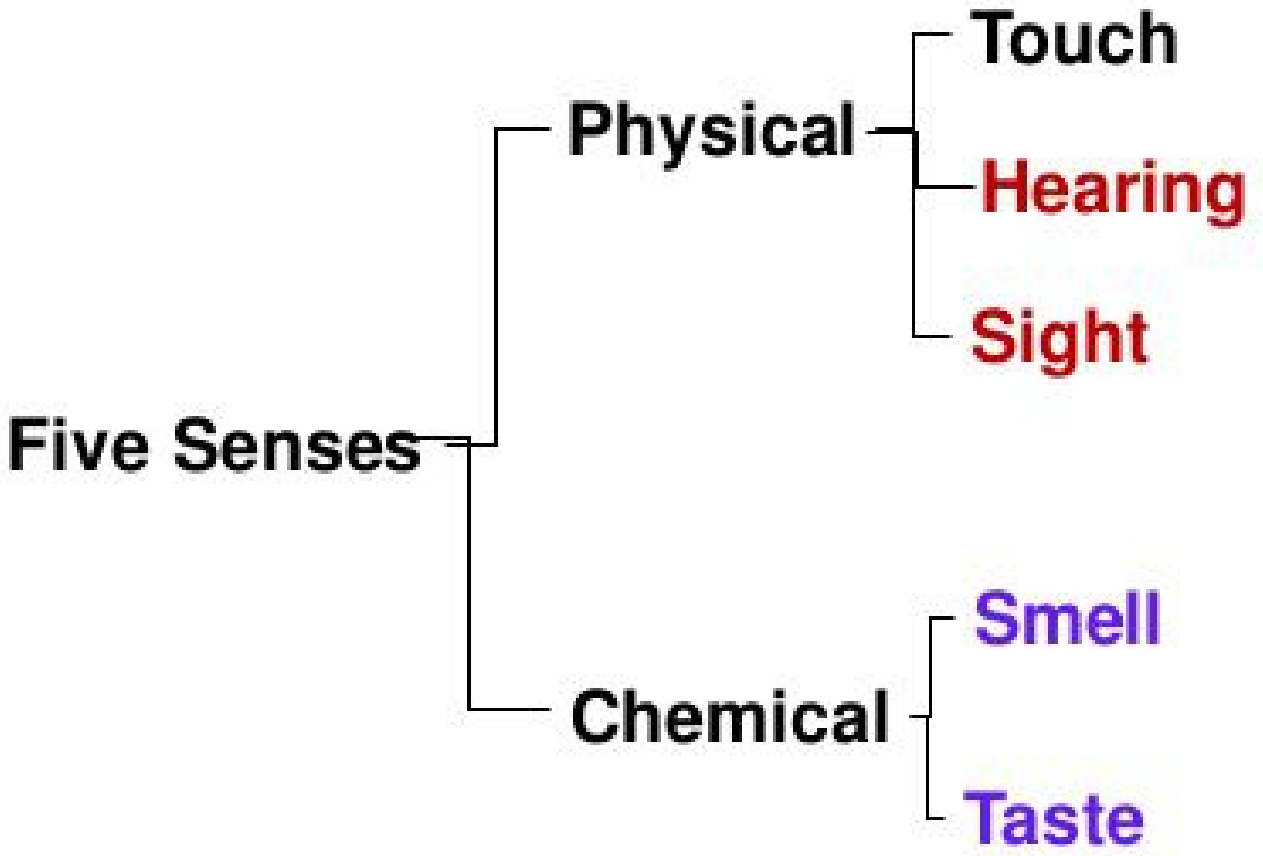
SOMATIC SENSES –

TACTILE, THERMAL, PAIN, AND PROPRIOCEPTION

SPECIAL SENSES—

SMELL, TASTE, VISION, HEARING & EQUILIBRIUM


Five Senses
Physical
Touch
Hearing
Sight
Chemical
Smell
Taste

OLFACTION – Sense of Smell

- Most primitive sense
- Poorly understood
- Poorly developed in humans
- Only sensory modality that doesnot relay in hypothalamus

INTRODUCTION

- **Olfaction**, also known as **olfactics**, is the sense of smell. This sense is mediated by specialized sensory cells of the nasal cavity of vertebrates, which can be considered analogous to sensory cells of the antennae of invertebrates.
- In humans, olfaction occurs when odorant molecules bind to specific sites on the olfactory receptors.
- Many vertebrates, including most mammals and reptiles, have two distinct olfactory systems—the main olfactory system, and the accessory olfactory system (used mainly to detect pheromones).
- Olfaction, along with taste, is a form of chemoreception.

Primary Sensations of Smell

Based on psychological studies, one attempt to classify these sensations is the following:

1. Camphoraceous - eucalyptus
2. Musky - musk
3. Floral - roses
4. Pepperminty - mint
5. Ethereal - pears
6. Pungent - vinegar
7. Putrid – rotten eggs

In recent years, specific studies of the genes that encode for the receptor proteins, suggest the existence of at least 100 primary sensations of smell

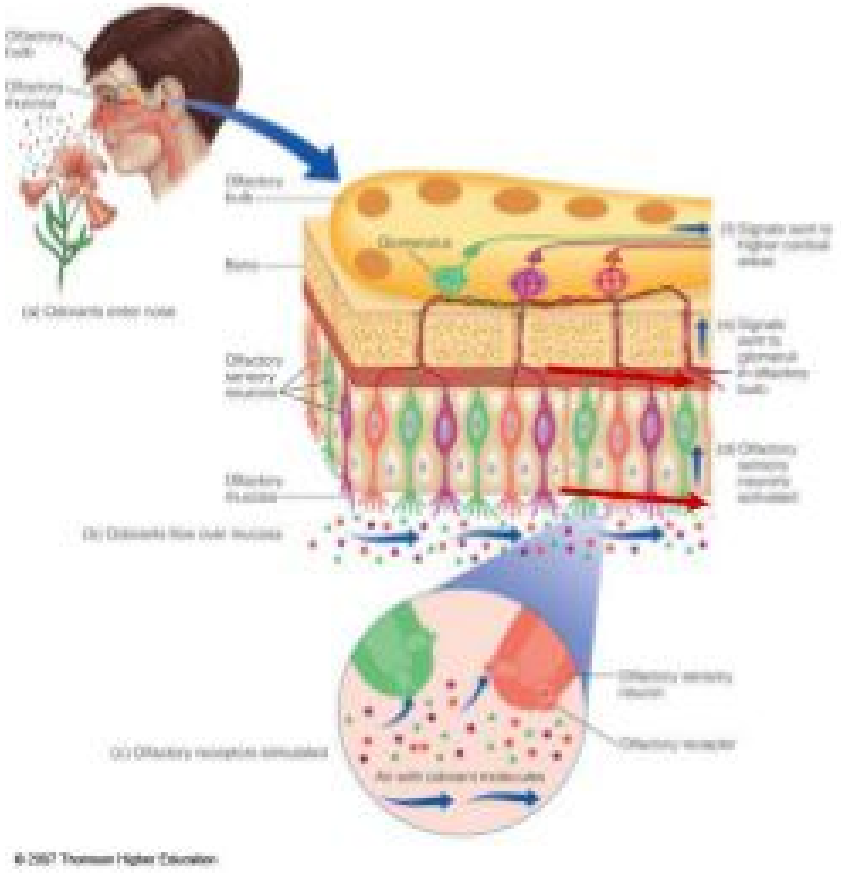
PHEROMONE

- A **pheromone** is a secreted or excreted chemical factor that triggers a social response in members of the same species.
- There are *alarm pheromones*, *food trail pheromones*, *sex pheromones*, and many others that affect behavior or physiology.
- when in close proximity smells also play a role in sociosexual behavior.
- Experiments have focused on three classes of putative human pheromones: axillary steroids, vaginal aliphatic acids, and stimulators of the vomeronasal organ.

VOMERONASAL ORGAN

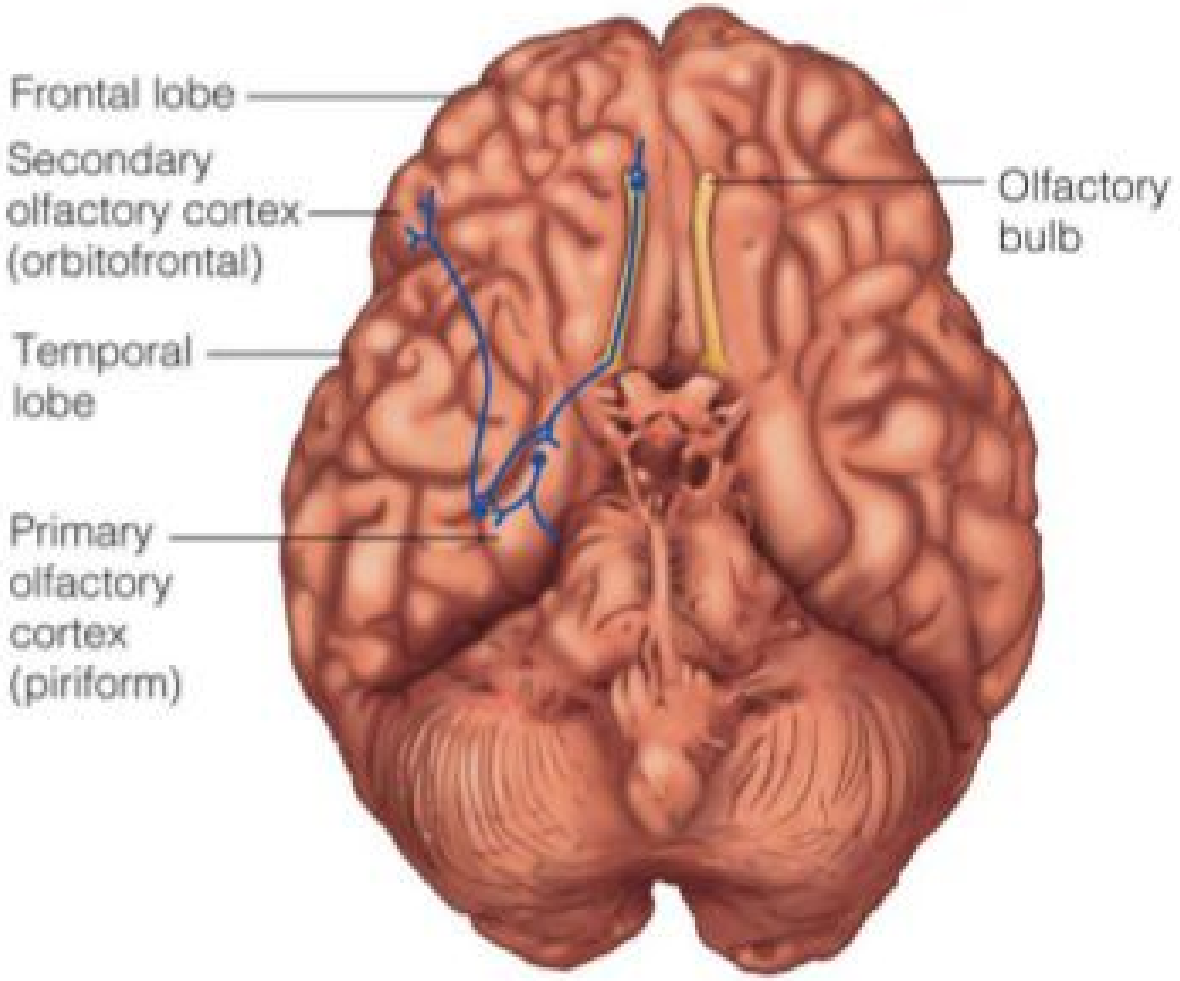
- The **vomeronasal organ** (**VNO**), or the **Jacobson's organ**, is an auxiliary olfactory sense organ. It lies close to the vomer and nasal bones.
- It was discovered by Frederik Ruysch prior to 1732 and later by Ludwig Jacobson in 1813.
- The vomeronasal organ is mainly used to detect pheromones.
- Its presence in human beings is controversial.

Structure of the Olfactory System

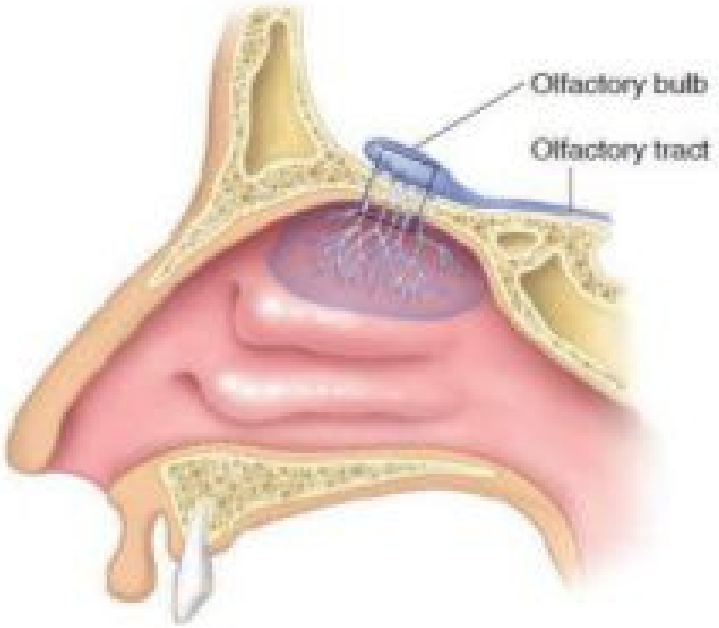


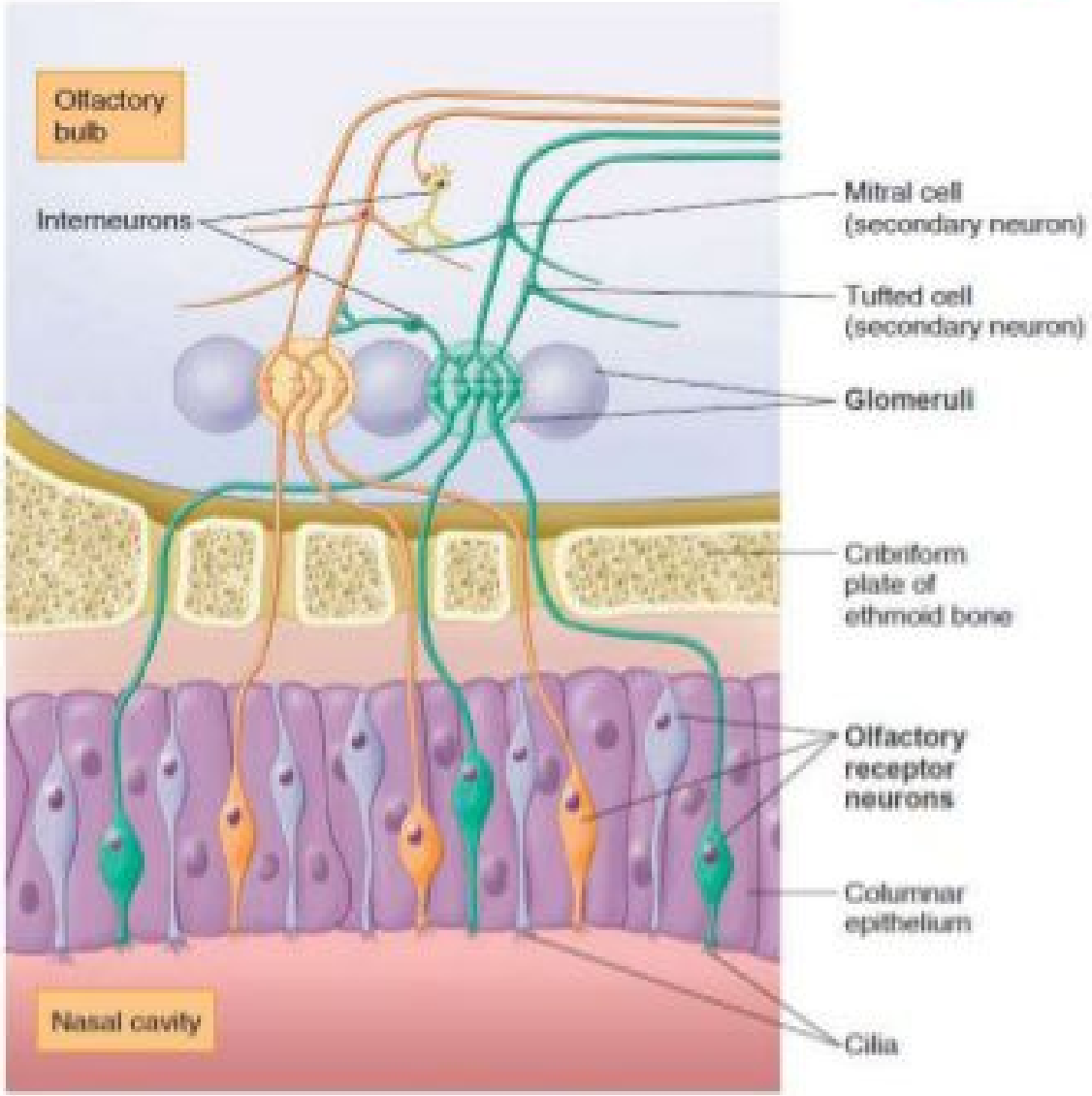
- Olfactory **mucosa** is located at the top of the nasal cavity
  - Odorants are carried along the **mucosa** coming in contact with the **sensory neurons**
  - **Cilia** of these neurons contain the receptors
  - Humans have about **350 types of receptors.**
  - Signals are carried to the **glomeruli** in the **olfactory bulb**

Structure of the Olfactory System - continued



- Signals are sent to
  - **Primary olfactory (piriform) cortex** in the temporal lobe
  - **Secondary olfactory (orbitofrontal)** cortex in the frontal lobe
  - **Amygdala** deep in the cortex


Olfactory bulb
Olfactory tract


Olfactory bulb
Interneurons
Mitral cell (secondary neuron)
Tufted cell (secondary neuron)
Glomeruli
Cribriform plate of ethmoid bone
Olfactory receptor neurons
Columnar epithelium
Nasal cavity
Cilia

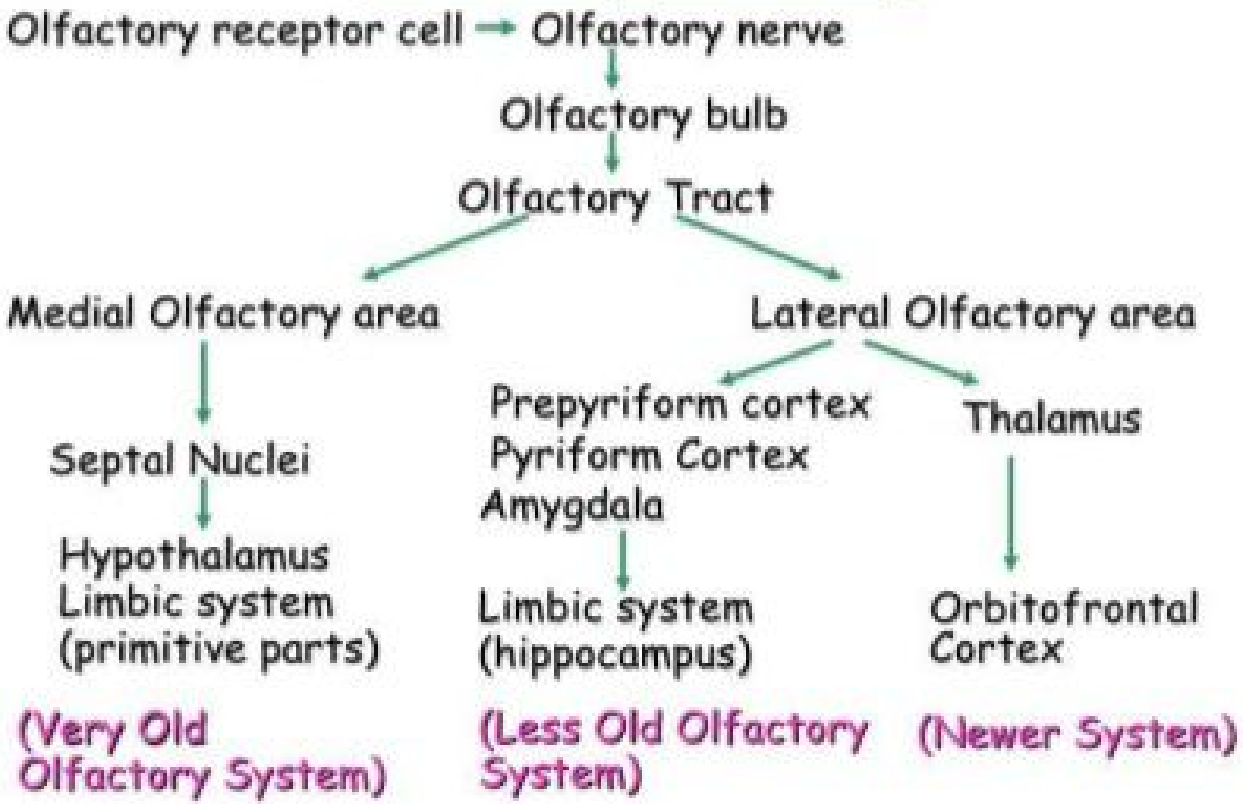
Olfactory receptors

- The receptor cells for the smell sensation are the olfactory cells .
- They are actually bipolar nerve cells derived from the CNS .
- There are about 100 million of these cells in the olfactory epithelium.
- The mucosal end of the olfactory cell forms a knob .
- From knob 4 to 25 olfactory hairs (olfactory cilia), project into the mucus that coats the inner surface of the nasal cavity.
- These projecting olfactory cilia form a dense mat in the mucus.
- These cilia react to odours in the air and stimulate the olfactory cells

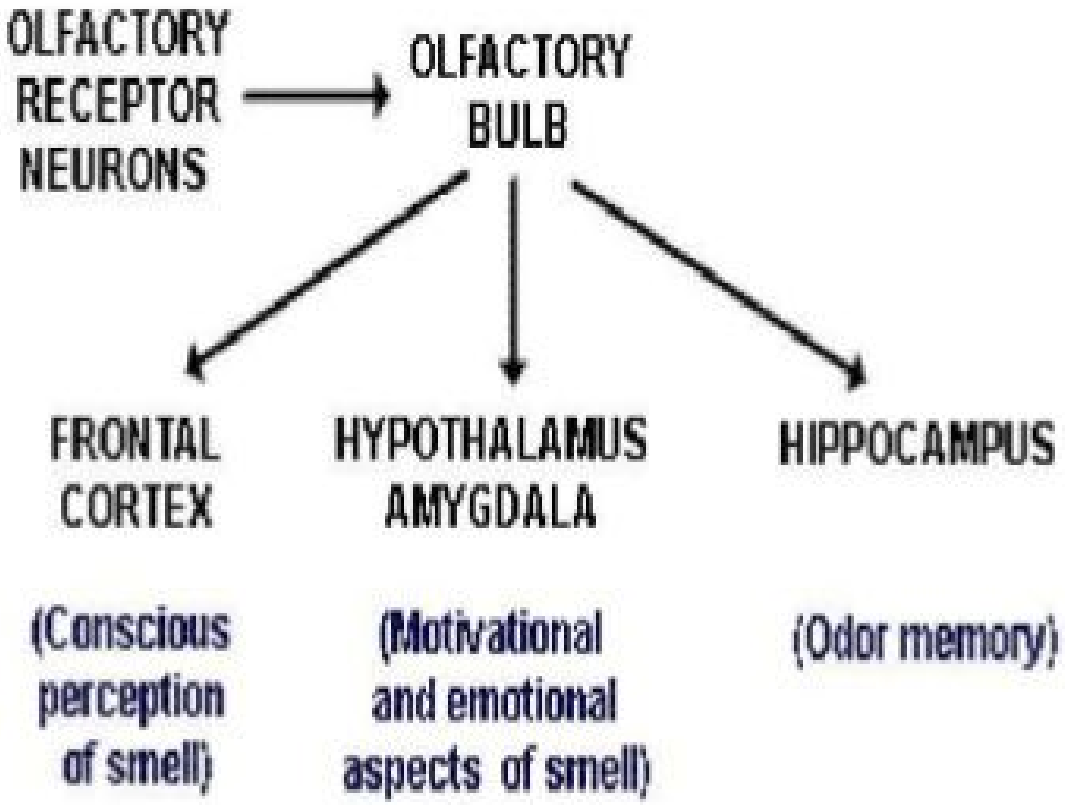
OLFACTORY PATHWAY

- **FIRST ORDER NEURON:**
  - From olfactory epithelium to glomerulus
- **SECOND ORDER NEURON:**
  - The olfactory bulb. where the second neurons of the olfactory pathway (mitral and tufted cells) are located.
  - The axons of these Second order neurons pass centrally as the olfactory tract.
- **THIRD ORDER NEURON:**
  - The prepiriform area (area 28) is considered the primary olfactory cortex which contains the third order neurons.

Olfactory pathway



Transmission of smell signals to CNS



MECHANISM OF EXCITATION OF OLFACTORY CELLS.

- Cilium is the portion which respond to the olfactory chemical stimuli.

- The odourant substance on coming in contact with olfactory surface first diffuse in to the mucus which covers the cilia.

- Then binds with a receptor protein that protrudes through the ciliary membrane.

- This receptor is a long molecule, it threads its way through the membrane 7 times, folding inward and outward.

- Odourant binds with portion of receptor and coupled to **G-PROTEIN.**

- G-PROTEIN –a combination of 3 subunits.

- On excitation of receptor,an alpha subunit breaks away from G-PROTEIN and activates adenylcyclase.

- Activated cyclase converts many molecules of intracellular adenosine-tri-phosphate into cyclic-adenosine monophosphate(cAMP).

- This cAMP activates another near by membrane protein,a gated sodium ion channel.

- Allows large number of sodium ions to pour into receptor cell cytoplasm.

- Sodium ions helps in exciting the olfactory neuron and transmitting action potential in to the CNS through an olfactory nerve.

Mechanism of olfactory cell stimulation

Odourant + receptor protein

↓

Activation of G protein

↓

Activation of adenylate cyclase

↓

ATP → cAMP

↓

Opening of Na^+ channels

↓

Na^+ influx

↓

depolarization

Physical factors affect the degree of stimulation.

- Only **volatile substances** that can be sniffed into the nostrils can be smelled.

- The stimulating substance must be at least slightly **water soluble** so that it can pass through the mucus to reach the olfactory cilia.

- The substance should be at least slightly **lipid soluble**, because lipid constituents of the cilium itself are a weak barrier to non-lipid-soluble odourants.

ROLE AND IMPORTANCE OF OLFACTION

- Many organisms live in an olfactory rather than a visual world.
- The sense of smell is closely related to food, for its finding, correct identification and assessment of its edibility.
- Sensing other animals whether prey or predators is largely olfactory.
- Bonding between parents and offspring is largely olfactory.
- Olfaction is a very important aspect in sexual reproduction throughout evolution because it triggers mating behaviour in many species.
- Olfaction is largely related to emotional behaviour, olfactory symptoms and disturbed psychological pattern is well known.

- In female humans, the sense of olfaction is strongest around the time of ovulation, significantly stronger than during other phases of the menstrual cycle and stronger than the sense in males.
- The MHC genes (known as HLA in humans) are a group of genes present in many animals and important for the immune system; in general, offspring from parents with differing MHC genes have a stronger immune system. Fish, mice and female humans are able to smell some aspect of the MHC genes of potential sex partners and prefer partners with MHC genes different from their own.

DISORDERS OF OLFACTION

- Anosmia - Inability to detect odors
- Hyposmia - Decreased ability to detect odors
- Dysosmia - Distorted identification of smell
- Parosmia - Altered perception of smell in the presence of an odor, usually unpleasant
- Phantosmia – Perception of smell without an odor present
- Cacosmia- sensation of unpleasant odor
- Agnosia - Inability to classify or contrast odors, although able to detect odors
- Presbyosmia- decreased sense of smell due to aging

ETIOLOGIES OF OLFACTORY DISORDERS

❖ *Conductive defects*

- Inflammatory processes - These may include rhinitis of various types, including allergic, acute, or toxic (eg, cocaine use).
- Chronic rhinosinusitis causes progressive mucosal disease and often leads to decreased olfactory function.
- Masses may block the nasal cavity, preventing the flow of odorants to the olfactory epithelium.
- These include nasal polyps (most common), inverting papilloma, or any nasal tumor.
- Developmental abnormalities (eg, encephaloceles, dermoid cysts) also may cause obstruction.

TREATMENT OF OLFACTORY DISORDERS

- Treatment of causative abnormality that has been identified .
- Local nasal and/or sinus conditions should be optimally managed with saline lavage, decongestants, antihistamines, antibiotics, and/or nasal and systemic steroids, if applicable.

- Polyps and sinus disease that are resistant to medical management should be surgically addressed to remove the conductive defect.
- Care must be exercised during surgery to avoid damage to the olfactory regions.
- In general, conductive olfactory losses are the most amenable to treatment.

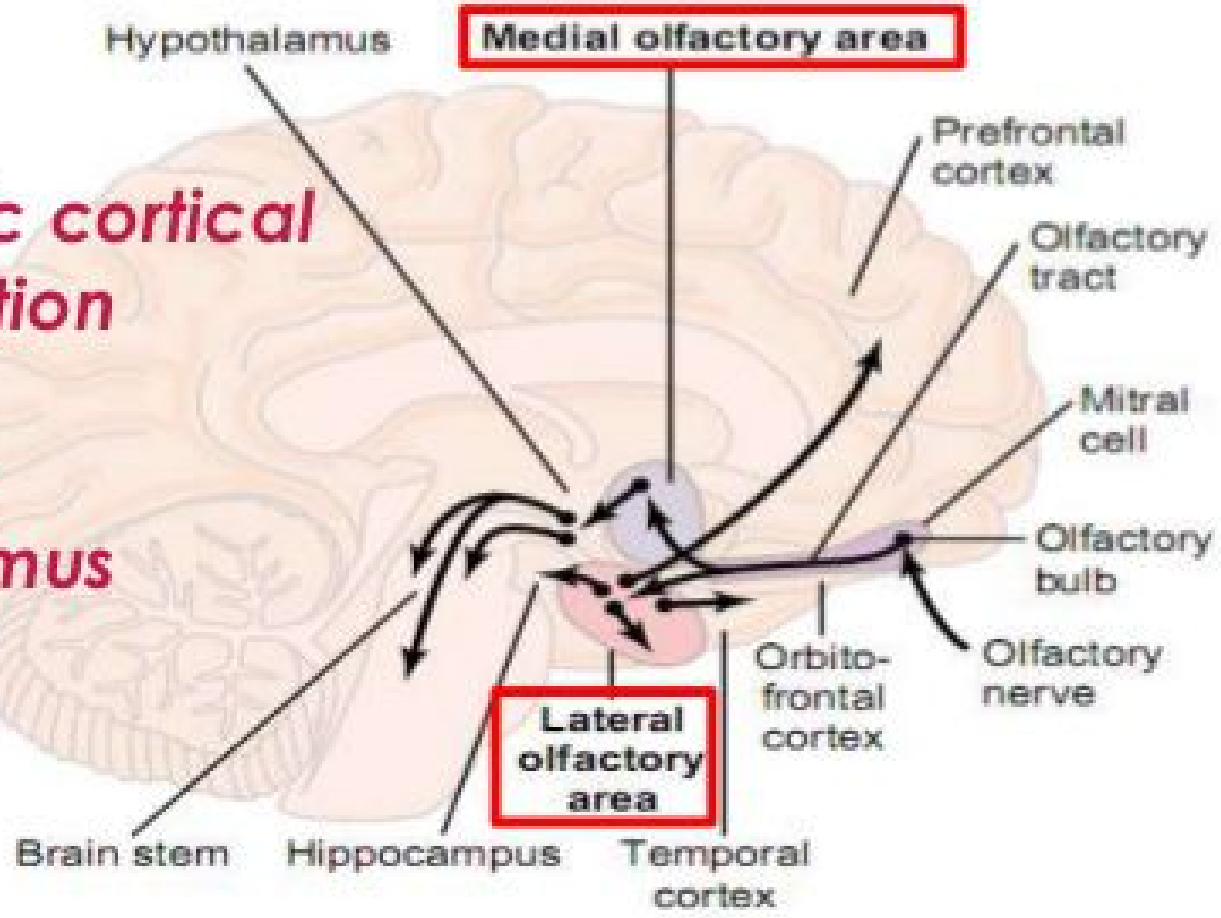
- Endocrine disturbances may be addressed by administration of the deficient hormone, as with hypothyroidism.
- Control of diabetes mellitus may slow neural degeneration of the olfactory system.
- Generally, viral processes that damage the olfactory neuroepithelium, sarcoidosis, and multiple sclerosis do not have specific remedies; however, steroids may be administered in an attempt to limit the inflammation.

SPECIAL FEATURES OF OLFACTORY EPITHELIUM

- These neurons have a limited lifespan of up to several months, but are continuously replenished from the pool of precursor cells
- New olfactory receptors are thus generated throughout adult life, and their axons enter the olfactory bulb to form new synapses with existing CNS neurons.
- The regenerative capacity of the olfactory mucosa gradually diminishes with advancing age.
- Resulting in net loss of receptors and a slow decline in overall sensory function

Neural connections of olfactory system

- ✓ *Asymmetric cortical representation*
- ✓ *No relay in Hypothalamus*



*Threshold for Smell

- the **minute quantity** of stimulating agent in the air can elicit a smell sensation.

- the substance **methylmercaptan** can be smelled when only one 25 trillionth of a gram is present in each milliliter of air.

- Because of this very **low threshold**, this substance is **mixed with natural gas** to give the gas an odor that can be detected when even small amounts of **gas leak** from a cylinder.

* Adaptation

- The olfactory receptors adapt about **50 per cent in the first second** or so after stimulation.

- Thereafter, they adapt **very little and very slowly**.

- our own experience that smell sensations adapt almost to **extinction within a minute** or so after entering a strongly odorous atmosphere.

THANK YOU