OLFACTION

- Sense of smell = OLFACTION
- Most primitive of all senses
- Chemical sense like taste
- Visceral sense → due to close association to GIT
- Related to taste sensation

MACROSMATIC OR MACROSMIC ANIMALS	***MICROSMATIC OR MICROSMIC ANIMALS***
Sense of smell is highly developed	Sense of smell is ill-developed
Insects Dogs	Man

IMPORTANCE OF SMELL

- ***Nutritive*** function – helps in search of food and enjoying the taste of food
- Increases ***gastrointestinal secretion and motility***
- Helps in ***defense***
- ***Protective function*** – makes the animal aware of environmental hazards
- Helps in ***reproduction*** – pheromones
- Olfactory ***memories***

OLFACTORY EPITHELIUM

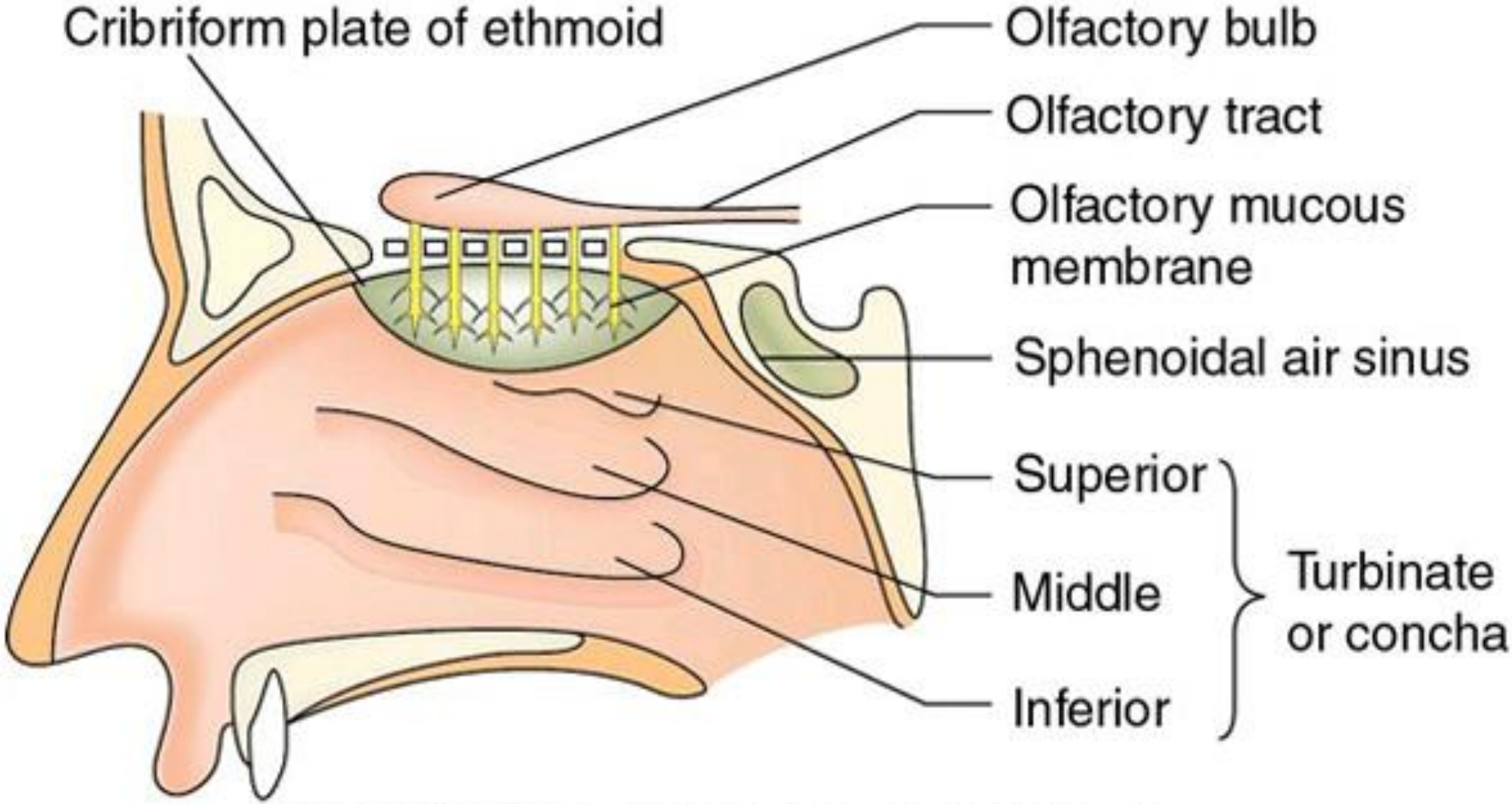


FIGURE 11.3-1 Location of olfactory mucosa.

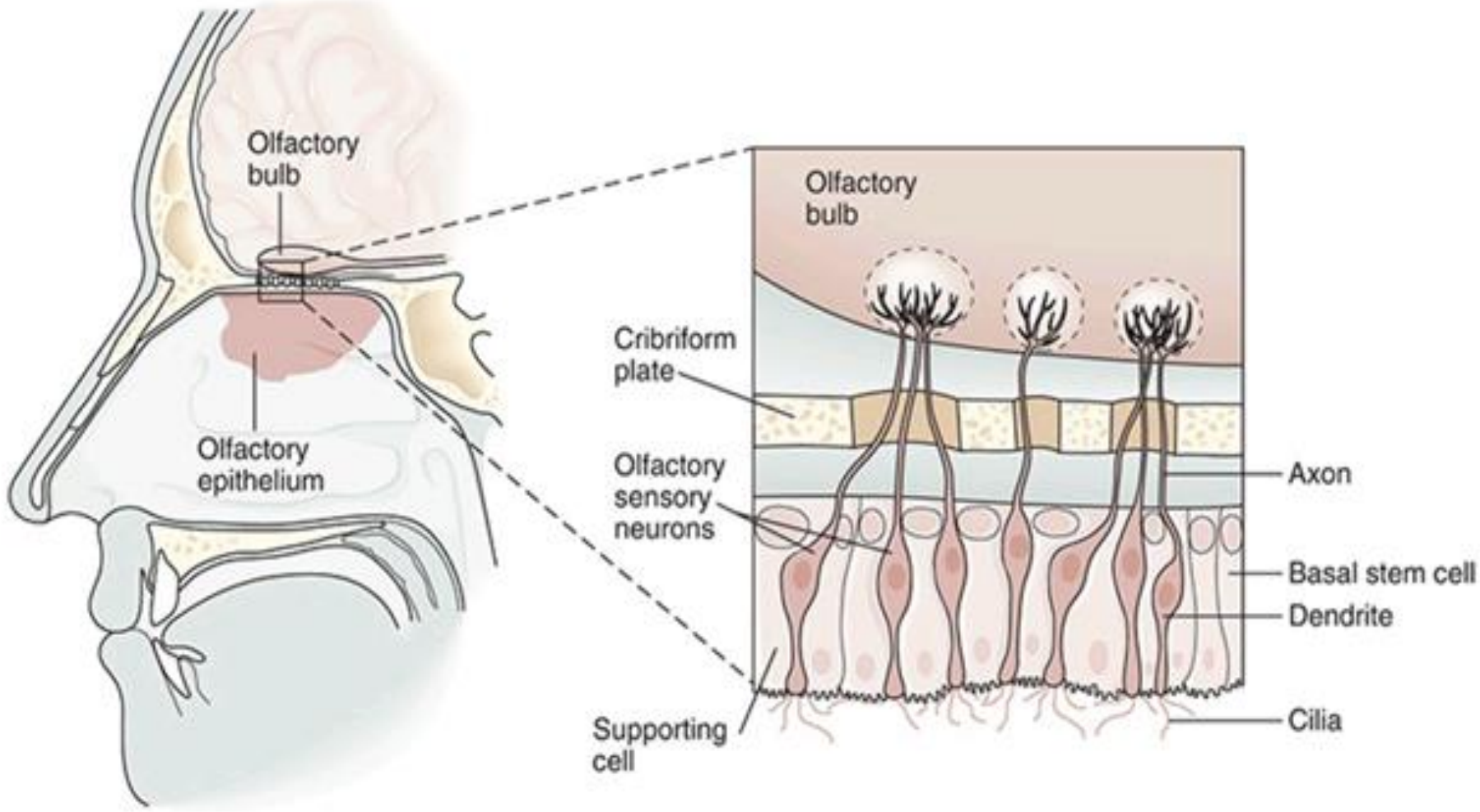


FIGURE 9–1 Structure of the olfactory epithelium. There are three cell types: olfactory sensory neurons, supporting (sustentacular) cells, and basal stem cells

- Specialized portion of the nasal mucosa where olfactory receptor cells are present
- Place in the body where the nervous system is closest to the external world
- Yellowish-brown in colour
- Lines the superior turbinate and upper 1/3rd of the nasal mucosa

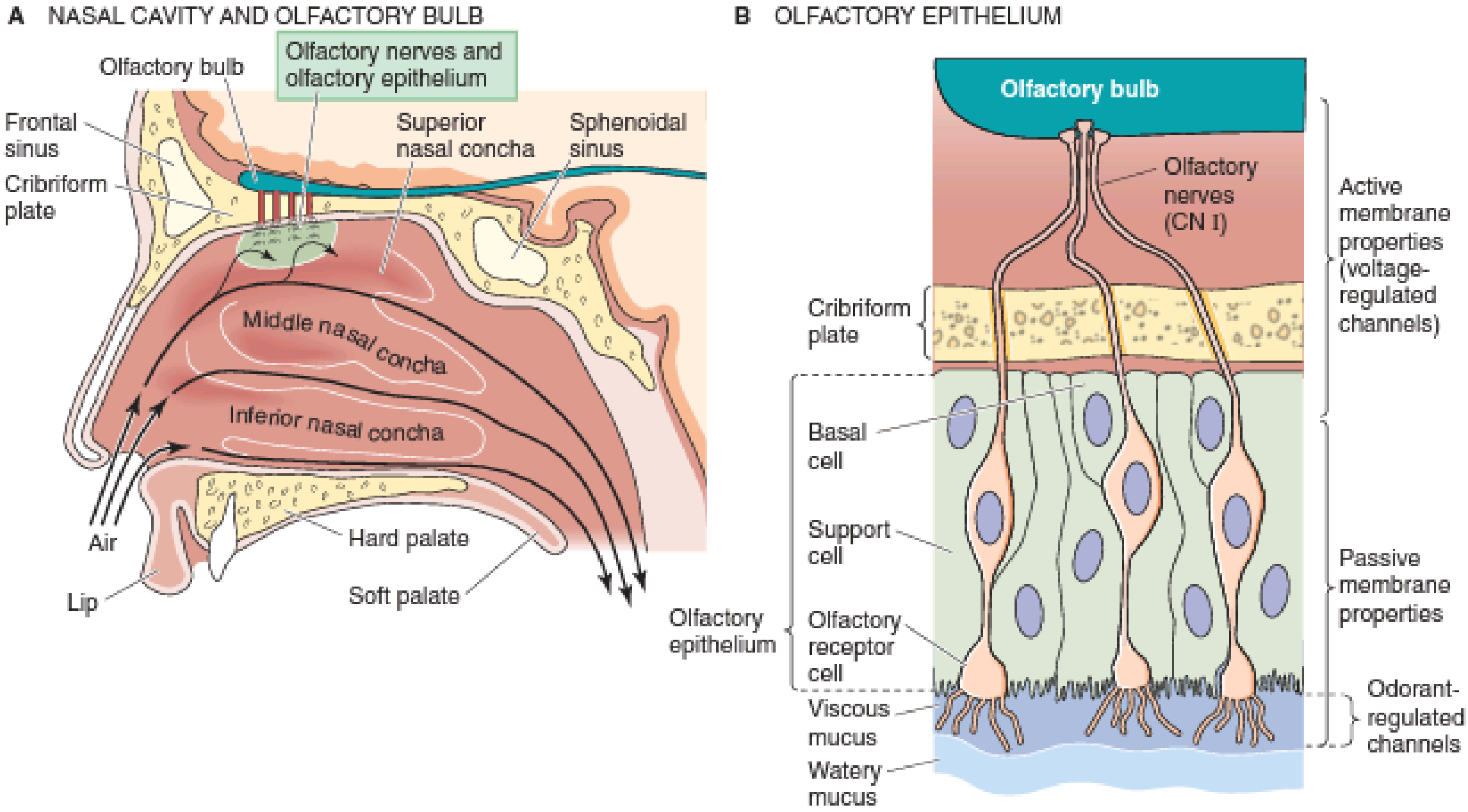
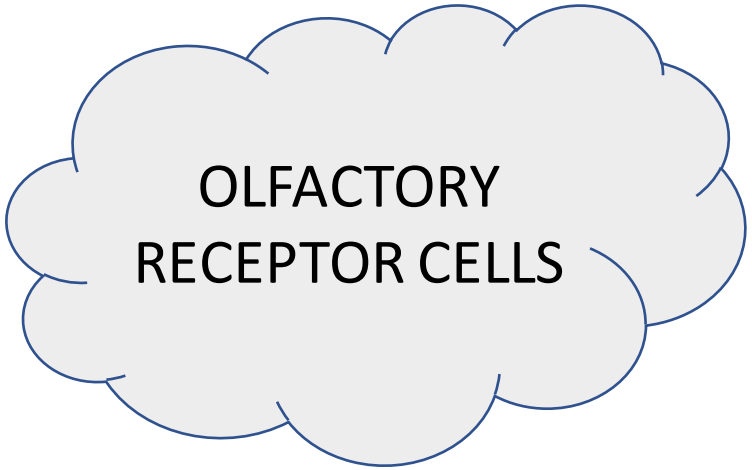
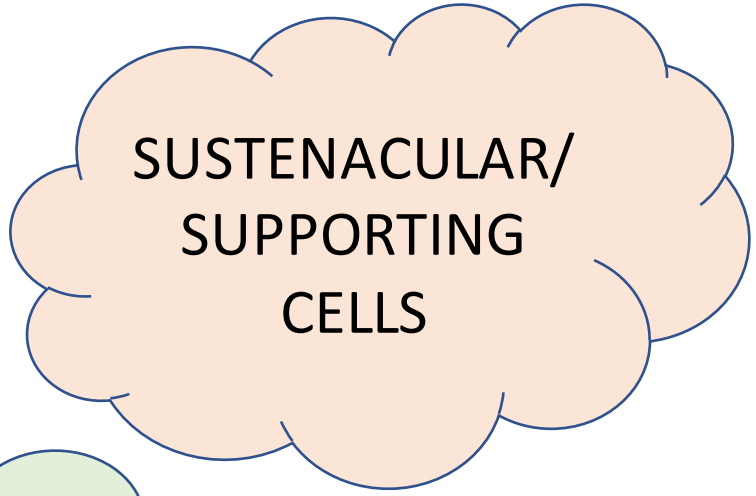


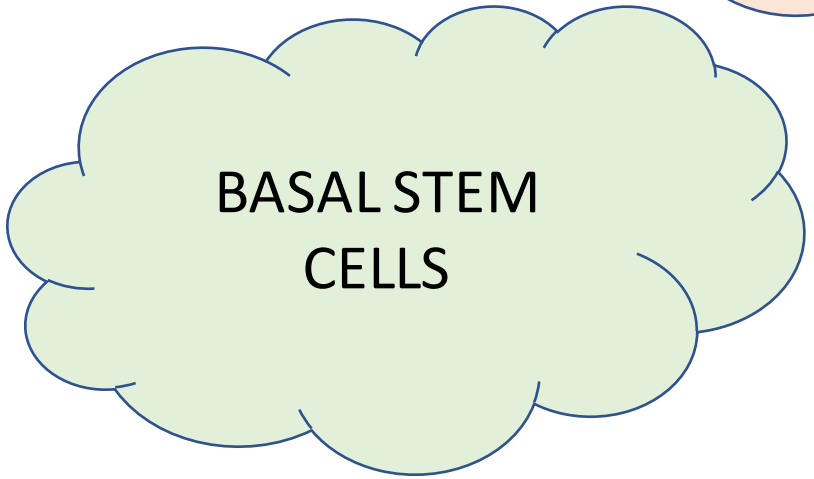
Figure 15-2 Olfactory reception.

Structure of olfactory epithelium

- Three types of cells







OLFACTORY RECEPTOR CELLS

- *BIPOLAR OLFACTORY SENSORY NEURONS*
- **First order neurons of the olfactory pathway**
- Interspersed with the supporting cells
- Has a cell body, axon and a dendrite

- Short, thick dendrite projects into the nasal cavity where it terminates in a knob → OLFACTORY ROD OR KNOB

- Each knob contains 6-12 cilia → OLFACTORY CILIA

- Cilia
- Protrudes into the mucus overlying the epithelium
- Contain odorant receptor proteins of smell

- Axons of the olfactory receptor cells

- Pierce the basal lamina and becomes ensheathed → OLFACTORY NERVE
- Pass through the Cribriform Plate of Ethmoid
- Enter the OLFACTORY BULB

- In the olfactory bulb
- Axons of olfactory sensory neurons synapse with the dendrites of the *MITRAL CELLS* and *TUFTED CELLS*
- This forms anatomically discrete synaptic units called **OLFACTORY GLOMERULI**

- Life span of olfactory receptor cell is about 60 days

- One of the neurons in the adult nervous system that is capable of regeneration

SUPPORTING / SUSTENACULAR CELLS

- Found interspersed with olfactory receptor cells

- Free surface → numerous MICROVILLI → secrete mucus which cover the olfactory epithelium

- Mucus – provides the appropriate molecular and ionic environment for odour detection
- Odorant molecules dissolve in the mucus and bind to odorant receptors on the cilia of olfactory sensory neurons

BASAL STEM CELLS

- stem cells confined to the basal lamina
- New receptor cells are formed from the basal cells
- To replace those damaged by exposure to the environment

ODORANT BINDING PROTEINS

- Present on the olfactory epithelium – cilia of olfactory receptor cells
- Produced by sustentacular cells
- Concentrate the odorants and transfer them to the receptors

OLFACTORY GLAND / BOWMAN'S GLAND

- Beneath the olfactory epithelium
- Secretes mucus that lines the epithelium

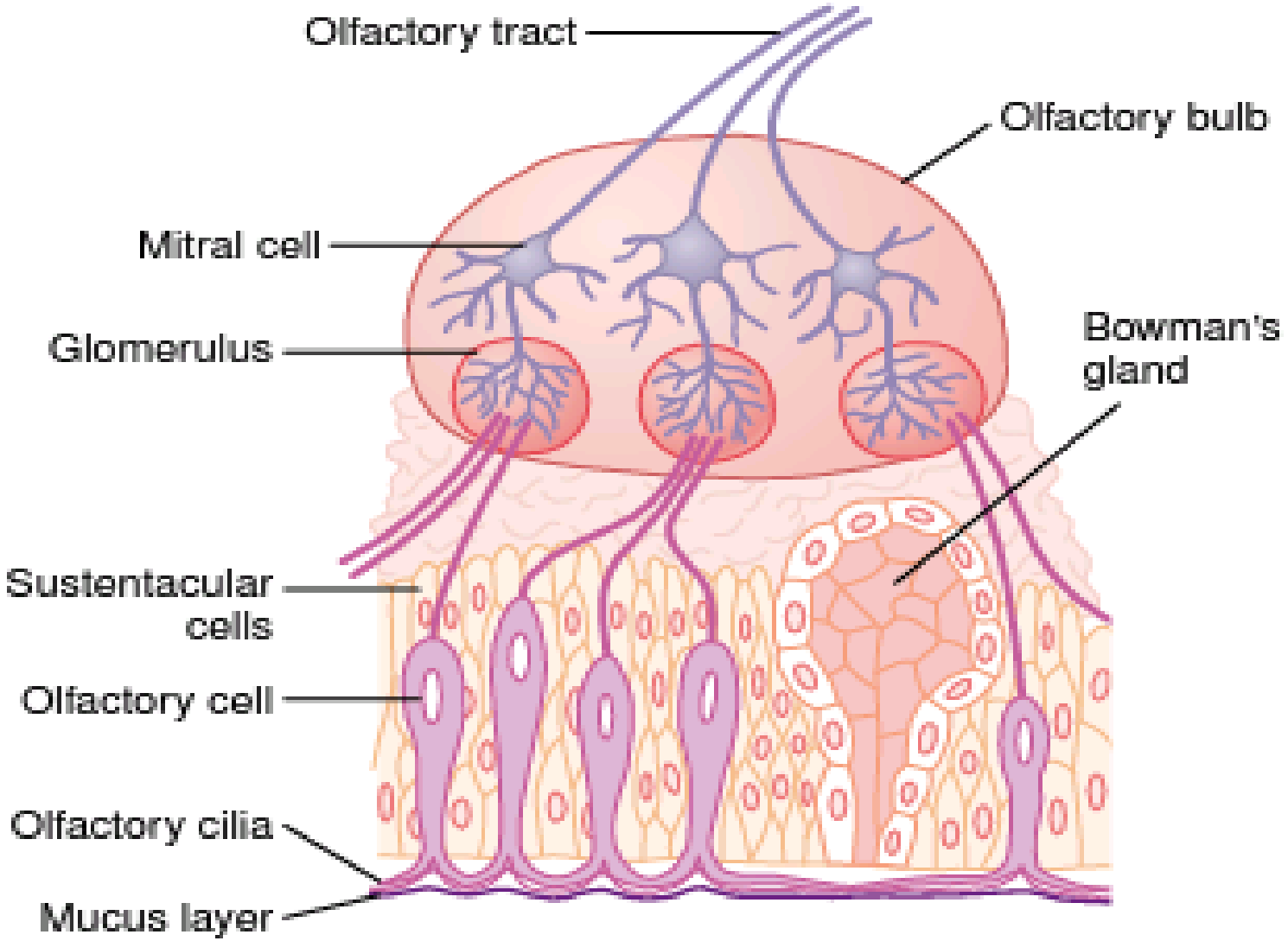


Figure 53-3 Organization of the olfactory membrane and olfactory bulb, and connections to the olfactory tract.

FREE ENDINGS OF MANY TRIGEMINAL PAIN FIBRES

- Stimulated by irritating substances
- Peppermint
- Menthol
- Chlorine

OLFACTORY BULB

- Flattened ovoid strip of grey matter seen on the cribriform plate of ethmoid

- Four types of cells
- Mitral cells
- Tufted cells
- Periglomerular cells
- Granule cells

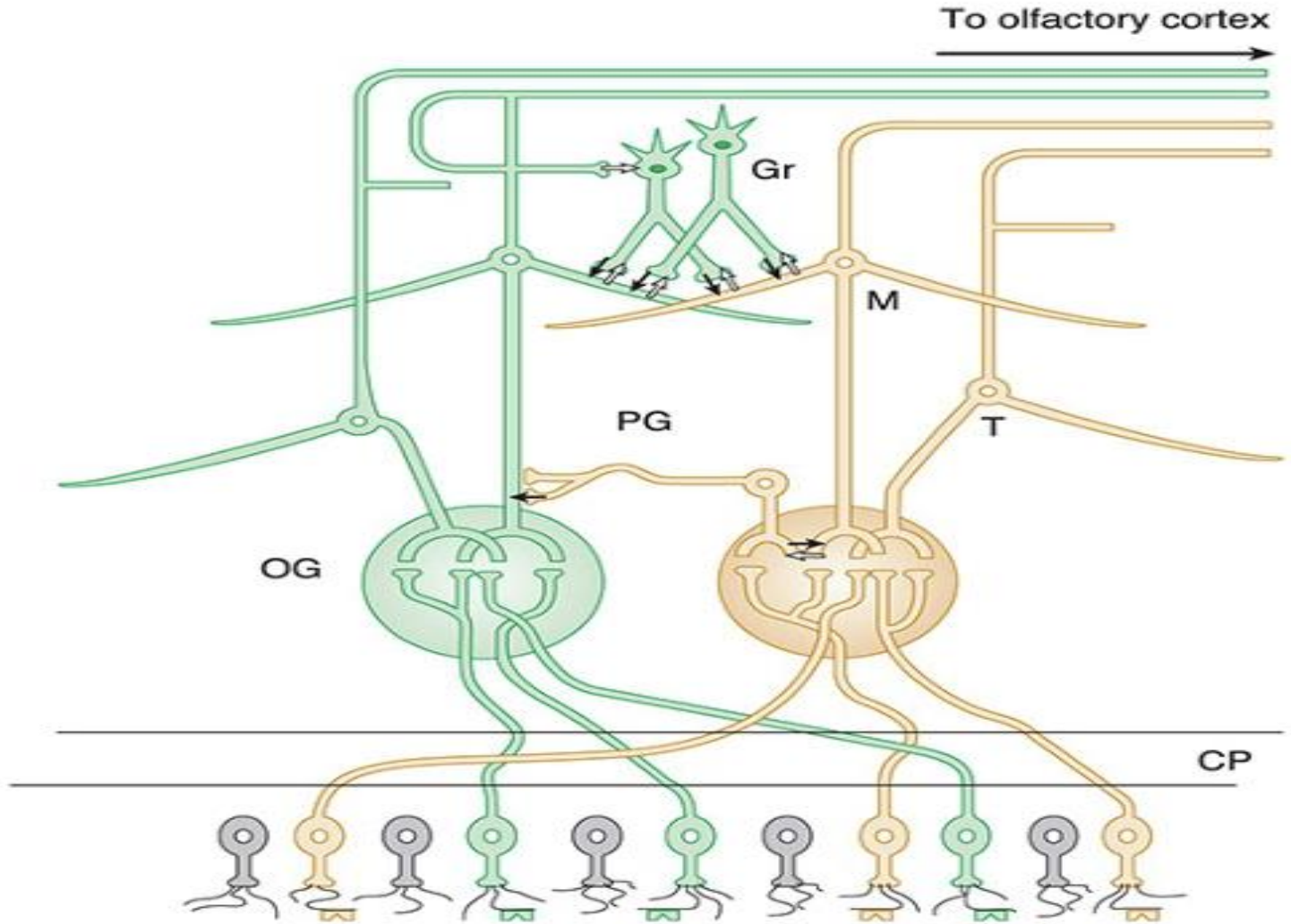


FIGURE 9–3 Basic neural circuits in the olfactory bulb. Olfactory receptor cells with one type of odorant receptor project to one olfactory glomerulus (OG) and olfactory receptor cells with another type of receptor project to a different OG. Solid black arrows signify inhibition via GABA release, and white arrows signify excitatory connections via glutamate release. CP, cribriform plate; Gr, granule cell; M, mitral cell; PG, periglomerular cell; T, tufted cell. (Adapted with permission from Mori K, et al: The olfactory bulb: coding and processing of odor molecular information, Science 1999 Oct 22; 286(5440): 711–715.)

- ***MITRAL CELLS***
- Dendrites of mitral cells synapse with axons of bipolar cells to form olfactory glomeruli

- ***TUFTED CELLS***
- Dendrites synapse with axons of bipolar cells to form olfactory glomeruli

- MITRAL CELLS & TUFTED CELLS
- Second order neurons of olfactory pathway
- Their axons constitute the **OLFACTORY TRACT**

- ***GRANULE CELLS***
- Inhibitory interneurons that have no axons
- Make reciprocal synapses with the lateral dendrites of the mitral and tufted cells

- ***PERIGLOMERULAR CELLS***
- Inhibitory interneurons connecting one glomerulus to another
- Inhibit mitral cells

- GRANULE CELLS → GABA → MITRAL CELLS
- MITRAL CELLS → GLUTAMATE → GRANULE CELLS

- GRANULE CELLS → GABA → TUFTED CELLS
- TUFTED CELLS → GLUTAMATE → GRANULE CELLS

- PERIGLOMERULAR CELLS → GABA → MITRAL CELLS

- Lateral dendrites of mitral and tufted cells are inhibited
- **LATERAL INHIBITION**
- Sharpens and focuses olfactory signals

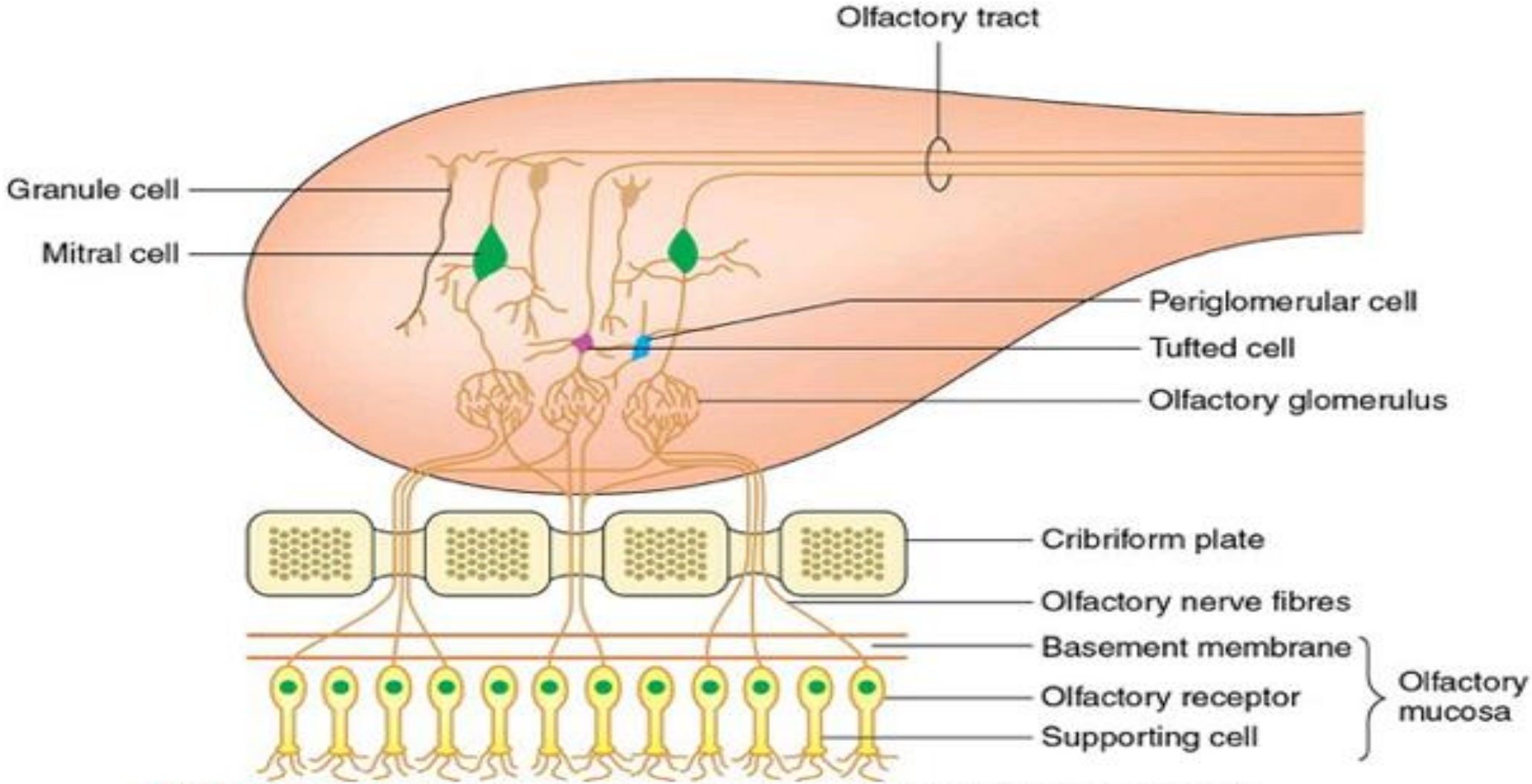


FIGURE 11.3-3 Diagrammatic depiction of the synapses between axons of olfactory neurons (first-order neurons) with the dendrites of mitral and tufted cells (second-order neurons) to form the olfactory glomeruli which lie in the olfactory bulb. The inhibitory neurons present in the olfactory

INNERVATION OF OLFACTORY MUCOSA

SENSE OF SMELL FROM THE OLFACTORY MUCOSA	***GENERAL SENSATIONS FROM THE OLFACTORY MUCOSA***
OLFACTORY NERVE	TRIGEMINAL NERVE

IRRITANTS LIKE AMMONIA SHOULD NOT BE USED TO TEST THE SENSE OF SMELL STIMULATES BOTH THE NERVES

OLFACTORY PATHWAY

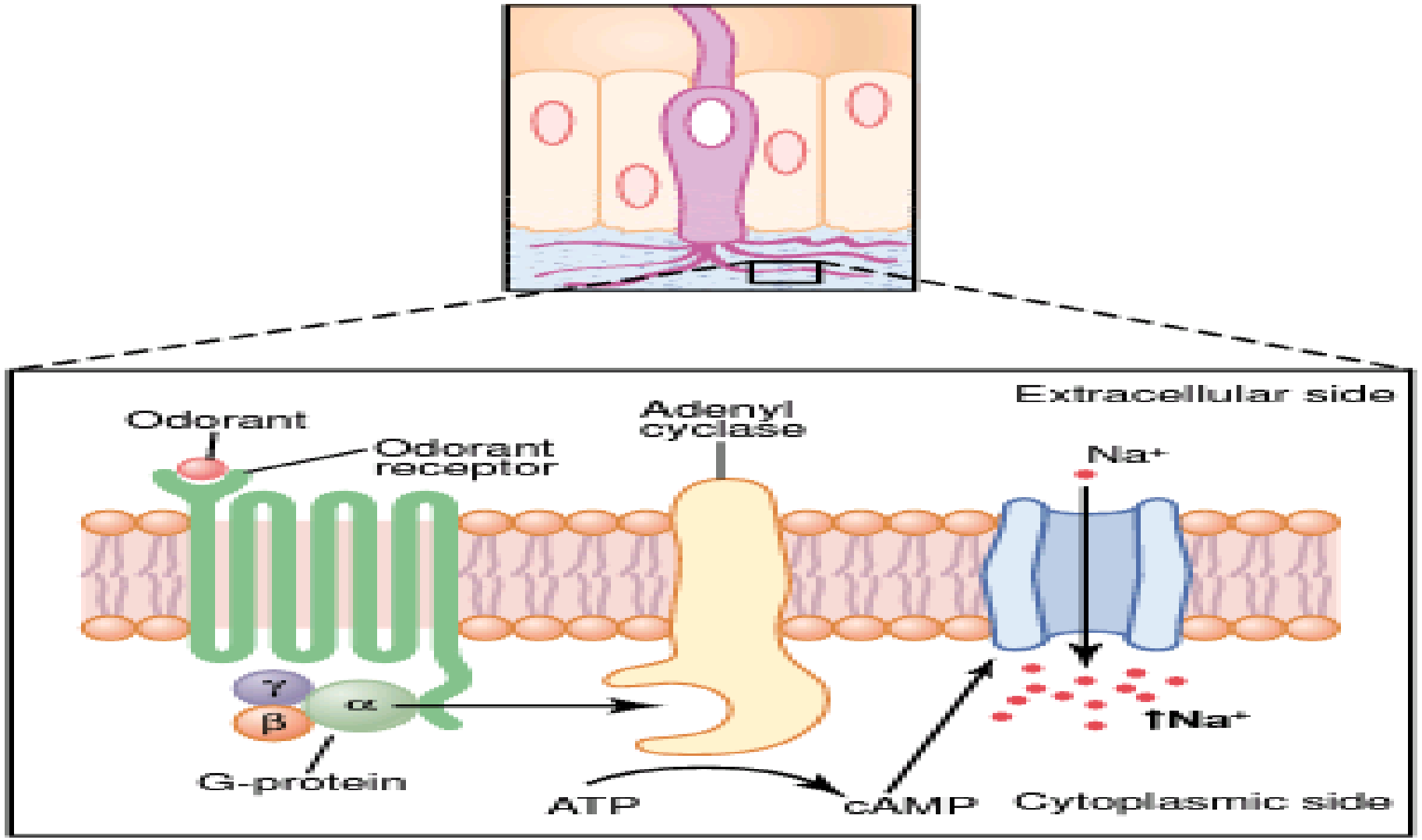
STIMULUS

- **Odorants**
- Odor producing molecules
- High water and lipid solubility
- Volatile

RECEPTORS

- Odorant molecules dissolve in the mucus and bind to olfactory receptor protein on the cilia of olfactory sensory neurons

- G protein coupled receptors - G_{olf}
- **Heterotrimeric** – 3 subunits – alpha, beta and gamma subunits


Extracellular side
Odorant
Odorant receptor
Adenyl cyclase
Na+
γ
α
β
G-protein
ATP
cAMP
↑Na+
Cytoplasmic side

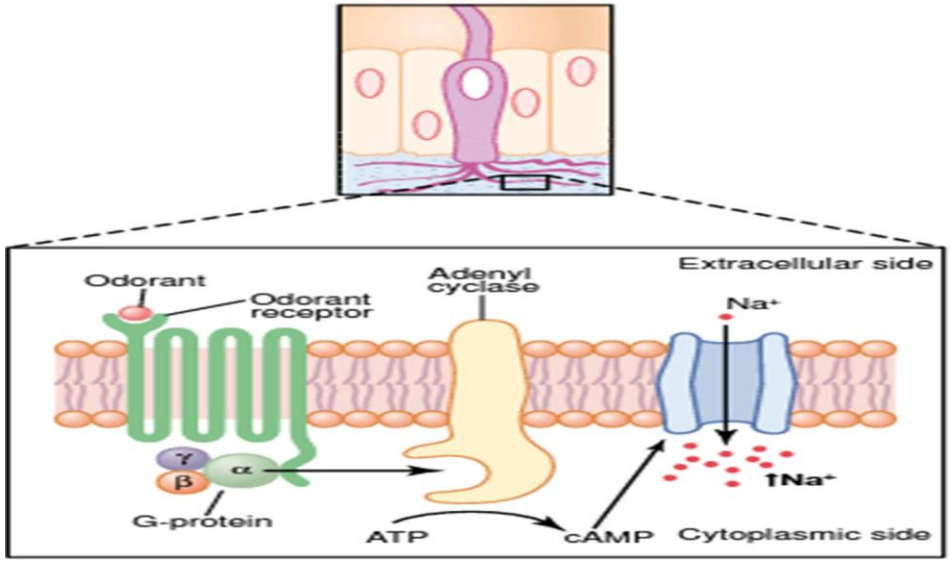
- **STEP 1** : The odorant binds to a specific OLFACTORY RECEPTOR PROTEIN in the membrane of a cilium of an olfactory receptor cell

- **STEP 2** : Receptor activation stimulates a heterotrimeric G protein called G_{olf}

- **STEP 3** : The alpha subunit of G protein activates Adenylyl cyclase which produces cAMP

- **STEP 4** : The cAMP binds to the cAMP-gated cation channel

- **STEP 5** : Opening of this channel increases permeability to Na^{+}, K^{+} and Ca^{2+}



- STEP 6 : Increased positivity inside produces membrane depolarization

- STEP 7 : This activates Calcium-activated Chloride channels to open producing increased intracellular calcium

- STEP 8 : Further depolarization of the cell

- STEP 9 : When receptor potential exceeds its threshold, it triggers an ACTION POTENTIAL in the axon of the olfactory neuron

- Bipolar olfactory sensory neuron – FIRST ORDER NEURON
- Axons of bipolar cells form the olfactory nerve
- Pierce the cribriform plate and reach the olfactory bulb
- Synapses with Mitral and Tufted cells which form the SECOND ORDER NEURONS – olfactory glomeruli
- The axons of the mitral and tufted cells pass posteriorly as the olfactory tract

- Reach the ANTERIOR PERFORATED SUBSTANCE and divide into three striae which terminate in five areas of olfactory cortex

- *ANTERIOR OLFACTORY NUCLEUS*
- *OLFACTORY TUBERCLE*
- *PIRIFORM CORTEX*
- *AMYGDALA*
- *ENTORRHINAL CORTEX*

- Later information is taken up to **ORBITOFRONTAL CORTEX**

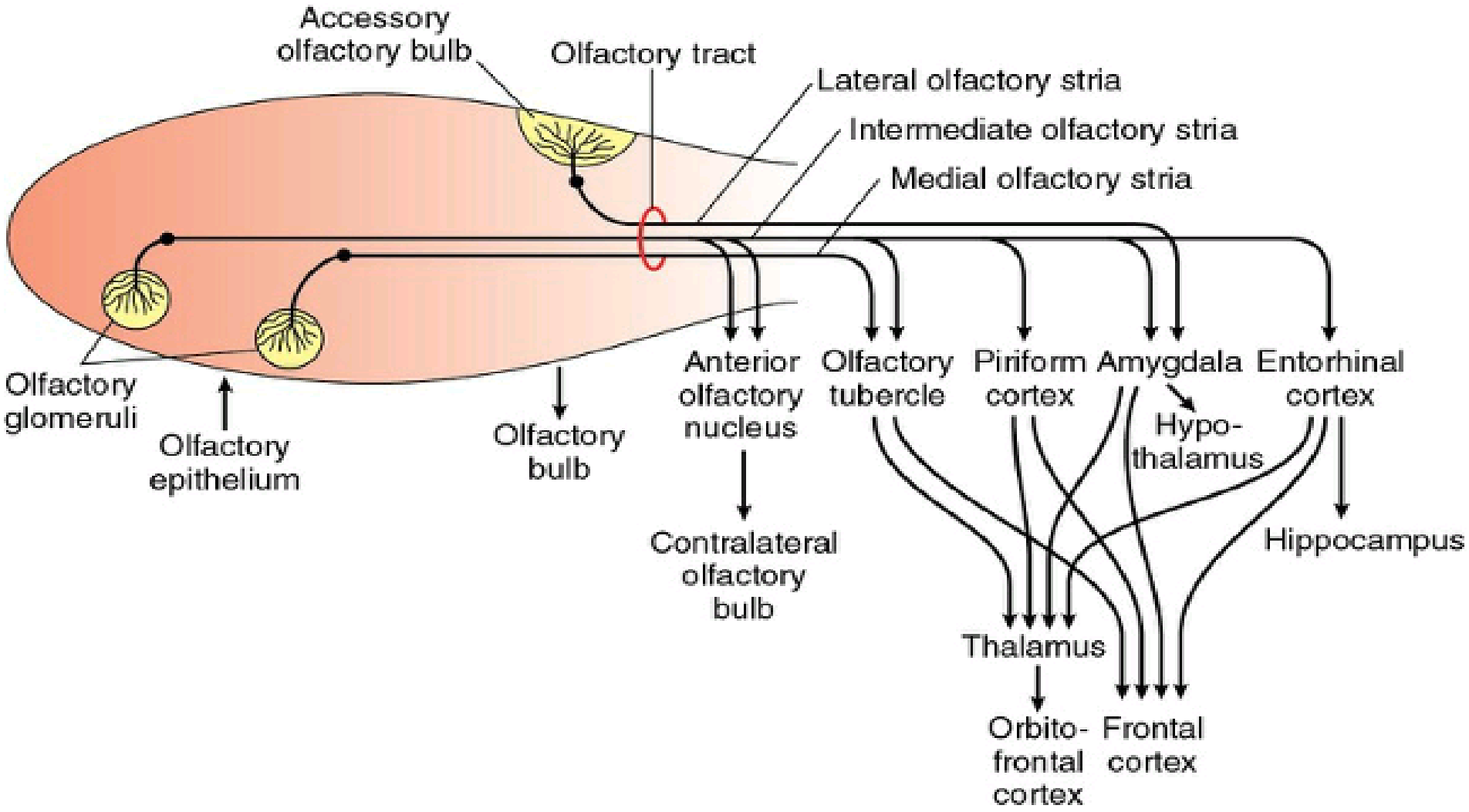
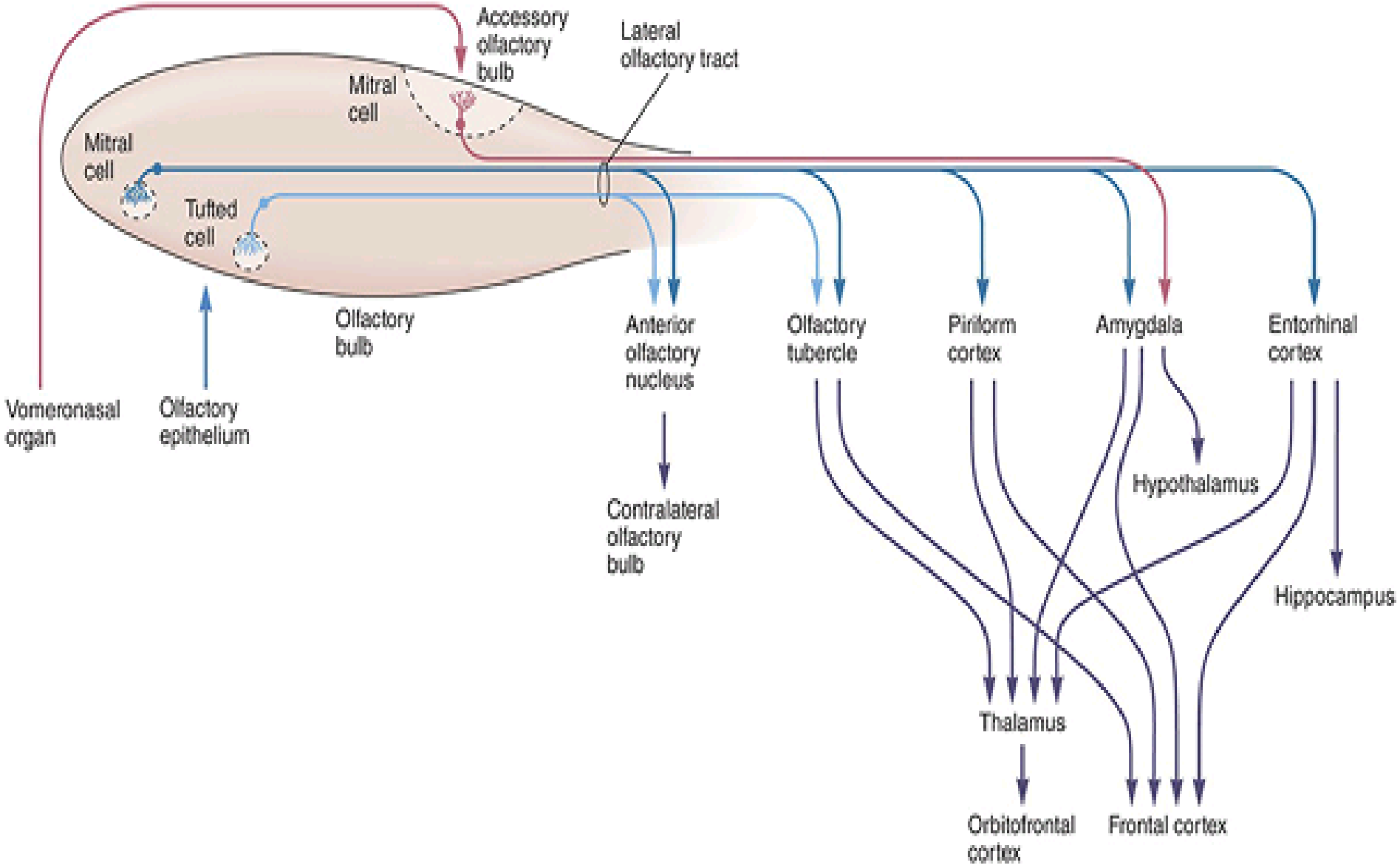


FIGURE 11.3-5 Olfactory pathways.


Accessory olfactory bulb
Lateral olfactory tract
Mitral cell
Mitral cell
Tufted cell
Olfactory bulb
Anterior olfactory nucleus
Olfactory tubercle
Piriform cortex
Amygdala
Entorhinal cortex
Vomeronasal organ
Olfactory epithelium
Contralateral olfactory bulb
Hypothalamus
Hippocampus
Thalamus
Orbitofrontal cortex
Frontal cortex

- Asymmetric cortical olfactory representation
- More on right side

- Orbitofrontal cortex → conscious discrimination of odors
- Amygdala → emotional responses to olfactory stimuli
- Entorrhinal cortex → olfactory memories
- Piriform cortex → integration of complex aspects of olfaction

ODOR DETECTION THRESHOLD/ OLFACTORY THRESHOLD

- Lowest concentration of a chemical that can be detected

- Not all individuals have the same odor detection threshold for a given odorant

OLFACTORY ADAPTATION

- When continuously exposed to the same odor → perception of the odor decreases and eventually ceases

- Due to fairly rapid adaptation or desensitization

- 50 % receptors adapt in the first second
- Thereafter they adapt very little and very slowly

MASKING OF ODORS

- An offensive odor can be masked by a pleasant odor
- Eg: deodorants

PHEROMONES

- Hormone like substances which emit specific odor produced by animals that can attract another animal at a distance

- Secreted during mating season

- Present in humans also – recent studies
- More acute in women

VOMERONASAL ORGAN

- In rodents and other mammals

- A patch of olfactory epithelium located along nasal septum
- Project to ACCESSORY OLFACTORY BULB
- AMYGDALA & HIPPOCAMPUS

- Concerned with reproduction and ingestive behaviour

- Not well-developed in humans
- Concerned with perception of odor that acts as pheromones

VARIATIONS IN THE SENSE OF SMELL

- **SEX** – more in females especially during ovulation

- **AGE** – sensitivity decreases with advancing age

- **HYPEROSMIA**
- Increased sensitivity to smell
- Hysteria
- Increased ICP
- Adrenal insufficiency

- **HYPOSMIA**
- Decreased sensitivity to smell
- Olfactory adaptation
- Hypogonadism
- Vitamin A deficiency

- **ANOSMIA**
- Absence of sense of smell
- Unilateral → lesions of olfactory nerve, bulb or tract
- Bilateral → common cold, congenital, fracture of cribriform plate

- **PAROSMIA**
- Altered sense of smell
- Sinusitis

- **OLFACTORY HALLUCINATION**
- Perception of non-existing odors
- Temporal lobe epilepsy
- Temporal lobe lesions
- Psychiatric disorders

FACTORS INFLUENCING OLFACTORY FUNCTION

- Threshold of olfactory receptors
- Concentration of odorant substances
- Solubility of the odorant
- Olfactory adaptation

AFFECTIVE NATURE OF SMELL

- Person who has previously eaten food that disagreed with him is often nauseated by the smell of that same food on a second occasion

REFLEXES ASSOCIATED WITH OLFACTION

- Sniffing at the arrival of new odor
- Salivation/gastric secretion/pancreatic secretion at the smell of food
- Sneezing, lacrimation and in extreme case, respiratory inhibition in response to irritant odors
- Vomiting in response to a foul smell

UNIQUE FEATURES

- Olfactory receptor cell is the only nerve cell that is exposed to the external environment
- Olfactory receptor cells are not only receptors but also neurons
- Can regenerate
- No direct relay on thalamus

- No direct neo-cortical projection
- Afferent pathway has only two neurons