

# CNS

## Physiology

Modified no. 9

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# Neurophysiology

## Color code

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Slides

Doctor

Additional info

Important

## Olfaction

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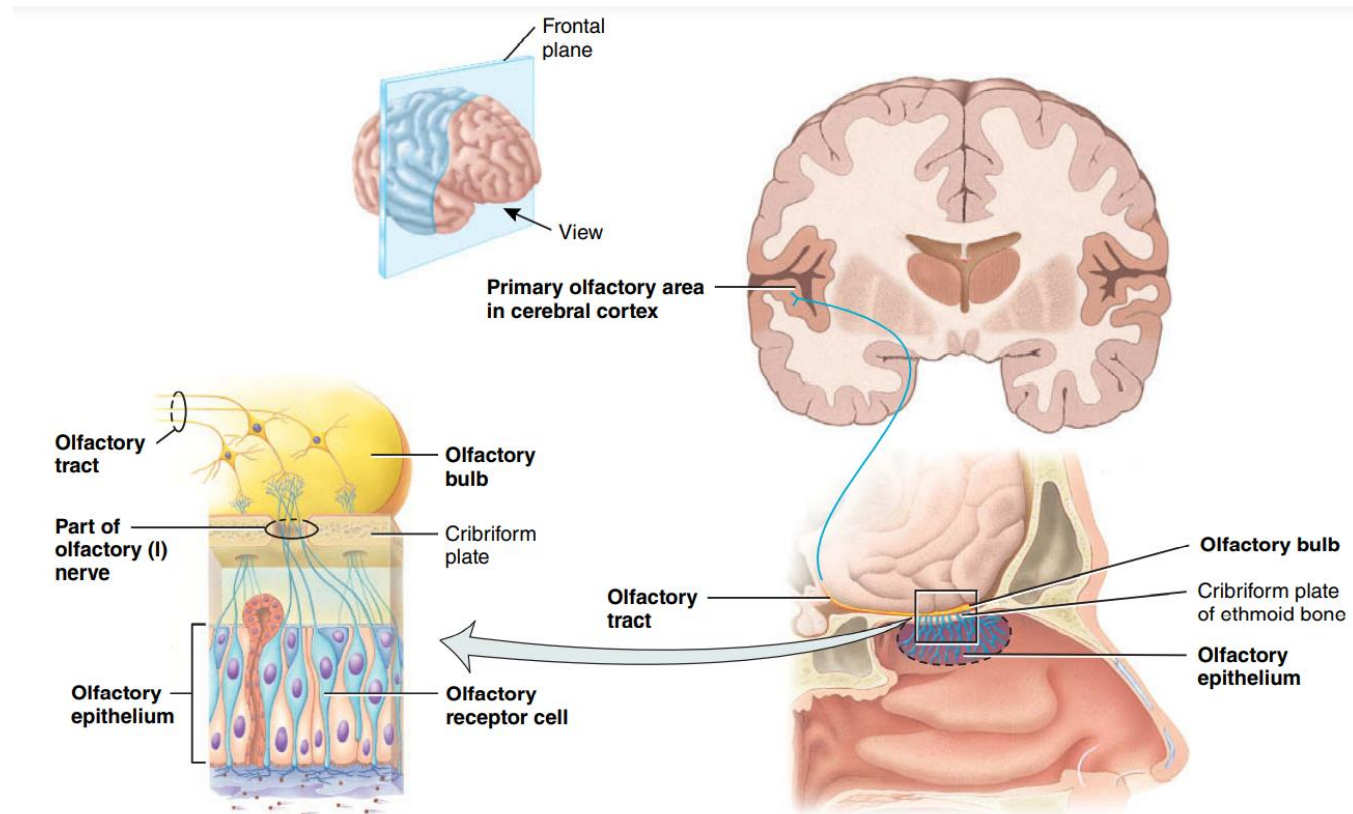
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# Special senses

- Olfaction (smell) and gustation (taste) are chemical senses.

In these senses, the stimulus is a chemical substance that binds to specific receptors.



# Olfactory epithelium

- Sensory receptors are located in the olfactory epithelium (membrane) which occupies the superior part of the **nasal cavity**, covering the **inferior surface of the cribriform plate** and extending along the superior nasal concha.
- The olfactory epithelium consists of three types of cells: **olfactory** receptor cells, **supporting** cells, and **basal** cells.

# Olfactory receptor cells

- 1) Olfactory receptor cell** is a bipolar neuron (first-order neuron of olfactory pathway) with an exposed, knob-shaped dendrite and an axon projecting through the cribriform plate that ends in the olfactory bulb, *to synapse with the second-order neuron.*

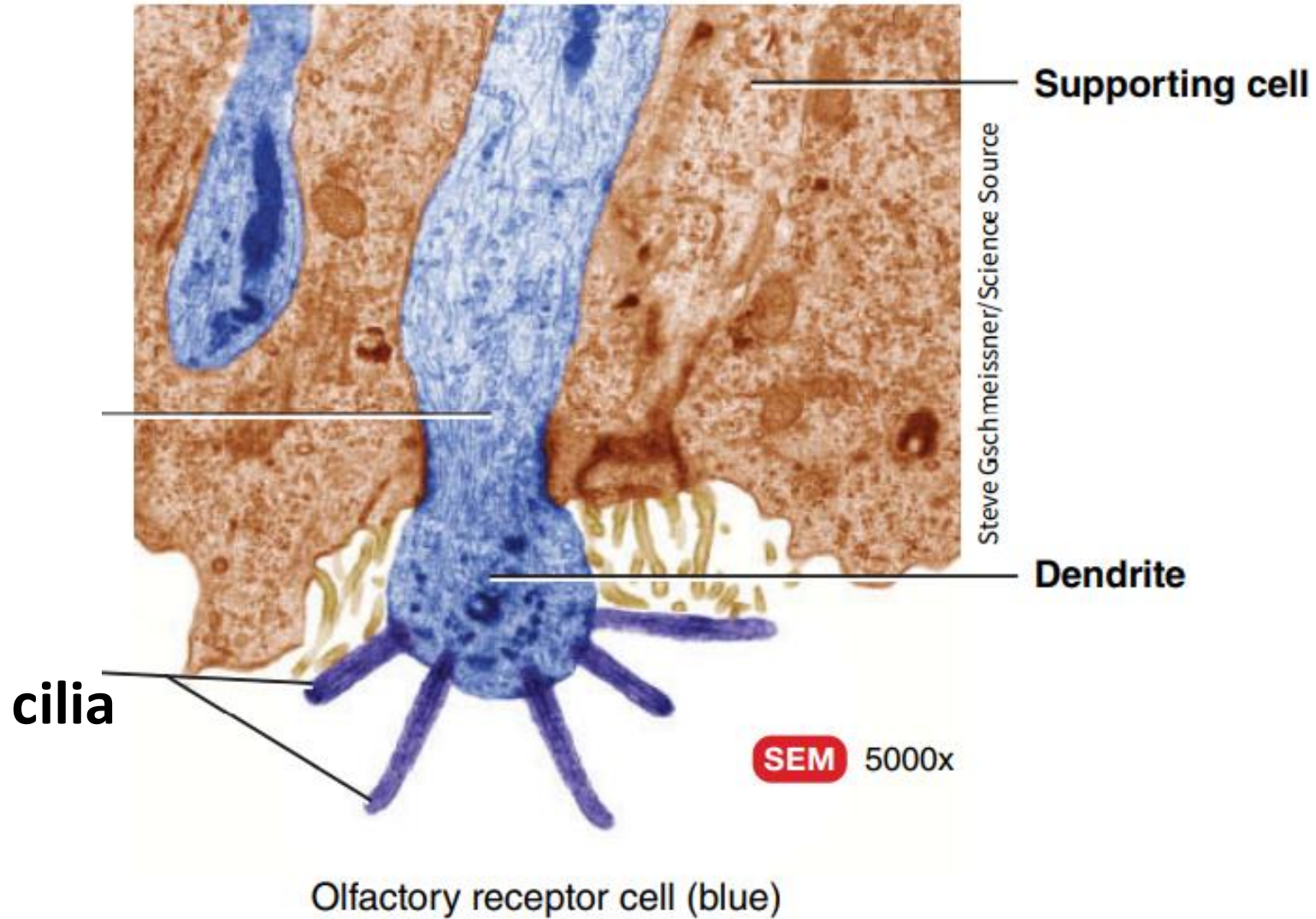
Extending from the dendrite of an olfactory receptor cell are several nonmotile olfactory **cilia**, which are the sites of olfactory transduction.

# Olfactory receptor cells

Within the plasma membranes of the **olfactory cilia** are **olfactory receptor proteins** that detect inhaled chemicals.

Chemicals that bind to and stimulate the olfactory receptors in the olfactory cilia are called odorants.

Olfactory receptor cells respond to the chemical stimulation of an odorant molecule by producing a receptor potential, thus initiating the olfactory response.



- This is an electron microscope image showing an olfactory receptor cell, which is the first-order neuron in this case.
- We can see the dendrites and nonmotile cilia extending from it, with the olfactory receptor proteins present on the cilia.

# Olfactory epithelium

**2) Supporting cells (sustentacular cells)** are columnar epithelial cells lined with microvilli at their mucosal border and filled with secretory granules.

**3) Basal cells** are located at the base of the olfactory epithelium and are undifferentiated stem cells that give rise to the olfactory receptor cells, **almost every 2-3 months**.

- Within the connective tissue that supports the olfactory epithelium are **Bowman's glands**, which produce mucus that moistens the surface of the olfactory epithelium and dissolves odorants so that transduction can occur.



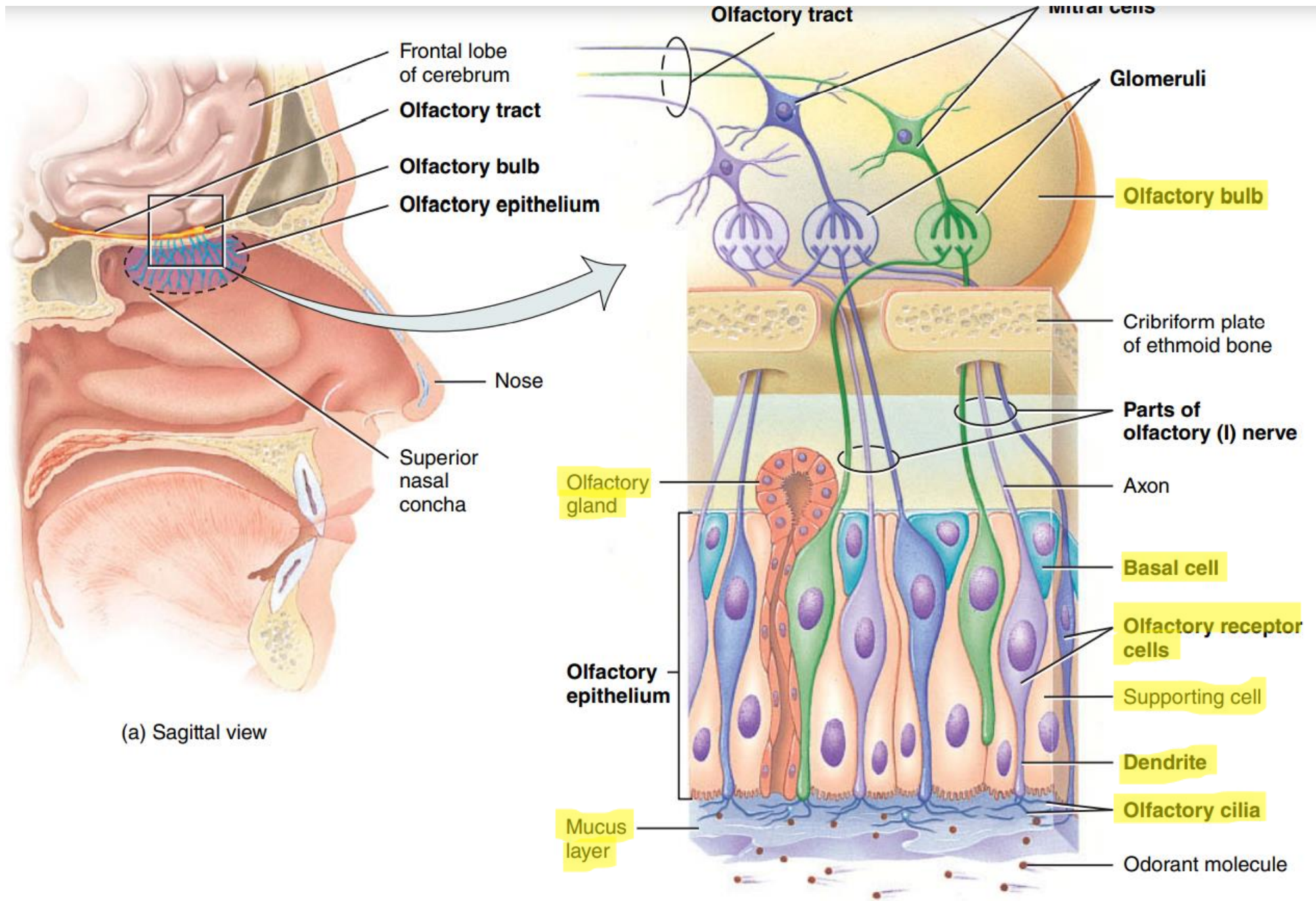
# Characteristics of odorants

- There are several physical factors affect the degree of stimulation.
- First, only **volatile** substances that can be sniffed into the nasal cavity can be smelled. Or it comes from the mouth while you are eating, some of these volatile molecules will come up through the pharynx to the olfactory epithelium.
- Second, the stimulating substance must be at least slightly **water-soluble** so that it can pass through the mucus to reach the olfactory cilia.

- This implies that there are certain substances, such as natural gas, that are odorless.
- However, it is crucial for our safety to detect gas leakage. To address this, companies add a small amount of **methyl mercaptan**, as little as one trillionth of a gram, to the gas. This minute quantity is enough for us to detect the odor and be alerted to the presence of the gas.

# Olfactory threshold

- The importance of this mechanism for activating olfactory nerves is that it greatly multiplies the excitatory effect of even the weakest odorant.
- Even a minute concentration of a specific odorant initiates a cascading effect that opens extremely large numbers of sodium channels. This process accounts for the exquisite **sensitivity** of the olfactory neurons to even the slightest amount of odorant.
- Olfaction, like all the special senses, has a **low threshold**. Only a few molecules of certain substances need to be present in air to be perceived as an odor.

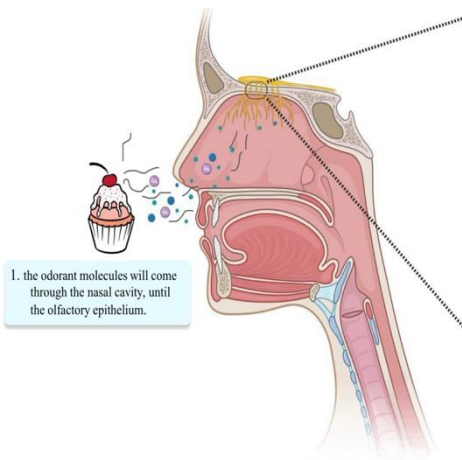


(a) Sagittal view

NOW, we will follow the smell of this delicious cupcake 🧁

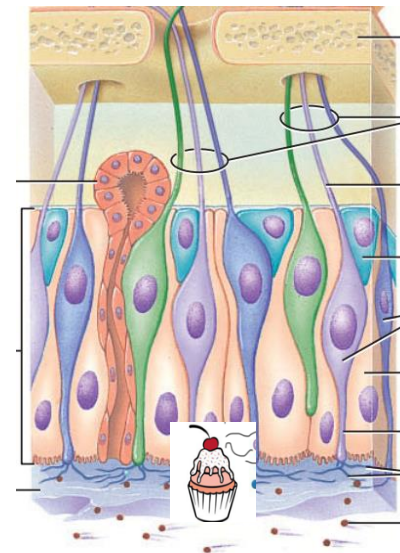


- The steps in olfactory transduction are as follows:
- 1. Odorant molecules bind to specific olfactory receptor proteins located on the cilia of olfactory receptor cells. Olfactory receptor proteins are members of the superfamily of G protein–coupled receptors, each encoded by a different gene and each found on a different olfactory receptor cell.



1. the odorant molecules will come through the nasal cavity, until the olfactory epithelium.

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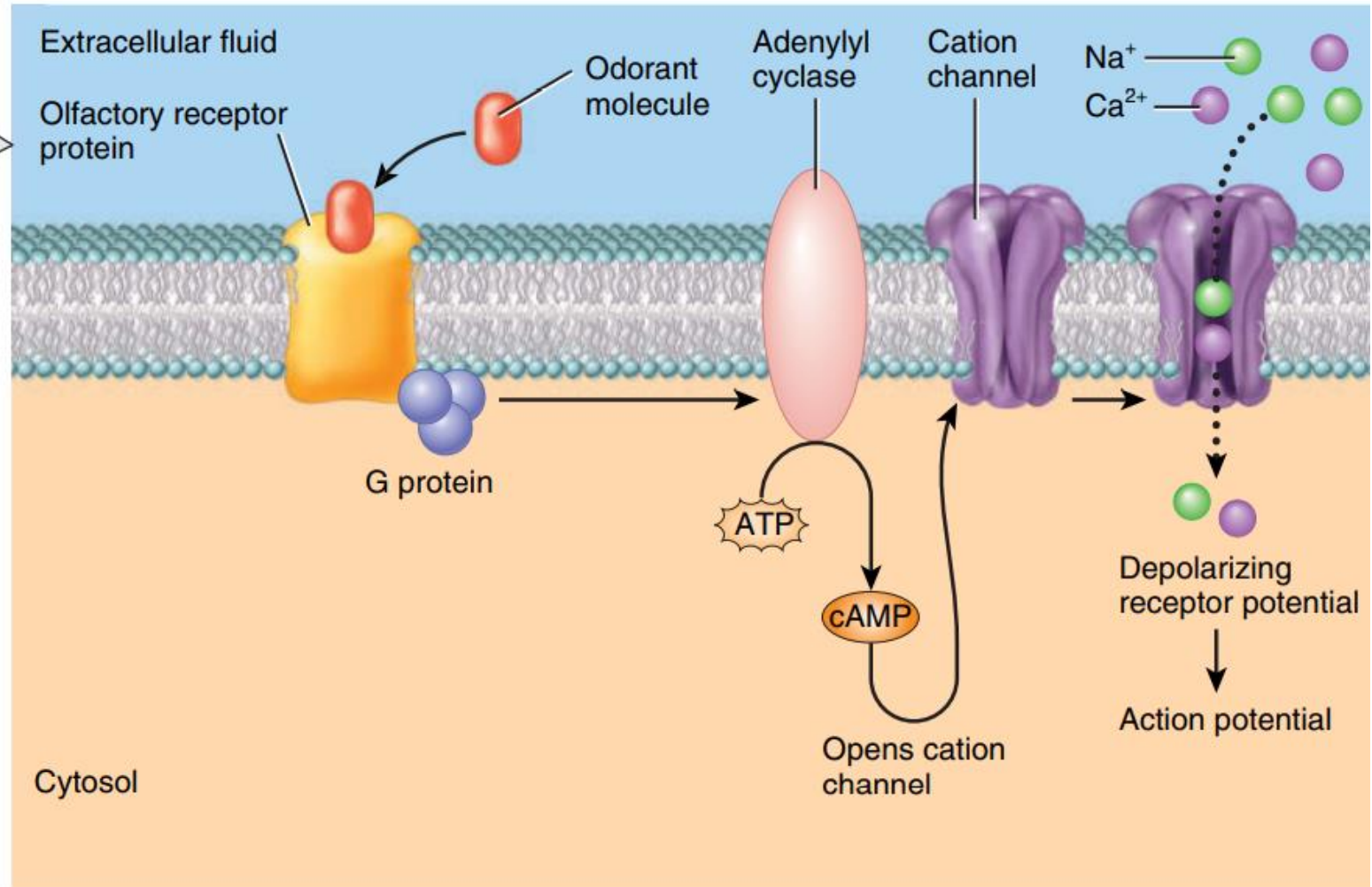
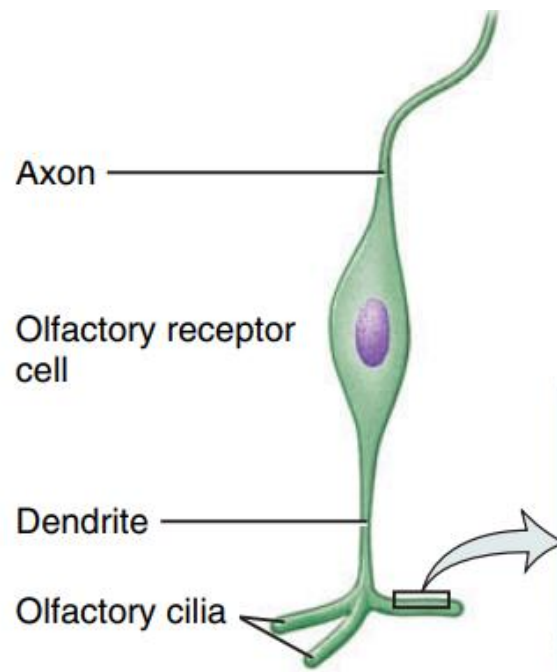
2. Once they reach the olfactory epithelium, they will dissolve in the mucus layer and bind to specific receptors on the cilia.

# Olfactory receptors

- Olfactory receptors are many types. Each type of olfactory receptor can react to only a select group of odorants. [for example: if it's a vanilla cupcake it will stimulate certain receptors, and if it's a chocolate cupcake it will stimulate other certain receptors, so we can differentiate between different odors]
- Genetic studies suggest the existence of hundreds of primary odors. Our ability to recognize about 10,000 different odors probably depends on patterns of activity in the brain that arise from activation of many different combinations of the olfactory receptor cells.

# Olfactory transduction

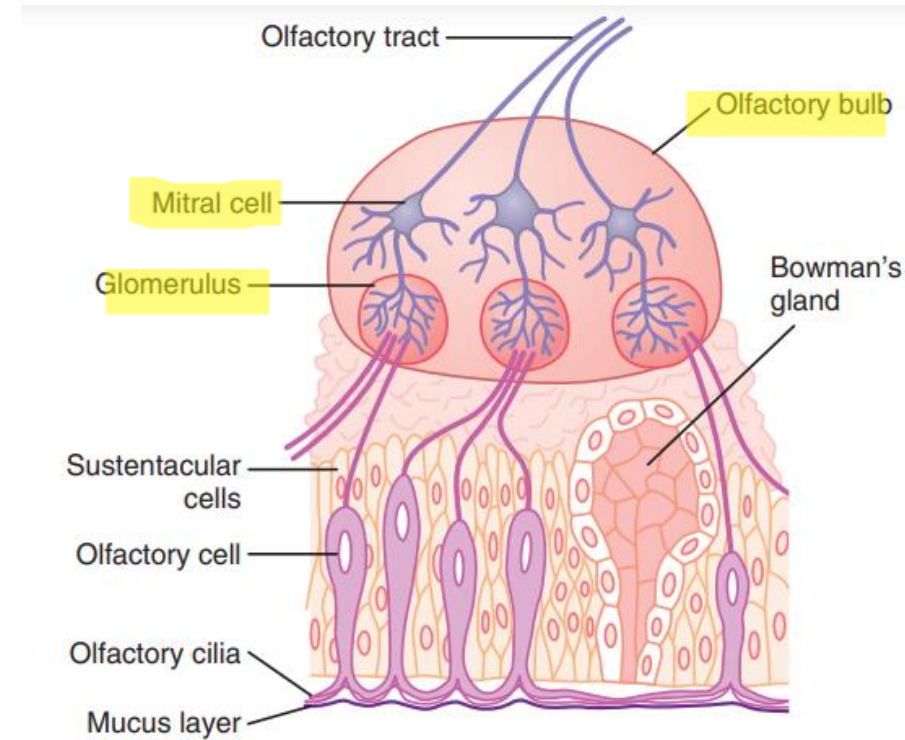
- 2. The olfactory receptor proteins are coupled to adenylyl cyclase via a **G protein**.
- 3. Adenylyl cyclase catalyzes the conversion of ATP to cAMP. Intracellular levels of cAMP increase, which opens cation channels in the cell membrane of the olfactory receptor, **mainly Na<sup>+</sup> channels**.
- 4. The receptor cell membrane depolarizes, **and generates receptor potential, then the action potential generates if it reaches the threshold**.
- 5. Action potentials are then generated and propagated along the olfactory nerve axons toward the olfactory bulb.



# Olfactory pathways

- Axons from the receptor cells leave the olfactory epithelium, pass through the cribriform plate, and synapse on apical dendrites of **mitral cells** (the second-order neurons) in the olfactory bulb. These synapses occur in clusters called **glomeruli**.
- In the glomeruli, the mitral cells are arranged in a single layer in the olfactory bulb and have lateral dendrites in addition to the apical dendrites.

Note: Different olfactory cells will synapse with different mitral cells in different glomerulus, this makes us precipitate different odors.





# Olfactory pathways

- The olfactory bulb also contains **granule cells** and **periglomerular cells** [interneurons]. The granule and periglomerular cells are inhibitory interneurons that make dendro-dendritic synapses on neighboring mitral cells. The inhibitory inputs may provide **lateral inhibition** that “sharpens” the information projected to the CNS.
- Mitral cells of the olfactory bulb project to higher centers in the CNS. As the olfactory tract approaches the base of the brain, it divides into two major tracts, a **lateral tract** and a **medial tract**.

# Olfactory pathways

- **The medial olfactory area or primitive olfactory system:**
- Consists of a group of nuclei located in the midbasal portions of the brain immediately anterior to the hypothalamus.
- Most nuclei feed into the hypothalamus and other primitive portions of the limbic system.
- This is the brain area most concerned with **basic behavior** and autonomic responses associated with olfaction, such as an increase in **salivation** (activation of superior and inferior salivary nuclei) and **gastric peristalsis/secretion** in response to the smell of food (interacts with dorsal vagal nucleus in the medulla), **and lip licking**.

# Olfactory pathways

- **The lateral olfactory area** contains the largest number of fibers in the olfactory tract and is responsible for the majority of functional olfactory transmission. [\[more advance than the medial\]](#)
- The primary olfactory cortex is the main site of olfactory information processing, through the integration of olfactory sensory information to encode, recognize, and contextualize scenarios.

# Olfactory pathways

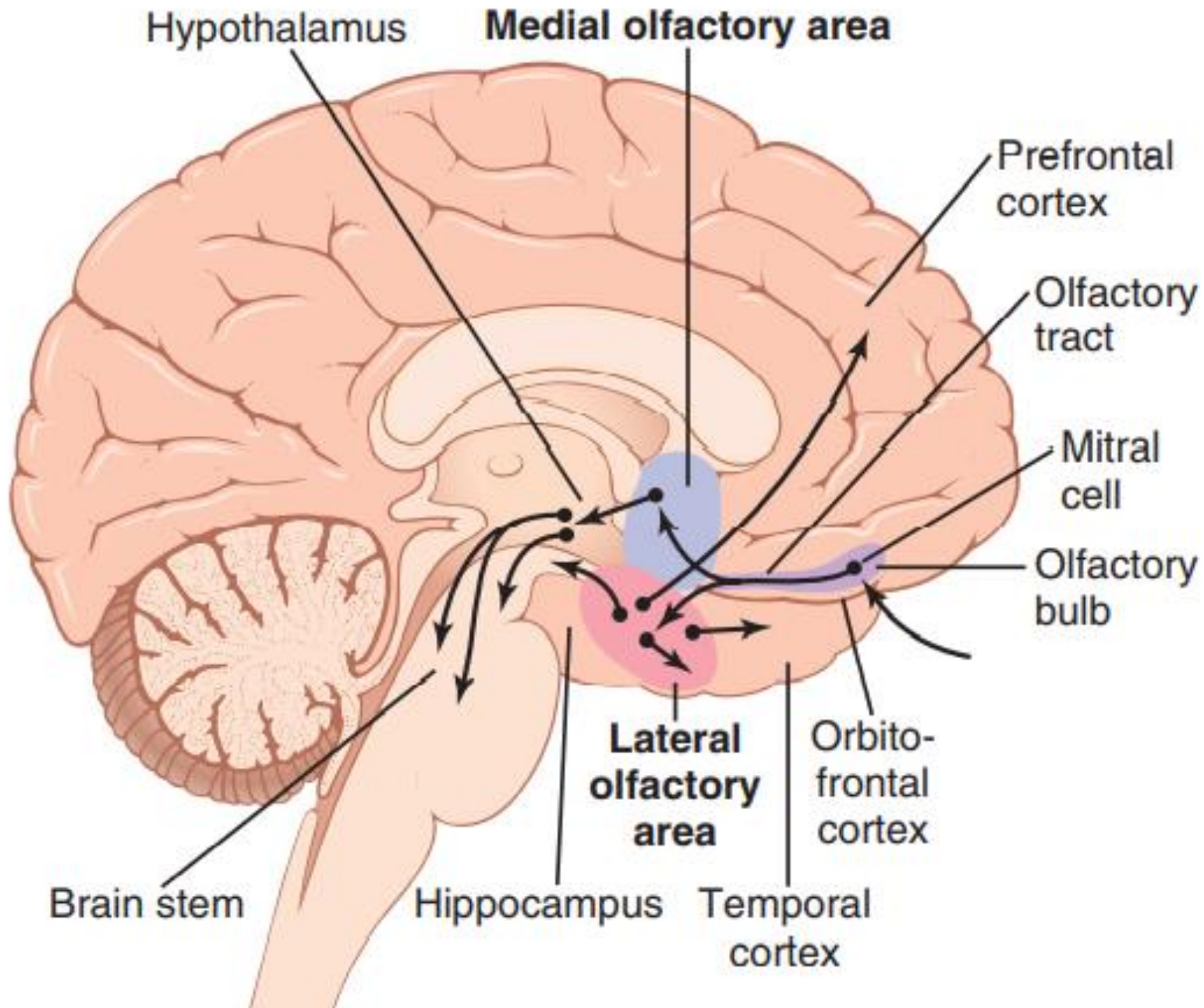
- **The lateral olfactory area:**
- Is composed mainly of the prepyriform and pyriform cortex plus the cortical portion of the amygdaloid nuclei.
- From these areas, signal pathways pass into almost all portions of the **limbic system** especially the **hippocampus**,
- which seem to be most important for **learning** to like or dislike certain foods depending on one's experiences with them, as well as the **emotional character of odors** and in the recalling of **memory** records.

The limbic system is a network of brain structures that are primarily involved in emotions, memory, and motivation.

# Olfaction pathway

- An important feature of the **lateral olfactory** area is that many signal pathways from this area also feed directly into an older part of the cerebral cortex called the **paleocortex** in the anteromedial portion of the temporal lobe.
- **This area is the only area of the entire cerebral cortex where sensory signals pass directly to the cortex without passing first through the thalamus.**

However, there is another one besides these two [medial & lateral] for perception by sending information to the cortex, but it's not well understood .



- Olfactory receptors are rapidly adapting, after a short time we no longer smell anything, due to the adapting in the **receptors level**.
- However, there are some studies suggest that there is adaptation in the **CNS level** by negative feedback mechanisms send to the olfactory bulb.

# Affective Nature of Smell

- Smell, even more so than taste, has the affective quality of either pleasantness or unpleasantness, and thus smell is probably even more important than taste for the selection of food.
- Indeed, a person who has previously eaten food that disagreed with him or her is often nauseated by the smell of that same food on a second occasion. Conversely, perfume of the right quality can be a powerful stimulant of human emotions.

اللَّهُمَّ بَلِّغْنَا مَا نُوَدِّعُ  
وَاجْعَلْ لَنَا دَعْوَةً لَا تُرَدُّ  
وَهَبْ لَنَا رِزْقًا لَا يُعَدُّ  
وَافْتَحْ لَنَا لِلْجَنَّةِ بَابًا لَا يُسَدُّ

VERSIONS	SLIDE #	BEFORE CORRECTION	AFTER CORRECTION
V1→ V2			
V2→V3			



امسح الرمز و شاركنا بأفكارك لتحسين أدائنا !!