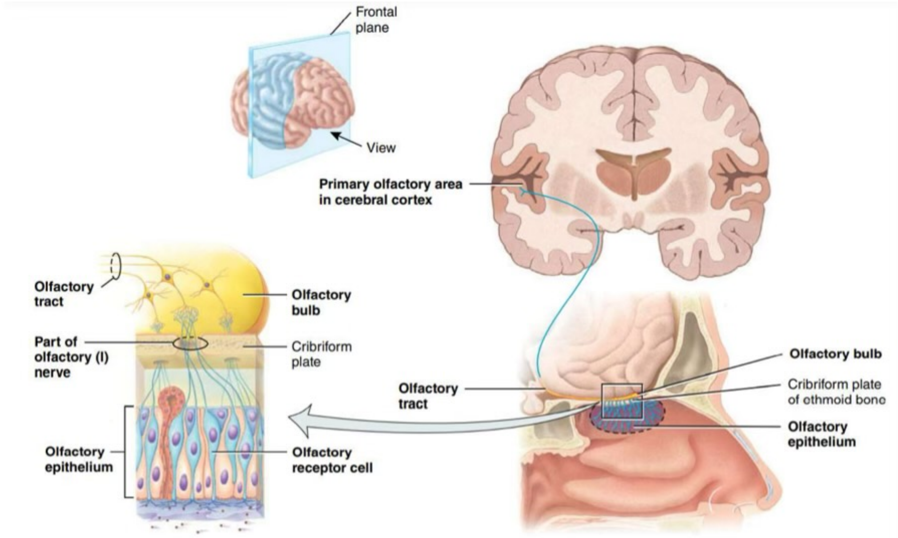
Olfaction

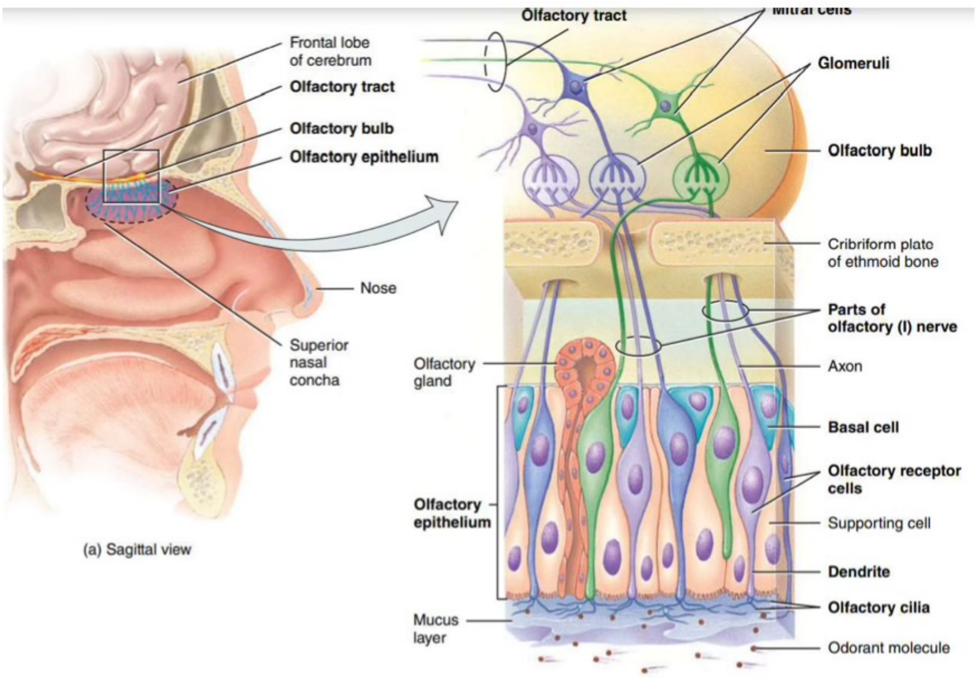
Special senses

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



Olfactory epithelium

- Olfactory epithelium (membrane) 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.
- Supporting cells (sustentacular cells) are columnar epithelial cells lined with microvilli at their mucosal border and filled with secretory granules.
- Basal cells are located at the base of the olfactory epithelium and are undifferentiated stem cells that give rise to the olfactory receptor cells.
- 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.

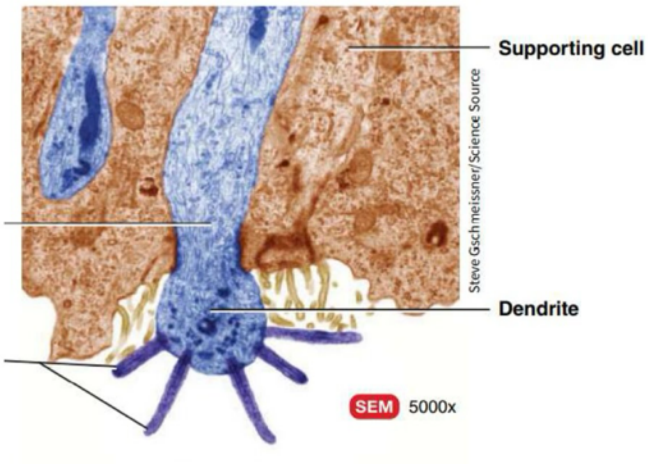


Olfactory receptor cells

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

Olfactory receptors

- Olfactory receptors are many types. Each type of olfactory
receptor can react to only a select group of odorants.
- Genetic studies suggest the existence of hundreds of primary odors .



Olfactory receptor cell (blue)

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.

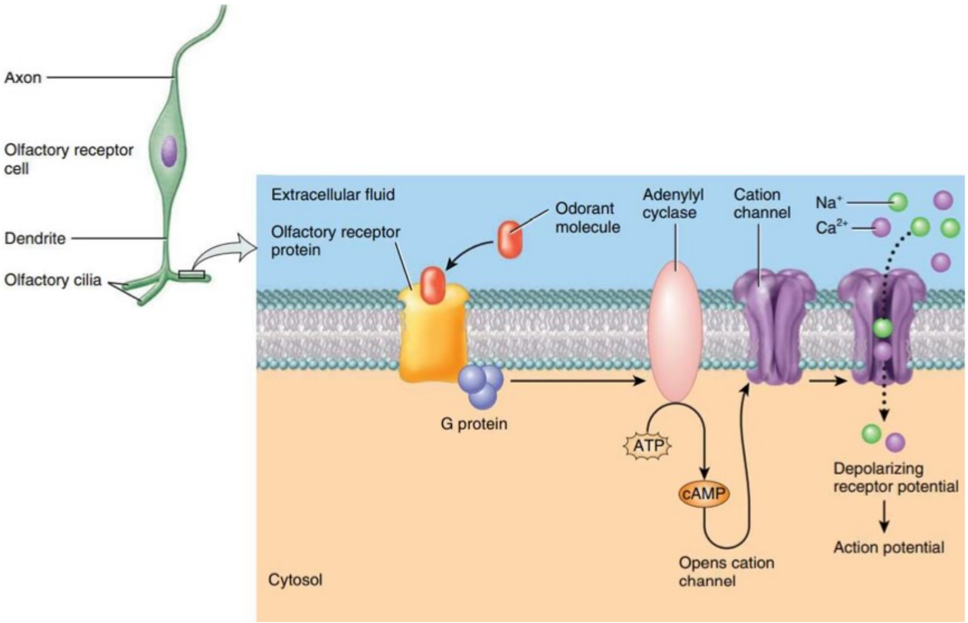
Olfactory transduction

- 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.
- 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.

• 4. The receptor cell membrane depolarizes.

• 5. Action potentials are then generated and propagated along the olfactory nerve axons toward the olfactory bulb



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.

Characteristics of odorants

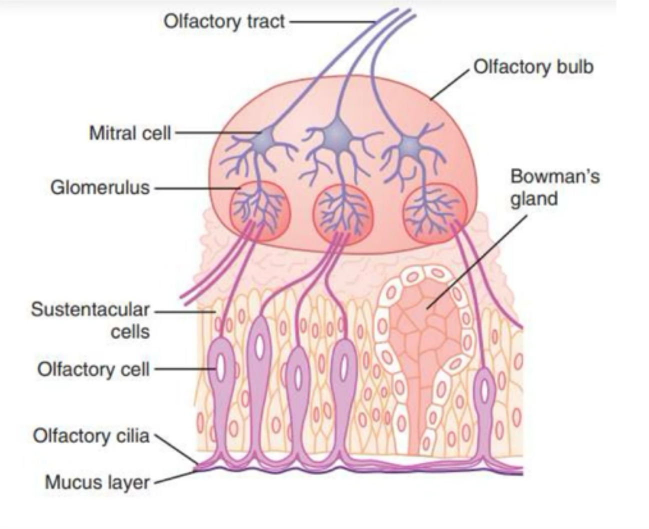
• There are several physical factors affect the degree of stimulation.

• First, only volatile substances that can be sniffed into the nasal cavity can be smelled.

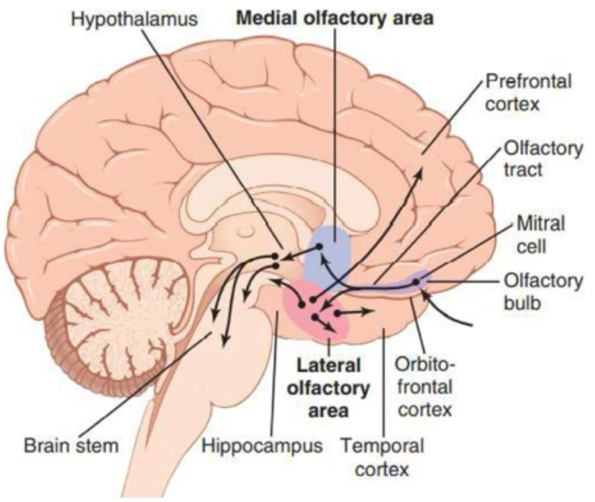
• Second, the stimulating substance must be at least slightly water-soluble so that it can pass through the mucus to reach the olfactory cilia.

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.
- The olfactory bulb also contains granule cells and periglomerular cells. 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.
- 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).

• The lateral olfactory area contains the largest number of fibers in the olfactory tract and is responsible for the majority of functional olfactory transmission.
• 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.

• 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.

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.

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

Adaptation of olfactory sensations

- The olfactory receptors adapt about 50 percent in the first second or so after stimulation. Thereafter, they adapt very little and very slowly.
- Most of the adaptation occurs within the central nervous system, which seems to be true for the adaptation of taste sensations as well.
- The suggested neuronal mechanism for the adaptation is: Large numbers of centrifugal nerve fibers pass from the olfactory regions of the brain backward along the olfactory tract and terminate on special inhibitory cells in the olfactory bulb, the granule cells.