CNS PHYSIOLOGY

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Writer: Sarah Basel

Science: Ameen Alsaras

Final: Obada Froukh

Doctor: Faisal Mohammad

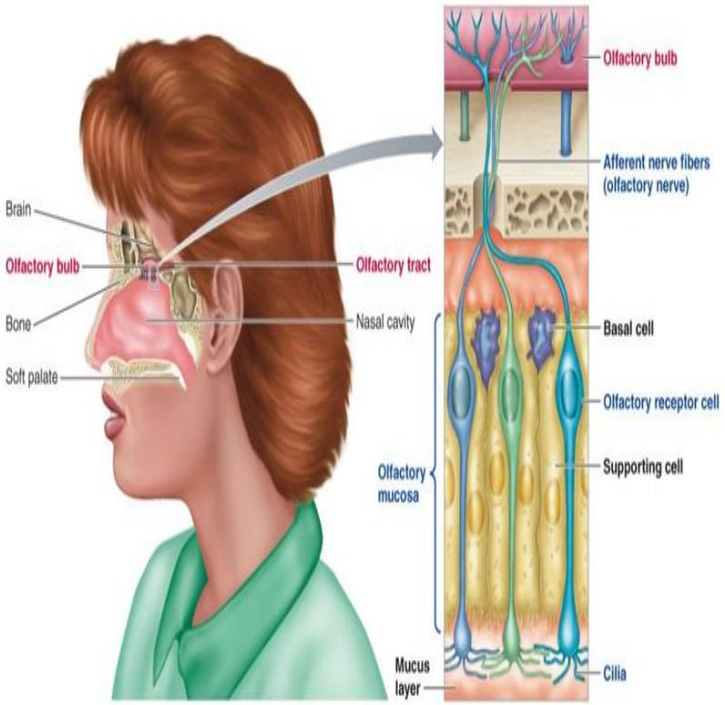
"Odors have a power of persuasion stronger than words, appearances, emotions, or will. The persuasive power of an odor cannot be fended off, it enters into us like breath into our lungs, it fills us up, imbues us totally. There is no remedy for it.

Patrick Süskind. **What is so special about this sense?**

Olfaction

- Just like taste sensation, the receptors for smell are **chemoreceptors**, which generate neural signals upon binding with particular chemicals (**odorant molecule**).

- The olfactory mucosa in the ceiling of the nasal cavity (superior part of each nostril), contains the olfactory receptor cells, supporting cells, and olfactory glands that secrete mucous.



- Olfactory receptors are actual neurons (Bipolar) but as an exception these neuronal cells **can regenerate** and are replaced every around 30-45 days, the olfactory receptor cell is an **afferent neuron** whose receptor portion lies in the olfactory mucosa and its afferent axon synapses with mitral cells. The axons of these cells collectively form the **olfactory nerve**.
- The receptor portion of an olfactory cell consists of an enlarged knob bearing several long cilia that extend to the surface of the mucosa, these cilia contain the binding sites for **odorants** (molecules that can be smelled) attachment.

- To be smelled, a substance must be:
  1. Sufficiently **volatile** (easily vaporized) that some of its molecules can enter the nose in the inspired air. Have you ever asked yourself why perfumes are diluted? It's not that manufactures are stingy. The reason behind diluting perfumes with alcohols is to spread out the smells so that you can distinguish them. If a perfume is oily, you wouldn't be able to distinguish separate smells. Smelling it would be like hearing an orchestra playing all the notes in a symphony at once.
  2. At least **slightly water soluble** that it can dissolve in the mucous coating of the olfactory mucosa.
  3. At least **slightly lipid soluble** to interact with the membrane which is basically phospholipids.

Olfaction signal pathway;

- The afferent fibers in the nose pass through tiny holes in the cribriform plate that separates the olfactory mucosa from the overlying brain. These fibers immediately synapse in the **olfactory bulb**. Each olfactory bulb is lined by neural junctions known as (glomeruli "little balls"). Within each glomerulus the terminals of receptor cells synapse with the next cell in the olfactory pathway, the **mitral cells**.
- A single odor usually contains multiple components. Your favorite perfume is not made of a single material, usually perfumes are manufactured by combining different scents/ fragrances. This simple fact raises some questions: What makes us capable of differentiating between different odors? How can we recognize different odor components in a mixture? How is the olfactory message decoded? The answer is simple, like every other sensation in our body, receptors play the major role and sort things out. During smell detection an odor is "dissected" into various components (Jasmine, Amber, …). Each receptor responds to only one discrete component of an odor rather than to the whole odorant molecule. This is the same as the three cone types that code vision, and the different taste buds that accomplish coding for taste discrimination

"labelled lines", this mechanism of sorting ensures odor discrimination by different patterns of glomeruli activity, in this way the cortex can distinguish different odors.

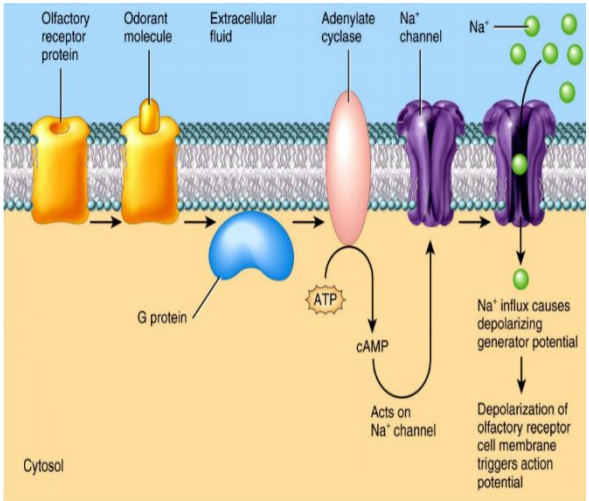
- Each glomerulus receives signals only from receptors that detect a particular odor component serving as "smell files". The separate components of an odor are sorted into different glomeruli, one component per file.
- The mitral cells rely the smell signal to the brain for further processing.

Primary Sensations of Smell:

The human nose contains millions of olfactory receptors, of which there are 1000 different types that detects different components:

- Camphoraceous
- Musky
- floral
- pepperminty
- ethereal
- pungent
- putrid

Olfactory transduction:



1. Binding of an appropriate odor component activates the receptor.
2. The activated receptor stimulates a G-protein.
3. The α-subunit disassociates and activates the enzyme adenylate cyclase, that converts ATP into cAMP.
4. Increases in cAMP causes the opening of Na+ channels, the resultant net Na+ entry causes a depolarizing receptor potential that induces the release of neurotransmitters (glutamate mainly).
5. This generates action potentials in the afferent fiber.

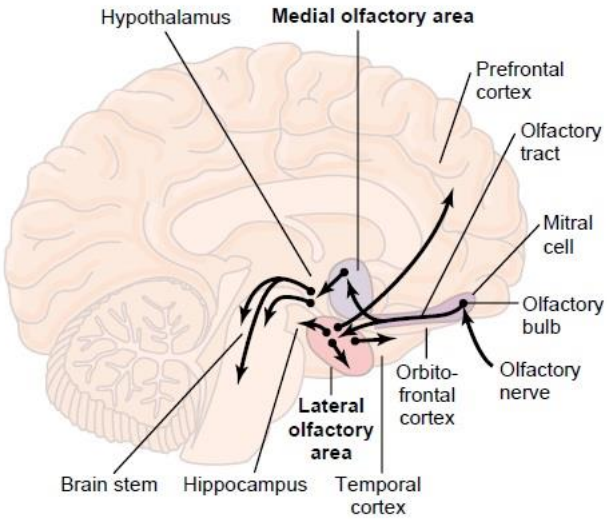
- The frequency of action potentials depends on the concentration of the stimulating chemical molecules.
- cAMP activates a cAMP dependent kinase which phosphorylates the channel and activate it indirectly.

The human olfactory system is effective in distinguishing different odors, but despite this impressive sensitivity, humans have a poor sense of smell compared to other species.

Transmission of Smell Sensation to CNS:

Fibers leaving the olfactory bulb travel in two different routes:

A. **Old tract passes medially** primarily to regions of the limbic system, especially the lower medial sides of the temporal lobes (considered the primary olfactory cortex).



medial olfactory area of the brain stem (very old tract) → septal nuclei to hypothalamus and limbic system. This route, which includes the hypothalamic and limbic involvement, permit coordination between smell and behavioral reactions associated with feeding (licking lips, salivation, and other feeding responses caused by smell of food) or by primitive emotional drive associated with smell (like mating).

B. **Another passes laterally to the lateral olfactory area:**

- **Less old-** prepyriform, pyriform cortex and cortical portion of amygdaloid nuclei. Paleocortex and anteromedial portion of the temporal lobe, **Limbic system and hippocampus**. For learning to like or

dislike certain food depending on past experiences with them and also food aversion to nauseated food.

- **The newer pathway:** passes through the thalamus to the cortex. dorsomedial nucleus of the thalamus → lateroposterior quadrant of the orbitofrontal cortex. As with other senses, the cortical route is important for conscious perception and fine discrimination of smell → gives a meaning to what you smell. (remember we once said that olfaction is the only sensation that does not pass through the thalamus, this tract is considered an exception of olfactory sensation because it passes through the thalamic route up to the cortex).

The olfactory system adapts quickly:

Although the olfactory system is sensitive and highly discriminative, it also adapts quickly. Sensitivity to a new odor diminishes rapidly after a short period of exposure to it, even though the odor source continues to be present. This reduced sensitivity does not involve receptor adaptation, actually the olfactory receptors themselves adapt slowly. It apparently involves some sort of adaptation process in the CNS.

- Our body becomes desensitized to certain stimuli after prolonged exposure in order to prevent overloading of the nervous system, thus allowing it to respond to new stimuli that are "out of ordinary", perfume companies try to keep pace with this rapidly adapting sense by manufacturing new " out of ordinary" perfumes every once in a while

Smell and Taste Abnormalities:

- **Anosmia:** loss of smell sensation.
- Loss of taste sensation due to nerve damage.
  Taste perception is also influenced by information derived from other receptors, especially odor. When you temporarily lose your sense of smell during cold, your sense of taste is also markedly reduced, even though your taste receptors are not affected by the cold (the exact mechanism is still unknown).