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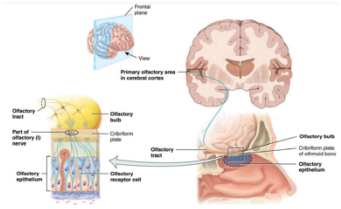
Olfaction

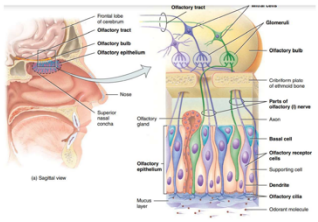
Special senses

- **Olfaction** (smell) and **gustation** (taste) are **chemical senses**.
  - This means that the **stimulus** is a **chemical substance** that will **bind** to a **receptor**



Olfactory epithelium

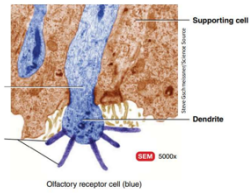
- **Olfactory epithelium** (membrane) **occupies** the **superior part of** the **nasal cavity**, **covering** the **inferior surface** of the **cribriform plate** and **extending along** the **superior nasal concha**.
- The **olfactory epithelium consists** of **three types of cells**:
  - 1. **olfactory receptor cells**
  - 2. **supporting cells**
    - **Supporting cells** (sustentacular cells) are **columnar epithelial cells lined with microvilli** at their **mucosal border** and **filled with secretory granules**.



  - 3. **basal cells**.
    - **Basal cells** are **located** at the **base** of the **olfactory epithelium** and are **undifferentiated stem cells** that **give rise** to the **olfactory receptor cells**.
      - **Responsible** for **regeneration** of these **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.**
- The **olfactory epithelium also contains glands** that **secrete mucus** which is **important** for **covering** the **cilia** that **contain receptor proteins**
- In **order** for **any substance** to be **smelled** it **has** to **have two conditions**
  - 1. **Volatile**
    - can **move from** the **air to** the **nasal cavity** to the **olfactory epithelium** or **can come form** the **mouth up** to the **pharynx to** the **olfactory epithelium**,
  - 2. **Water soluble**
    - to be **dissolved in** the **mucus layer** to **bind to the receptor**

- ☐ There are **some substances we cant smell** like the **natural** but it's **important for us** to be able **to smell** it so **companies add** a **substance** to **make us able** to **smell** it in **which we only need 1 millionth of a gram of concentration for us to smell it**
- **In general** the **smell sensation/olfaction** is **very sensitive** has a **low threshold** so **only** a **few molecule** is **needed form** that **substance** to be **sensed** and **smelled**

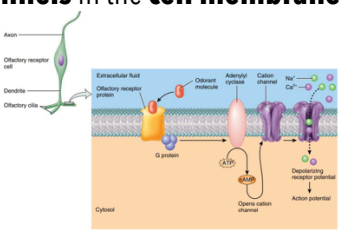
Olfactory receptor cells



- 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**.
  - The **olfactory receptor proteins** are **present here on the cilia**
- 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** 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.
- **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 **open cation channels** in the **cell membrane** of the **olfactory receptor**
  - 4. The **receptor cell membrane depolarizes**



- 5. **Action potentials** are then **generated** and **propogated along** the **olfactory nerve axons towards the olfactory bulb**

Olfactory threshold

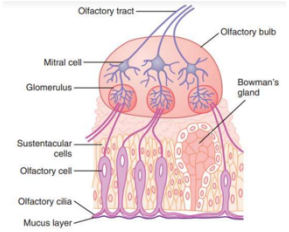
- The **importance** of this **mechanism** for **activating olfactory nerves** is that it **greatly multiplies** the **excitatory effect** of **even the weakest odorant**.
- Even a minute **concentration** of a **specific odorant initiates** a **cascading effect** that **opens extremely large numbers 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**

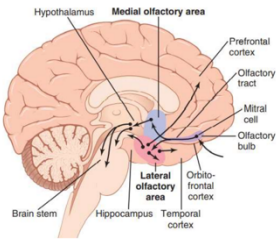
Olfactory pathways

- **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 ad**aptation** 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**.