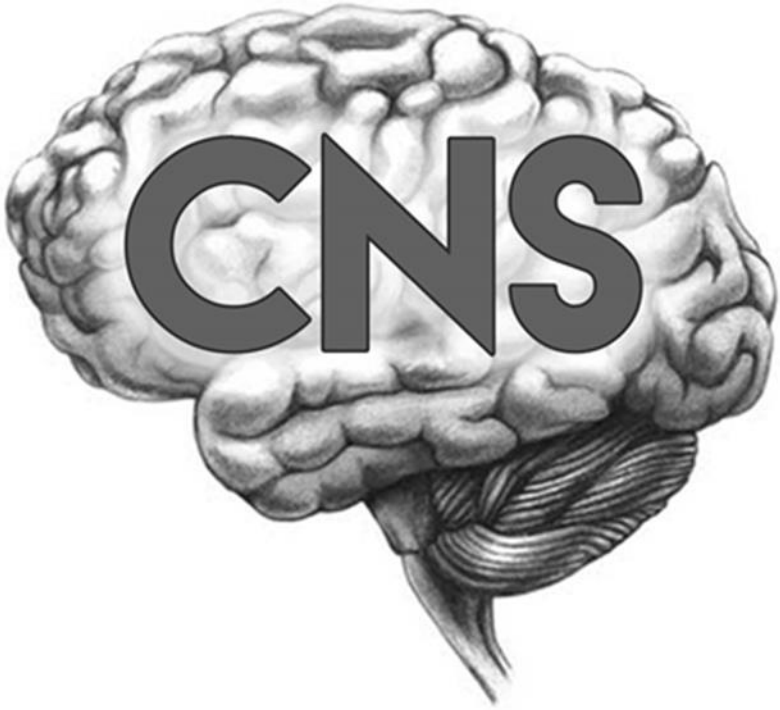

PHYSIOLOGY

☑ Sheet ○ Slide ○ Handout

Number

19

Subject

Gustatory & Olfactory Sensations

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Date: 00/00/2016

Price:

بسم الله الرحمن الرحيم

- This sheet was written according to section 1 recording
- I'm really sorry for taking this long to write this one☹

Olfactory and Gustatory Senses (Smell and Taste)

- They are primitive sensations, especially the olfaction as it is not well developed in humans
- Taste and smell are chemical sensations, allows one to separate undesirable or lethal foods from those that are nutritious
- recognize the proximity of other individuals or animals
- tied to primitive emotional and behavioral functions of the nervous system, like when we smell good pleasant sensation we smile and if it was unpleasant smell we "grimace" and may vomit,

Gustatory (Taste)

➢ There are too many substances that might stimulate chemical receptors, around 13 possible chemical receptors in **taste buds**:

- 2 for sodium

- 2 for potassium

- chloride

- adenosine

- inosine

- 2 sweet

- 2 bitter

- glutamate

- hydrogen ion

❖ Primary Sensation of Taste:

- We can perceive hundreds of different tastes
- Yet We have 5 primary taste sensation: *"It is similar to the perception of color"*

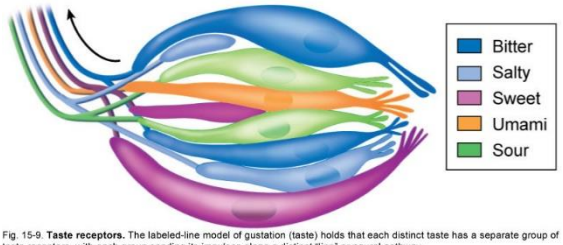


Fig. 15-9. **Taste receptors.** The labeled-line model of gustation (taste) holds that each distinct taste has a separate group of taste receptors, with each group sending its impulses along a distinct "line" or neural pathway.

1. Sour
   - caused by acid concentration
2. Salty
   - caused by ionized salts (e.g Na+)
3. Sweet:
   - many chemicals mostly organic compounds
4. Bitter
   - long chain organic substances containing nitrogen
   - Alkaloids (drugs)
5. Umami
   - Not familiar (special sensation), a distinctive and delicious taste associated with certain amino acids such as glutamate and arginine (meats)

❖ Location of Taste Buds:

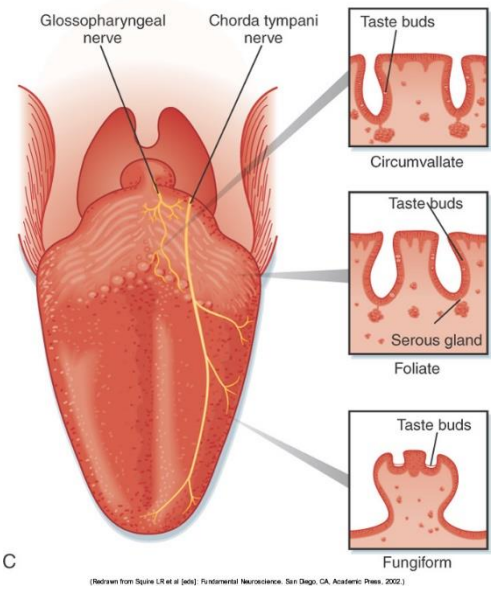
- Found on three types of papillae of the tongue:
  1. Circumvallate:

     form a V on the posterior surface of the tongue (the posterior 1/3rd of the tongue)
  2. foliate:

     located along the lateral surfaces of the tongue
  3. fungiform:

     located over the flat surface of the tongue
  4. extra-glossal taste buds:

     on the tonsillar pillars, palate, epiglottis, and proximal esophagus



(Redrawn from Squire LR et al [eds]: Fundamental Neuroscience. San Diego, CA, Academic Press, 2002.)

◘ Innervation:

"the posterior 1/3rd of the tongue is developed from a completely different part than the anterior 2/3rds of the tongue, and that's why the innervated by different nerves"

**Just Like the anterior & posterior parts of the pituitary gland,*

Now:

- the posterior 1/3 of the tongue is innervated by the **glossopharyngeal** nerve,
- the anterior 2/3 is innervated by the **facial** nerve.
- there are also some taste buds that are located in the pharynx and they are innervated by the **vagus** nerve!
- The taste sensation from all of these nerves is transmitted to the solitary nucleus (in medulla oblongata) → thalamus → cortex

❖ Taste threshold:

- The threshold for all taste sensations is very low but relatively some are lower than the others:

  - Bitter are usually toxic, so their threshold is very small "the lowest", their receptors are located far back in the tongue (in the posterior 3rd) close to the pharynx, why?

    - Because if there are stimulated by a toxic material, they will induce vomiting. (this is how they are related to nutritious & lethal materials)

  - The sour & umami have a medium threshold
  - The highest threshold is for salt and sweet

taste and smell receptors in contrast to all other receptors in other systems are able to regenerate.

Taste receptors are epithelial cells, so they can regenerate every 2 weeks.

While smell receptors are neurons and yet they have the ability to regenerate!

Yet they take longer time than the taste receptors

Taste Buds Facts

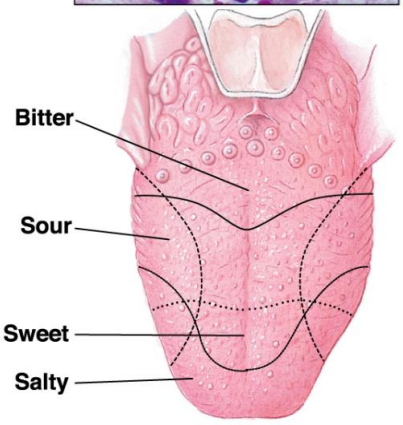
- Adults have *3-10,000 buds,* children have **more**
- Taste receptors are **epithelial** cells able to regenerate every 2 weeks
- *Beyond age 45 taste buds start to degenerate, taste becomes less critical*

- Location of the receptors:

Sweet and salty buds located on the tip of the tongue *(example: we taste the ice cream by the tip of the tongue)*

Sour buds on the lateral sides of the tongue

Bitter buds are located on the posterior tongue and soft palate



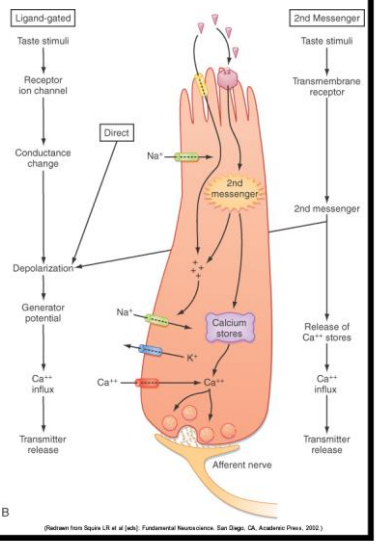
Transduction of taste mechanism:

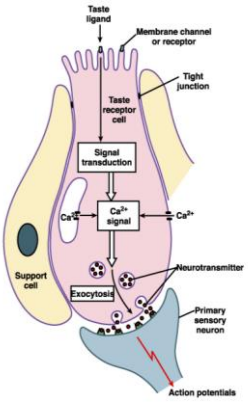
- Taste substance binds to the receptors on the membrane
  - This binding may induce:

A. Opening of ion channels, if the ion channel was Na, it will cause depolarization in the cell, allowing the entry of Ca^{+2} which releases the neurotransmitters from it (Glutamate most probably)

B. Closing of K channels, will cause reduction of K loss → depolarization etc...

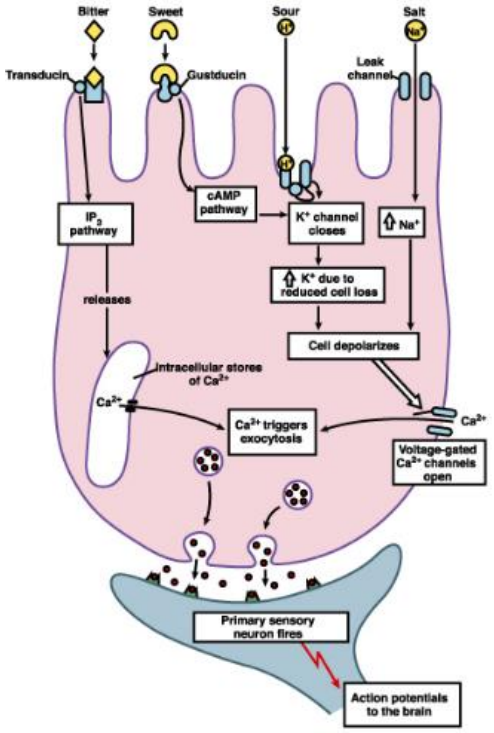
C. Other substances have the mechanism of the <u>second messenger</u>,
   i) activation of G protein → ↑cAMP → certain effect → neurotransmitter release
   ii) stimulation of IP3 pathway → causes the release of Ca^{+2} from the ER etc…





❖ **Each type of taste has a certain mechanism:**

I. Salt: opening of Na channels
II. Sweet & bitter: second messenger mechanism
III. Sour: closing of K channels



- All these mechanisms will cause the increment of Ca concentration & the release of neurotransmitters.
- This will lead to generation of AP in the afferent neuron

Adaptation of Taste & Abnormalities

- taste sensations adapt rapidly, but smell adapts even faster
- adaptation of the taste buds themselves accounts for only about 50% of the adaptation *(in 1 minute)*
- central adaptation must occur but the mechanism for this is not known

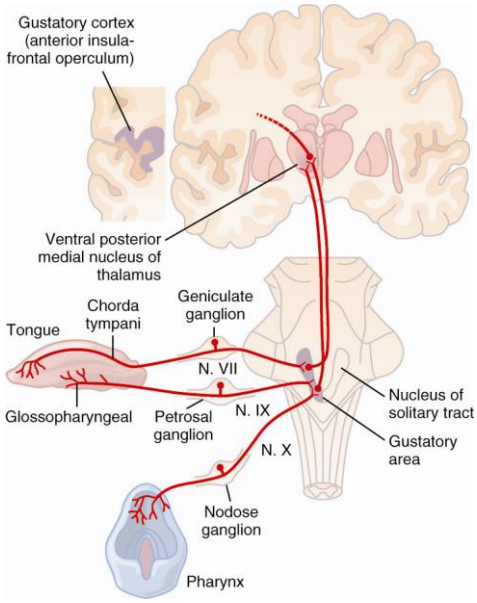
- the loss of taste sensation is called **Ageusia**
- **Dysgeusia** is the disturbance of taste sensation
- There's also **Hypergeusia & Hypogeusia**

Taste Pathways:

- It is usually Bilateral but predominantly uncrossed

- Anterior 2/3 **facial** n., Posterior 1/3 **glossopharyngeal** n., The pharynx part **Vagus** n.

- These 3 nerves go to the medulla oblongata **(solitary nucleus)** → thalamus **(VPM)** → cortex **(insula)**



- Then from the insula the fibers will go to the orbitofrontal part of the cortex
- The orbitofrontal cortex receives information from taste, smell & vision, that's why taste sensation is related to these other two!

○ e.g.: when someone has common cold, in addition to loss of olfaction, he may lose his tasting ability due to this relation, which causes inhibition of this sensation "and sometimes the vision may also be affected"

- The orbitofrontal cortex is connected to the hypothalamus & amygdala which affects the emotional, motivational, memory and other behavioral factors

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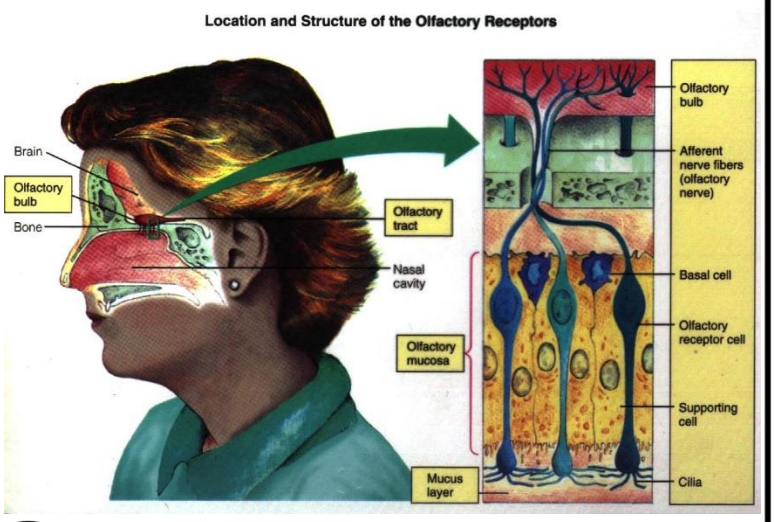
OLFACTION (SMELL)

- Smell is very primitive and <u>more developed in lower animals</u> compared to humans. There's no primary smell sensation (i.e. colors are classified in a list, but smells can't be classified).
- Smell receptors are real (bipolar) neurons, but needs longer time to regenerate (30-45 days) compared to taste receptors *"taste receptors are epithelial cells".*
- These receptors are located at the <u>superior nasal concha.</u>
- Also, the receptors have **<u>Cilia</u>** covered by mucus that is secreted from glands in between these receptors. (on the cilia, there are odorant-binding proteins):
  - binding of chemical to those proteins induces the G-protein
  - transduced formation of cAMP which opens ion channels



- We have supporting (nutritional) cells too.
- The axons of the bipolar neurons pierce the **ethmoid** bone to form the **<u>cribriform</u>** plate.

E.g. person with ethmoid fracture due to car accident loses smell sensation as the olfactory nerve is damaged.

- After it enters the bone, it will form the olfactory bulb where axons synapse with globular cells called glomeruli, and these merges to go directly to the cortex (not the thalamus)

❖ Characteristics of substance to be Smelled:

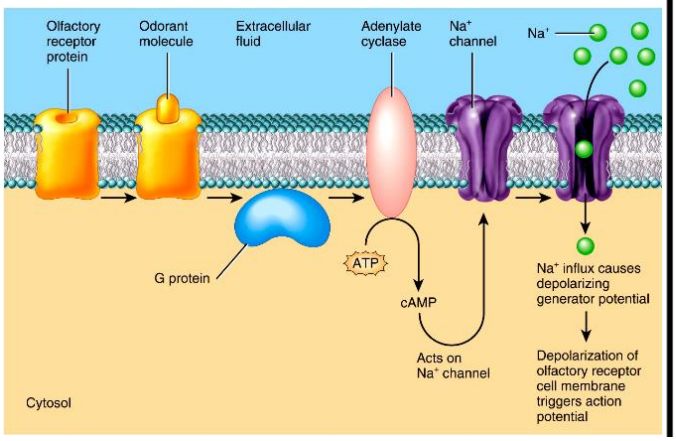
- substance must be volatile so that it can be sniffed into the nostrils
- substance must be at least slightly water soluble to penetrate the mucus to reach the olfactory cells
- substance must be at least slightly lipid soluble to interact with the membrane
- Best example for a substance that is volatile, water and lipid soluble is **alcohol**, so they use it to make perfumes.
- Smell adapts very fast (i.e. if you use the same perfume for a period of time, you feel like you need a change, and that's why we see a company produces new editions of perfumes continuously)
- Yet, olfactory receptors adapt very **slowly**

"this slide is the opposite to what the doctor said previously"

Primary Sensations of Smell

- camphoraceous
- musky
- floral
- peppermint
- ethereal
- pungent
- putrid

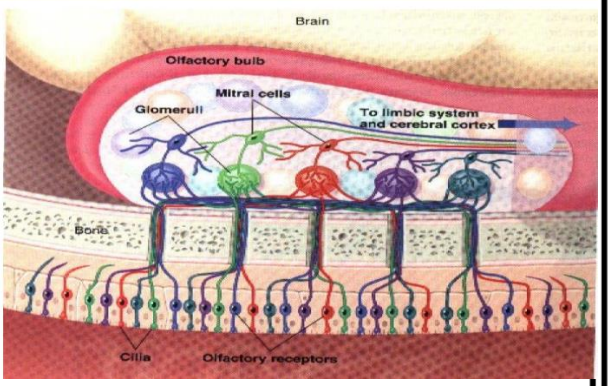
- The odorant substance binds the receptors and activate G-protein system.
- Adenylyl-cyclase converts ATP to cAMP, which opens Na+ channels and causes depolarization that leads to action potential.

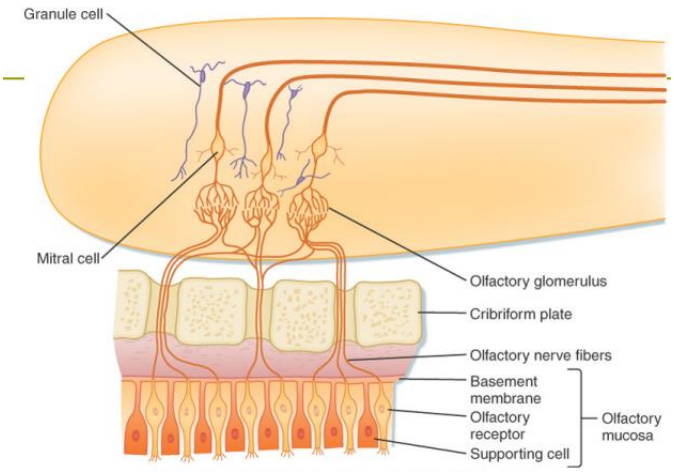


❖ Olfactory bulb:

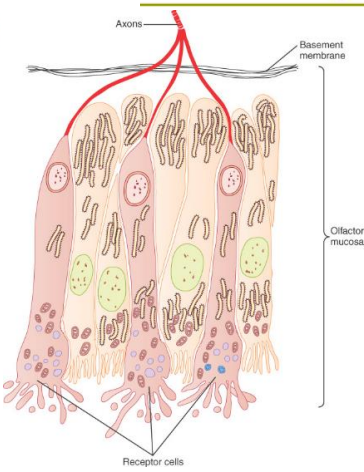
- contains the glomeruli & mitral cells (inhibitory interneurons).
  - All merges to form the <u>olfactory tract</u>.

Olfactory bulb





Olfactory receptors



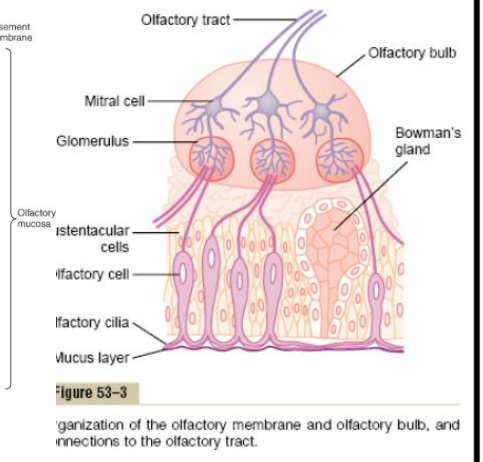
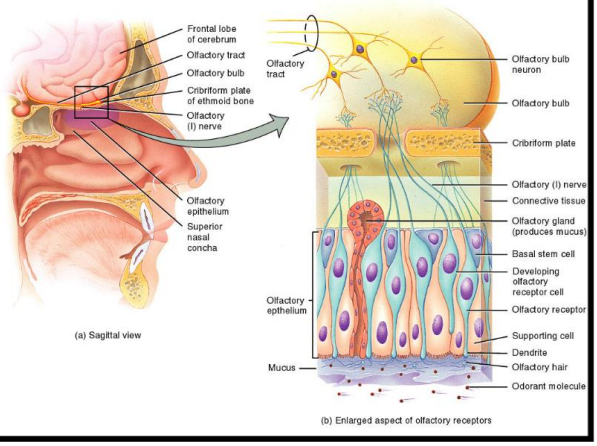


Figure 53–3
ganization of the olfactory membrane and olfactory bulb, and nnections to the olfactory tract.

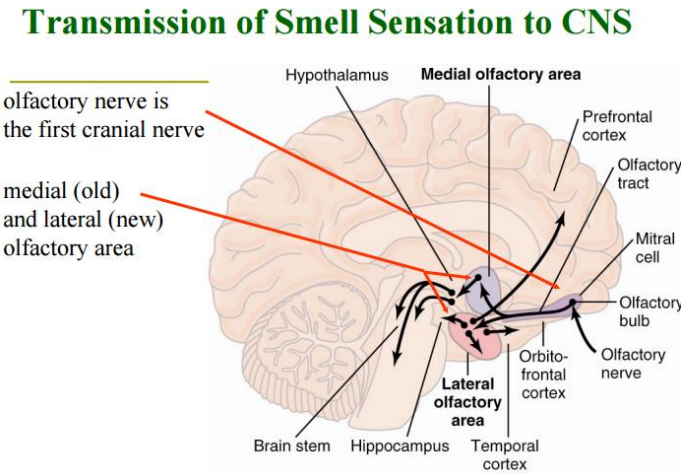
- Here we notice that nerves go from the cribriform plate → olfactory tract and bulb:
  - medial olfactory area is the oldest and from there fibers go to the limbic system for the <u>behavioral</u> aspect of smell.



- The lateral (less old & newer) area is concerned with the conscious perception of smell.

➢ So, smell fibers go to the thalamus after it passes the cortex. (always indirect)

❖ Olfactory pathway:



- The olfactory tract enters the brain at the anterior junction between the mesencephalon and cerebrum
- Generally, the olfactory tract goes to two areas:

A. **Medially: Older area** (in older animals) passes medially → medial olfactory area of the brain stem (very old tract), septal nuclei go to the hypothalamus and limbic system (licking lips, salivation, and other feeding responses caused by smell of food or by primitive emotional drive associated with smell) **"behavioral aspect of smell"**

B. **Laterally:**

1) Less old area: pre-pyriform, 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
2) Newer area: The newer pathway: passes through the thalamus, dorsomedial nucleus of the **thalamus** and then to the lateroposterior quadrant of the orbitofrontal cortex, for conscious analysis of odor **"voluntary/conscious perception of smell substance",** (integration with taste, sight and sensation.)

❖ Smell Abnormalities

A. Anosmia: loss of smell sensation
B. Others: hyposmia, hyperosmia and dysosmia *(not mentioned by the doctor : parosmia or phantosmia) .*

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