TASTE & SMELL

Objectives:

- Describe the location and function of olfactory receptors and olfactory neurons
- Explain the mechanism of smell
- Describe the location and function of taste receptors and taste neurons
- Explain the mechanism of taste

Done by

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[Color index | Important | Explanation]

References

435 Slides (Boy's & Girl's),

Taste & Smell (Overview)

- **Smell**
  - Olfactory pathway
  - Pathophysiology
- **Taste**
  - Taste pathway
  - Nerve supply
  - Pathophysiology

Sense of Taste (Gustation)

Five established taste sensations:

Sweet	Sour	Bitter	Salty	Umami
Sugars	Acids (free H ions)	Alkaloids, other substances	Chemical salts (NaCl)	Glutamate "meat taste"
Tips of the tongue	Tongue margins	Back of the tongue	Widely distributed	-

- These sensations are detected by taste receptors found in **Taste Buds** *(What are taste buds?)*
- **Taste buds** are barrel-shaped structures that contain **taste receptors.**

بس عشان تكونون بالصورة الكلام هذا مب صحيح يعني لو تجرب تحط مكعب سكر على أطراف لسانك بتحس إنه حالي (:

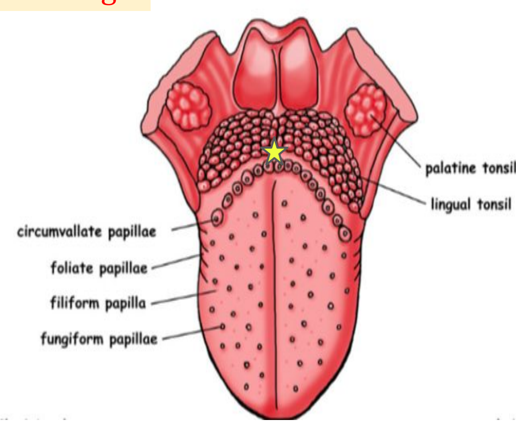
Location of the Taste Buds : أبيكم تتخيلون الترتيب: (Papillae جواها-> Taste buds جواها->Taste receptors)

We find these taste buds in a larger structure on the tongue called papillae, and in the mucosa of palate, epiglottis, pharynx. *(What are the types of papillae?)*

Types of papillae

No taste buds on the mid dorsum of the tongue

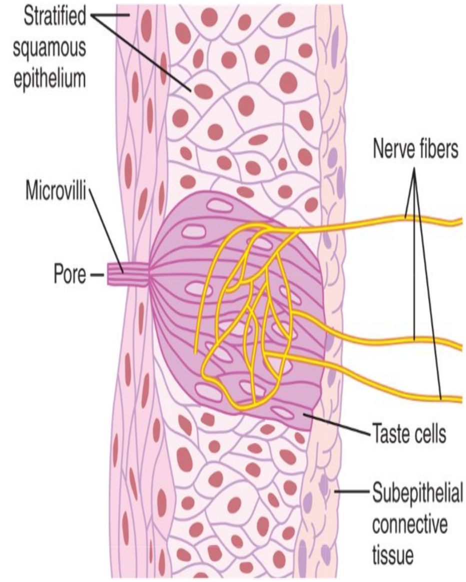
- Foliate
- Fungiform
  on the upper surface of the tongue
- Circumvallate
  In front of the foramen cecum ☆
- Filiform (no taste buds)
  At most of the front two thirds of the tongue's surface



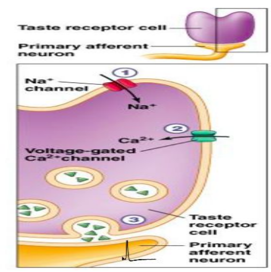
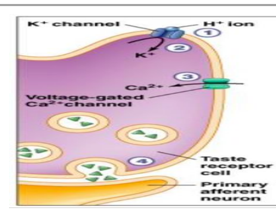
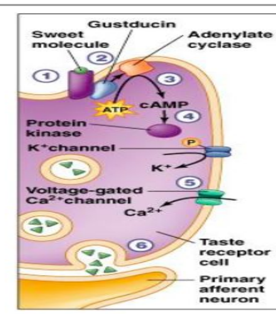
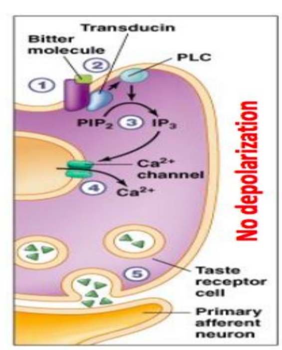
Taste bud consists of : فتحات + مستقبلات + خلايا مساعدة + عَصب، وش اسم العصب؟	**Taste pore :** Opening through which fluids come into contact with taste receptor cells.
	Taste receptor cells (~50 cells)
	Supporting cells
	Endings of afferent fibers

What are Taste Receptor cells?

- Are modified epithelial cells with surface folds called **microvilli** (hairs) [*lifespan is ~10 days*]
- **Are NOT neurons (unable to generate action potentials)**
- Able to be depolarized upon stimulation and generate **receptor potentials!** (not an action potential)
- Make chemical synapses with the endings of afferent fibers of cranial nerves (VII, IX and X)
- Plasma membrane of microvilli contain receptor sites that bind selectively with chemical molecules in saliva.



Taste transduction : لاتخافون من الجدول الكبير هذا مفهوم وسهل مرة

Salty	**1)** Na+ from salty food enter the cell through Amiloride-sensitive (epithelial) Na+ channels in microvilli (Amiloride = K+-sparing diuretic) **2)** Entry of Na+ into the cell causes depolarization which opens voltage-gated Ca2+ channels **3)** Influx of Ca2+ causes neurotransmitter release which is needed for signal transmission to the post-synaptic afferent neuron	
Sour	**1)** H+ ions from sour food block K+ channels in the microvilli **2)** This blockage prevents K+ from leaving the cell **3)** This causes depolarization which opens voltage-gated Ca2+ channels **4)** Influx of Ca2+ causes neurotransmitter release which is needed for signal transmission to the post-synaptic afferent neuron	
Sweet	**1)** A sweet molecule binds to a G- protein-coupled receptor causing conformational change. **2)** This activates the protein Gustducin which in turn activates Adenylate cycalse **3)** This enzyme catalyzes conversion of ATP into cAMP. **4)** The cAMP activates a protein kinase causing closure of K+ channels **5)** This causes depolarization which opens voltage-gated Ca2+ channels **6)** Influx of Ca2+ causes NT release	
Bitter	**1)** A bitter molecule binds to a G- protein-coupled receptor causing conformational change. **2)** This activates the protein Transducin which in turn activates phospholipase C (PLC) **3)** This enzyme catalyzes conversion of PIP2 (phospholipid) into second messenger IP3 **4)** P3 causes Ca2+ release from intracellular stores **5)** Release of Ca2+ causes NT release which is needed for signal transmission to the post-synaptic afferent neuron.	

Nerve supply of the tongue:

- When taste bud get stimulated, it produces nerve impulse to specific brain area through :

Facial nerve (VII)	Anterior 2\3 of the tongue
Glossopharyngeal nerve (IX)	Posterior 1\3 of the tongue
Vagus nerve (X)	Taste buds in pharynx, palate, epiglottis

Taste center :

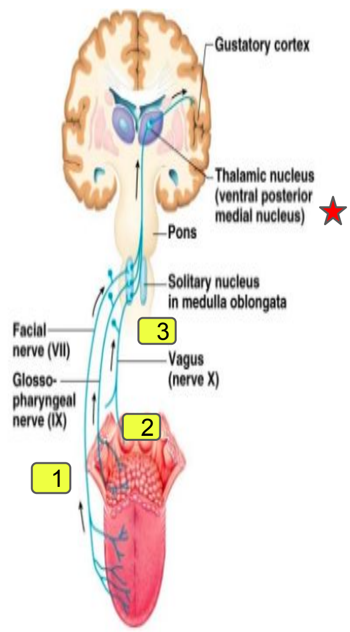
1. Anterior insular cortex (brown) : folded deep within the lateral sulcus.
2. Operculum (Green blue): covering the insula.

Taste pathway:

1) Taste impulses from **anterior 2/3 of tongue** pass in cranial nerve (CN VII)

2) Impulses from the **posterior 1/3 of tongue** and other posterior parts of mouth are transmitted by (CN IX)

3) Few taste signals from base of the tongue and other posterior parts are carried by Vagus nerve (CN X)



First order neurons	Second order neurons	Third order neurons
Synapse in in the nucleus of tractus solitarius (TS) in the medulla	from TS cross the midline to ascend in the medial lemniscus to the VPM ★ of the thalamus	From VPM nucleus project to the gustatory cerebral cortex

Pathophysiology of taste sensation:

- **Adeusia :** **Complete** loss of taste.
- **Dysgeusia :** **D**istrubed taste.
- **Hypogeusia :** It can be caused by many diseases, and drugs such as penicillamine
- **Hypergeusia.**

Taste sensation can be modified by Meraculin (from Miracle fruit):When Meraculin applied to tongue makes acids taste sweet!!

★ *For further reading : it is explained in guyton page 645*

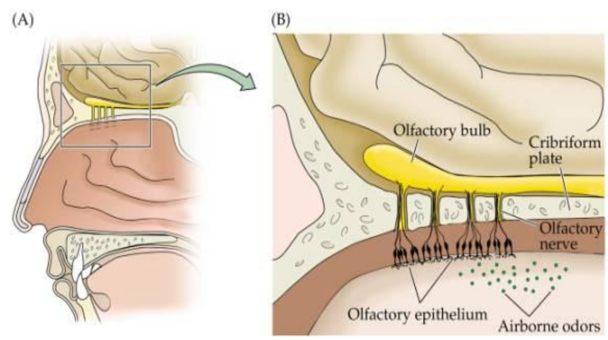
Sense of Smell (Olfaction)

The Olfactory (Smell) System:

- The olfactory system is the least understood sensory system.
- It helps us enjoy life (e.g. perfume, and food).
- Smell can be a powerful stimulant of human emotions.
- It is also a warning system alerting us to dangerous signals (e.g., gas leak, spoiled food).
- It helps in choosing mates in some mammals (release of pheromones).
- Minute quantity of an odorant in the air can elicit a smell sensation.
- Methylmercaptan can be smelled when only 25x10-12 g is present in each ml of air.This substance is mixed with natural gas so that even a small amount of gas leak can be detected.

Olfactory Chemoreceptors:

- Smell is detected by **olfactory chemoreceptors** which are specialized endings of afferent (bipolar) neurons that convert olfactory stimuli (chemicals in gaseous state) into nerve impulses.
- They are found in the roof of each nasal cavity



What are Olfactory Stimuli? (Not important):

- Odorants (airborne molecules) must be volatile (they give off vapors)
- More vapors are given off when an odorant is heated!! (warm soup smells better than cold soup)
- Odorants reach olfactory receptors by being inhaled:
  - Through the nose,
  - Through the mouth
  - Vapors circulate up through throat.

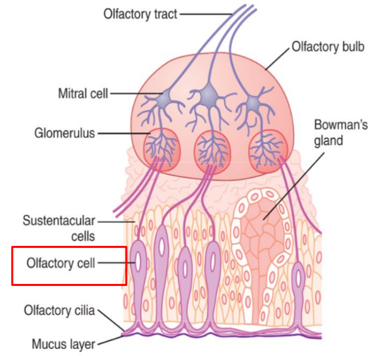
Anatomy of the Olfactory System:

Anatomy of the olfactory system

- **Peripheral components**
  - **Olfactory receptors** located in the olfactory epithelium
  - **Olfactory nerve fibers** *in the the olfactory nerve (CN I)*
- **Central components**
  - **Olfactory bulb** In the brain
  - **Olfactory tract**
  - **Olfactory Cortex** deep in temporal lobe and base of frontal lobe (interpretation of olfactory signals)

Now, we will discuss the functions of these anatomical structures in details :

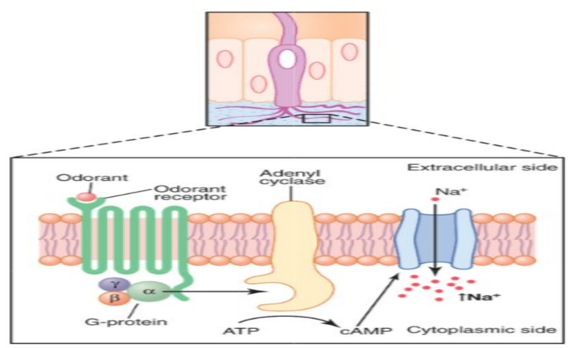
Olfactory receptor cells: *The receptor cells for smell sensation*



- There are ~ 100 million of these cells in the olfactory epithelium
- They convert olfactory stimuli into nerve impulses
- Chemicals must be *dissolved* in mucus for detection
- They are **bipolar nerve cells** and , unlike other primary afferent neurons terminate directly in the telencephalon
- The mucosal end of the olfactory cell forms a knob
- 4 to 25 olfactory hairs (cilia) emerge from the knob
- The cilia react to odors in the air, and stimulate the olfactory cells (causing depolarization) *How?*

- Mechanism of Excitation of the Olfactory Cells :

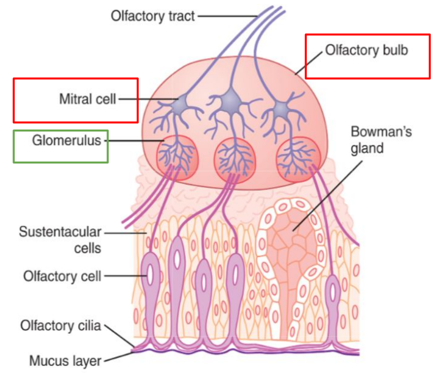
Diffusion of the odorant substance, into the mucus → Odorant binds and activates the receptor protein, resulting in activation of G-protein complex → Activation of adenyl cyclase in the cell membrane → This enzyme converts ATP into cAMP (a second messenger) → This causes activation of sodium ion channels → Depolarization and excitation of the olfactory neuron → Transmission of nerve impulses into CNS by the olfactory nerve



- Membrane Potential & Action Potential of Olfactory Cells :

- The resting membrane potential of olfactory cells is ~ **–55 mV**
- At this potential, most of the olfactory cells generate continuous nerve impulses/action potentials (APs) *at a very slow rate* (0.05 to 3 Hz).
- Most odorants cause depolarization and an increase in the rate of APs up to 30 Hz
- Like other sensory receptors, the rate of olfactory nerve impulses is dependent on of the stimulus strength.

Transmission of Olfactory Signal to Olfactory Bulb:

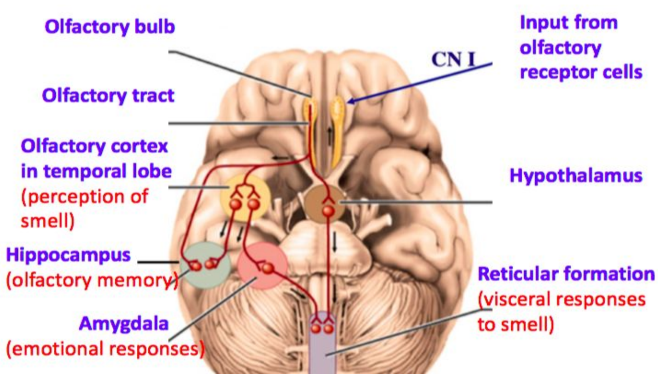


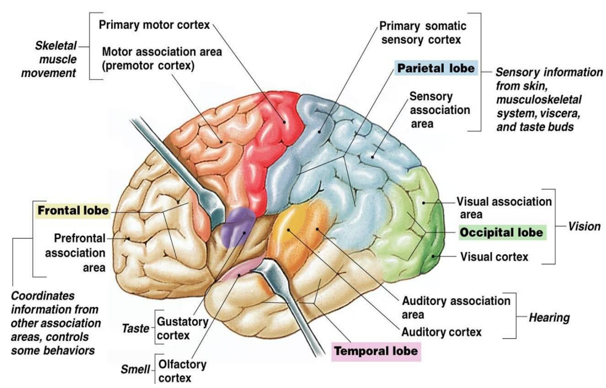
1. Axons of the receptor cells penetrate the **cribriform plate** and form the olfactory nerve (CN I)
2. They synapse on **Mitral cells** in the olfactory bulb which is just superior to the cribriform plate
3. Axons of Mitral cells travel along the olfactory tract to reach the olfactory cortex and the limbic system.

Olfactory Glomeruli:

- Olfactory receptor neurons express one type of odor receptor
- Receptor neurons with the same receptor type project to the same **glomerulus**
- They synapse with dendrites of mitral cells in the glomerulus
- Mitral cells project to the olfactory cortex.
- Granule & Periglomerular cells **(inhibitory interneurons)** modulate mitral cell activity.
- **Each glomerulus represents a single odorant receptor**

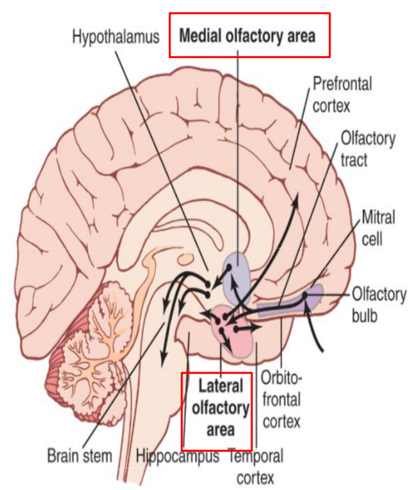
Olfactory Cortex & Olfactory Projection Pathways:





Neuronal Connections of the Olfactory system:

The medial olfactory area	The lateral olfactory area
- Consists of nuclei anterior to the hypothalamus - Concerned with basic behavior e.g. responses to the smell of food (salivation)	The lateral olfactory area: Provide inputs to all portion of the limbic system e.g. hippocampus



Olfactory Pathways (EXTRA FROM LINDA.5th edition)
olfactory receptor cells are the primary afferent neurons in the olfactory system. 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, approximately 1000 olfactory receptor axons converge onto 1 mitral cell. The mitral cells are arranged in a single layer in the olfactory bulb and have lateral den- drites 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 dendrodendritic synapses on neighboring mitral cells. The inhibitory inputs serve a function similar to that of the horizontal cells of the retina and 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 lateral olfactory tract synapses in the primary olfactory cortex, which includes the prepiriform cortex. The medial olfactory tract projects to the anterior commissure and the con- tralateral olfactory bulb.

Smell Sensations Adapt Rapidly:

- Olfactory receptors adapt about 50 % in the first second or so
- After that, they adapt very little and very slowly.
- Smell sensations adapt almost to extinction within a minute or so (from experience)
- The additional psychological adaptation occurs in the CNS
- Centrifugal (efferent) nerve fibers pass from the brain backward and terminate on the granule cells **(inhibitory neurons)**.
- After onset of an olfactory stimulus, the CNS quickly develops strong **feedback inhibition** to suppress relay of the smell signals.

Pathophysiology of Smell:

<table>
<tr><td>Anosmia</td><td colspan="3">loss of smell sensation “Not insomnia :)”</td></tr>
<tr><td>Hyposmia</td><td colspan="3">Decreased ability to smell / Vitamin A deficiency</td></tr>
<tr><td rowspan="3">Dysosmia</td><td colspan="3">Distorted identification of smell</td></tr>
<tr><td>Parosmia</td><td>Phantosmia</td><td>Agnosia</td></tr>
<tr><td>Altered perception of smell in the presence of an odor, usually unpleasant</td><td>Perception of smell without an odor present</td><td>Inability to classify or contrast odors, although able to detect odors</td></tr>
<tr><td>Hyperosmia</td><td colspan="3">Increase in smell sensation</td></tr>
</table>

What causes smell disorders?

Common causes of smell disorders are:

- Aging.
- Sinus and other upper respiratory infections.
- Smoking.
- Growths in the nasal cavities.
- Head injury.
- Hormonal disturbances.
- Exposure to certain chemicals (e.g. insecticides) and medications, including some common antibiotics and antihistamines.
- Parkinson’s disease or Alzheimer’s disease.

★ *The whole lecture is **amazingly** explained in Linda page 93*