Smell and Taste Sensations
(Chemical senses)

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Introduction to Chemical Senses

- **Smell** (olfaction) and **taste** (gustation) are closely related due to:

1. Common cold depresses smell & alters taste.

2. Both are related to food intake, we smell and taste food. When both smell and taste of food are agreeable, food is ingested, otherwise it will be rejected.

- The combined effect of smell and taste on food is called **flavor.**
- But, they **differ** in:
- Smell receptors are tele-receptors (distance receiver) while those of taste are not.
- Smell Pathways do not relay in **thalamus** & do not reach the sensory cortex.

- **Critical for**:

-Survival and nutrition - Detecting danger (spoiled food, toxins)

-Quality of life and enjoyment - Social behavior and memory formation

Smell (Olfaction)

Olfactory mucosa

- It lies in the roof of the nasal cavity covering surface area of **5:6 cm2**
- Olfactory mucosa contains **three types** of cells:

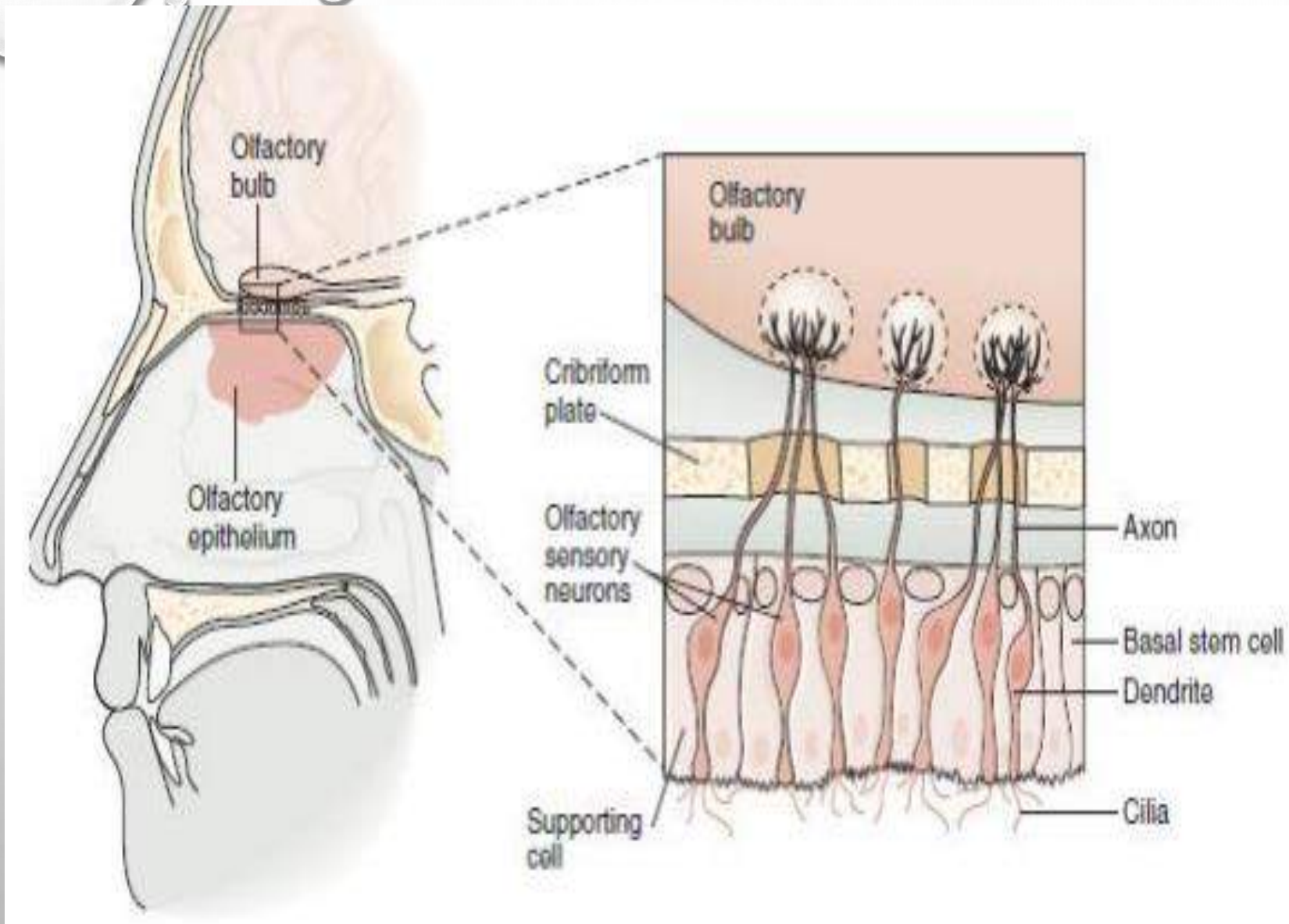
1. **Receptor cells:** True bipolar neurons (10 - 20 millions in number).

a) The dendrites are short & thick called the olfactory rod.

b) The axons penetrate the cribriform plate of the ethmoid bone.

2. **Supporting cells:** Together with the Bowman's gland secrete a mucous.

3. **Stem cells (basal):** Differentiate into new receptor cells (regeneration).


Olfactory bulb
Olfactory epithelium
Olfactory bulb
Cribriform plate
Olfactory sensory neurons
Supporting cell
Axon
Basal stem cell
Dendrite
Cilia

Physiological information about olfaction

➢ Characters of stimulus

1) Substances must be volatile and it must be both water and lipid soluble to be dissolved in mucous and to cross the cell membrane.

2) Heating of substance leads to increase in smell sensation (increase volatile molecules).

3) Sniffing helps to increase the sensitivity to odorous substances.

4) Threshold of concentration of substances varies greatly.

- Ethyl ether threshold = 5.8 mg/L of air.

- Methyl mercaptan (garlic odor) = only 0.0000004 mg/L of air.

Characters of receptors

1) Continuous constant exposure to odor leads to **adaptation** (moderately adapting).

2) 30% change in concentration of substance must occur to be differentiated by the olfactory receptors.

3) There are about 1000 different odorant receptors and this explains the ability of normal individual to discriminate more than 10.000 odors.

4) The olfactory mucus contains odorant binding proteins that transmits & concentrate the odorant substances to the receptors.

Mechanism of stimulation of olfactory receptors

A. Chemical theory

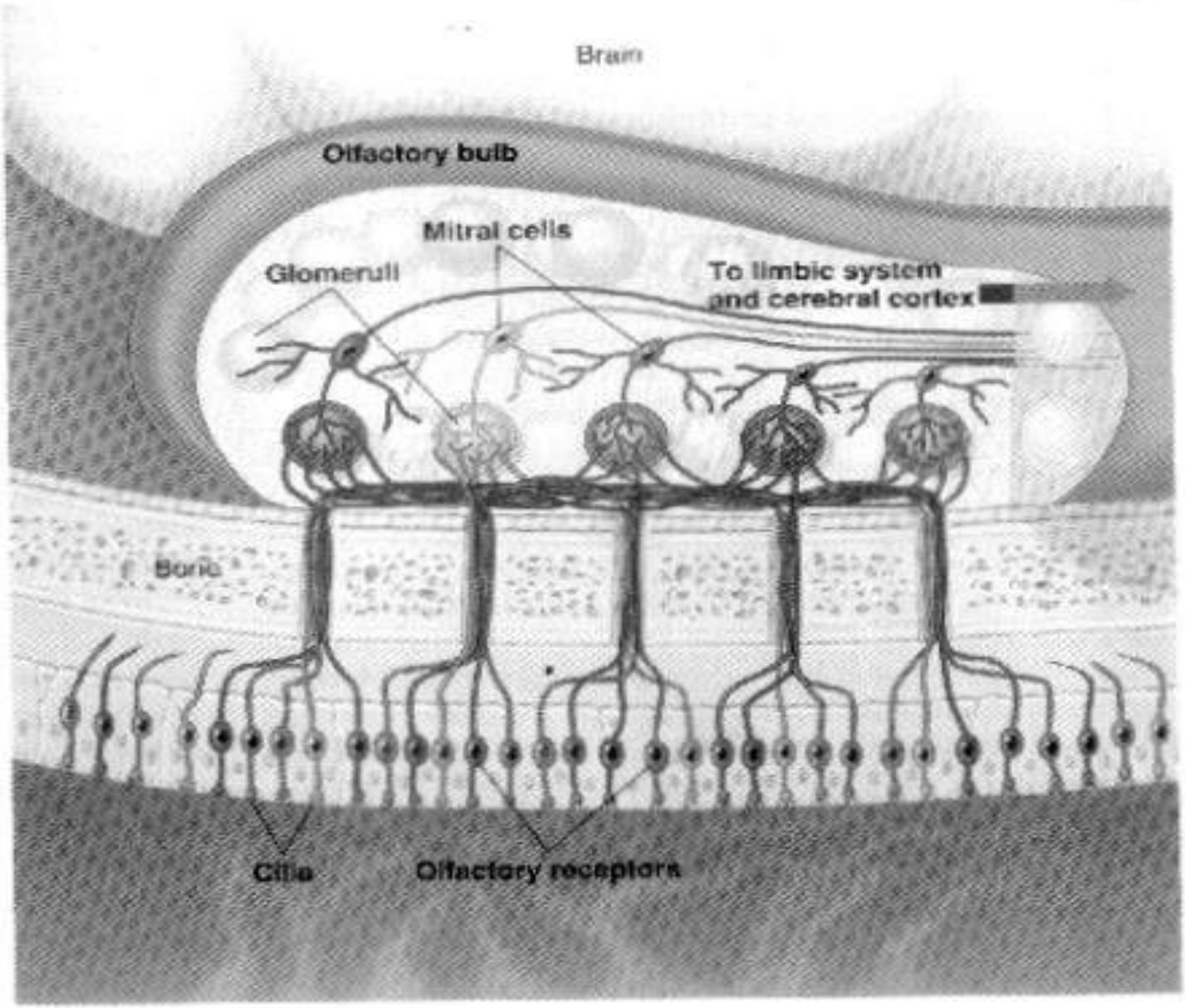
- RMP of olfactory receptors is -55 mv and at this level → continuous impulses arise from these receptors at a rate of **1: 3/ second**.
- Stimulation of olfactory receptors by odorant substance → decrease this potential from -55 to -30 mv (depolarization) → ↑ number of impulses up to **20/second**.
- When odorant substances come in contact with the olfactory area, they diffuse into mucous layer and bind with receptor protein on cilia.
- Such binding → activate **G protein** → activate **adenyl cyclase** → ↑ **cAMP** → open **Na^+ channels** → **depolarization (receptor potential).**

B. Physical theory

- It was observed that many substances have different chemical properties But, have identical **molecular shape**. So, they have the same odor.
- There are about 100 types of receptor sites for the different odors on the cell membrane of the olfactory receptors.
- Each odor bind to one or more of these sites according to the **shape** of its molecule and this binding causes stimulation of the receptor.

Olfactory pathway

- **Olfaction** is the only sense which has no area in neocortex unlike other sensations but it is detected mainly in limbic system.
- **The first order neurons**: Are the receptor cells in the olfactory mucosa. Their axons unit to from "olfactory nerve" (1st cranial nerve), these axons penetrate the cribriform plate of ethmoid bone to enter the "olfactory bulb".
- **The second order neurons**: Are "mitral & tufted cells" in the olfactory bulb and they synapse with axons of olfactory cells forming "olfactory glomeruli", each glomerulus contains axons of 25,000 receptor cells that synapse with 25 large mitral and 60 small tufted cells.
- **Different glomeruli respond to different odors.**


Olfactory bulb
Mitral cells
Glomeruli
To limbic system
and cerebral cortex
Cilia
Olfactory receptors

- ***Periglomerular inhibitory cells*** connecting one glomerulus to another.
- When **mitral** & **tufted** cells stimulate ***Granule cells*** by **G**lutamate, then they inhibit mitral & tufted cells by **G**ABA **(-ve FB inhibition).**
- **Lateral inhibition** is mediated by **Periglomerular & *Granule cells*** → **sharpening of olfactory signals.**

The axons of tufted and mitral cells pass posteriorly to form **"Olfactory tract"** which enter the brain then divides **into three stria:**

1) Medial stria: Cross to opposite side in midline in anterior commeasure. Lesion in this part leads to marked decrease in olfaction.

2) Lateral stria: Terminate in prepyriform, pyriform cortex and amygdaloid nuclei, concerned with basic olfactory reflexes and Learning to Like or dislike some foods.

3) Intermediate stria: Terminate in olfactory tubercle. This area controls the primitive response to smell such as licking the lips & salivation.

The vomeronasal organ (VNO)

- A structure on each side of the nasal septum of human and more common in animals.
- It is a chemical sensory center for detection of **pheromones** (chemical signals that carry information between individuals of the same species).
- It is responsible for good or bad feeling between people.
- Binding of pheromones to receptors on neurons in VNO → action potential travels through **non** olfactory pathway to limbic system.

Smell abnormalities

1. **Anosmia**: Absence or marked loss of smell sensation.

- Due to bilateral nasal obstruction, degeneration or atrophy of nasal mucosa or destruction of anterior commeasure.

- It is associated with disturbance or loss of taste sensation.

2. **Parosmia**: Smelling of non existing odors usually is psychogenic.

3. **Cacosmia**: Receiving a bad smell.

- Due to chronic sinusitis, foreign body in the nose or other inflammatory conditions in the respiratory tract e.g. Lung abscess.

Significance of olfaction

1) Olfaction is related to taste (in severe rhinitis→ loss of specific taste of some foods).

2) The receptors of olfaction are chemoreceptors (moderately adapting) and they are true neurons & close to external environment.

3) Olfaction may produce changes in **GIT** motility & secretion.

4) Olfaction may produce sexual & psychogenic effects.

5) Olfaction has a protective function (dangerous odors as gases or fires).

6) Olfaction is highly developed in females (at ovulation time) than males.

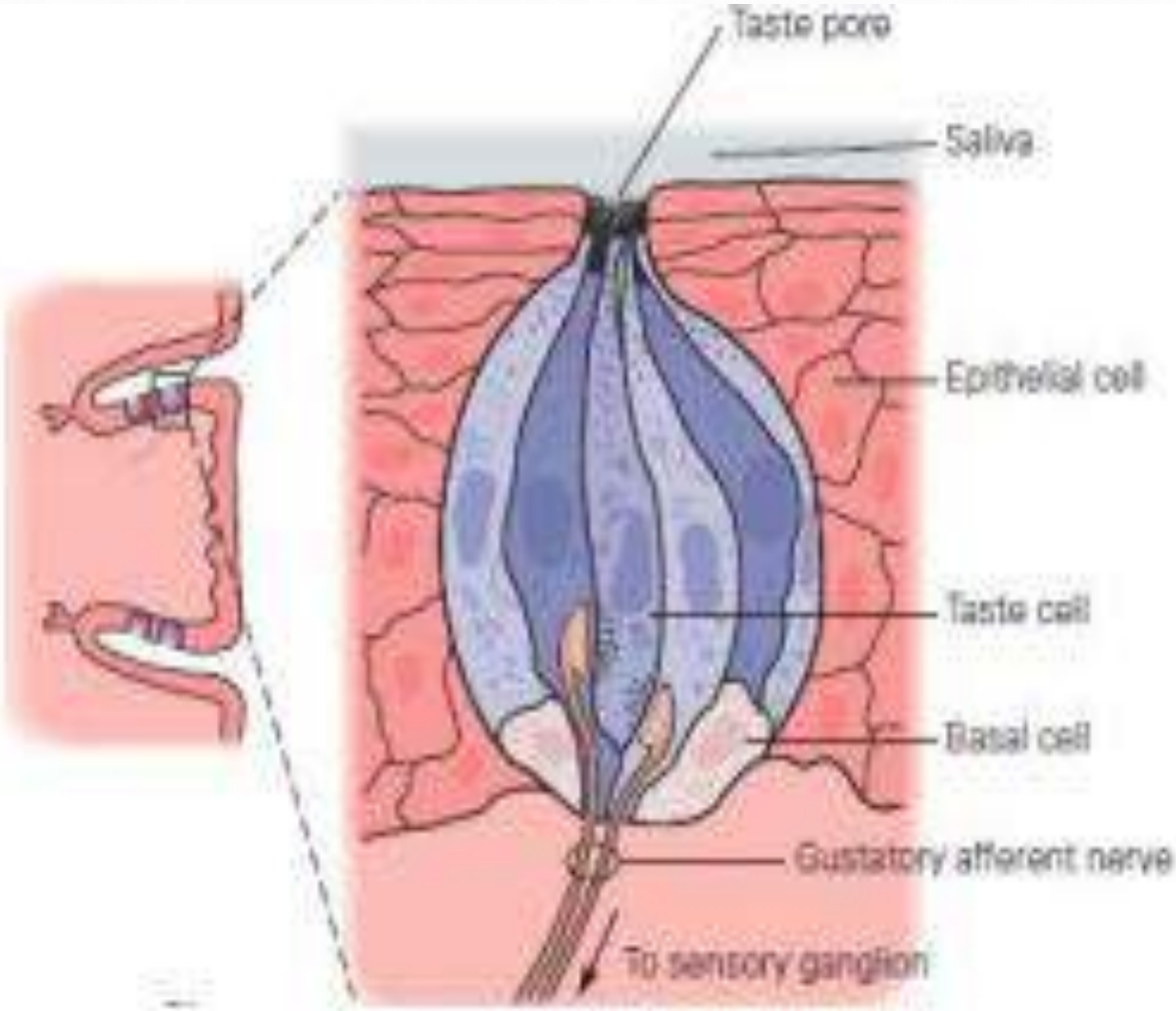
TASTE (GUSTATION)

Taste buds: The taste buds are barreled shaped structures (about **10000 in adults**)(**chemoreceptors**) located in the papillae

Circumvallate papillae	Fungiform papillae
The most prominent.	Rounded.
Arranged in "V" shaped manner at dorsum of the tongue.	Concentrated at tip of the tongue.
Contains 100 taste buds.	Contains 5 taste buds.

Each taste bud contains **3 types** of cells:

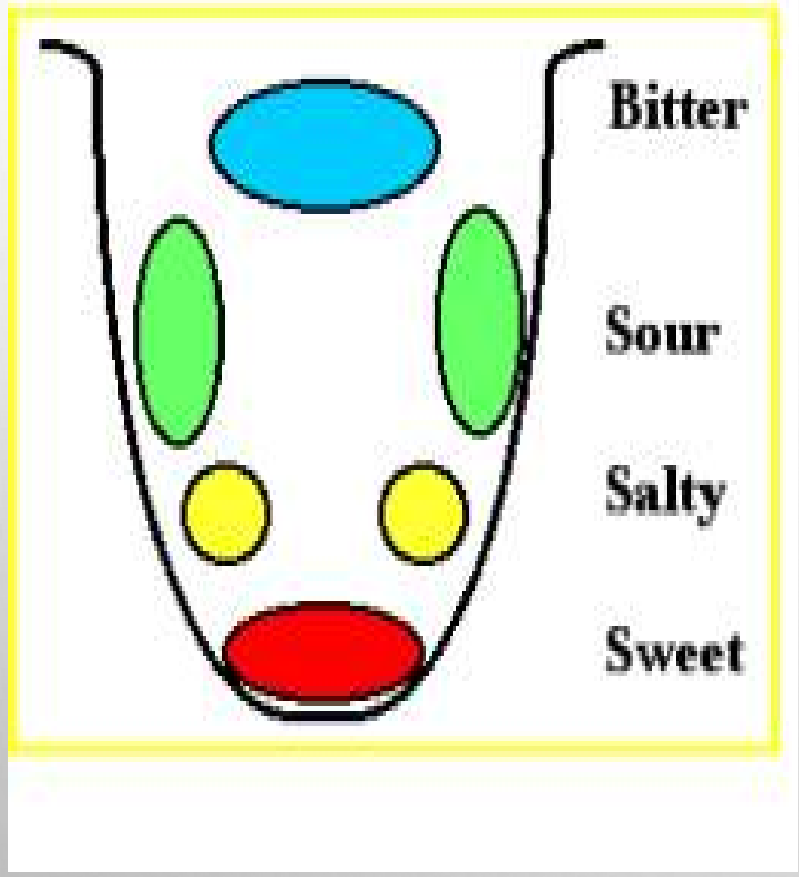
1. **Receptor cells**: Type 3 cells. Have microvilli that project to surface of the tongue through taste pore to be exposed to the fluids in the oral cavity.
2. **Stem cells**: Differentiate into new cells (regeneration every 10 days).
3. **Supporting cells**: Type 1 & type 2 cells.

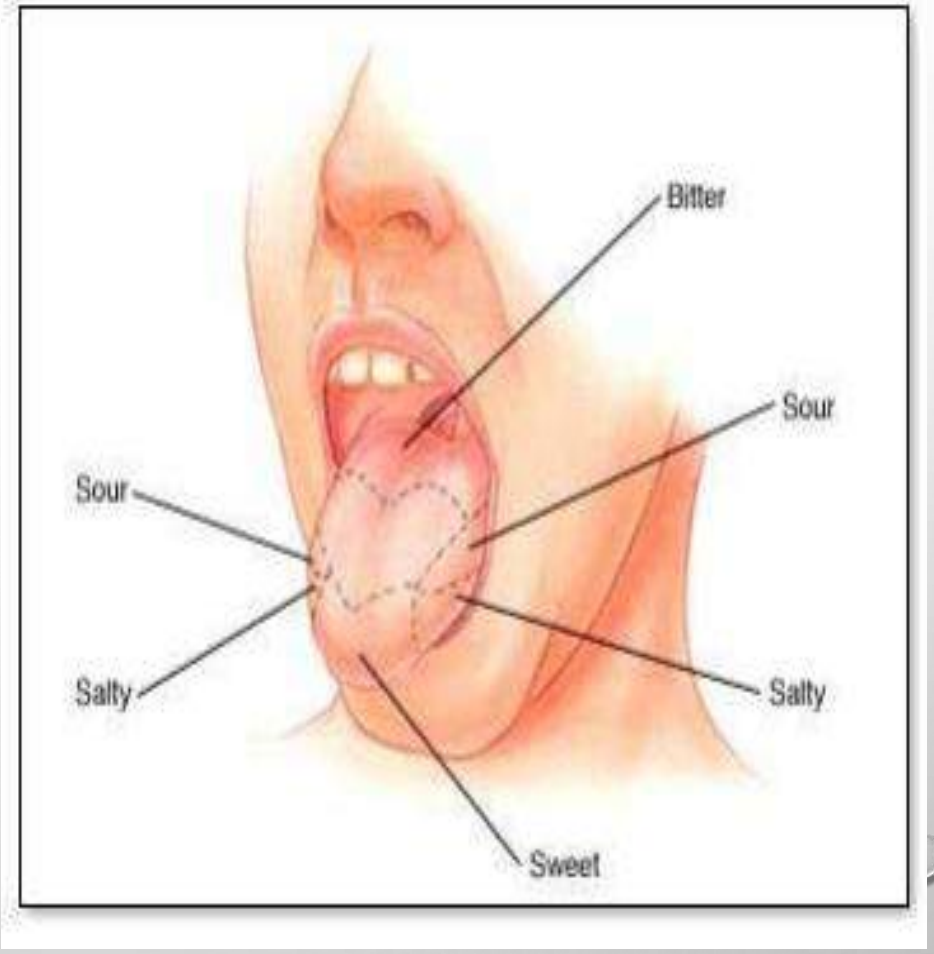

Taste pore
Saliva
Epithelial cell
Taste cell
Basal cell
Gustatory afferent nerve
To sensory ganglion

Taste modalities

- In human there are **5 basic taste modalities**. But, human can differentiate more than **200 taste sensations** as **a mixture** by **different degrees of these 5 types**.

	1- Sweet (sugar)	2- Bitter	3- Salt	4- Sour (acidic)
Site of best feeling	At tip of the tongue.	At the dorsum of the tongue.	At anterior part of the tongue.	At edges of the tongue.
	All the four modalities are felt on the pharynx & epiglottis.			
Stimulated by	Organic sugars as (glucose, sucrose, fructose). Saccharine is 700 times as sweet as sucrose and it is non calorie. So, it is used in obese or diabetic	- Quinine. - Strychnine. - Caffeine. - Many toxins.	- Ionized substances e.g. NaCl.	- H^+ ion. ⇧ Ionization of acid ⇨ stronger acidic sensation HCl is stronger than vinegar, citrus fruit, sour milk.
	Thaumatin from African berries is 100.000 times as sweet as sucrose.			Organic acids penetrate more than mineral acids ⇨ give more sourness.
Threshold	Glucose: 80 mmol/L	Very low. (most sensitive)	NaC1: 2 mmol/L.	Low.
	Smell sensation and heat greatly increase taste sensation.			


Bitter
Sour
Salty
Sweet


Bitter
Sour
Sour
Salty
Salty
Sweet

5- Umami: Recent modality means meaty (umami = flavor).

It is felt at the dorsum of the tongue. It is triggered by glutamate amino acid.

Used as flavor enhancers.

Has specific receptors called (taste-mGluR4).

- **IV injection:** of some substances ⇨ stimulate taste sensation.

  e.g. sodium dehydrochloride ⇨ give bitter sensation.

- **Systemic diseases:** ⇨ change sensitivity of taste sensation.

  e.g. jaundice with high blood levels of bile & diabetes with ketone bodies.

- **Electric current:** application on the tongue ⇨ taste sensation.

  Clinically importance in location of the facial nerve lesion.

Mechanism of receptor stimulation

- The taste buds contain taste binding proteins that transmits & concentrate the taste-producing substances to the receptors.
- This protein is secreted by Ebner's glands on the dorsum of the tongue.
- Dissolved substance ⇨ stimulation of exposed microvilli at the taste pores ⇨ generator potential in receptor cells ⇨ action potential in the afferent nerve.

★ Receptor potential:

Sweet (sugar)	Bitter	Salt	Sour (acidic)
Activation of adenyl cyclase ⇨ ⇧ **cAMP** ⇨ closure of K^+ channels ⇨⇩ K^+ outflux ⇨ depolarization ⇨ production of generator potential.	Stimulation of G protein called: **α- gusducin** ⇨ ⇩ **cAMP** ⇨ stimulate the receptors. Other theory: Activation of phospholipase **C** ⇨ ⇧ **Ca**$^{++}$ inside the cells.	Salty substance ⇨ Na^+ influx via passive ungated channel in the receptor membrane ⇨ depolarization ⇨ production of generator potential.	Acid substance ⇨activating H^+ gated cation channels ⇨ closure of K^+ channels **⇨⇩ K^+ outflux** ⇨ depolarization ⇨ production of generator potential.

Umami meaty taste is due to activation of metabotropic glutamate receptors and ionotropic glutamate receptors to depolarize Umami receptors.

Water: stimulates taste receptors by **W**ashing certain ions from them causing their discharge.

Pathway of taste sensation:

1st order neuron:

	Anterior 2/3 of the tongue	Posterior 1/3 of the tongue	Any site other than tongue
Afferent nerve	Chorda tympani branch of facial nerve (**VII**).	Branches of glosso pharngeal nerve (**IX**).	Branches of vagus nerve (**X**).
Cell body	Geniculate ganglion.	Petrosal ganglion.	Nodosa ganglion.
Axon	Ascend to terminate in **upper** part of nucleus solitarius.	Ascend to terminate in **middle** part of nucleus solitarius.	Ascend to terminate in **lower** part of nucleus solitarius.

2nd order neuron: Nucleus solitarius in medulla.

- Axons of the 2nd order neurons cross the midline, join the **medial lemniscus** which end in posterior ventral nucleus of the thalamus.

3rd order neuron: Posterior ventral nucleus of the thalamus.

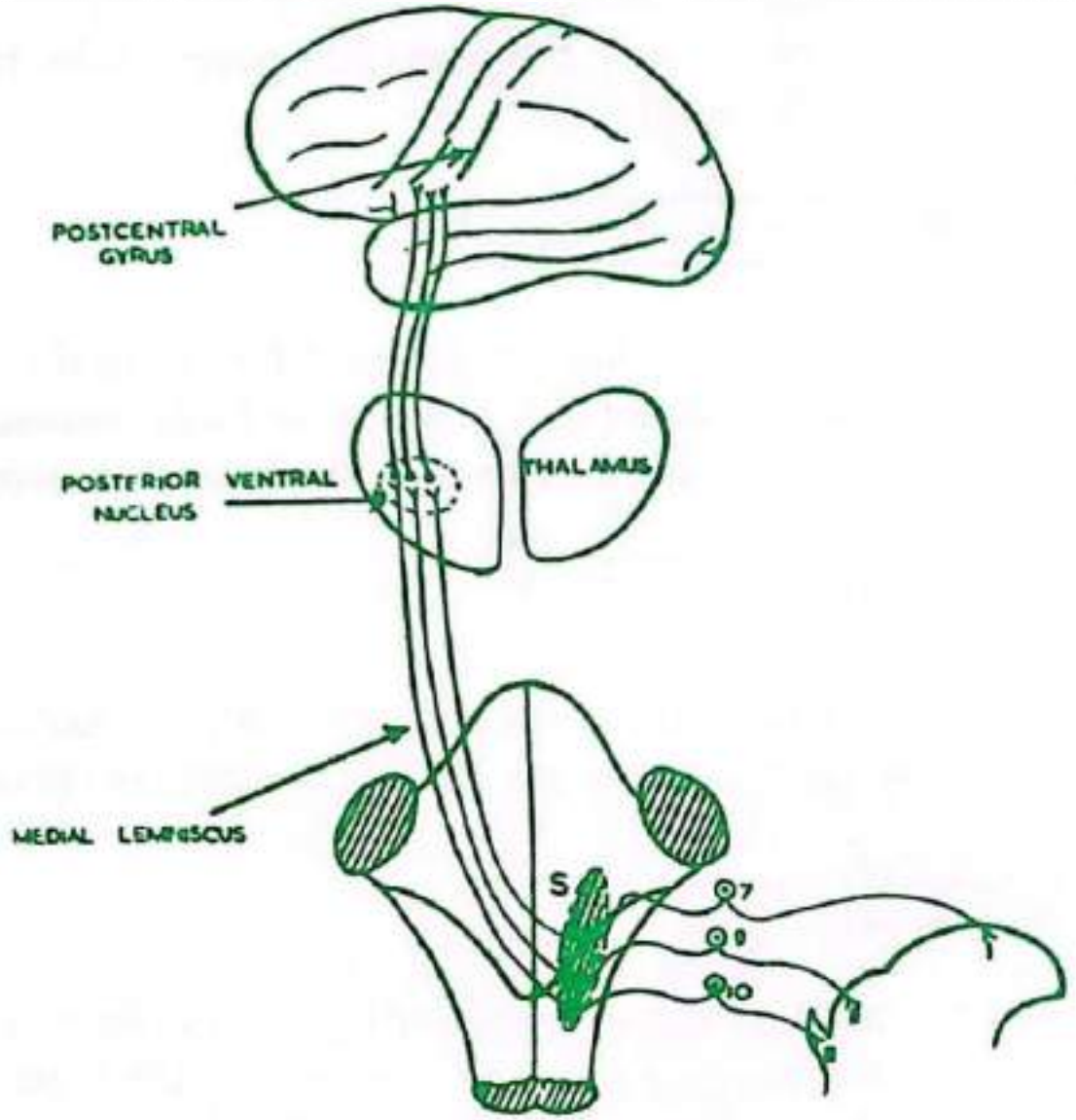
- Axons of the 3rd order neurons runs in the sensory radiation to reach the **insula** and the **frontal operculum** in the cerebral cortex. (In the somatic sensory area I **(area 3,1,2)** in it's lower part i.e. face area.

Somatic sensations from the tongue: as pain & touch & temperature.

1) Anterior 2/3: by lingual nerve branch of trigeminal nerve (V).
2) Posterior 1/3: by glossopharngeal nerve (IX).

Taste abnormalities:

1. *A geusia:* Absence of taste sensation.
2. *Hypo geusia:* diminished taste sensation.
3. *Dys geusia:* disturbed taste sensation. (bad).



Nervous pathway of the taste sensation. S = Nucleus of tractus solitarius.

Importance of taste

1. It is the first line of defense (Protective) against toxic or putrefied.
2. It causes Psychic happiness with pleasant tasty food.
3. It causes reflex stimulation of salivary and GIT secretions & motility.
4. It can play a role in homeostasis

e.g. pregnant women that suffer from Ca++ deficiency always craving for chalky substances.

Diabetic patients always seek for food that contains "much sugar".

Patients with Addison's disease prefer salty foods.

Thank you!