# Taste sensation (Gustation)

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# Learning outcomes:

- **At the end of the lecture, you will be able to:**

1. Describe the basic taste modalities.
2. Describe the site, number and structure of taste buds.
3. Explain the mechanism of stimulation of the taste buds.
4. Explain the taste intensity discrimination.
5. Explain the specificity of taste receptors.
6. Explain the adaptation and significance of taste.
7. Explain the taste preference.
8. Explain the disturbances of taste sensation.

# Basic taste modalities

## 1) Sour Taste:

- It is caused by **acids**, and the intensity of this taste sensation is proportional to the **$H^+$ ion** concentration.
- It is tasted by **edges** of the tongue.

## 2) Salty Taste:

- It is elicited by **ionized salts**, mainly by the sodium ion and to less extent by Cl ions.
- It is tasted by **anterior** part of the dorsum of the tongue.

## 3) Sweet Taste:

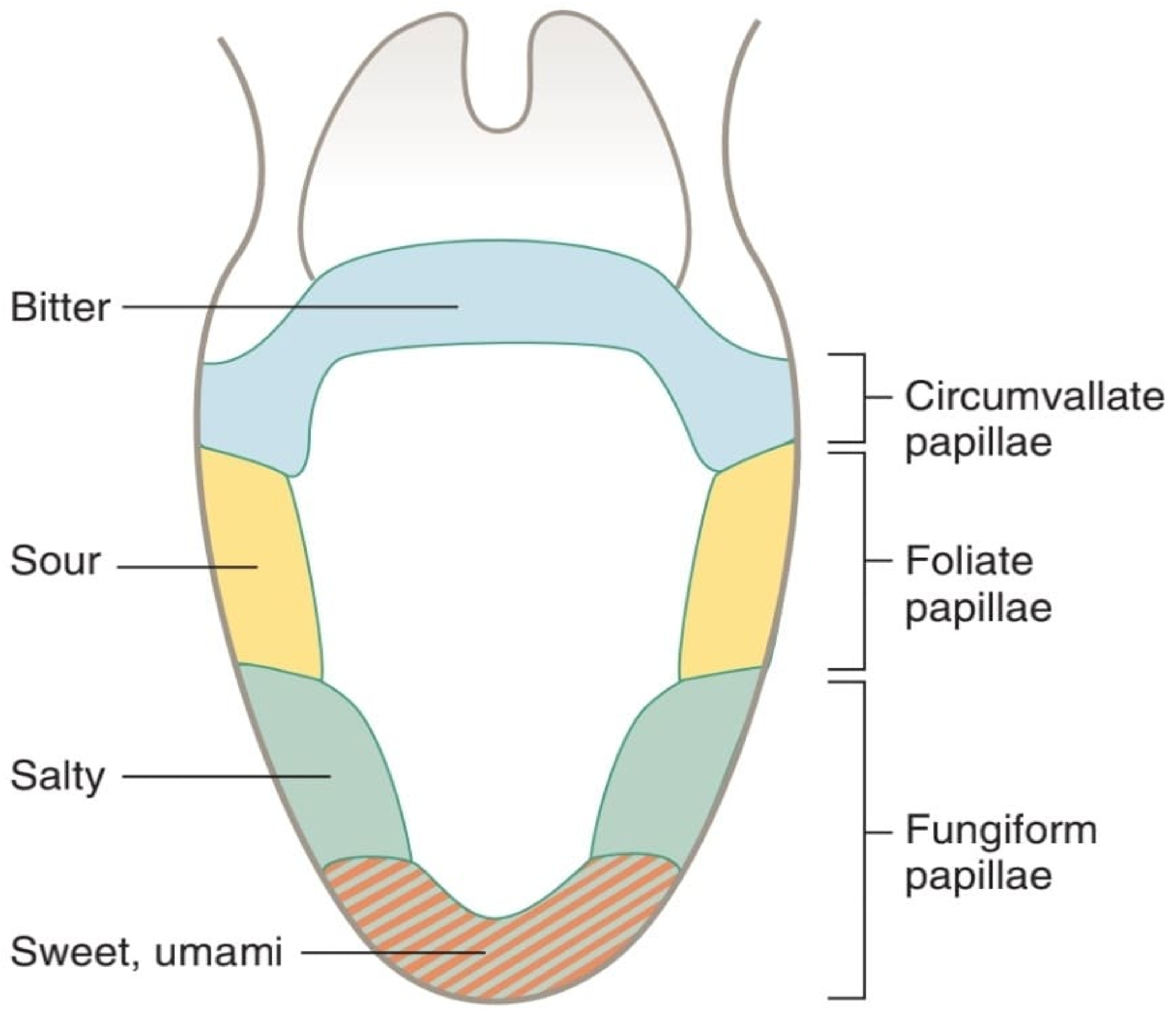
- It is elicited by organic chemicals e.g. sugars, alcohols, aldehydes and ketones.
- It is tasted by the **tip** of the tongue

# 4) Bitter Taste:

- It is **caused by** alkaloids **e.g.** quinine, caffeine, strychnine, and nicotine.
- It is **tasted by** the **back** of the tongue.

# ***5) Umami Taste:***

- **Umami (=delicious)** designate a pleasant taste sensation that is different from sour, salty, sweet, or bitter.
- Umami is the dominant taste of food containing **L-glutamate** (particularly monosodium glutamate, MSG), such as meat extracts and aging cheese.
- It is **tasted by all parts** of the tongue.


Bitter
Sour
Salty
Sweet, umami
Circumvallate papillae
Foliate papillae
Fungiform papillae

# Gustatory receptors (Taste buds)

***- Site of taste buds:***

Taste buds are **oval structures** present in:

***a) Lateral walls of :***

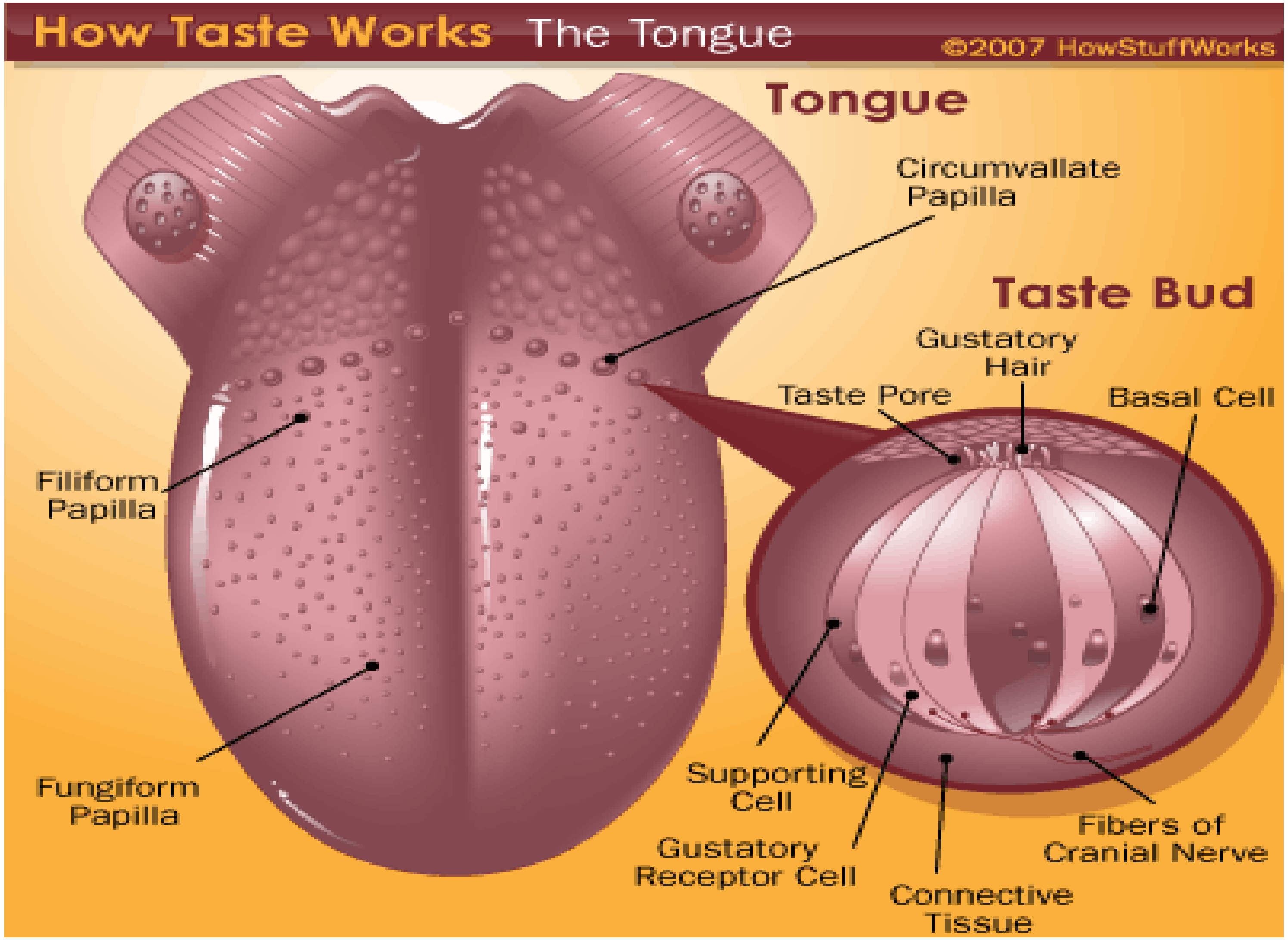
- ✓ ***Fungiform papillae*** which are present in **tip and edges of tongue**
- ✓ ***Circumvallate papillae*** which are present in **V-shaped area** in the back of the tongue

***b) Mucosa of palate, epiglottis and pharynx.***

- N.B. **Filliform papillae** which present on the dorsum of the tongue **do not contain taste buds**.

***- Number of taste buds:***

The adult man has about **10,000** taste buds that start to **decrease after the age of 45 years**.



How Taste Works The Tongue
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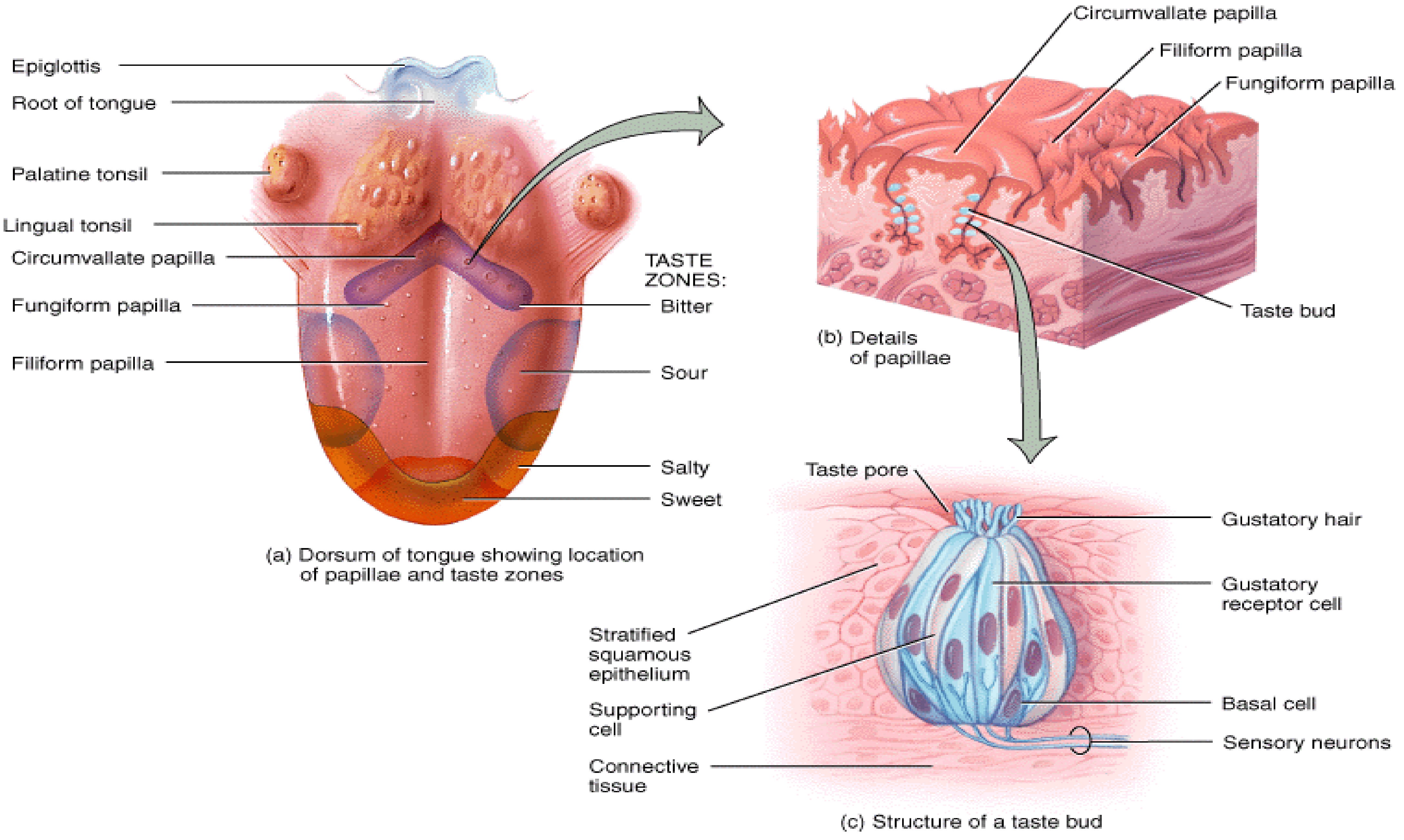
Tongue
Circumvallate Papilla
Filiform Papilla
Fungiform Papilla
Taste Bud
Gustatory Hair
Taste Pore
Basal Cell
Supporting Cell
Gustatory Receptor Cell
Connective Tissue
Fibers of Cranial Nerve


Epiglottis
Root of tongue
Palatine tonsil
Lingual tonsil
Circumvallate papilla
Fungiform papilla
Filiform papilla
TASTE ZONES:
Bitter
Sour
Salty
Sweet
(a) Dorsum of tongue showing location of papillae and taste zones
Circumvallate papilla
Filiform papilla
Fungiform papilla
Taste bud
(b) Details of papillae
Taste pore
Gustatory hair
Gustatory receptor cell
Stratified squamous epithelium
Supporting cell
Basal cell
Sensory neurons
Connective tissue
(c) Structure of a taste bud

## - Structure of taste buds:

**Each bud is formed of 3 types of cells:**

***a) Supporting cells.***

***b) Gustatory receptor cells:***

- ✓ They are **modified epithelial cells.**
- ✓ Each taste bud contains **50-150 receptor cells**.

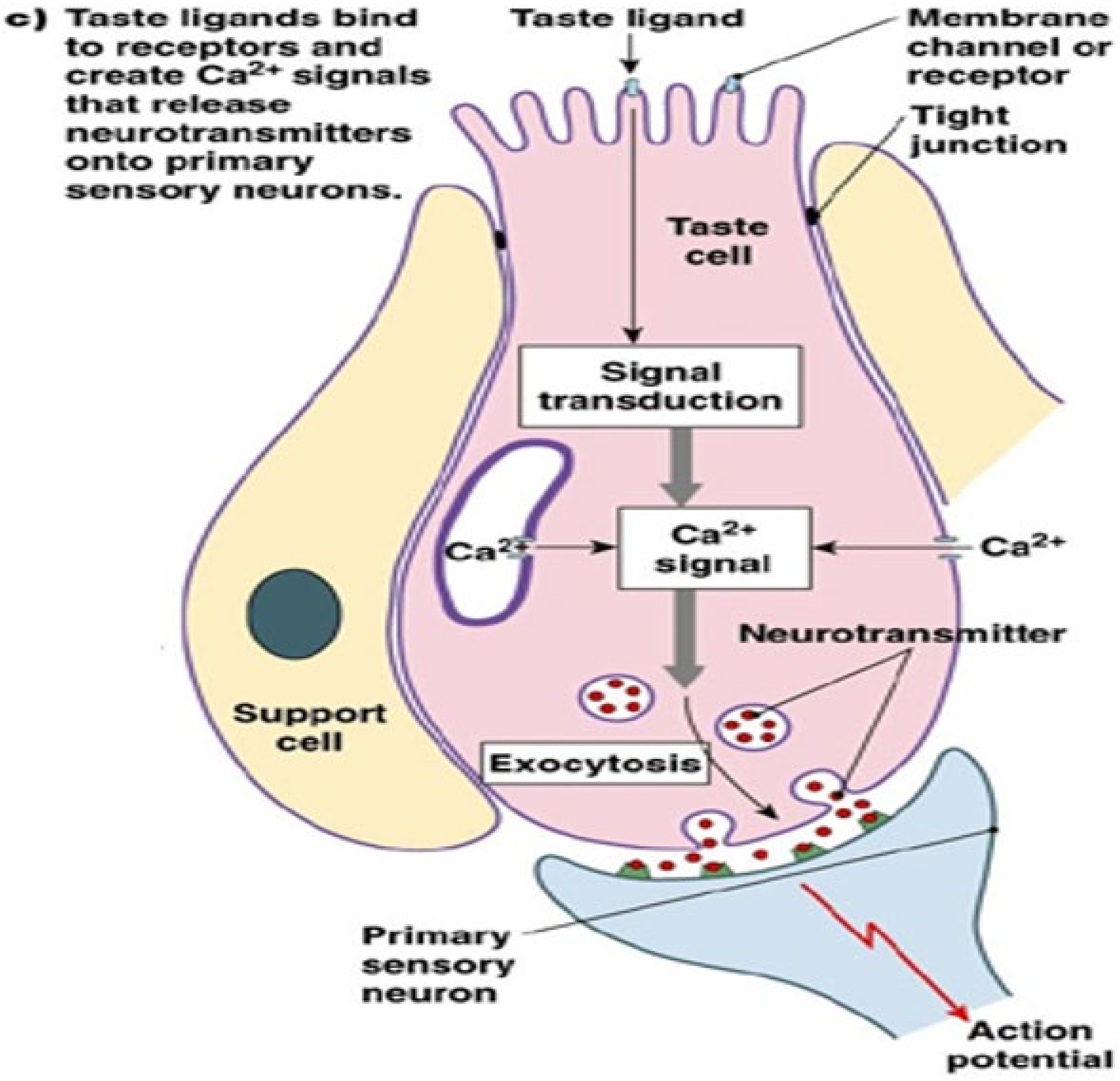
- ✓They are **long cells** with their upper poles containing cilia that project from the taste pore.
- ✓**Sensory nerve endings** synapse with their lower poles.
- ✓Their **life span** is **1-2 week** (**10 days**), and then they are **degenerated and continuously regenerated from the basal cells**.

***c) Basal cells:*** They are **stem cells** for production of new receptor cells.

## - ***Mechanism of stimulation of taste buds:***

- For a chemical substance (**tastant**) to bind to the taste receptor, it must be in a **solution or dissolved in saliva**.
- **Taste binding protein (TBP)** (produced by **Ebner's glands**) transports the tastant and concentrates it at taste buds.

- Then the tastant binds to its **specific receptors** in the microvilli of gustatory cells ➔ opens or closes **ion channels** ➔ potential changes in the taste receptor cell and release of the chemical transmitter **e.g**. **glutamate** which excite the nerve fibers to generate nerve impulses.



c) Taste ligands bind to receptors and create Ca2+ signals that release neurotransmitters onto primary sensory neurons.
Taste ligand
Membrane channel or receptor
Tight junction
Taste cell
Signal transduction
Ca2+
Ca2+ signal
Ca2+
Neurotransmitter
Support cell
Exocytosis
Primary sensory neuron
Action potential

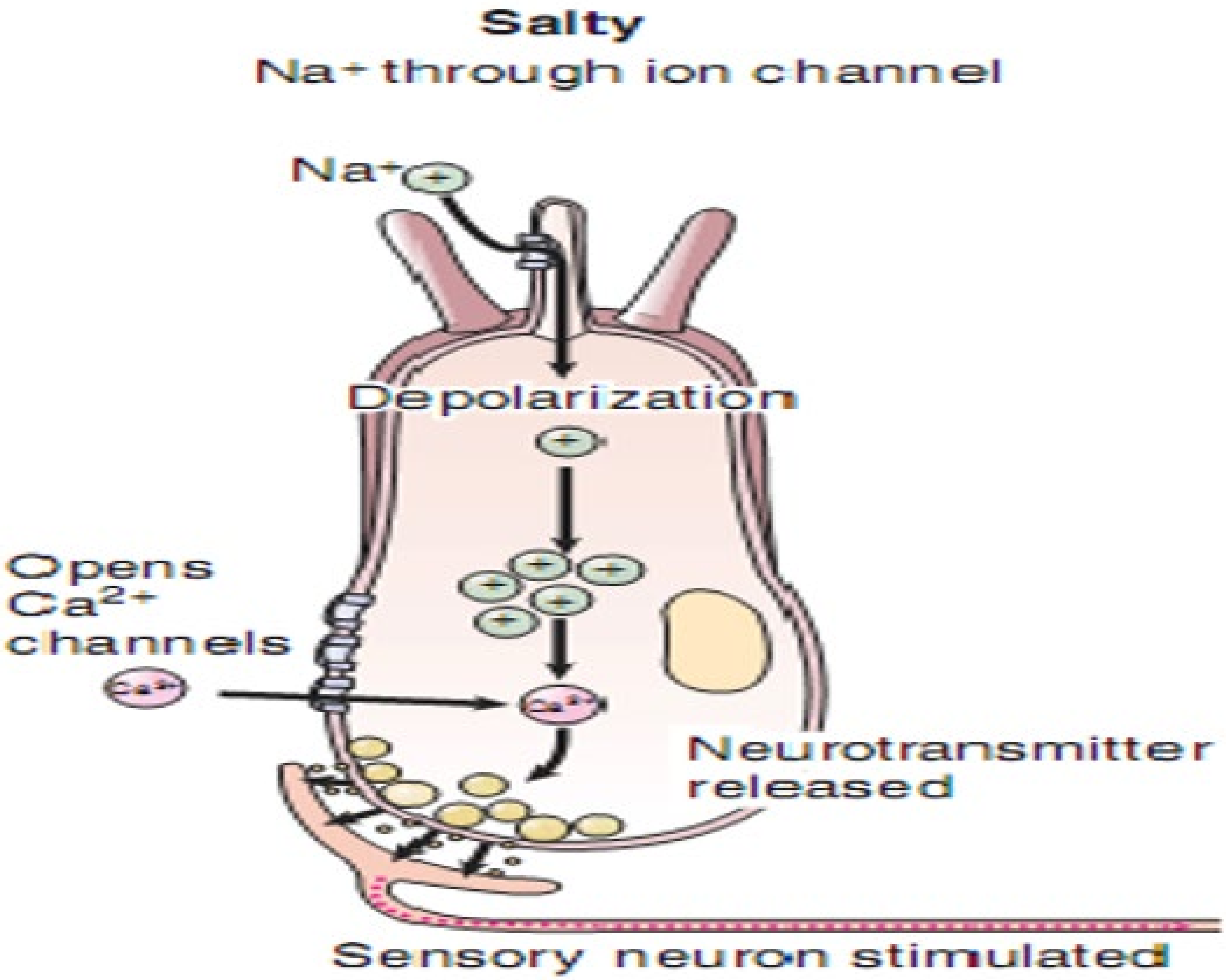



Fig. 10-15

- **For each tastant, there is a different mechanism:**

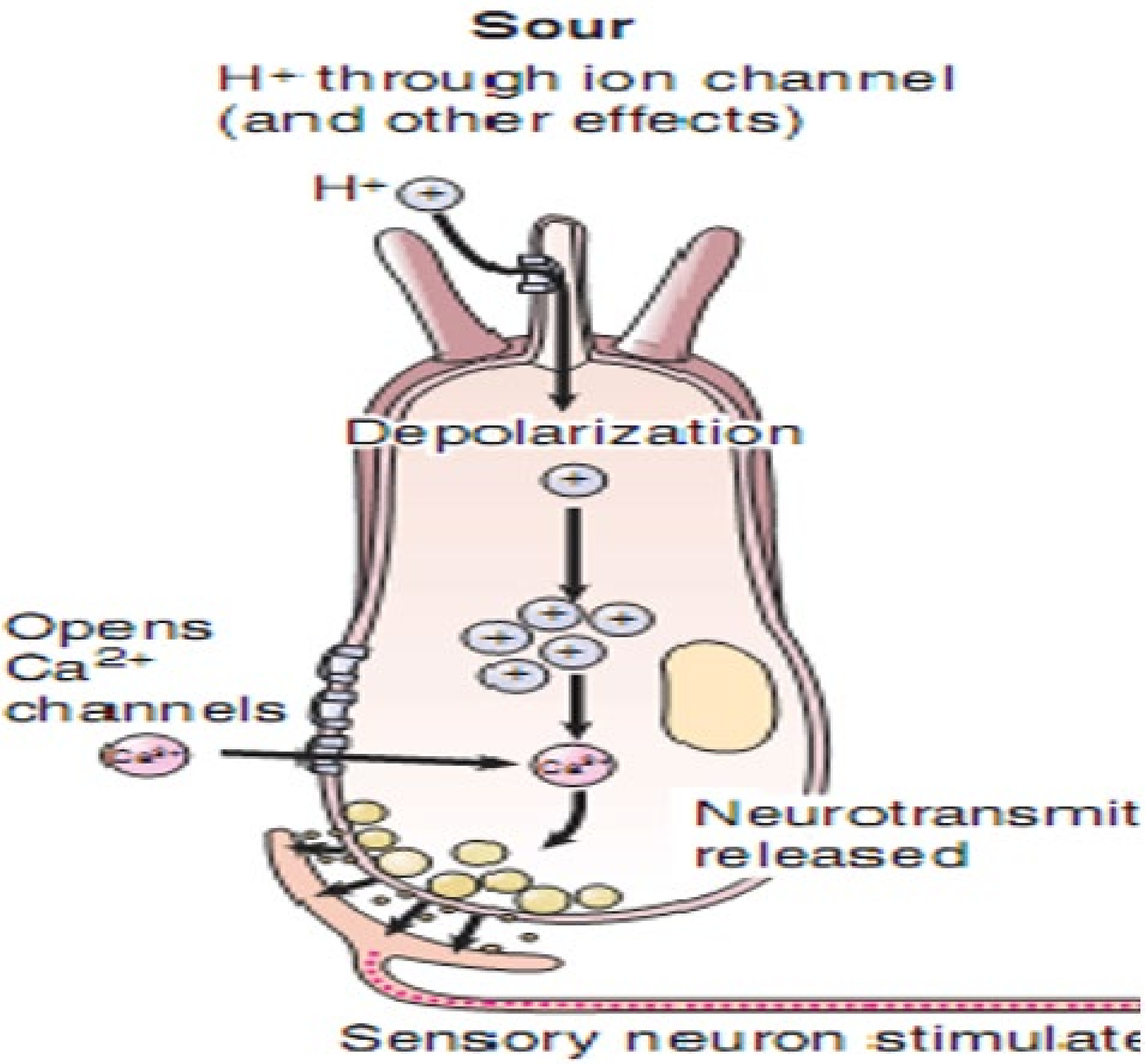
***a) Salty taste:***

Nacl in food activates **epithelial $Na^+$ channels (ENaC)** ➔ **$Na^+$ influx** (down the electrochemical gradient) ➔ cell depolarization ➔ opening of voltage-gated $Ca^{2+}$ channels allowing $Ca^{2+}$ to enter the cell ➔ triggers the release of the transmitter.


Salty
Na+ through ion channel
Na+
Depolarization
Opens
Ca2+
channels
Ca2+
Neurotransmitter
released
Sensory neuron stimulated

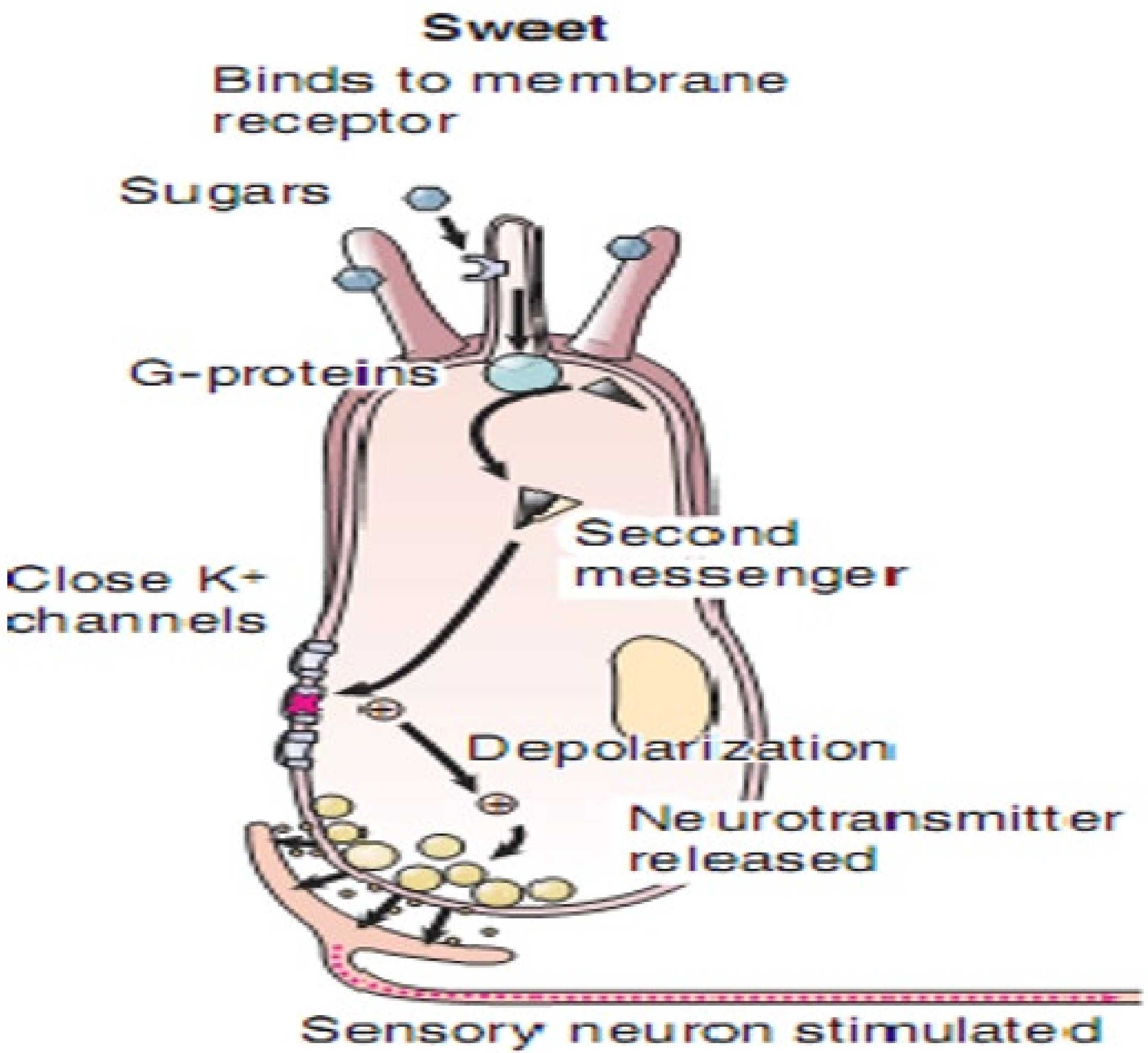
## b) Sour tastes:

$H^+$ ions in the food bind to **$K^+$ channels**, **blocking them**, and preventing $K^+$ from leaving the cell → depolarization→ opening of voltage-gated $Ca^{2+}$ channels allowing $Ca^{2+}$ to enter the cell → trigger the release of the transmitter.


Sour
H+ through ion channel
(and other effects)
H+
Depolarization
Opens
Ca2+
channels
Neurotransmit
released
Sensory neuron stimulate

## c) Sweet tastes:

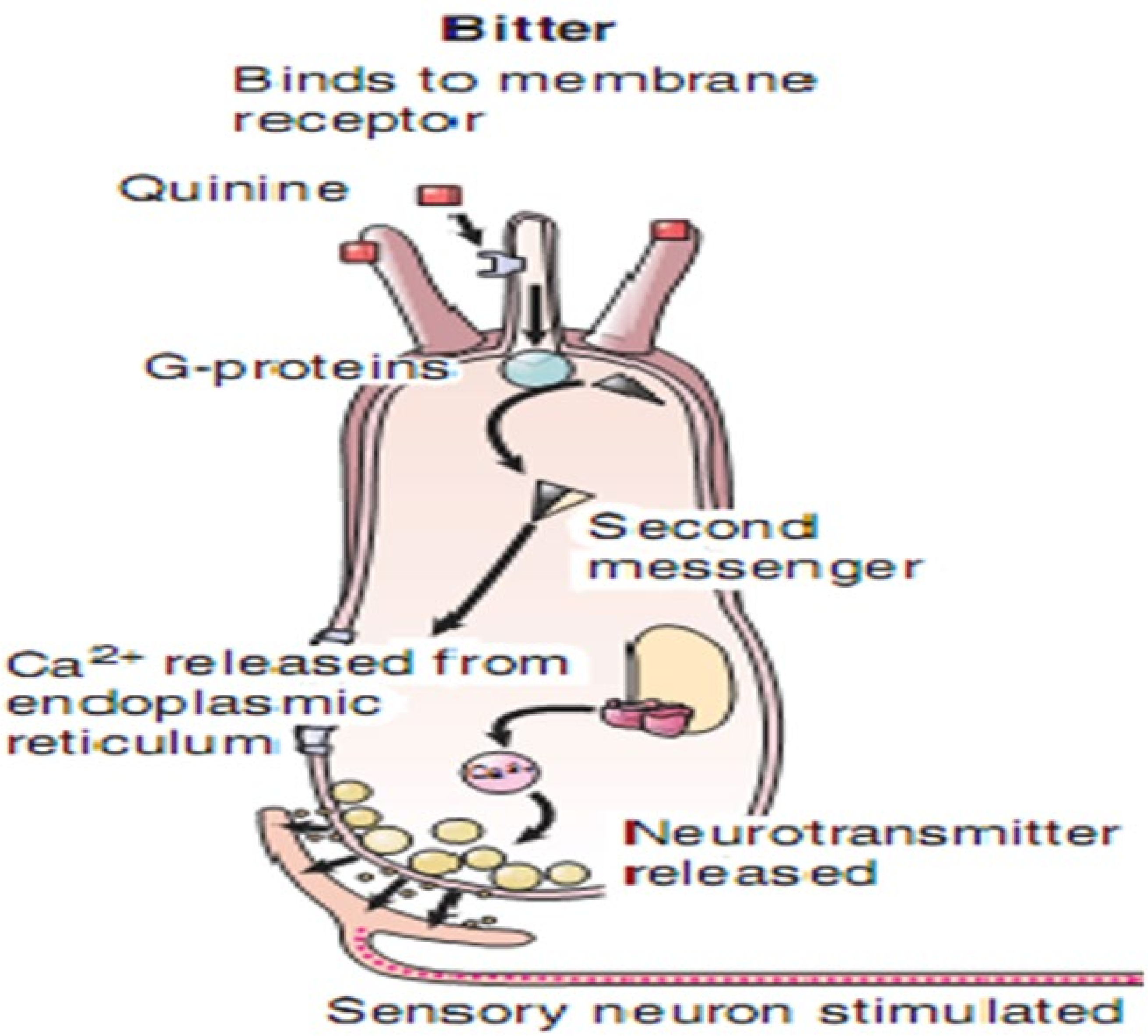
They bind with a plasma membrane receptor that activates a **G-protein** called ***"gustatin"***, which stimulates the production of **cAMP** → phosphorylation of $K^+$ channels → **decreasing $K^+$ leakage out** of the cell causing **depolarization**; which opens $Ca^{2+}$ channels that trigger release of transmitter.


Sweet
Binds to membrane receptor
Sugars
G-proteins
Second messenger
Close K+ channels
Depolarization
Neurotransmitter released
Sensory neuron stimulated

## d) Bitter tastes:

1- **Some compounds** ($Ca^{2+}$ & quinine) ***decrease conductance of $K^+$*** selective channels.

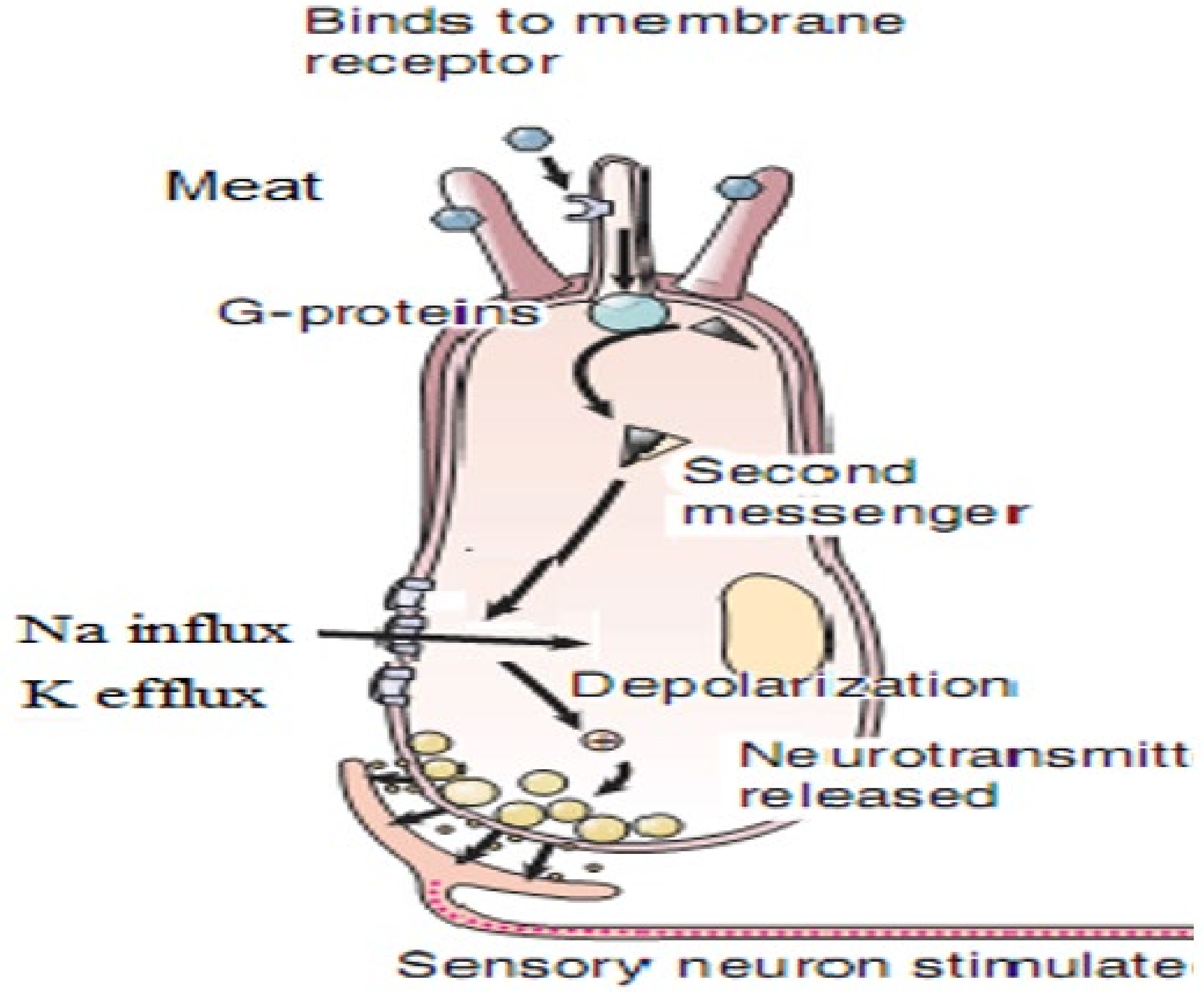
2- **Others** ***increase intracellular messenger inositol triphosphate ($IP_3$)*** which causes the release of $Ca^{2+}$ from internal storage sites which in turn directly stimulates the release of the neurotransmitter.

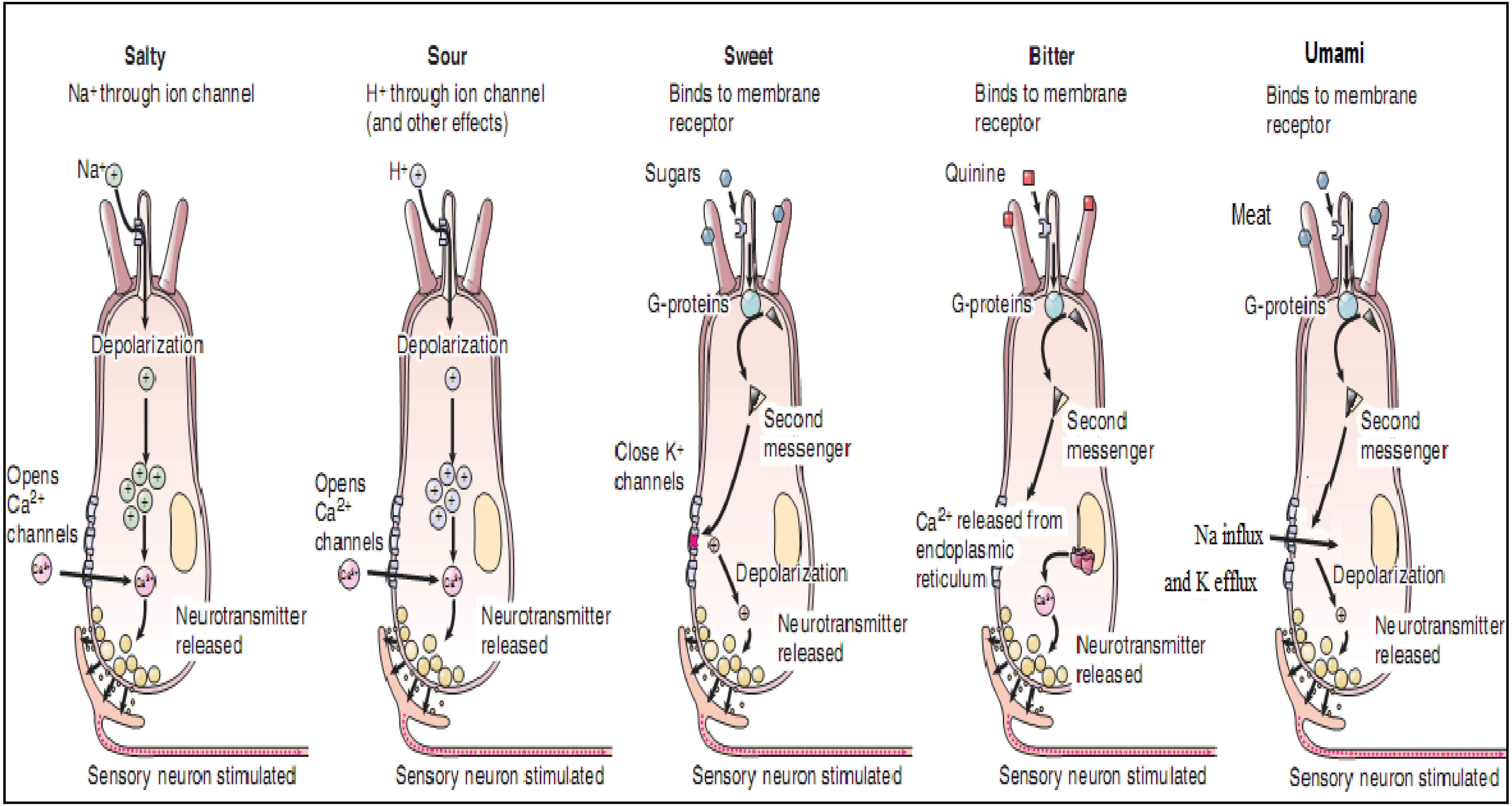

Bitter
Binds to membrane receptor
Quinine
G-proteins
Second messenger
Ca2+ released from endoplasmic reticulum
Neurotransmitter released
Sensory neuron stimulated

## ***e) Umami taste:***

It is due to activation of a ***truncated metabotropic glutamate receptor***, **mGluR4.** These receptors allow **$Na^+$ influx** & **$K^+$ efflux** with the net effect is **depolarization** which releases the neurotransmitter.

# Umami


Binds to membrane receptor
Meat
G-proteins
Second messenger
Na influx
K efflux
Depolarization
Neurotransmitt released
Sensory neuron stimulate



Salty
Na+ through ion channel
Na+
Depolarization
Opens Ca2+ channels
Neurotransmitter released
Sensory neuron stimulated
Sour
H+ through ion channel (and other effects)
H+
Depolarization
Opens Ca2+ channels
Neurotransmitter released
Sensory neuron stimulated
Sweet
Binds to membrane receptor
Sugars
G-proteins
Second messenger
Close K+ channels
Depolarization
Neurotransmitter released
Sensory neuron stimulated
Bitter
Binds to membrane receptor
Quinine
G-proteins
Second messenger
Ca2+ released from endoplasmic reticulum
Neurotransmitter released
Sensory neuron stimulated
Umami
Binds to membrane receptor
Meat
G-proteins
Second messenger
Na influx
and K efflux
Depolarization
Neurotransmitter released
Sensory neuron stimulated

# Taste intensity discrimination

- The ability to **discriminate differences in intensity** of taste is **limited.**
- A **30%** change in the intensity of the substance being tasted is necessary before an **intensity difference** can be detected.

# Specificity of taste receptors

- Each taste bud responds to **only one of the 5 primary taste modalities** when the **concentration of tastant is low** (adequate stimulus).
- But **at high concentration**, most taste buds can be excited by **2 or more taste stimuli**. This explains the **great number of tastes** that a person can perceive.

# Adaptation of taste

- Taste sensations adapt **rapidly within minutes** in spite of continuous stimulation.
- It occurs in the **CNS itself**. This is **different from most other sensory systems which adapt mainly at the receptors**.

# Significance of taste

1. **Stimulation of GIT secretions** **e.g.** salivary secretion through unconditioned reflexes.

2. **Prevention of ingestion of most poisons** which have strong bitter taste.

3. **Determination of the flavor of food**.

# Taste preference

- This **means** the **selection of certain types of food in preference to others**.
- Usually, these types are **needed to the body**.
- **In experimental animals** it has been found that **adrenalectomised** animals show great preference to **salty water** (containing Nacl) while **parathyroidectomised** animals prefer **$Ca^{++}$ containing water**.
- Taste preference occurs in the **CNS** by unknown mechanism.

# Disturbance of taste sensation

1. **Ageusia (taste blindness):** absence of taste sensation for certain substance.
2. **Hypogeusia:** diminished taste sensation
3. **Gustatory hallucination:** False sensation of certain tastes
4. **Dysgeusia:** disturbed taste sensation.

# References


1. Costanzo, Linda S. "BRS Physiology (Board Review Series)." (2018).
2. Ganong, William F. "Review of medical physiology." (2020).
3. Hall, John E and Hall, Micheal E. “Guyton and Hall Textbook of medical physiology." (2021).