Round 5
The Chemical Senses: Smell & Taste

01/15/2021

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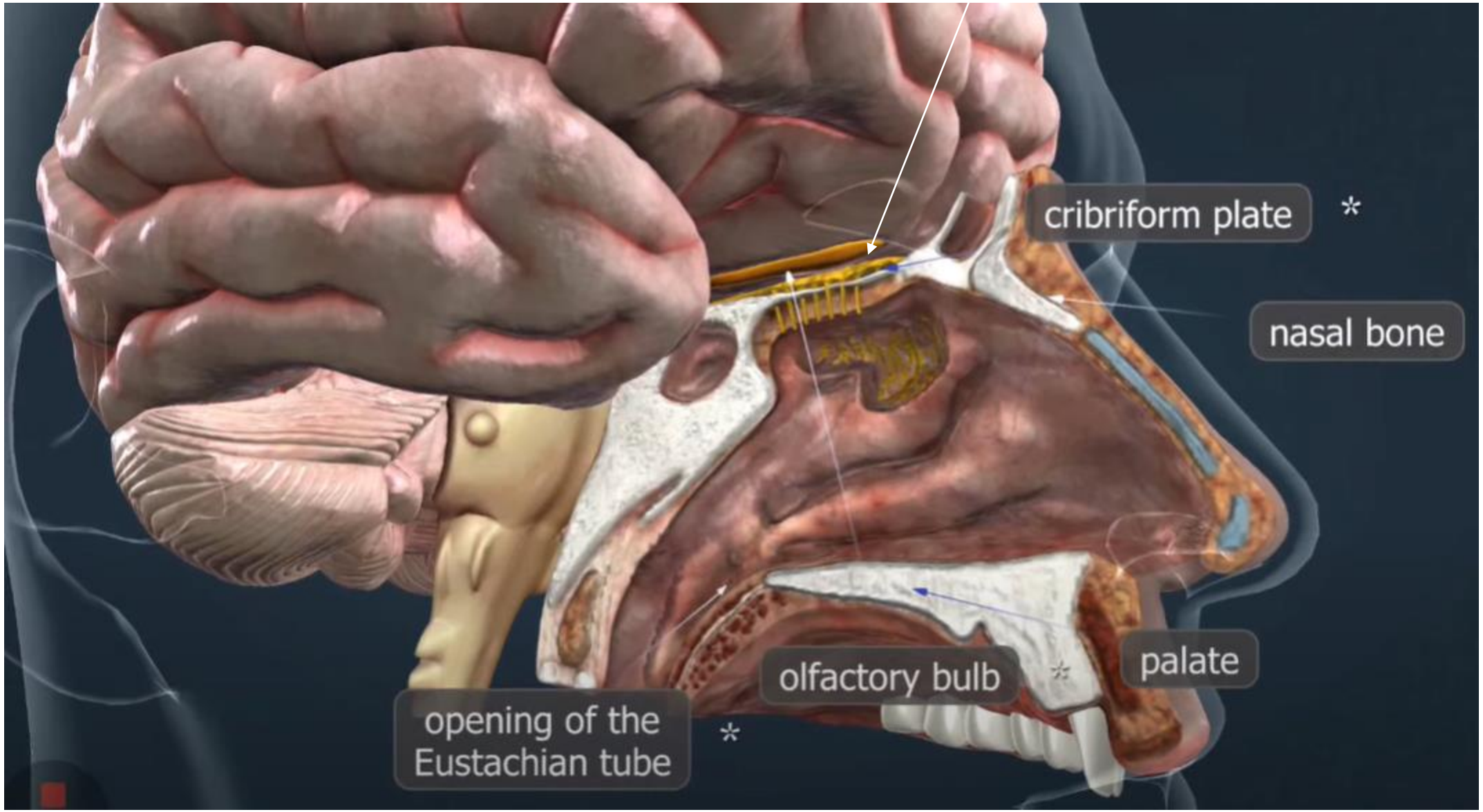
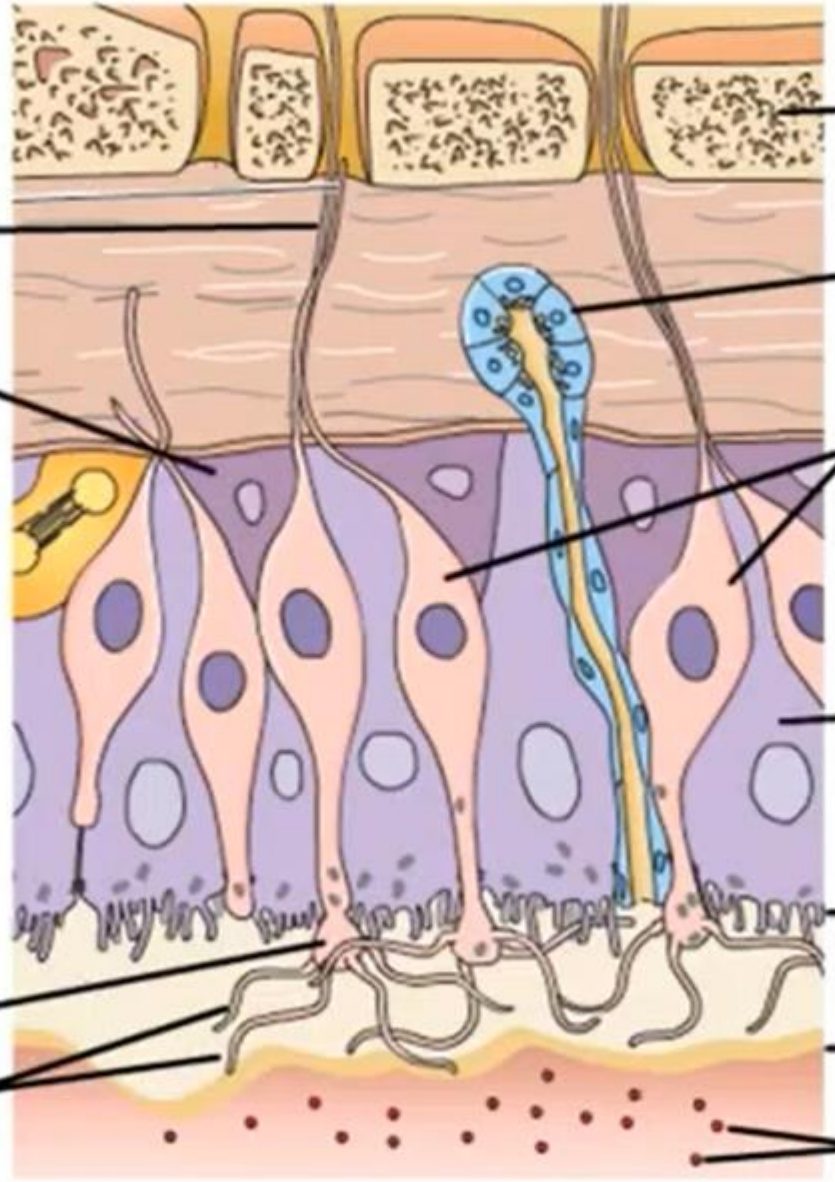
Olfactory Epithelium (5 cm^2)

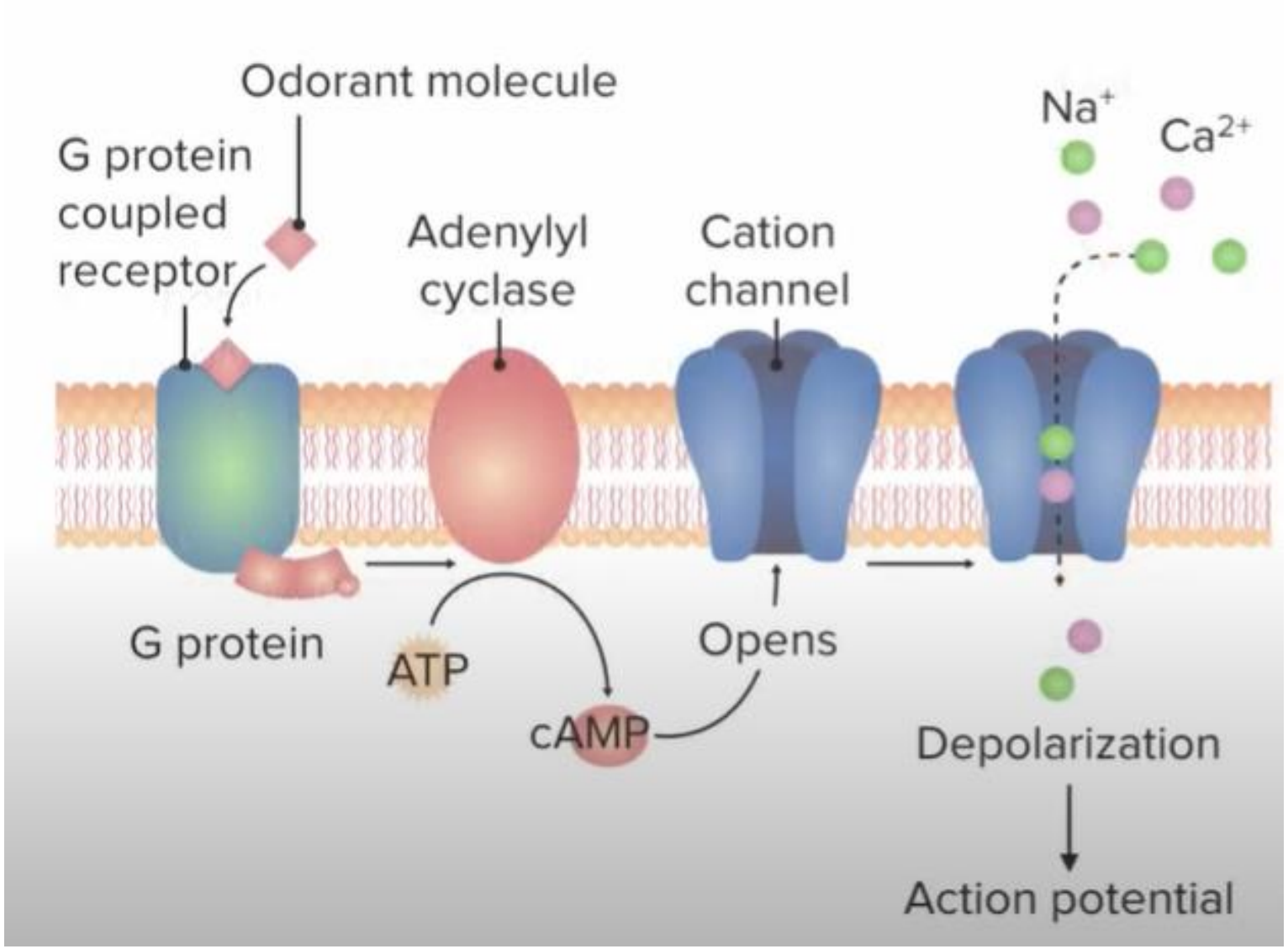


Olfactory Epithelium

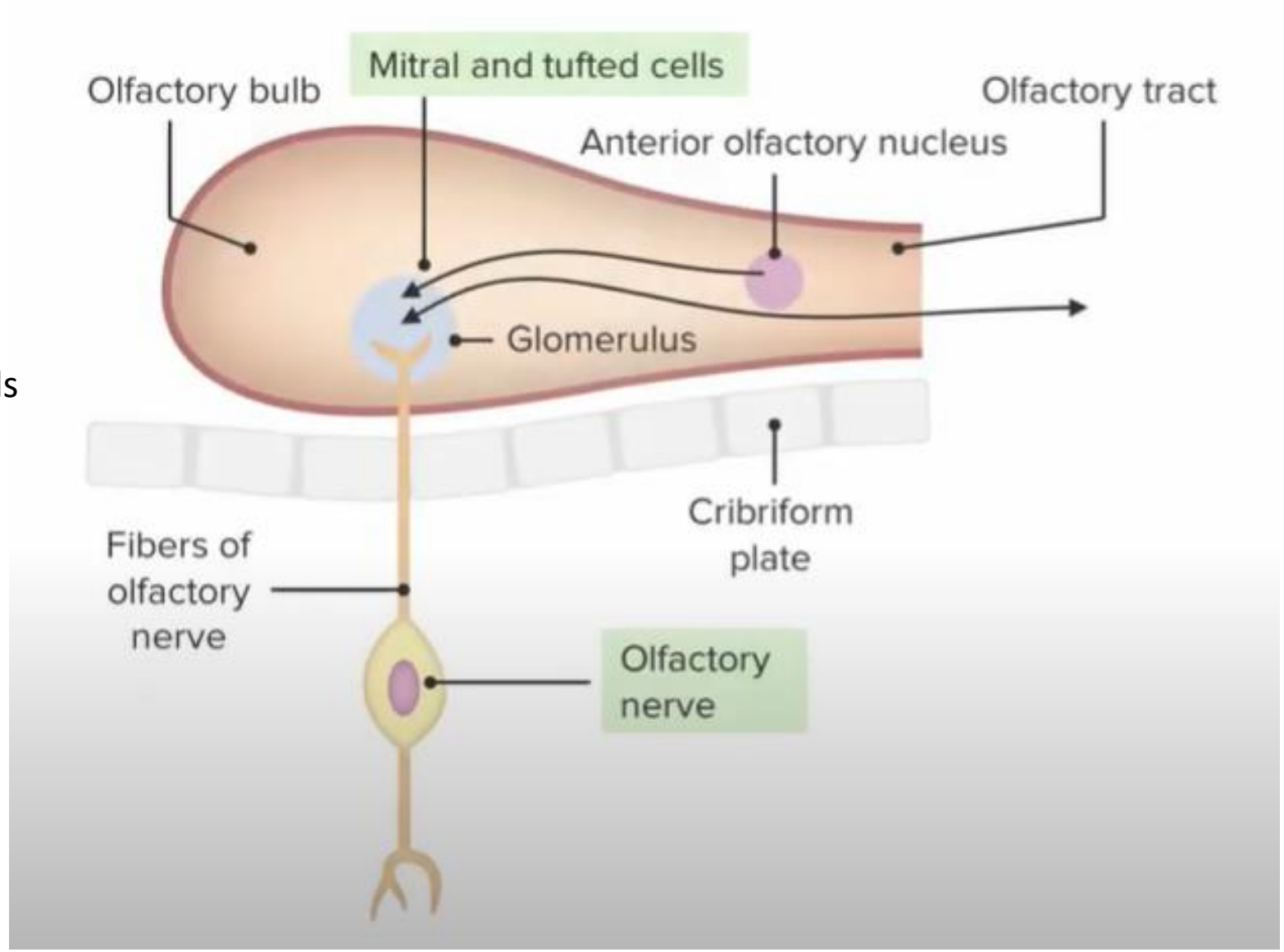


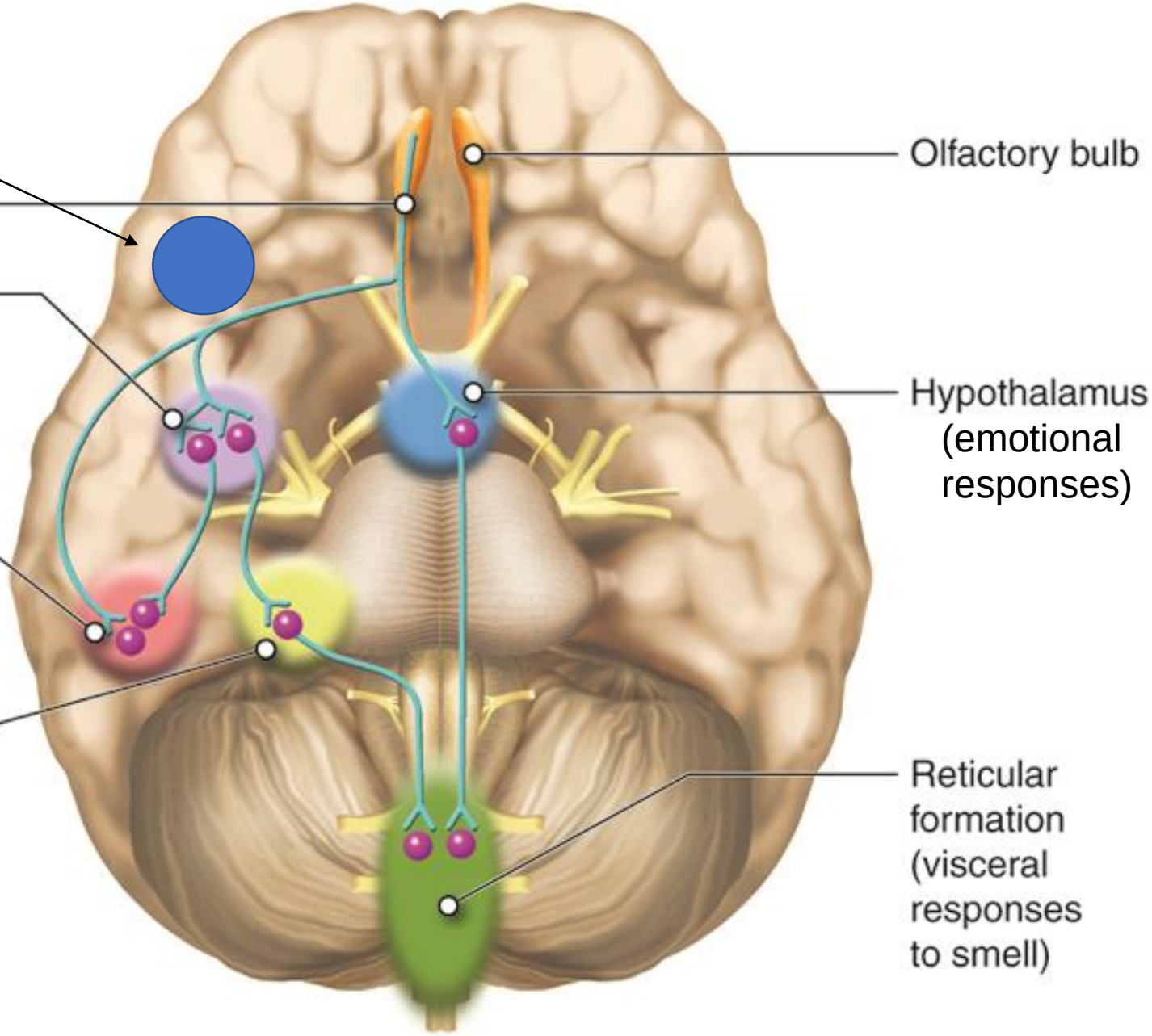
Stem cells undergo mitosis to replace Olfactory neurons ~30-60 days

- ~400 different types.
- Each responds to a different protein.
- The ~ 1 trillion scents we can distinguish depends on pattern of activation.


Odorant molecule
G protein coupled receptor
Adenylyl cyclase
Cation channel
Na^+
Ca^{2+}
G protein
ATP
cAMP
Opens
Depolarization
Action potential

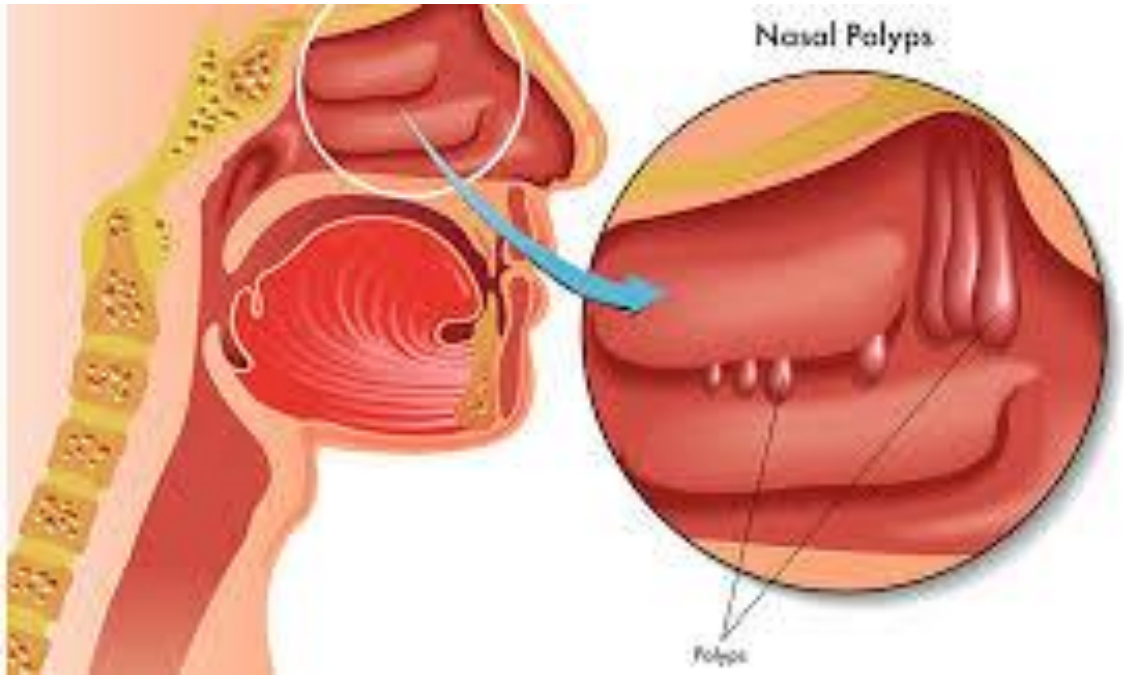
Glomerulus - axon terminals of olfactory cells & dendritic extension of Mitral cells

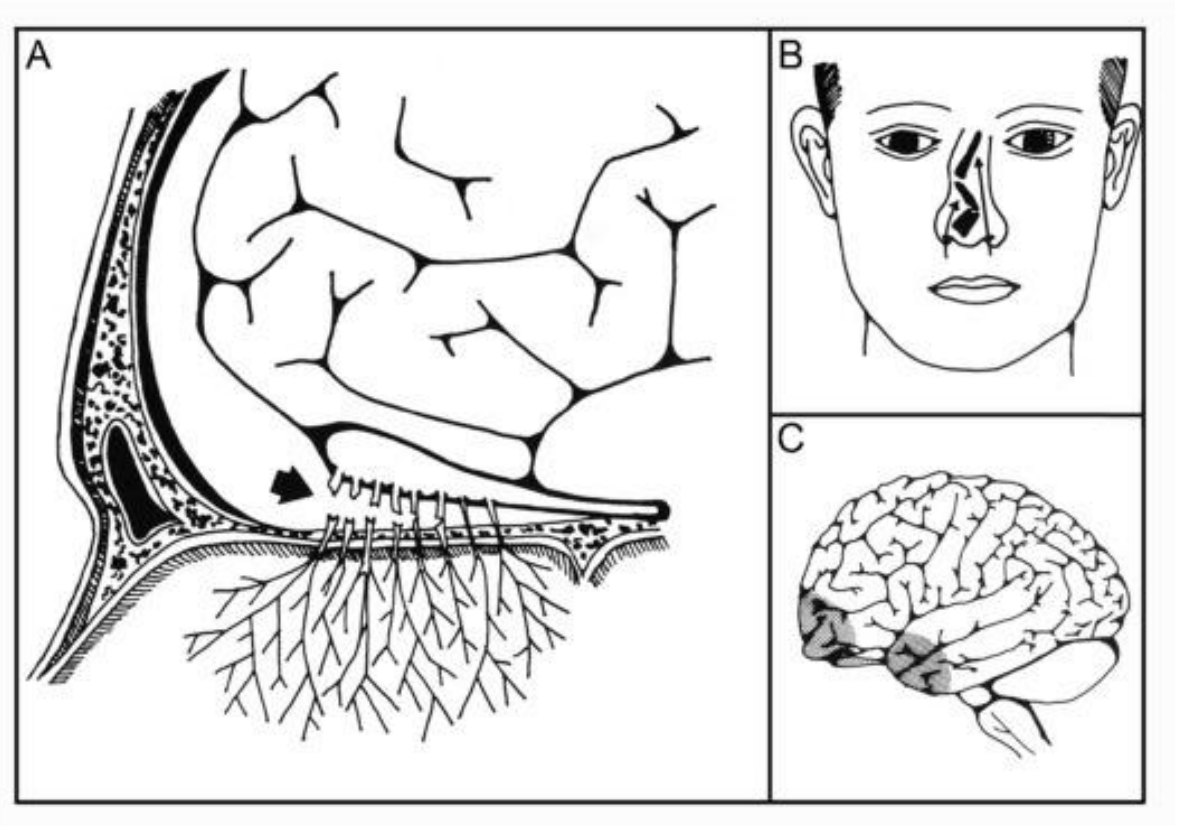



Orbitofrontal region
(reward/value)
Olfactory bulb
Olfactory tract
Piriform cortex
Olfactory cortex
of temporal lobe
(conscious
perception
of smell)
Hypothalamus
(emotional
responses)
Entorhinal cortex –
entrance to hippocampus
Hippocampus
(olfactory
memory)
State-dependent
memory
Amygdala
(emotional
responses)
Reticular
formation
(visceral
responses
to smell)
Evolutionarily important for the
detection of threat (fight or flight
response) – role in anxiety

Anosmia – loss of the ability to detect smell

- Trauma to the face
- Damage to the temporal lobe
- Nasal polyps





Anosmia – loss of the ability to detect smell

- Disorders & Disease

  - Aging & Age-related Neurodegeneration
    - 10% of 65 >, 62-80% of 80 >, men more than women
    - Retarded regeneration of olfactory receptor cells
    - Reduced activation of specific brain regions (e.g., piriform cortex, amygdala, entorhinal cortex)
    - Decreased olfactory bulb volume

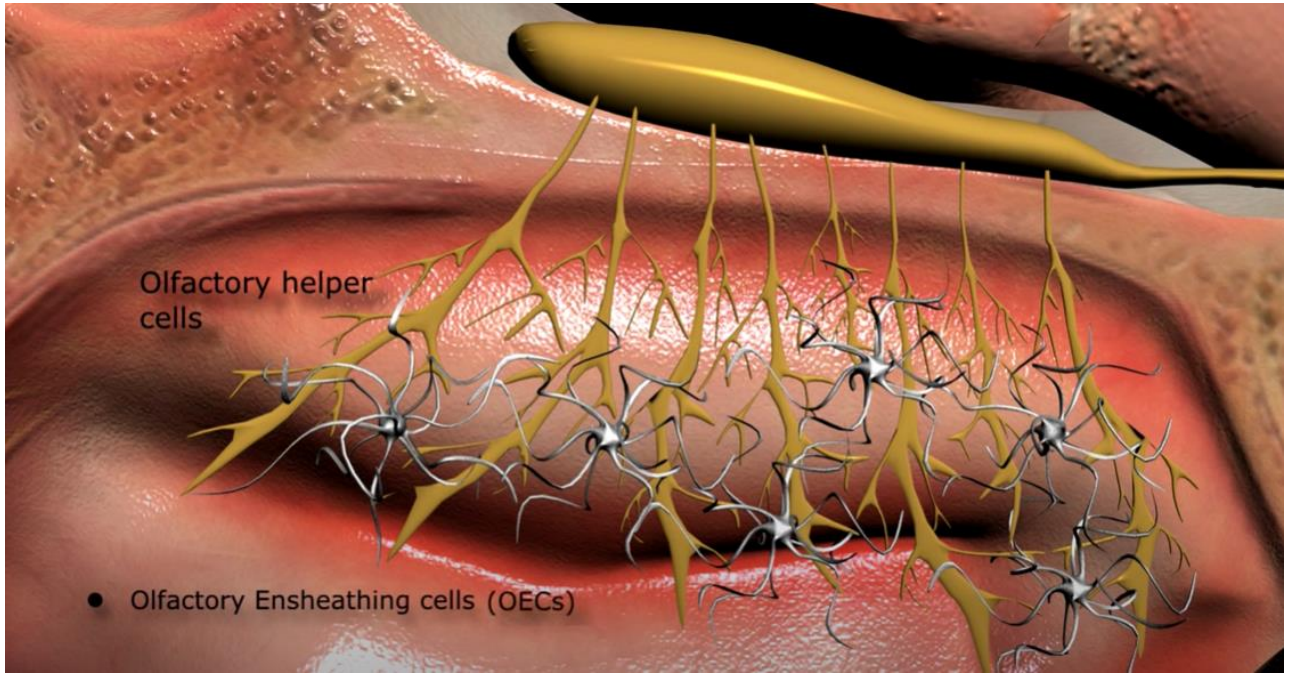
  - Parkinson's
    - Occurs in 85% of pts
    - 4-6 years before onset of motor symptoms
    - Characterized by loss of dopaminergic (DA) neurons in Substantia Nigra
    - DA also produced in olfactory bulb, which also receives DA input from midbrain
    - Reduced volume of olfactory bulb
    - Decreased connectivity among olfactory processing sites

  - Alzheimer's
    - Occurs in 85% of pts
    - Plaque deposits throughout the olfactory pathway (e.g., piriform cortex, entorhinal cortex)

Anosmia – loss of the ability to detect smell

- Cold & Flu
  - Inflammation of the nasal mucosa
  - Increased mucus

- Some viruses – avoid blood/brain barrier
  - 1930's prevent spread of polio in children by cauterizing olfactory epithelia

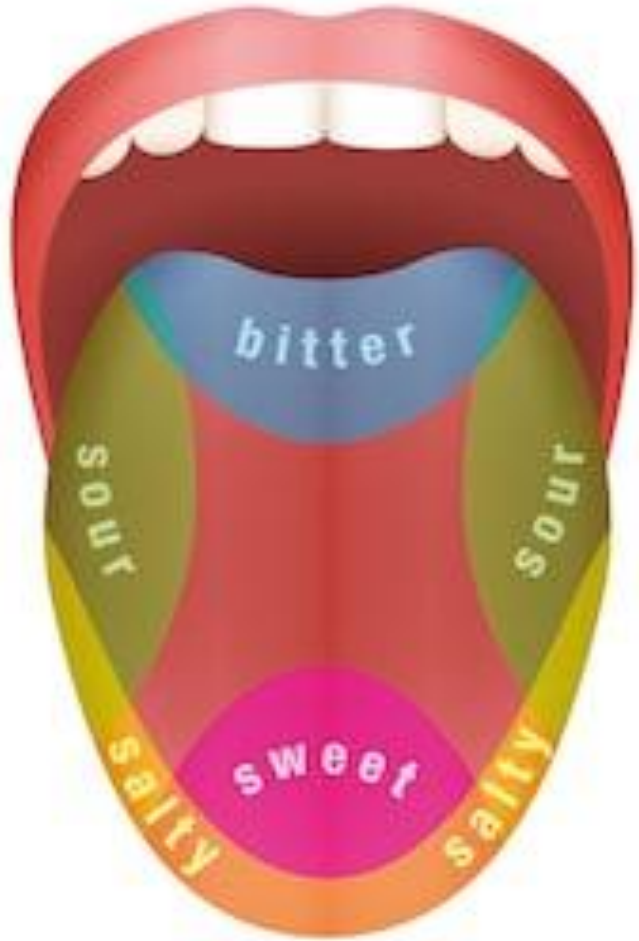


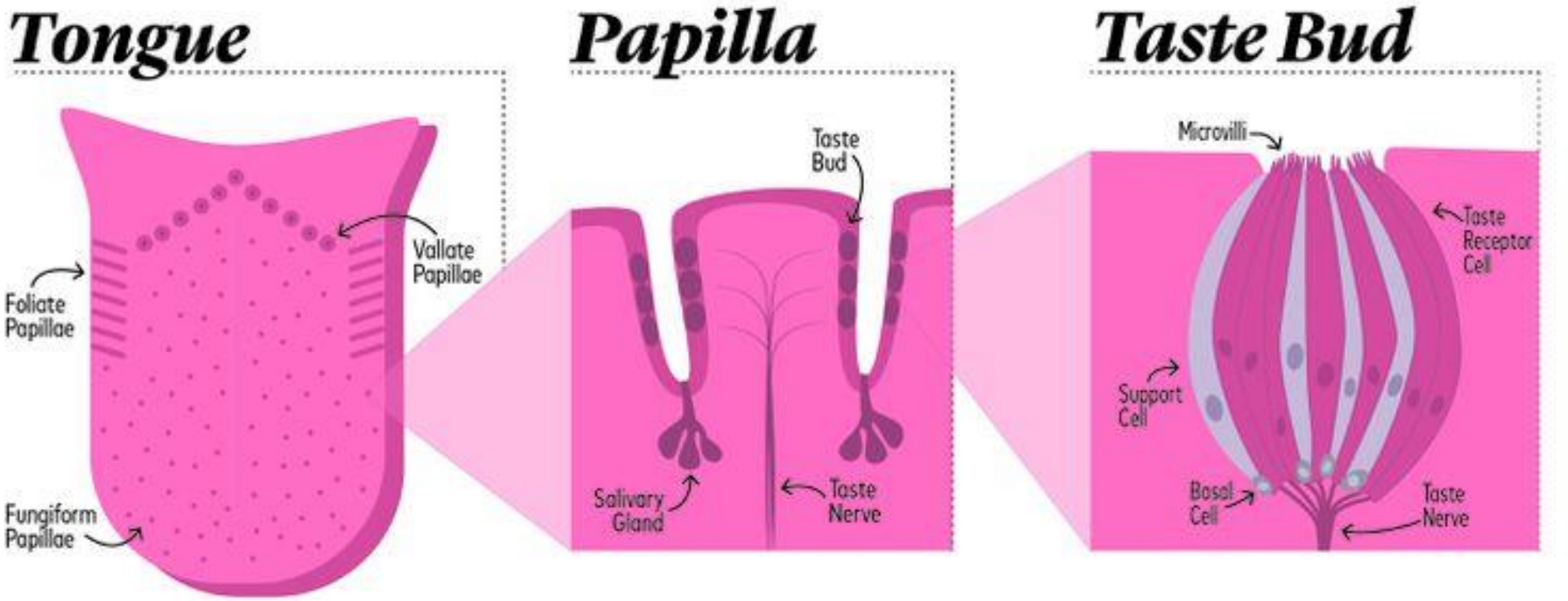
- COVID-19
  - Up to 86% of COIVD 19 pts lose sense of smell
  - May be better indicator symptom than fever
  - OECS express ACE-2 & TMPRSS2, which are surface proteins that can be targets for COVID 19
  - Olfactory nerves are not damaged
  - COVID-19 anosmia is not caused by damage to the central nervous system but rather by the loss of smell information before it gets to the brain.

Special Cases of Smell

- Pheromones
  - Chemicals that affect the behavior of other member of the species
  - Alarm – insects (e.g., bees)
  - Sexual attraction/ Reproductive behavior
    - Urine of male lions triggers the release of luteinizing hormone (ovulation)
  - Kinship

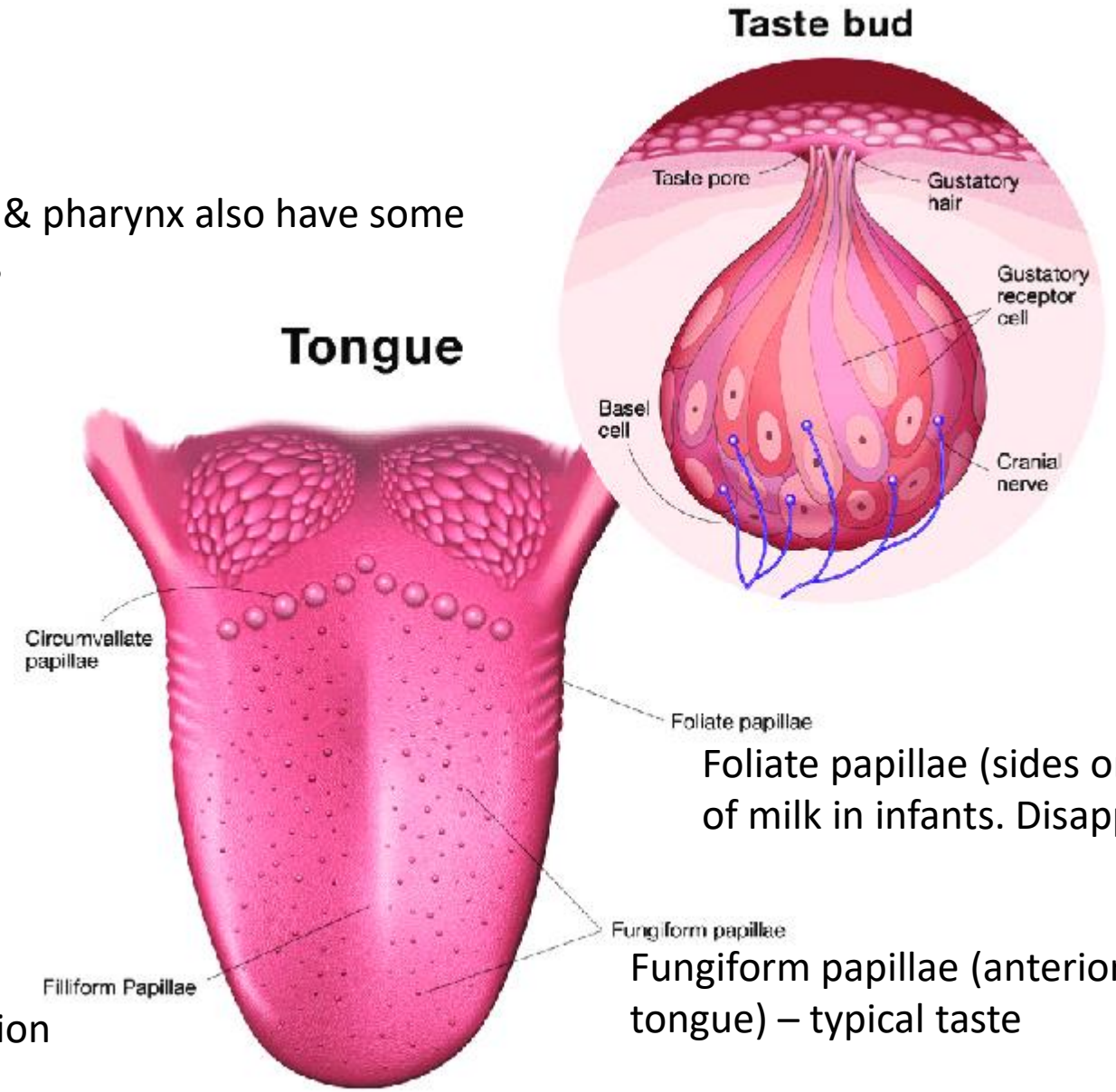
- Taste
  - Up to 8o% of taste is actually smell


bitter
sour
sour
salty
sweet
salty



- Born with ~ 10,000 taste buds but have ~5,000 by 20s
- Children are more sensitive to bitter flavors. Evolutionarily beneficial b/c many poisons taste bitter.
- Each taste bud has 50-150 taste cells
- Taste cells are regenerated about every two weeks.

Epiglottis & pharynx also have some tastebuds



Foliate papillae (sides on the tongue) – taste of milk in infants. Disappear as we age.

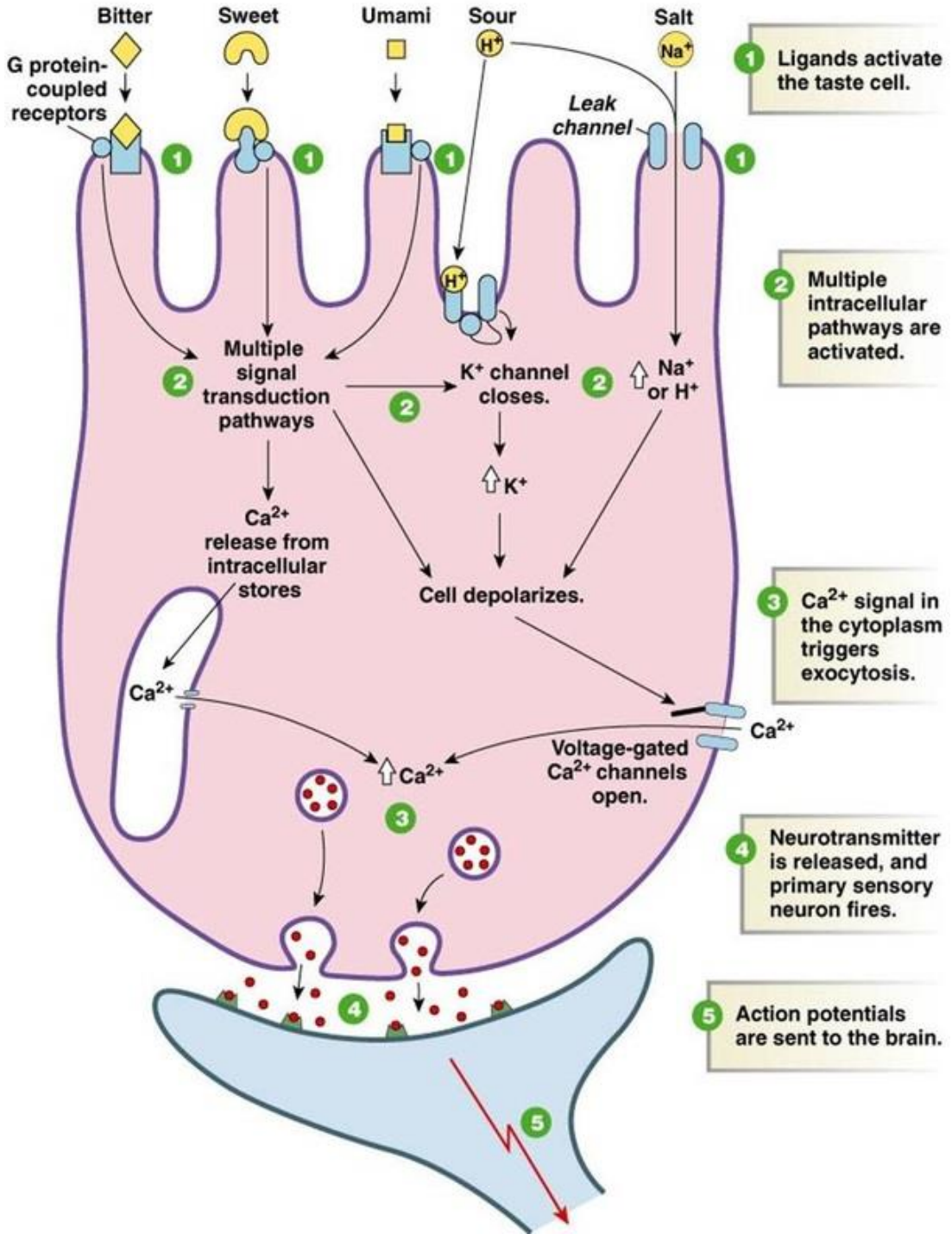
Fungiform papillae (anterior 2/3 on tongue) – typical taste

Filliform papillae– increased friction

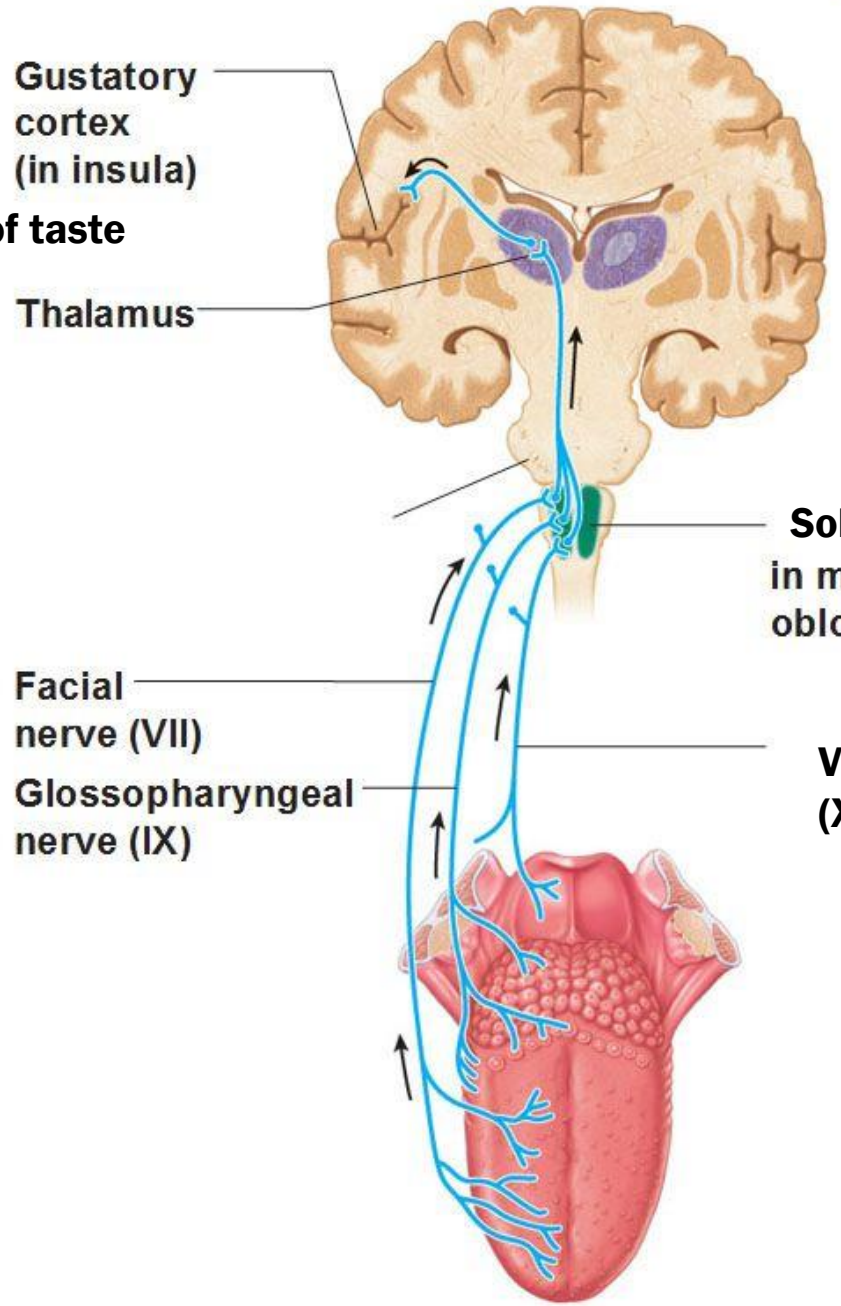
- Each taste bud has taste cells for 5 “tastes”
  - Sweet – polysaccharides, fructose, lactose, sucrose, etc.
  - Salty - Sodium
  - Sour - Acid
  - Bitter
  - Umami – savory rich meat, cheese monosodium glutamate (MSG)

- Some “tastes” aren’t perceived gustation but are actually felt by the somatosensory system
  - Spicey
    - stimulate hot thermoreceptors & pain receptors (capsaicin)
  - Menthol – stimulates cold receptors

- Sweet/Bitter/Umami
  - stimulates the taste cells to release calcium which starts a chain reaction triggering the release of serotonin and ATP into the synapse to the cranial nerve & an action potential is sent
- Salty
  - There are channels that are particular to sodium chloride. As sodium goes into cell it opens channels for calcium
- Sour
  - Acidic molecules are high in protons. They block the potassium from leaving the cell, opening calcium channel



Gustatory Pathway



Conscious perception of taste

Amygdala & Hypothalamus – Emotional quality of taste

Hippocampus – Memories of taste

Special Cases of Taste:

Cravings

- Nutrient deficiency
    - Animals tend to crave foods are high in a nutrient they are deficient in – specifically salt
    - Child with adrenal cortex tumor -> inability to maintain salt balance
        - When given unlimited access to any kind of food, the child consistently chose salty foods
    - Subsequent study in rats -> removal of adrenal cortex
        - Similar preference for salty foods
        - Salt receptors less sensitive to salt
    - Pregnancy cravings
    - Gut microbiome

Special Cases of Taste:

Taste Aversion – Conditioned response in which animals associate a specific food with negative visceral response (vomiting).

- Unique form of conditioning that can occur in only 1 trial with as much as 24 hours between food ingestion and vomiting. Can last a lifetime.

- Rat studies
  - Sugar water paired with tone and mild poison – only taste became aversive, not tone
  - Sugar water paired with tone and foot shock – only tone become aversive, not taste
    - Demonstrates that nausea & stomach illness is linked to taste & smell rather than other modalities

- What gets associated?
  - Case of the filet mignon with Bearnaise sauce & the stomach flu

- May be mediated by amygdala and/or insular cortex

Special Cases of Taste:

Role of other senses

- Vision
- Somatosensory (e.g., “mouth feel”)
- Audition – crunchiness of ships
- Personal beliefs – price, bottled vs. tap water