Taste - Chapter 15

Lecture 21

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Sensation & Perception (PSY 345 / NEU 325)

Spring 2022

Bi-nostral smelling: why have two nostrils?

“The world smells different to each nostril”

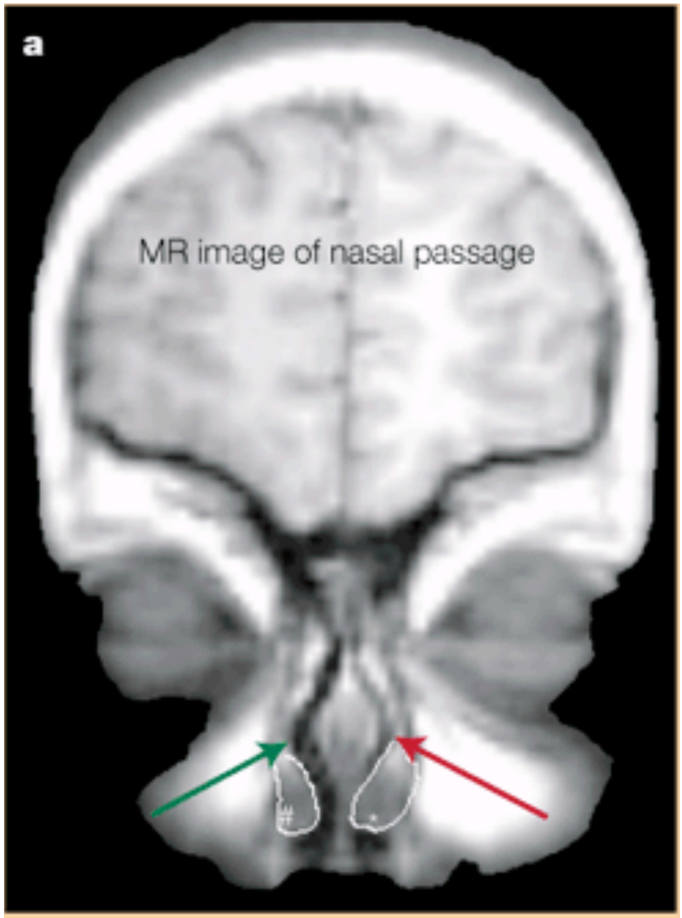
Sobel et al, Nature 2000

Background

1. Airflow is greater into one nostril than the other, due to slight swelling that obstructs airflow.
2. Switches nostrils several times per hour.

Q: What are the consequences for olfaction?

Bi-nostral smelling: why have two nostrils?



Background

1. Airflow is greater into one nostril than the other, due to slight swelling that obstructs airflow.
2. Switches nostrils several times per hour.

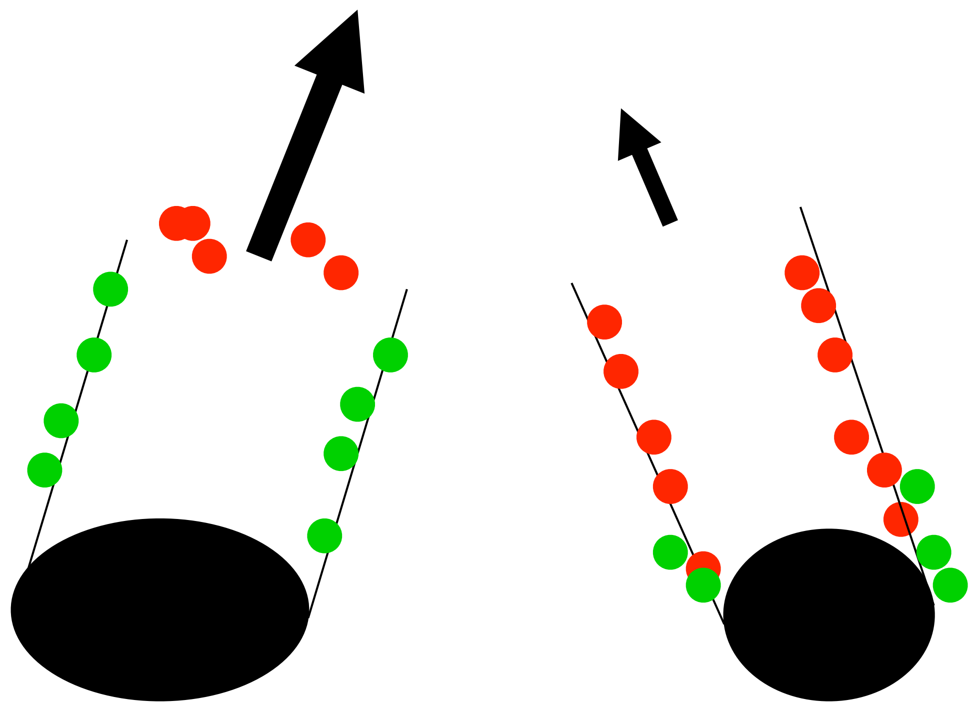
Obstructed nostril (swollen turbinates)

un-obstructed nostril (relaxed turbinates)

• Odorants sorb across nasal mucosa at different rates

● "high-sorption" odorant – induces small response when airflow is low, and large one when airflow is high

● "low-sorption" odorant – large response when airflow is low; small



Finding: odorants do indeed smell different in nostrils, depending on the air flow and sorption of the odorant!

Olfactory Psychophysics

- How much stimulation is required before we perceive something to be there?

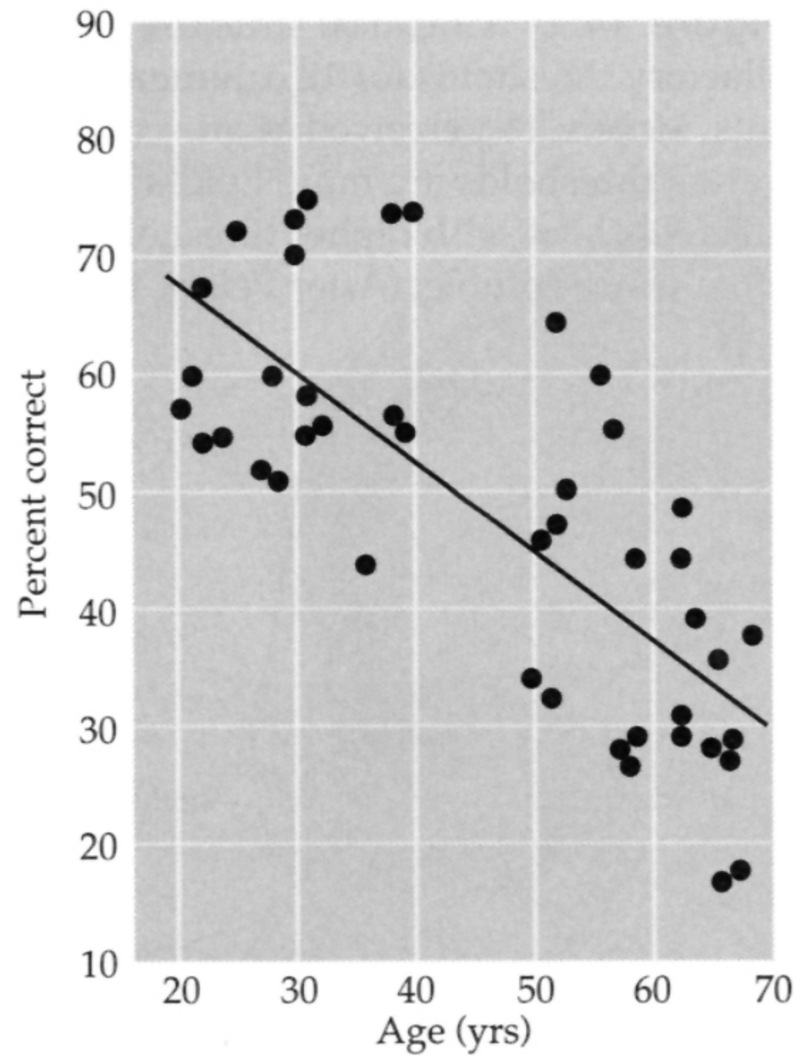
- Olfactory detection thresholds: Depend on several factors
  - Women: generally more sensitive than men, especially during ovulatory period of menstrual cycles,

  - Professional perfumers and wine tasters can distinguish up to 100,000 odors

And also:

- Age: By 85, 50% of population is effectively anosmic

(like those high-pitched sounds, enjoy smelling while you still can!)



Olfactory Hedonics

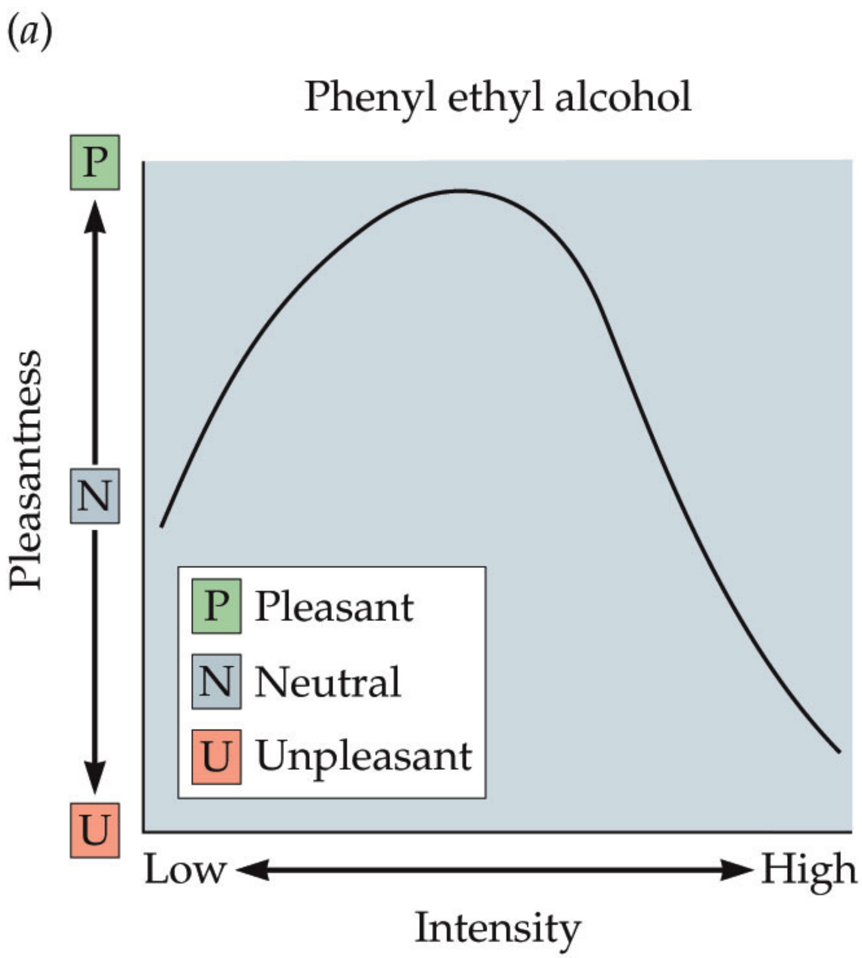
Odor hedonics: the "liking" dimension of odor perception

- measured with scales of *pleasantness*, *familiarity*, and *intensity*

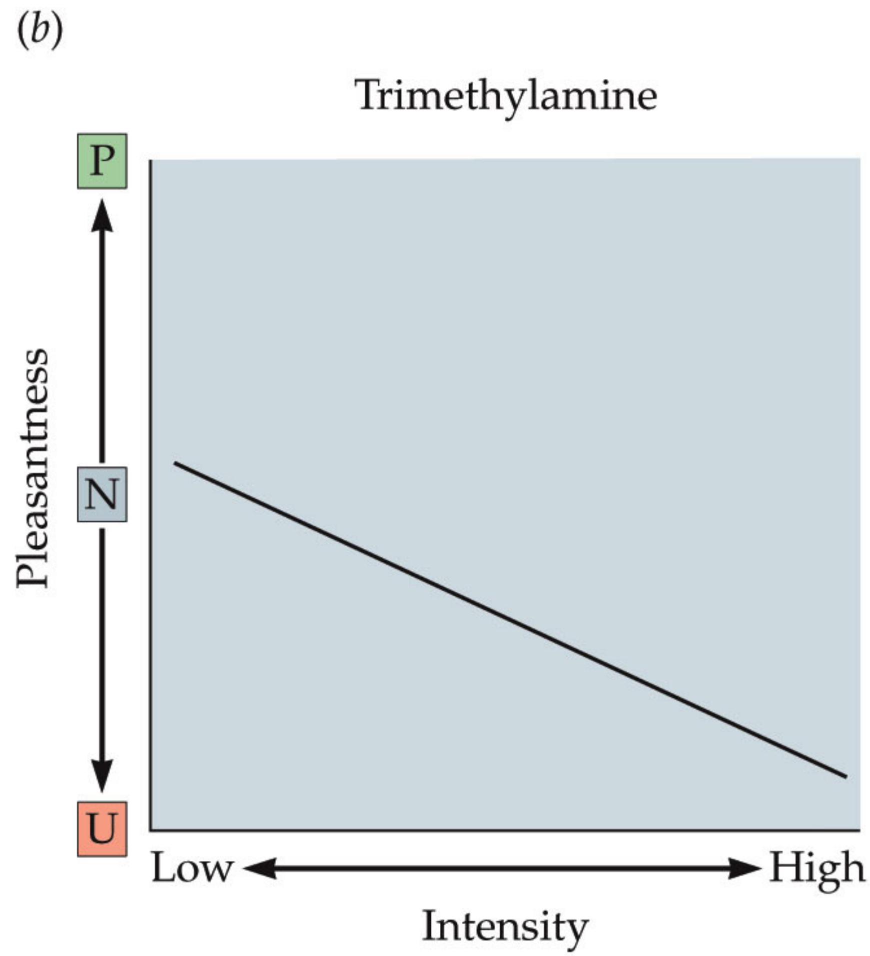
Familiarity and intensity:

- Pleasantness: obvious
- Familiarity: tend to like odors we've smelled before
- Intensity: more complicated relationship with odor liking

Odorants: Pleasantness vs. intensity



inverted U-shaped function



Linearly decreasing function

Olfactory Hedonics

Nature or nurture?

- Long-standing debate: innate vs. learned
- **verdict**: almost completely "nurture"
- infants: not put off by sweat or feces; don't discriminate banana from smell of rancid food
- Cross-cultural data support associative learning
- Wintergreen study (Moncrief, 1966)
  - Americans like it.
  - English rated it the most unpleasant of many odors (used in medicine)
- US Army: tried to develop stink bomb for crowd dispersal: couldn't find a smell that was universally disgusting (including "US Army Issue Latrine Scent")

Japanese and American people have very different tastes in food

Cheese
- disgusting to most Japanese

Natto
- fermented soybeans; Japanese breakfast food

Olfactory Hedonics

- Evolutionary argument: *generalists* (like us, and roaches) don't need innate smell aversions to predators

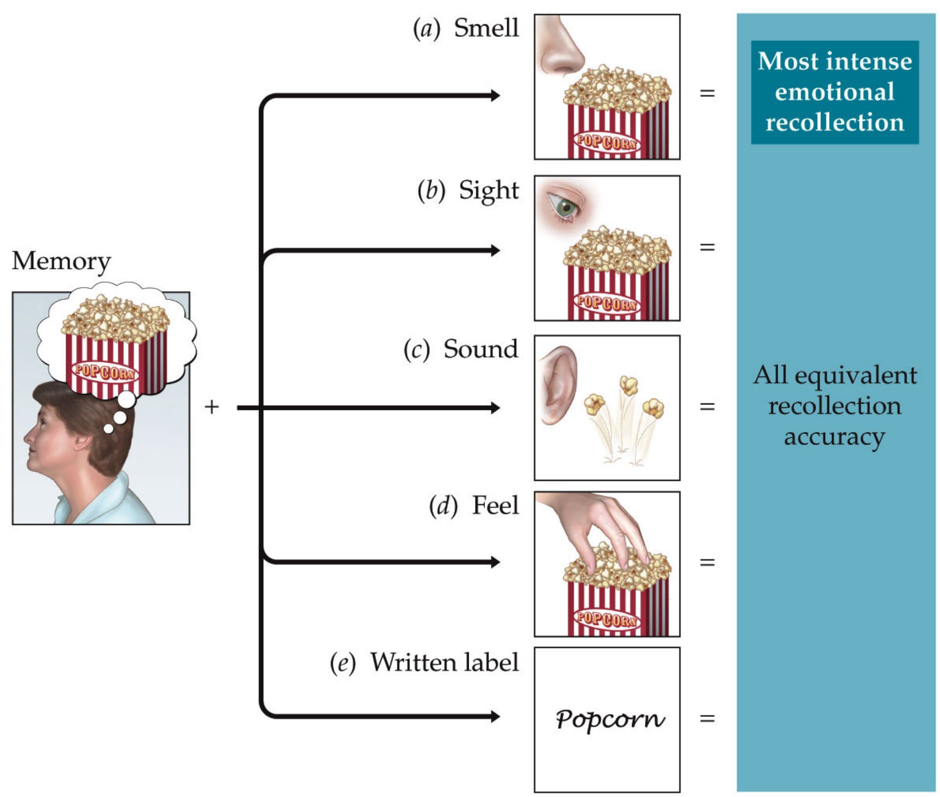
- **learned taste aversion**: Avoidance of a flavor after it has been paired with gastric illness.
    - finding: from the smell, not the taste (Bartoshuk 1990)

Olfaction and memory

Q: are odors really the best cues to memories?

- Memories triggered by odor cues are distinctive in their emotionality
- But *not* (it turns out) more accurate

The smell, sight, sound, feel, and verbal label of popcorn elicit memories equivalent in terms of accuracy but not emotion



See extra from last lecture
(not discussed in lecture):

Pheromones and the
Vomeronasal Organ (VNO)

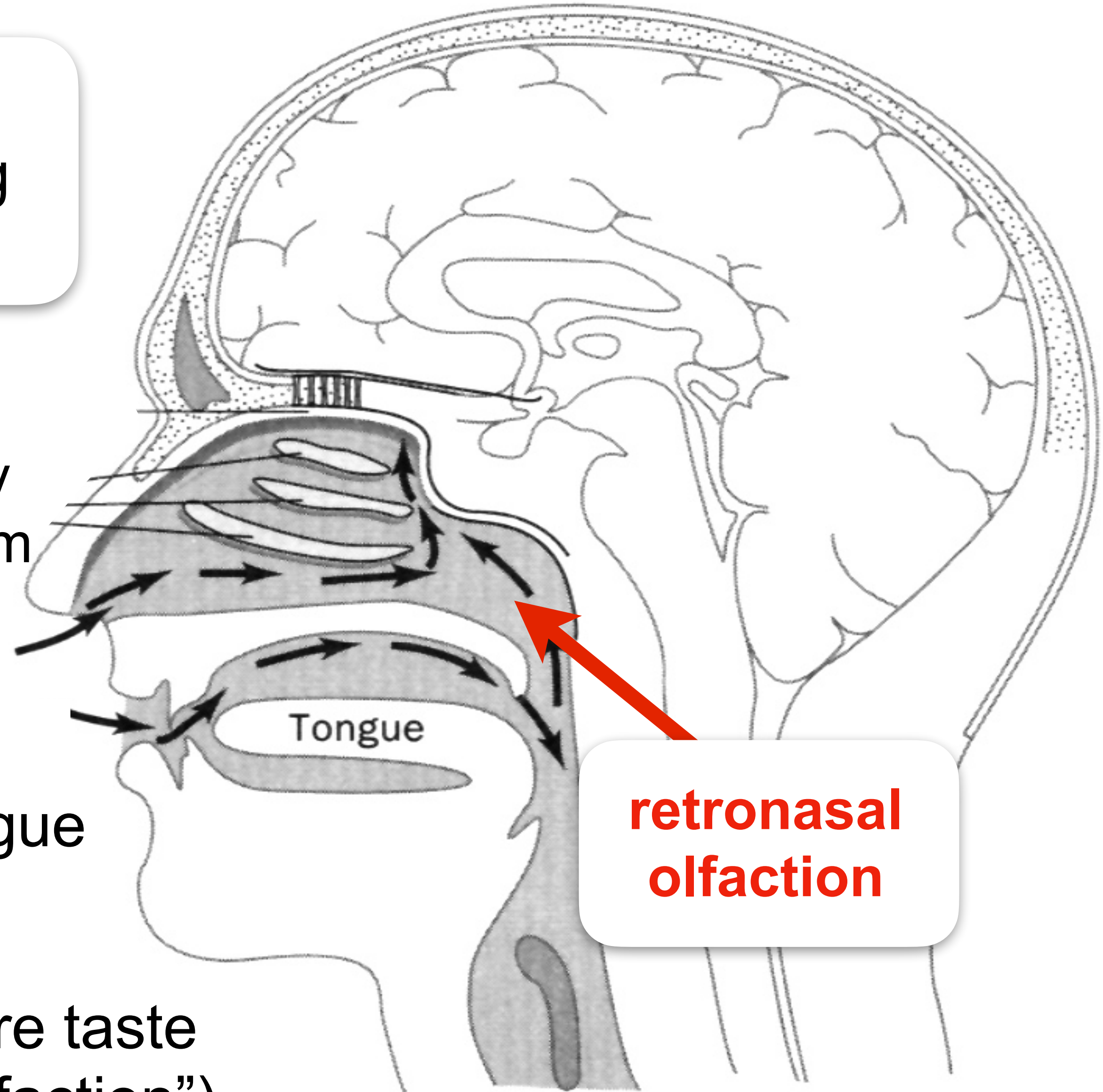
Olfaction summary

- odors, odorants
- scent tracking, binostril smelling (2 reasons)
- olfactory cleft, olfactory epithelium
- Olfactory Receptors (ORs), located on cilia
- Olfactory Sensory Neurons (ORNs)
- cribiform plate, glomeruli, mitral cells, olfactory bulb, primary olfactory cortex, limbic system
- anosmia
- pseudogenes and trichromatic color vision
- shape-pattern theory
- olfactory hedonics, learned taste aversion
- olfaction and memory
- pheromones / chemosignals & VNO (in book)

Taste
(Chapter 15)

“Taste versus Flavor”

flavor sensations still perceived as originating from the mouth!



Taste: sensation from tongue and mouth

Flavor: combination of pure taste and smell (“retronasal olfaction”)

What happens when we can't perceive taste but *can* perceive smell?

- Famous case: patient with normal olfaction but damaged taste —— could smell lasagna, but reported it had no flavor

<u>Conclusion</u>: brain blocks olfactory contribution to taste, unless taste receptors report something!

Emerging view:
Taste & Olfaction work together to create flavor

Two options to enhance flavor:

1) add sugar - known to food industry since 1950s

2) add “volatile” molecules (to intensify retronasal olfaction).
- very recently discovered [Bartoshuk & Klee 2013]

(Different volatiles can have different sensory effects, e.g., enhance saltiness or decrease bitterness)

Heirloom Tomato Study (U. Florida; 2012)

- 80 types of heirloom tomatoes
- identified genes that enhance sweetness *without* increasing sugar
- increase volatile molecules detected via olfaction

Garden Gem Tomato (Harry Klee, U. Florida)

- stability + yield of grocery store tomato
- volatiles of heirloom tomato
- result: tastes much better than grocery store tomato, nearly as good as heirloom

This Is the Perfect Tomato

But supermarkets refuse to sell it.

By MARK SCHATZKER JULY 16, 2015 • 5:07 AM

The Garden Gem, the perfect tomato.

http://www.slate.com/articles/life/food/2015/07/garden_gem_tomato_why_harry_klee_s_perfect_cultivar_isn_t_sold_in_supermarkets.html

Experiment #1 (at home): taste vs. flavor

take a small piece of chocolate

1) Plug nose

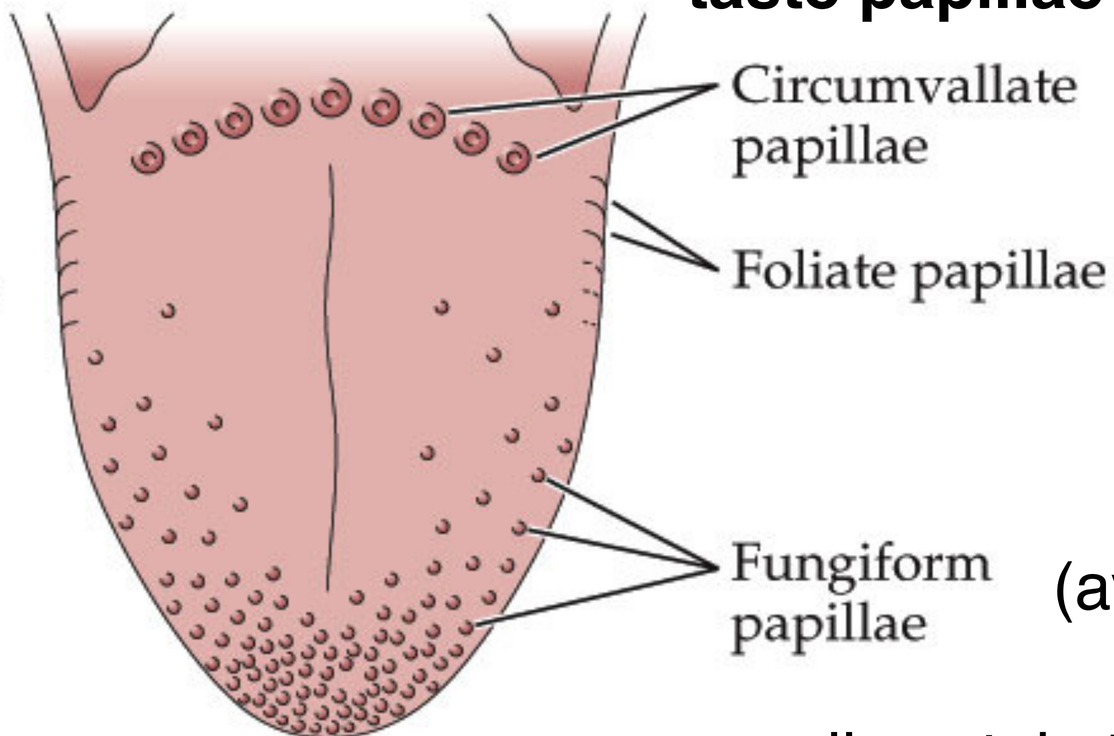
2) Chew and notice sensation
(eg. sweet with hint of bitter).

3) Swallow & release nose; volatile molecules will immediately flow up behind palate & into nasal cavity, releasing full flavor of chocolate

anatomy & physiology of taste

papillae - give tongue its bumpy appearance

taste papillae



(avg 6 taste buds each)

tongue

- all contain **taste buds** (also found on roof of mouth)

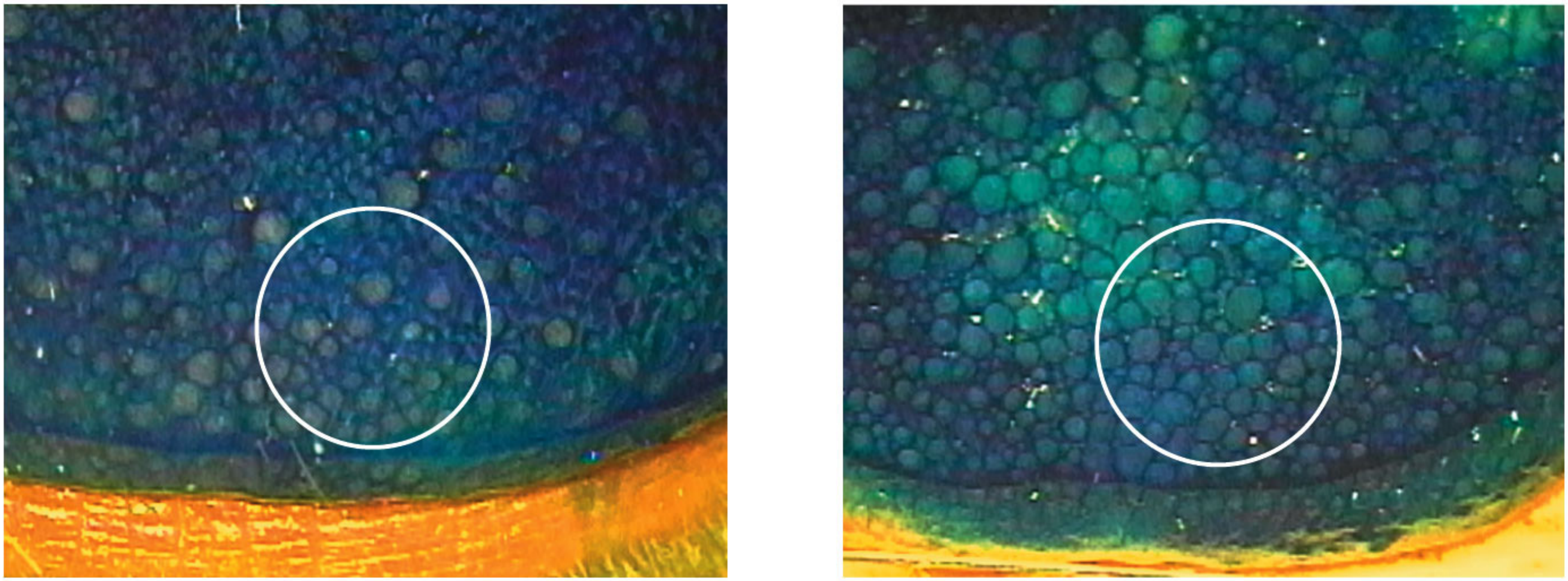
note: no subjective awareness of location within the mouth!

Genetic Variation in Taste Experience

Supertaster: have high density of fungiform papillae

- Perceive the most intense taste sensations

(*a*) Nontaster (*b*) Supertaster



- # of buds varies enormously - 3000 to 12,000 per tongue (4x more)
- such high variation is unique among the senses

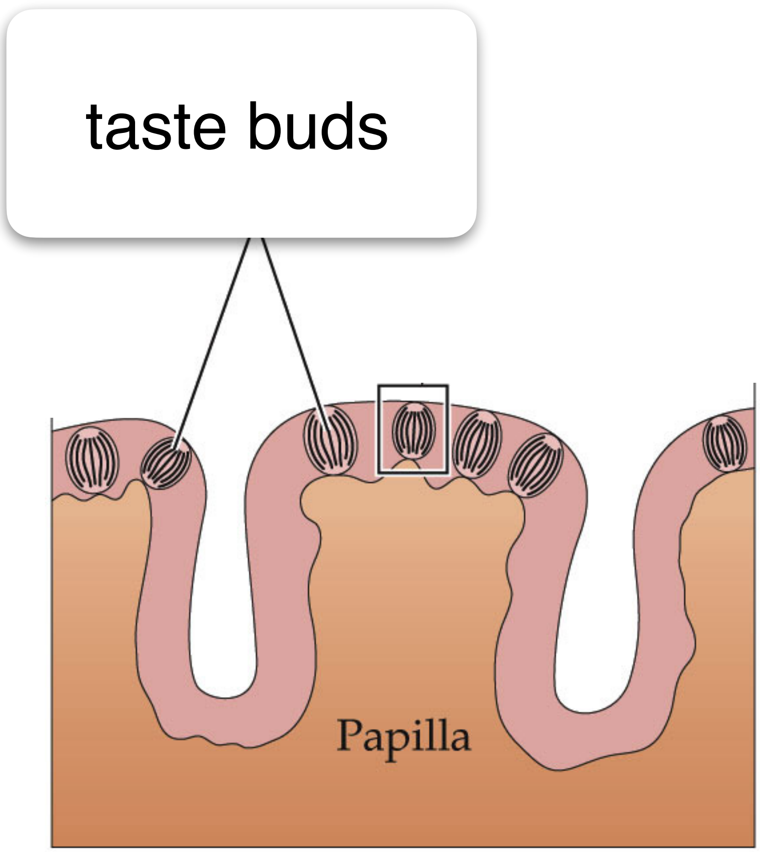
Experiment #2: find the taste buds on the roof of your mouth

1) Wet finger and dip it in salt

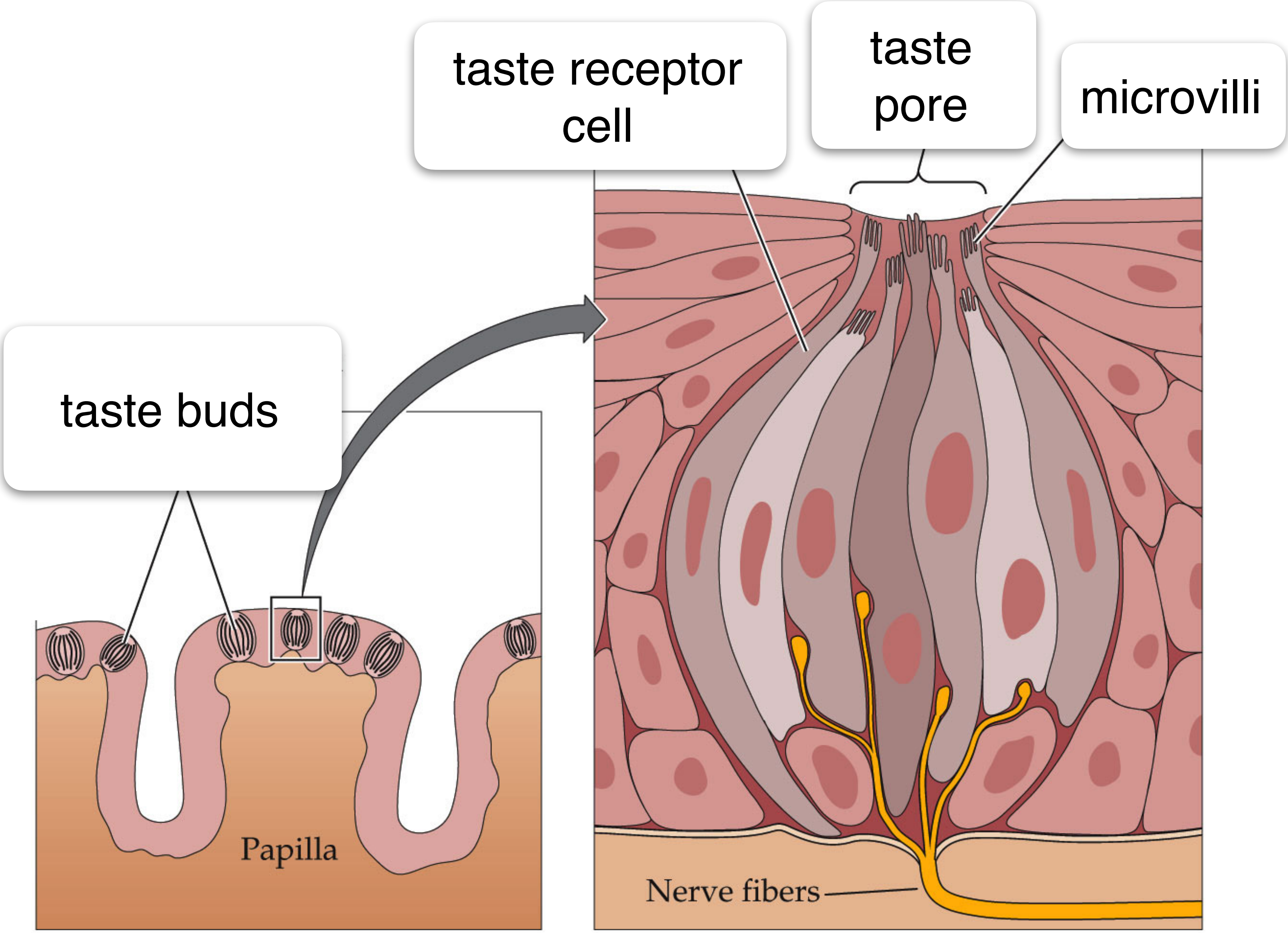
2) Touch roof of your mouth, move back until you feel the bone end (margin between soft and hard palates)

3) Should experience burst of saltiness when you find the taste buds.

Taste buds and taste receptor cells



Taste buds and taste receptor cells



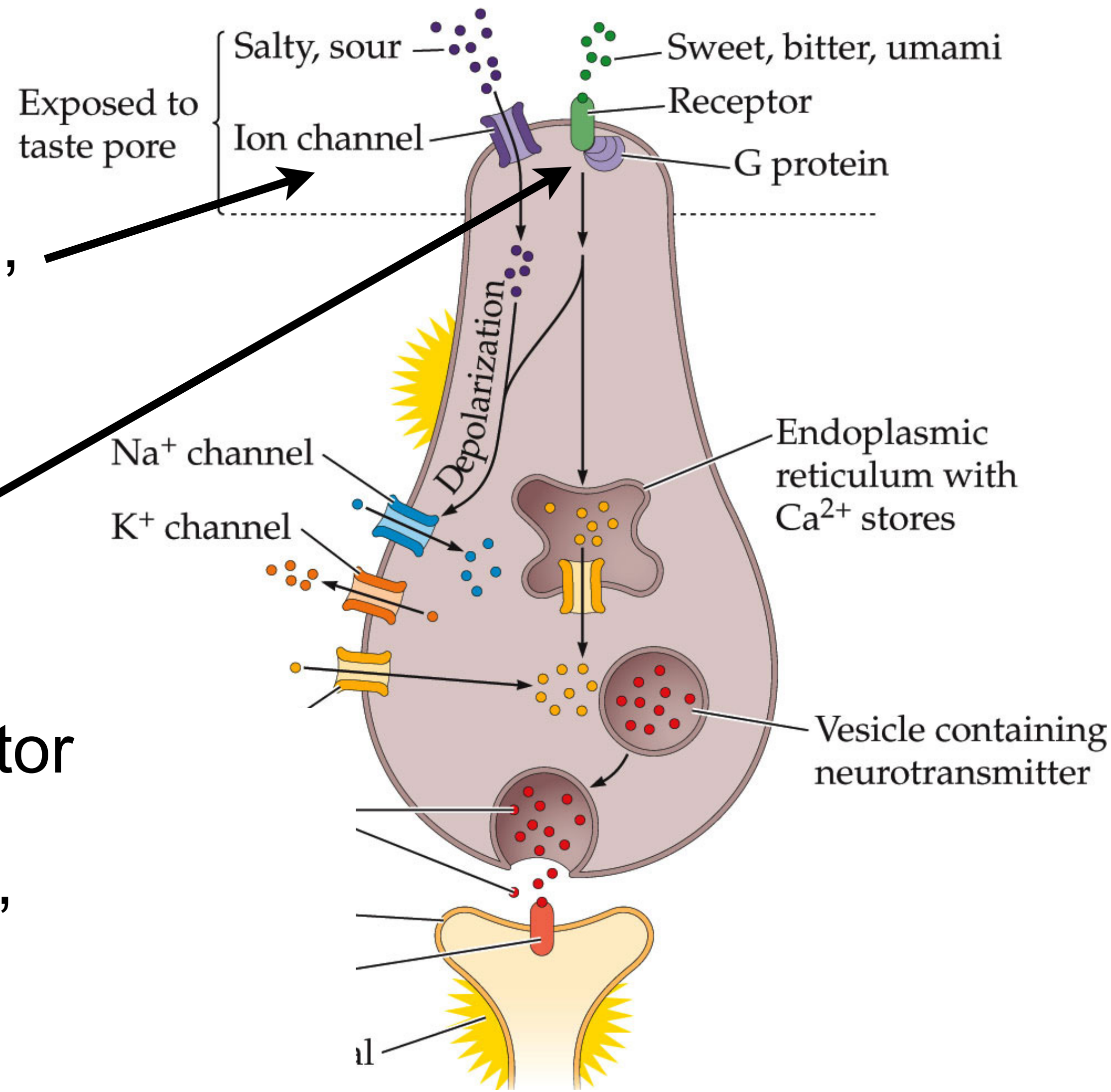
Two mechansisms for taste transduction

1. Small charged particles, or ions (salty and sour)

- enter ion channels in microvilli

2. Molecules bind to receptor (sweet and bitter)

- “lock and key mechanism” similar to receptors in the olfactory system.

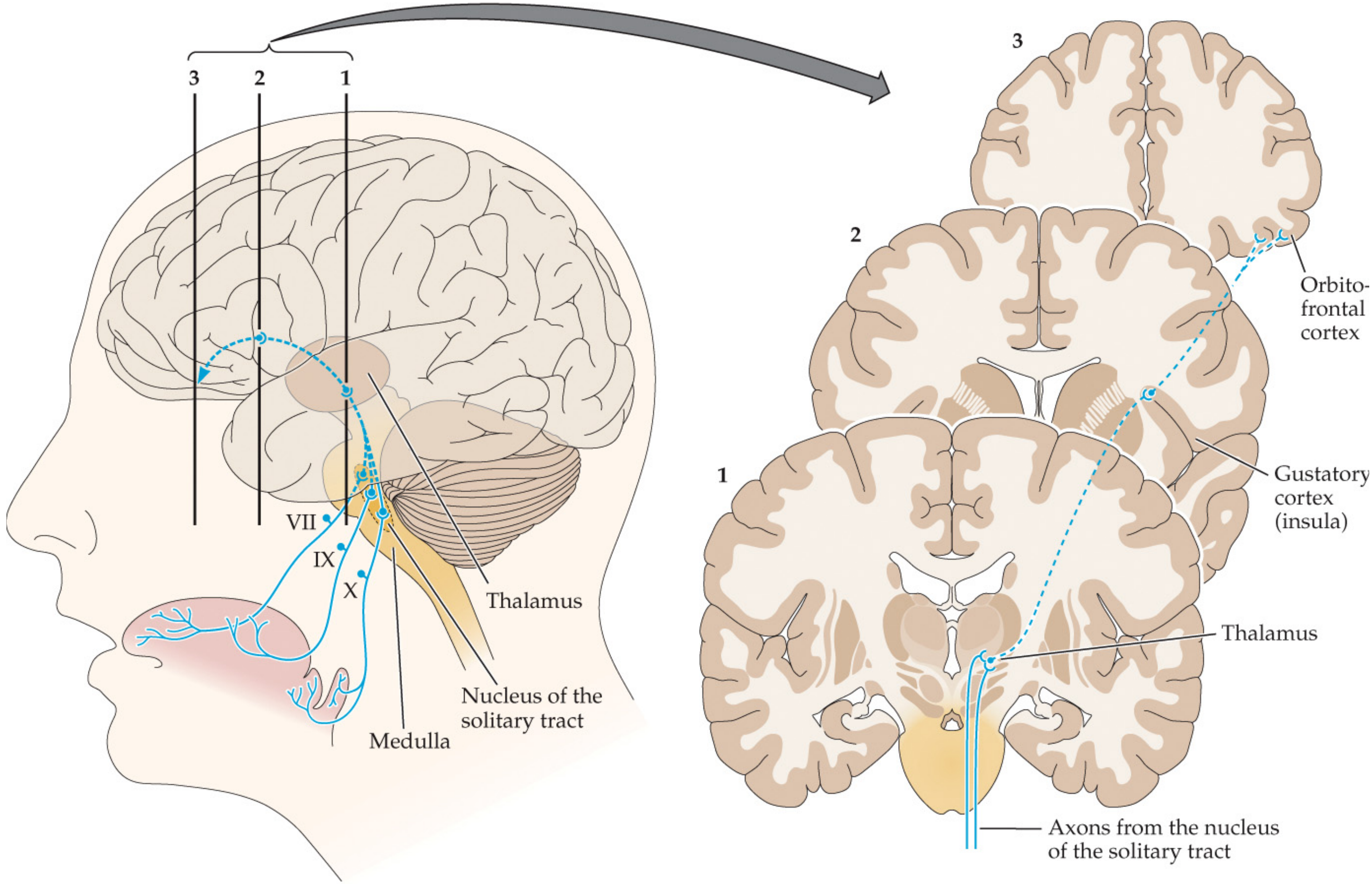


Bogus

Edwin Boring, 1942

- Each taste bud can detect multiple kinds of tastants.
- Coding depends on concentration of different receptors

Basic anatomy of taste system:



The Four Basic Tastes

Two categories of tastants:

- salty
- sour
- sweet
- bitter

salty, sour — ions enter the cell

sweet, bitter — tastant binds to receptor on cell

The Four Basic Tastes

(ionic)

Salty:

- Made up of two charged particles (cation & anion)
- Ability to perceive salt is not static
  - Low-sodium diets will increase intensity of salty foods over time

- Liking for saltiness is not static
  - Early experiences can modify salt preference. Chloride-deficiency in childhood leads to increased preference for salty foods later
  - Gestational experiences may affect liking for saltiness

The Four Basic Tastes

(ionic)

Sour:

- Comes from acidic substances
- At high concentrations, acids will damage both external and internal body tissues

The Four Basic Tastes

(receptor-linked)

Sweet:

- Evoked by sugars
- Many different sugars that taste sweet:
  - Glucose: Principle source of energy for most animals
  - Sucrose: Common table sugar. Combination of glucose and fructose (sweeter)

- Single receptor responsible for all sweet perception:
  -- how therefore to explain differences in sweetness of different sweeteners?
  - could be: activation of other receptors (e.g., bitter)
  - or: different binding to the receptor itself

The Four Basic Tastes

Sweet: (receptor-linked)

Aritificial sweeteners:

• synthesized molecules that bind to the same receptor

• saccharine - discovered in 1879 by Ira Remsen, researcher working on coal tar: noticed his hands "tasted sweet" after work

• but unclear whether they actually help with weight loss!

The Four Basic Tastes

(receptor-linked)

Bitter:

- 1000 different bitter molecules (many from plants that use them for protection)
- 25 different bitter receptors!
- quinine: prototypical bitter substance. (Sugar is added to tonic water to cancel out the bitter taste; has same sugar content as soda!)
- bitter sensitivity is affected by hormone levels in women, intensifies during pregnancy
- in general, we do not notice the difference between bitter-tasting compounds; we simply avoid them

Genetic Variation in Taste Experience

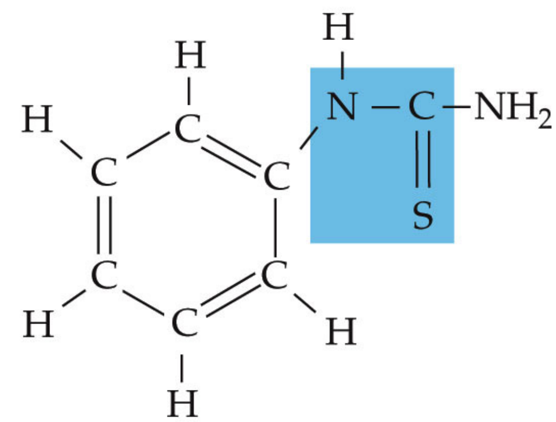
Arthur Fox (1931) discovered that phenylthiocarbamide (PTC) tastes dramatically different to different people

- Bitter taste to some but not to others
- 1960s: Started using propylthioracil (PROP) instead of PTC

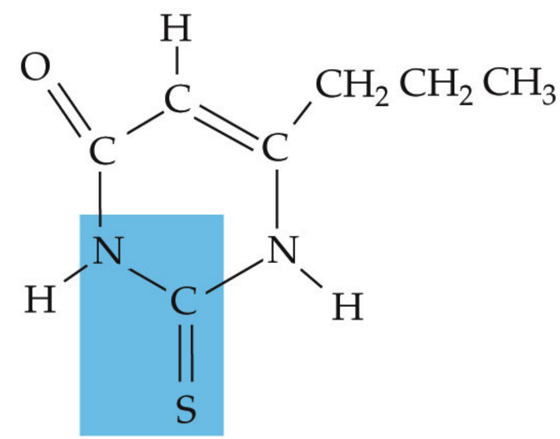
Gene for PROP receptors discovered in 2003

- Individuals with two recessive genes are nontasters of PTC/PROP
- Individuals with one or more of the genes are tasters of PTC/PROP

(*a*) Phenylthiolcarbamide



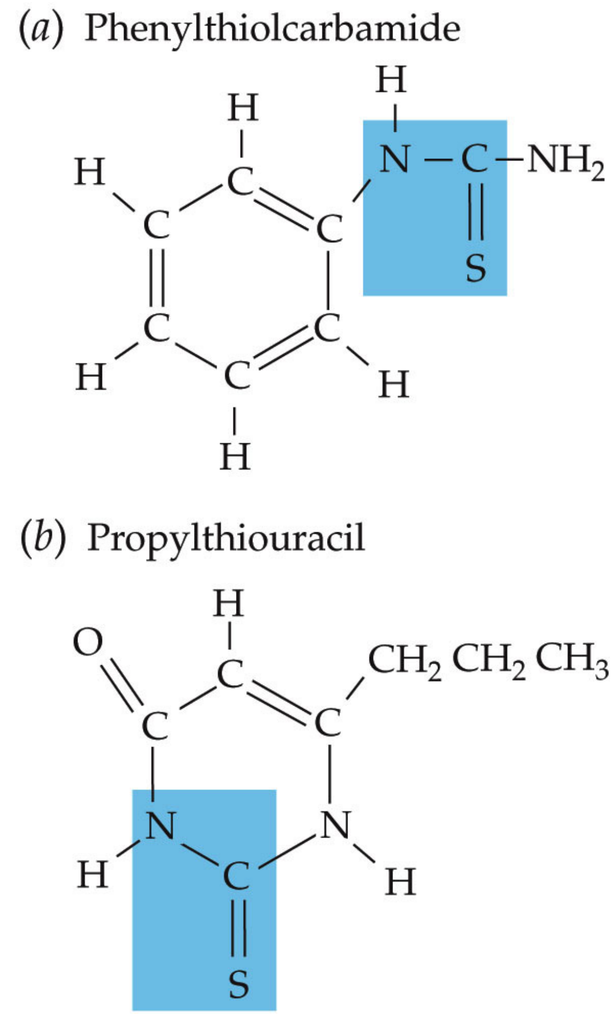
(*b*) Propylthiouracil



PROP supertasters - very intense sensations of PROP

Genetic Variation in Taste Experience

- roughly 2/3 of population are “tasters”
- in general, tasters reported to be more “finicky” eaters. (May be because of increased sensitivity to bitter compounds in food).



Experiment #3:
are you a PROP taster?

https://www.amazon.com/Bartovation-Phenylthiourea-PTC-Paper-Strips/dp/B01A9DOL9I/ref=sr_1_fkmr0_1?keywords=prop+supertaster+strips&qid=1556778972&s=gateway&sr=8-1-fkmr0

Umami: fifth basic taste?

- Comes from monosodium glutamate (MSG), identified by Japanese chemists in 1900s
- Glutamate: Important neurotransmitter
- claim to be "fifth basic taste" came from MSG manufacturers! (marketed as a "flavor enhancer")
- controversial: not perceptible in many foods; not a "basic taste" because not everyone reacts in the same way
- may bind to receptors in gut (soup with MSG preferred if eaten, but not if merely held in the mouth; *Prescott 2004*).

<u>Safety issues in human consumption:</u>

- 1960s: "Chinese restaurant syndrome" - controversial
- For most people, MSG poses no problem in small doses

Chili peppers & Capsaicin

• capsaicin - causes the burn; detected by pain receptors (not taste buds)

• No known instances of wild animals enjoying capsaicin

• socially induced in rats - can learn to like it if exposed to "demonstrator" rats

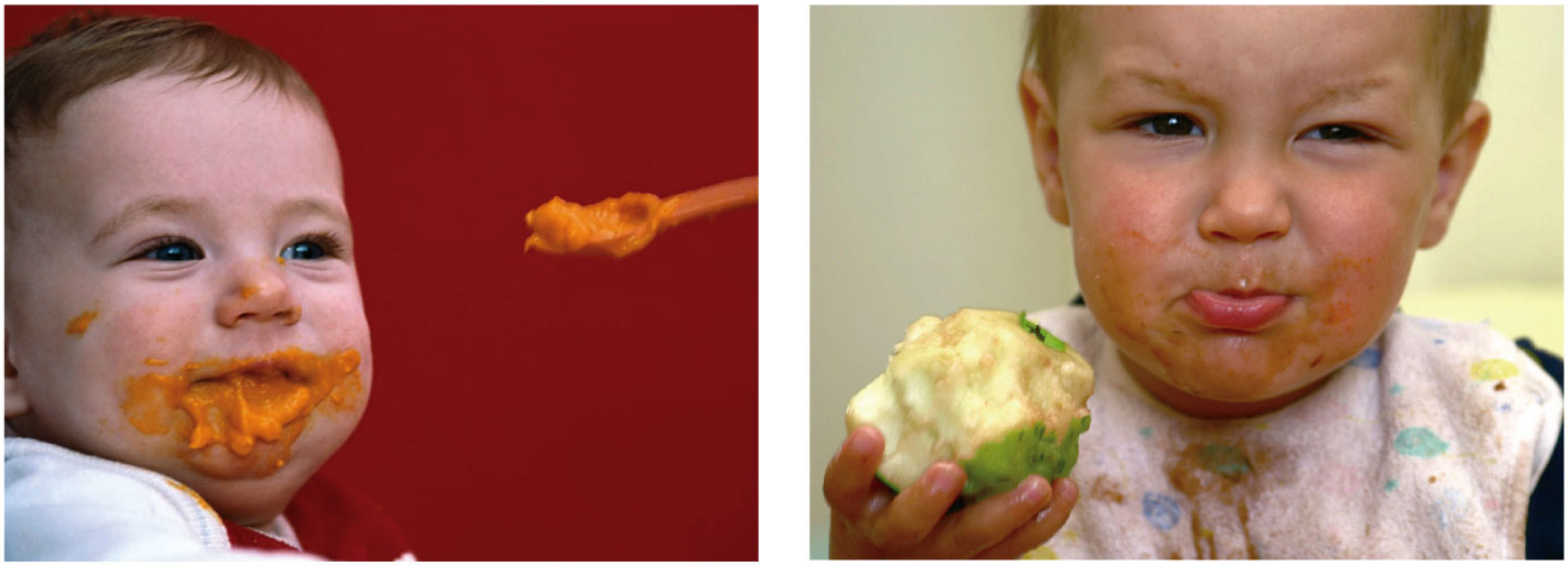
• in Mexico, added to diet around age 3.

• variety of theories why we like it: preservative? signal certain nutrients? endorphin release?

• repeated exposure: leads to desensitization of pain receptors, increased ability to tolerate spicy foods.
(clinical application: used by Mayans to treat mouth sores—ouch!)

Pleasures of taste (gustatory hedonics)

(*a*) (*b*)



- Infants' behavior and facial expressions reveal innate preferences for certain foods
- preferences for basic tastes (salty, sweet, sour, bitter) seem to be innate! (Unlike olfaction!)

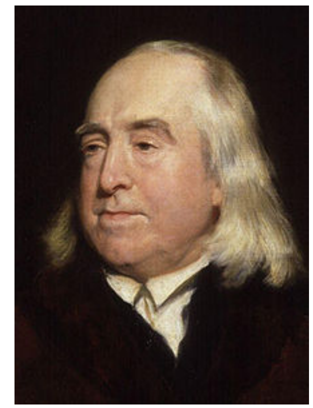
Pleasures of taste (gustatory hedonics)

(a)

(b)

- However: learning allows us to grow to like or dislike foods based on the consequences of consuming them.
- **learned taste aversion** - dislike for a food that made us sick (actually mediated by olfactory system).

"Nature has placed mankind under the governance of two sovereign masters: pain and pleasure. It is for them alone to point out what we ought to do, as well as to determine what we shall do."



- Jeremy Bentham (English Philosopher)

1748-1832

Good luck on the final exam!