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9.35 Sensation And Perception

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14

Taste

Taste versus Flavor

Retronasal olfactory sensation: The sensation of an odor that is perceived when chewing and swallowing force an odorant in the mouth up behind the palate into the nose

- Such odor sensations are perceived as originating from the mouth, even though the actual contact of odorant and receptor occurs at the olfactory mucosa

Flavor: The combination of true taste (sweet, salty, sour, bitter) and retronasal olfaction

Figure 14.1 Movement of molecules released into the air inside our mouths as we chew and swallow food

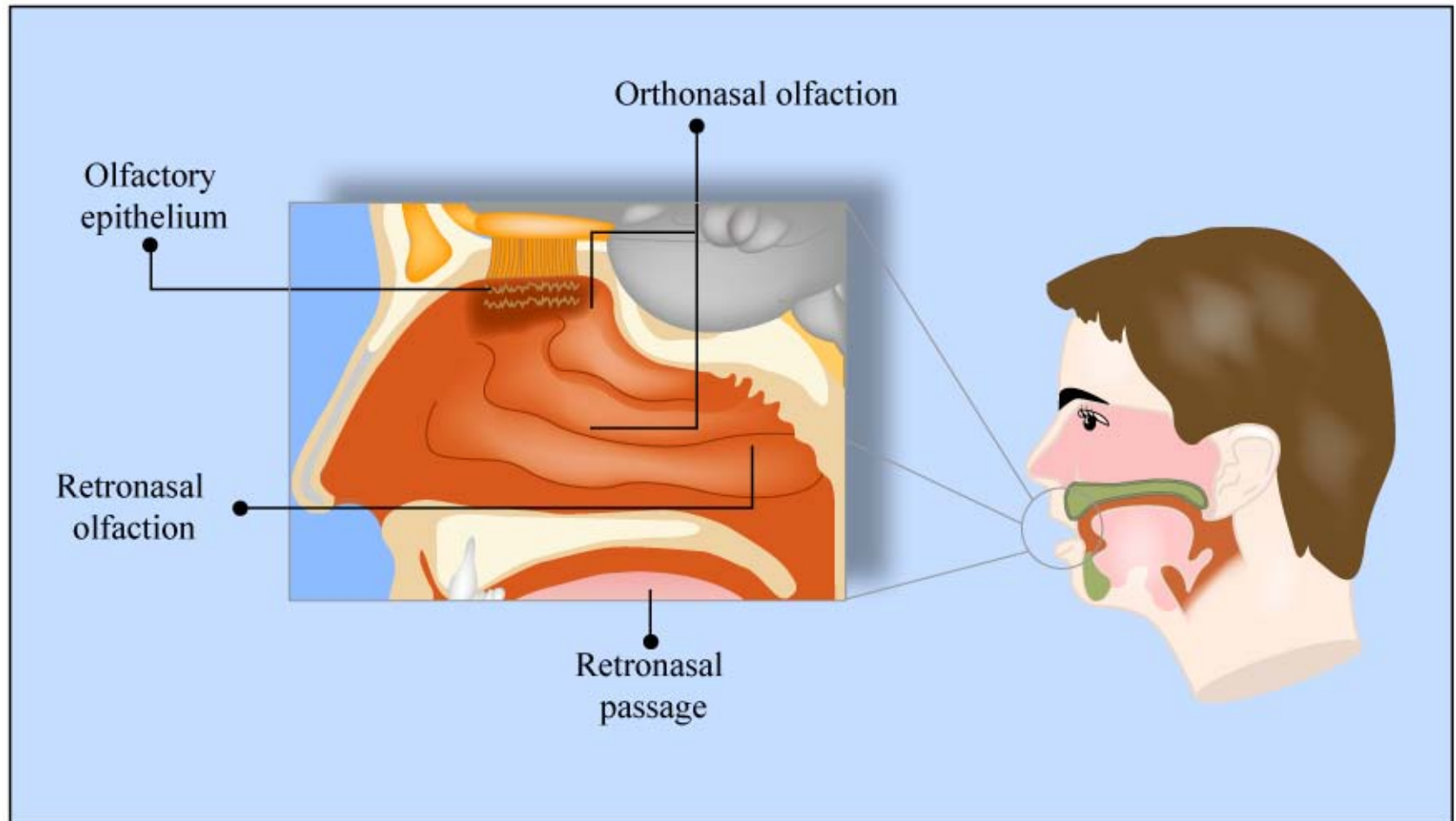


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Taste versus Flavor

What happens when we cannot perceive taste but can still perceive smell?

- Patient case: Damaged taste, but normal olfaction—could smell lasagna, but had no flavor
- Similar effect created in lab: Chorda tympani anesthetized with lidocaine
- Chorda tympani: The branch of cranial nerve VII (the facial nerve) that carries taste information from the anterior, mobile tongue (the part you can stick out)

Taste versus Flavor

Connection between taste and smell:

- Brain imaging studies: Brain processes odors differently, depending on whether they come from nose or mouth
- Food industry: Adds sugar to intensify sensation of fruit juice
 - Increase in sweetness (a pure taste sensation) increases perceived olfactory sensation of fruit

Anatomy and Physiology of the Gustatory System

Taste buds:

- Create neural signals conveyed to brain by taste nerves
- Embedded in structures: Papillae (bumps on tongue)
- Each taste bud contains taste receptor cells
- Information is sent to brain via cranial nerves

Anatomy and Physiology of the Gustatory System

Four kinds of papillae:

- 1. Filiform papillae: Small structures on the tongue that provide most of the bumpy appearance. Have no taste function
- 2. Fungiform papillae: Mushroom-shaped structures (maximum diameter 1 mm) that are distributed most densely on the edges of the tongue, especially the tip. An average of six taste buds per papilla are buried in the surface

Anatomy and Physiology of the Gustatory System

Four kinds of papillae: (cont'd)

- 3. Foliate papillae: Folds of tissue containing taste buds. Located on the rear of the tongue lateral to the circumvallate papillae, where the tongue attaches to the mouth
- 4. Circumvallate papillae: Circular structures that form an inverted V on the rear of the tongue (three to five on each side). Moundlike structures surrounded by a trench. Much larger than fungiform papillae

Figure 14.2 The locations of each type of taste papilla and their neural connections to the brain

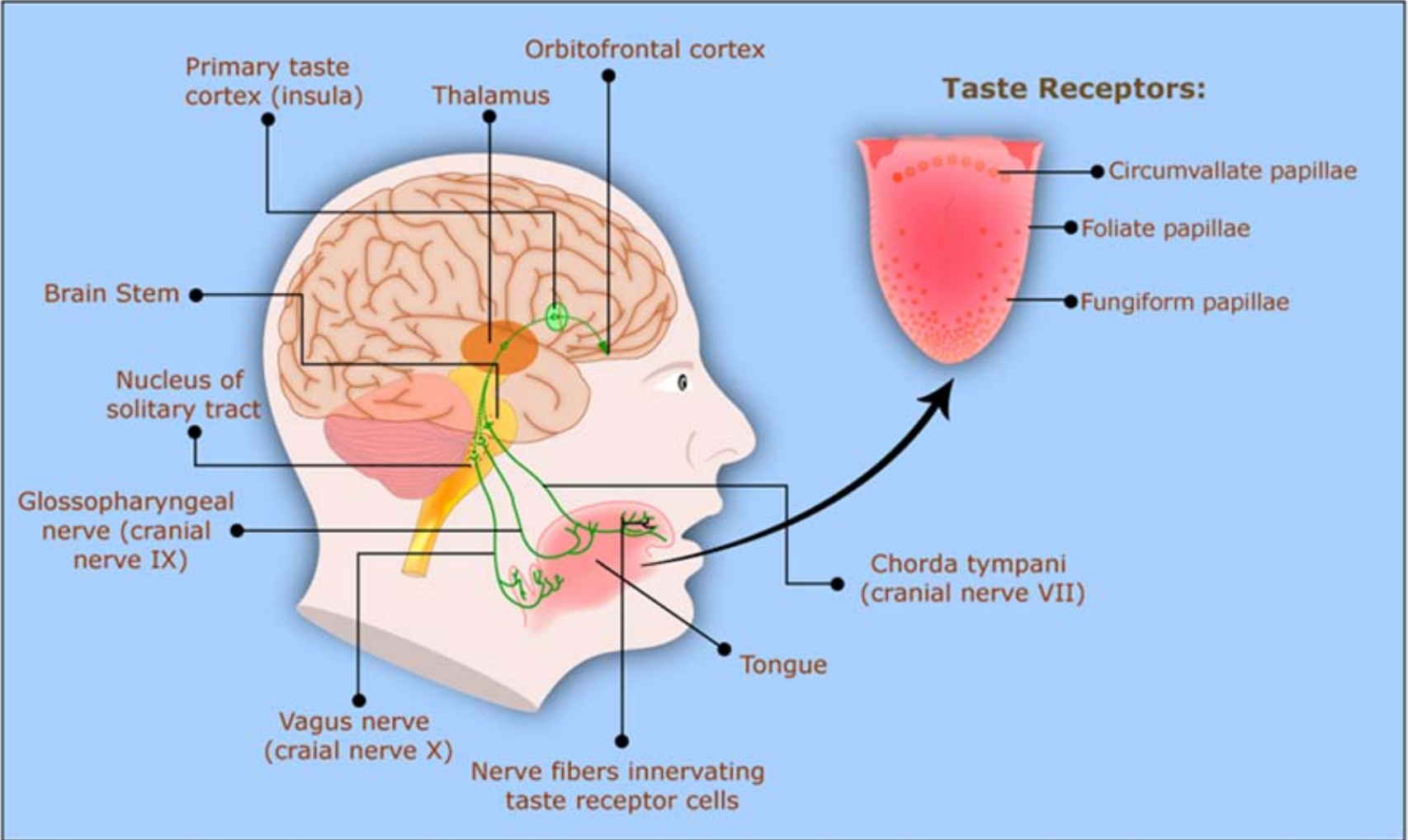


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Anatomy and Physiology of the Gustatory System

Taste buds and taste receptor cells

- Microvilli: Slender projections on the tips of some taste bud cells that extend into the taste pore
 - Contain the sites that bind to taste substances
 - Not tiny hairs (as the name implies): We now know they are extensions of the cell membrane

Figure 14.4 Taste buds

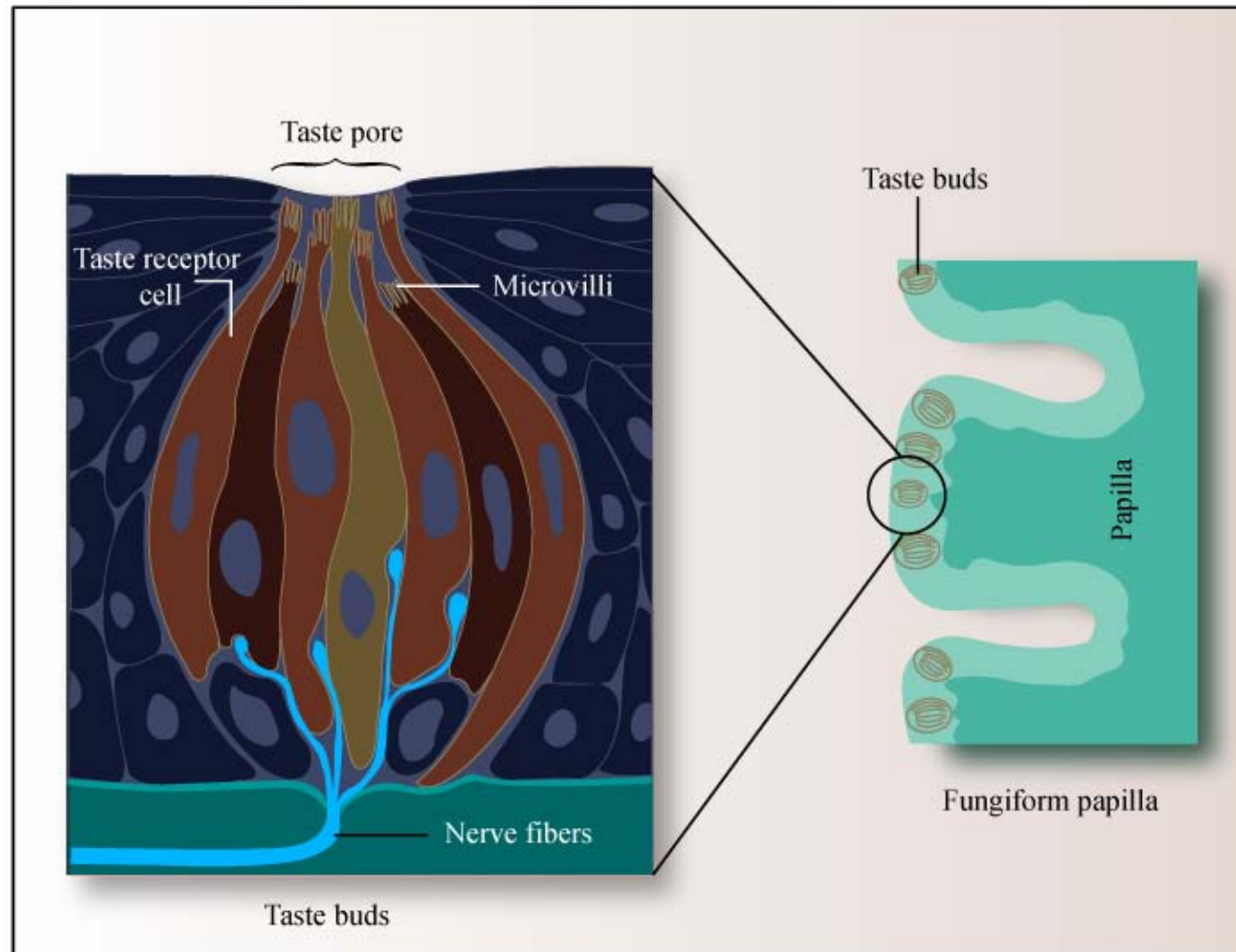


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Anatomy and Physiology of the Gustatory System

Tastant: Any stimulus that can be tasted

Tastants can be divided into two large categories:

- Some are made up of small, charged particles that taste salty or sour
 - Small ion channels in microvilli membranes allow some types of charged particles to enter but not others
- Other tastants are perceived via G protein-coupled receptors (GPCRs) similar to that in the olfactory system. These molecules taste sweet or bitter

Figure 14.5 The different receptor mechanisms for ionic stimuli and those using a lock-and-key mechanism

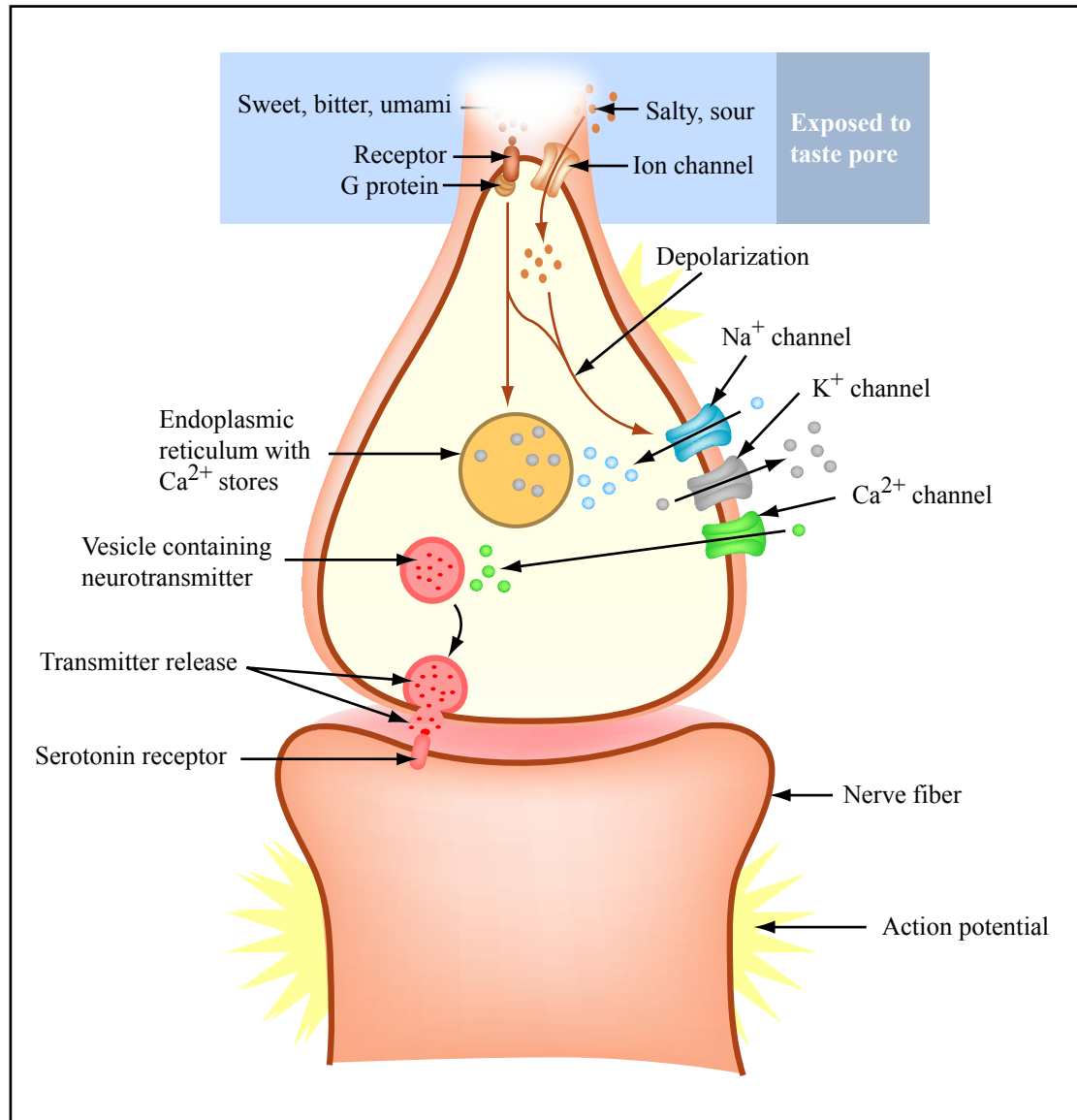


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Anatomy and Physiology of the Gustatory System

Taste processing in the central nervous system

- Pathway: Taste buds to cranial nerves to medulla and thalamus and then on to cortex
- Insular cortex: Primary cortical processing area for taste. The part of the cortex that first receives taste information
- Orbitofrontal cortex: The part of the frontal lobe of the cortex that lies above the bone (orbit) containing the eyes
 - Receives projections from insular cortex
 - Involved in processing of temperature, touch, smell, and taste, suggesting it may be an integration area

Figure 14.6 Taste information projects from the tongue to the medulla, then the thalamus, then the insula, and finally to the orbitofrontal cortex

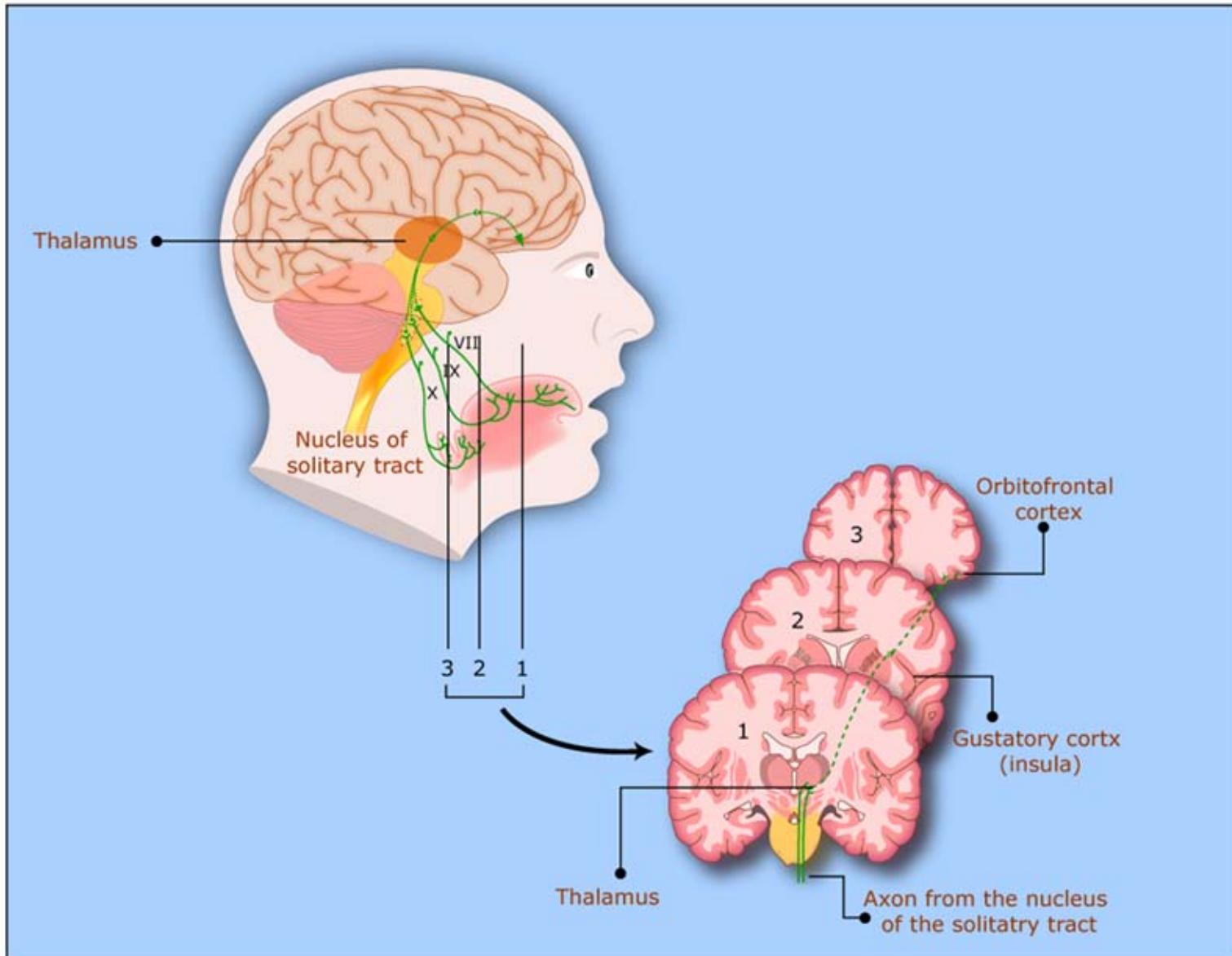


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Anatomy and Physiology of the Gustatory System

Inhibition: Plays an important role in processing taste information in the brain.

- Function: To protect our whole mouth perception of taste when we have injuries to taste system. Descending inhibition from taste cortex blocks pain perception
- Has survival value because we need to eat even if our mouth has been injured

The Four Basic Tastes

Four basic tastes:

- Salty
- Sour
- Bitter
- Sweet

The Four Basic Tastes

Salty:

- Salt is made up of two charged particles: Cation and anion.
- Ability to perceive salt is not static
 - Low-sodium diets will increase in 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

Sour:

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

The Four Basic Tastes

Bitter:

- Quinine: Prototypically bitter-tasting substance
- Cannot distinguish between tastes of different bitter compounds
- Many bitter substances are poisonous
- Ability to “turn off” bitter sensations—beneficial to liking certain vegetables
- Bitter sensitivity is affected by hormone levels in women, intensifies during pregnancy

The Four Basic Tastes

Sweet:

- Evoked by sugars
- Many different sugars that taste sweet:
 - Glucose: Principle source of energy for most animals
 - Fructose: Even sweeter than glucose
 - Sucrose: Common table sugar. Combination of glucose and fructose
- Single receptor responsible for all sweet perception
 - Different sweeteners stimulate different parts of receptor
 - Artificial sweeteners stimulate this receptor as well

Figure 14.9 Structure of the T1R2–T1R3 heterodimer sweet receptor

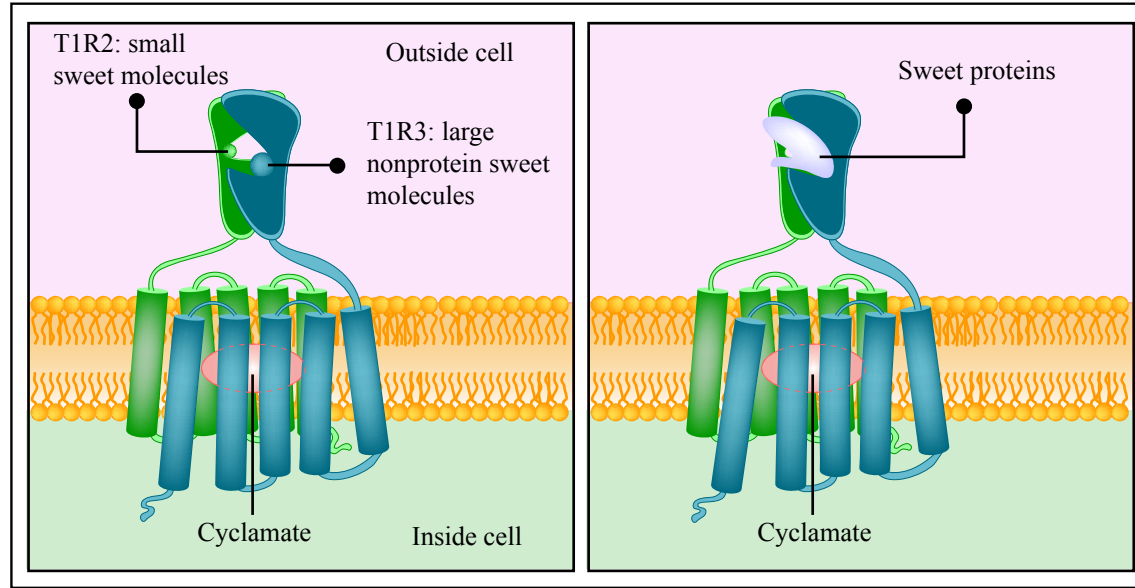


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The Four Basic Tastes

The special case of umami:

- Candidate for fifth basic taste
- Comes from monosodium glutamate (MSG)
- Glutamate: Important neurotransmitter
- Safety issues in human consumption:
 - Can lead to numbness, headache, flushing, tingling, searing, and tightness in the chest if sensitive individuals consume a large amount
 - For most people, MSG does not pose a problem in small doses

The Four Basic Tastes

Survival value of taste

- Taste is a system for detecting nutrients and antinutrients
 - Bitter: Might signal poisons
 - Sour: Configured to detect acidic solutions that might harm the body
 - Sweet and Salty: Our bodies need sodium and sugar to survive

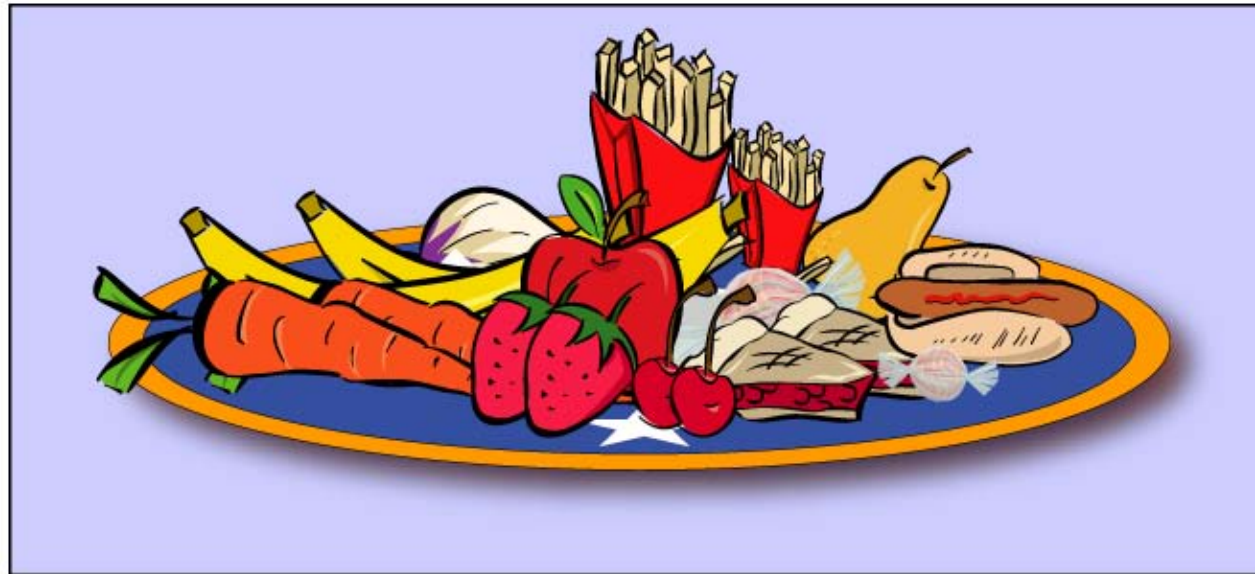


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The Pleasures of Taste

Infants' behavior and facial expressions reveal innate preferences for certain foods

Different flavored foods placed on tips of infants' tongues:

- Sweet food evokes a “smilelike” expression followed by sucking.
- Sour produced pursing and protrusion of lips
- Bitter produced gaping, movements of spitting, and sometimes vomiting movements

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The Pleasures of Taste

Specific hungers theory: The idea that deficiency of a given nutrient produces craving (a specific hunger) for that nutrient

- Cravings for salty or for sweet are associated with deficiencies in those substances
- However, the theory has not been supported for other nutrients, such as vitamins
- Theory only holds for sweet and salty foods

Coding of Taste Quality

Labeled lines:

- Theory of taste coding in which each taste fiber carries a particular taste quality
 - Major source of controversy in literature
- Other possibility: Patterns of activity across many different taste neurons
- Examples of both types of coding in other senses:
 - Color vision and olfaction use pattern coding
 - Hearing uses labeled-line approach

Figure 14.12 The tastes that human subjects perceive for each of four stimuli: sucrose, NaCl, HCl, and quinine

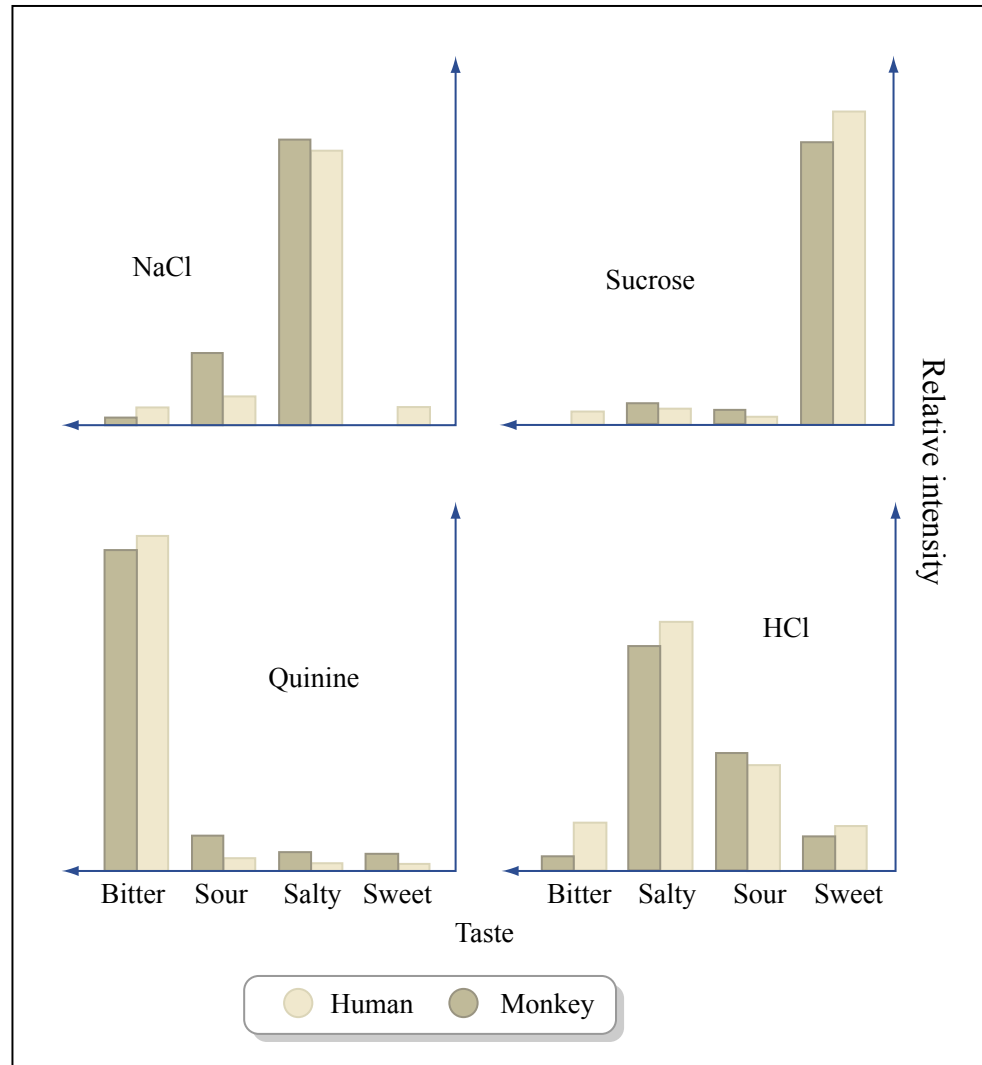


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Taste adaptation and cross-adaptation:

- All sensory systems show adaptation effects
- Constant application of certain stimulus temporarily weakens subsequent perception
 - Example: Adaptation to salt in saliva affects our ability to taste salt
- Cross-adaptation: When the taste of one food affects the taste of another
 - Example: A sour beverage tastes too sour after eating a sweet substance

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 because it is safer

Gene for PTC/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

Figure 14.13 The chemical structures of PTC (a) and PROP (b)

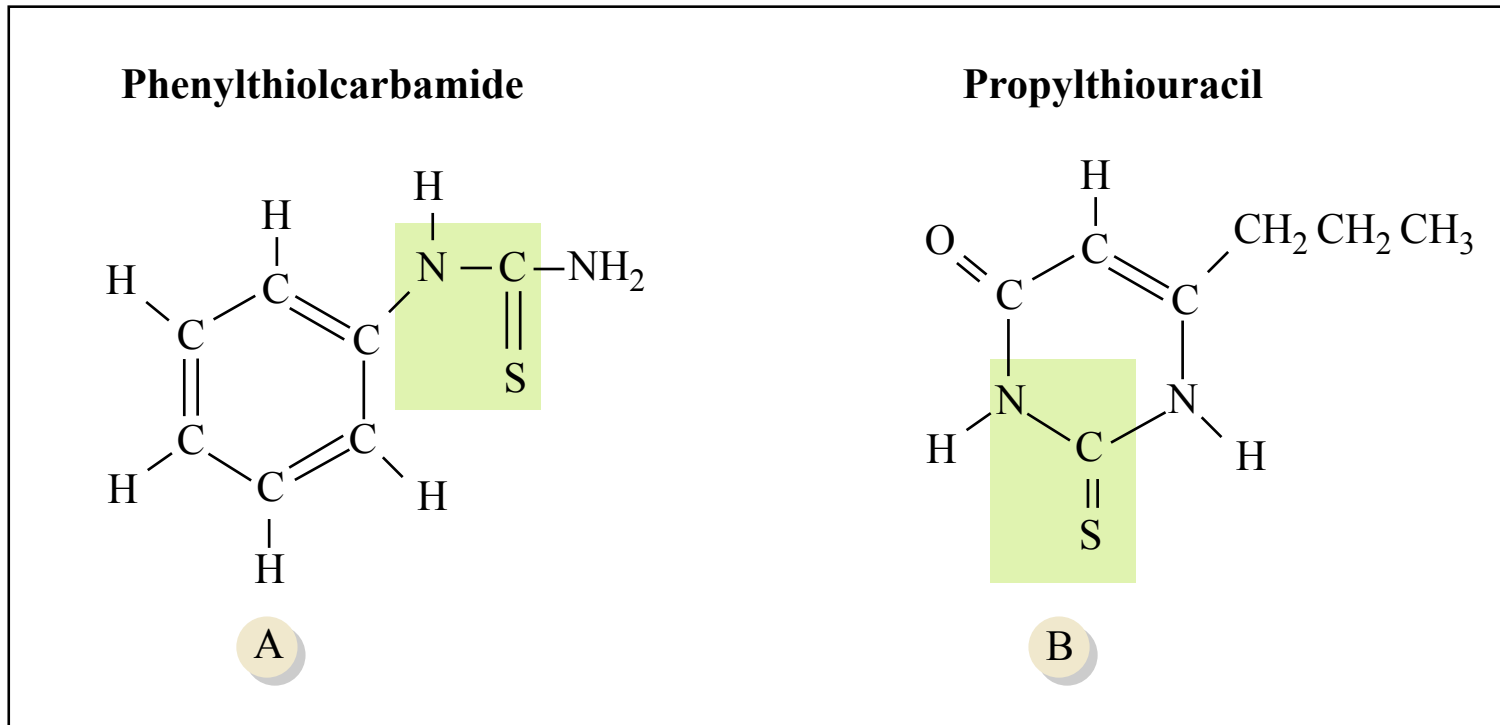


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Genetic Variation in Taste Experience

Supertaster: Individual who is a taster of PTC/PROP and has a high density of fungiform papillae

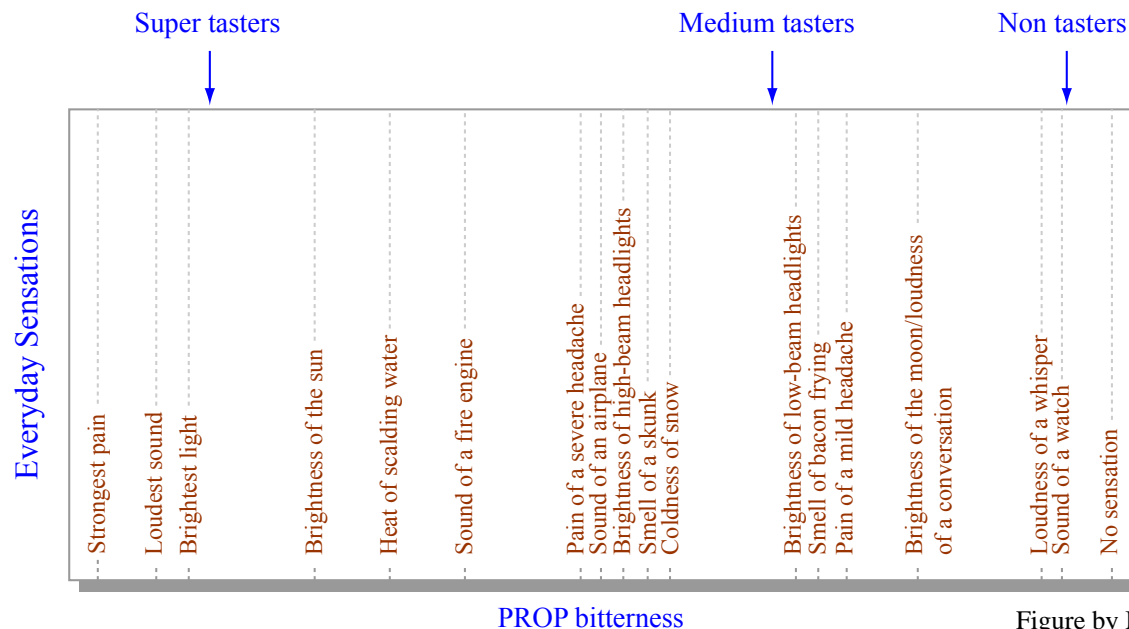
- Perceives the most intense taste sensations

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Genetic Variation in Taste Experience

Cross-modality matching:
Ability to match the
intensities of sensations
that come from different
sensory modalities

- Used to assess intensity of taste sensations for nontasters, medium tasters, and supertasters



Genetic Variation in Taste Experience

Health consequences of taste sensation

- Variations in sensory properties of foods and beverages affects food preferences and therefore diet
 - For instance, some vegetables have a bitter taste and so might be avoided by supertasters
- Valerie Duffy and colleagues showed that among men getting routine colonoscopies, those tasting PROP as the most bitter had the most colon polyps
- Note that fats also taste bitter to supertasters, so this may cause them to eat fewer high-fat foods, which could lower their risk for heart disease

Genetic Variation in Taste Experience

Pleasure and retronasal versus orthonasal olfaction

- Orthonasal olfaction: Olfaction through the nostrils
- Do we learn to like or dislike smells separately for retronasal versus orthonasal olfaction? Possibly
 - Example: Many people like the smell of freshly cut grass, but wouldn't want to eat it
- However, if an aversion is acquired retronasally, it usually shows up orthonasally as well
 - Example: Becoming sick from eating fish and then disliking even the smell of fish

Genetic Variation in Taste Experience

Chili Peppers

- Acquisition of chili pepper preference depends on social influences
- Restriction of liking to humans
- Variability across individuals, depending on number of papillae
- Capsaicin: The chemical that produces the burn in chilis. Desensitizes pain receptors
- Desensitization:
 - If a food is too hot for your palate, wait for burn to subside after the first mouthful. Your palate will desensitize (from the capsaicin) and you should be able to eat the rest of your meal

Figure 14.16 Do these images inspire fear or delight in your taste buds?

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