15

Taste

- Taste versus Flavor
- Anatomy and Physiology of the Gustatory System
- The Four Basic Tastes
- Genetic Variation in Bitter
- Wisdom of the Body: How Do We Solve the "Omnivore's Dilemma"?
- The Nature of Taste Qualities

Taste versus Flavor

Taste: Sensations evoked by solutions in the mouth that contact the receptors on the tongue and the roof of the mouth.

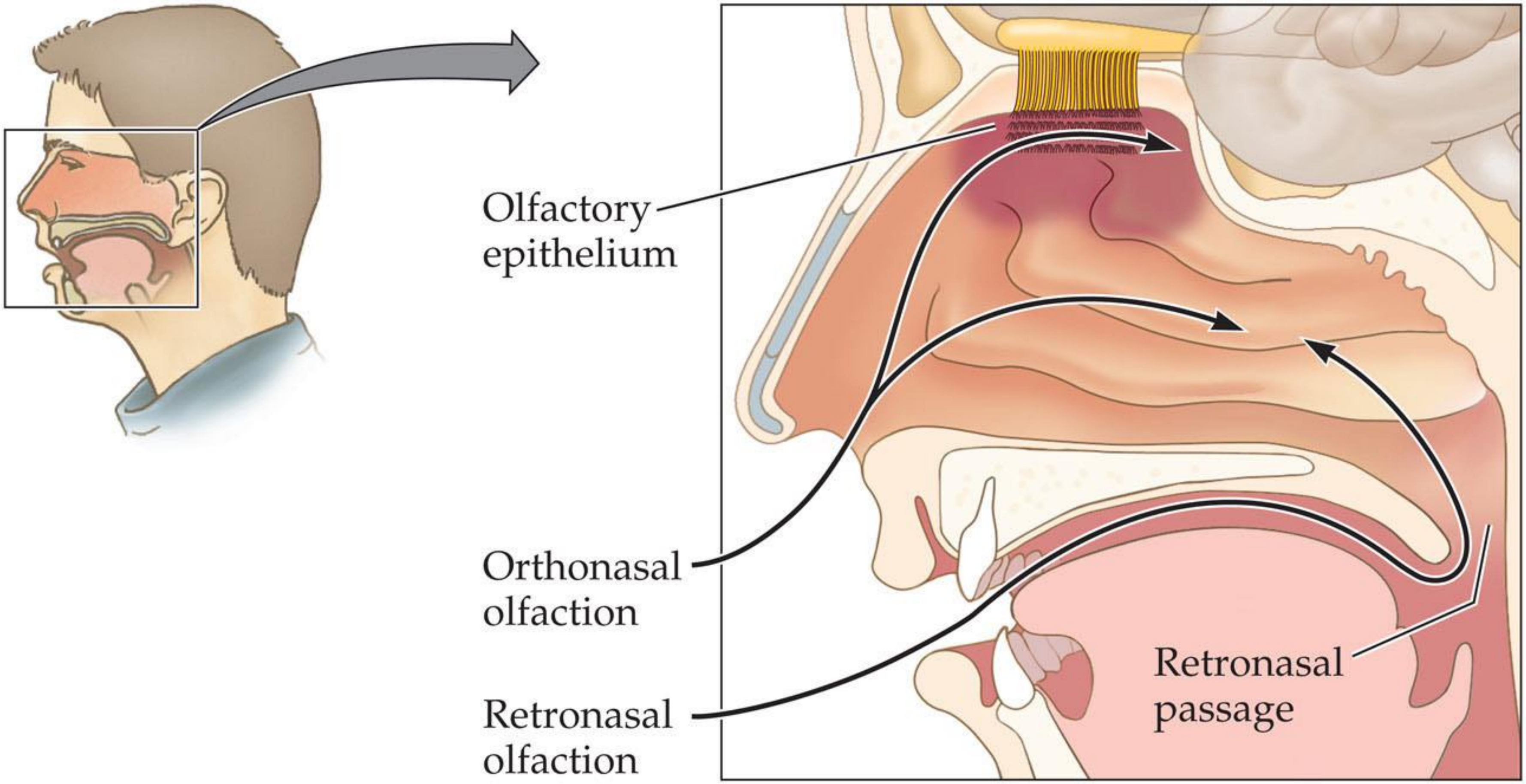
Taste versus Flavor

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 15.1 The path of molecules released into the air inside our mouths as we chew and swallow



SENSATION & PERCEPTION 4e, Figure 15.1

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

Taste versus Flavor

Recent studies of heirloom tomatoes indicate that volatile compounds contribute to perceived sweetness.

- Volatile compounds contribute greatly to retronasal olfaction.
- These volatiles may increase perceived sweetness without adding more sugar.
- Potential way to increase sweet flavor without adding more calories

Taste buds

- Create neural signals conveyed to brain by taste nerves
- Are embedded in structures—papillae (bumps on tongue)
- Contain taste receptor cells
- Send information to brain via cranial nerves

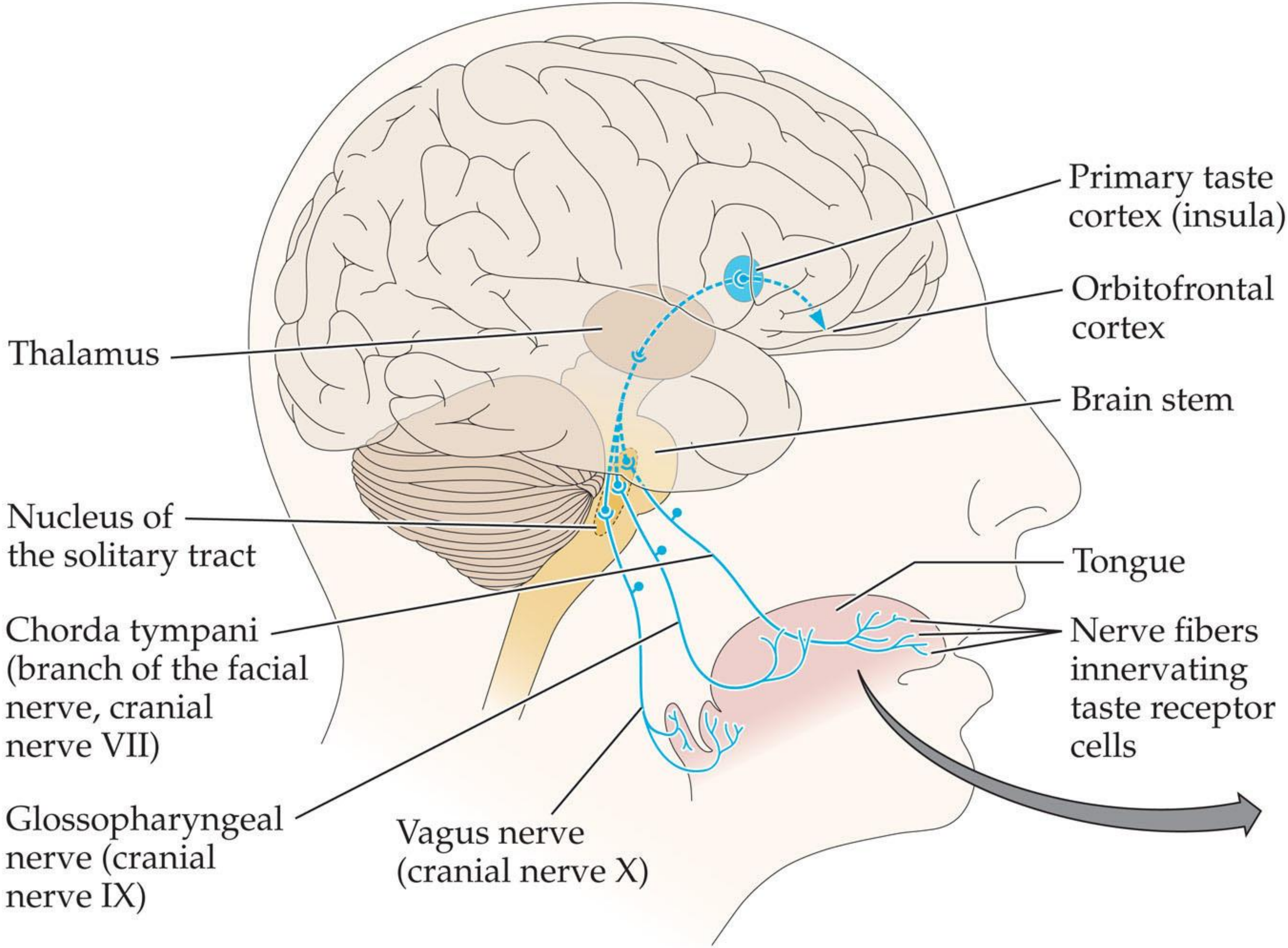
Four kinds of papillae

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 (max diameter 1 mm) distributed most densely on edges of tongue, especially the tip. Average of six taste buds per papilla are buried in the surface.

Four kinds of papillae (*continued)*

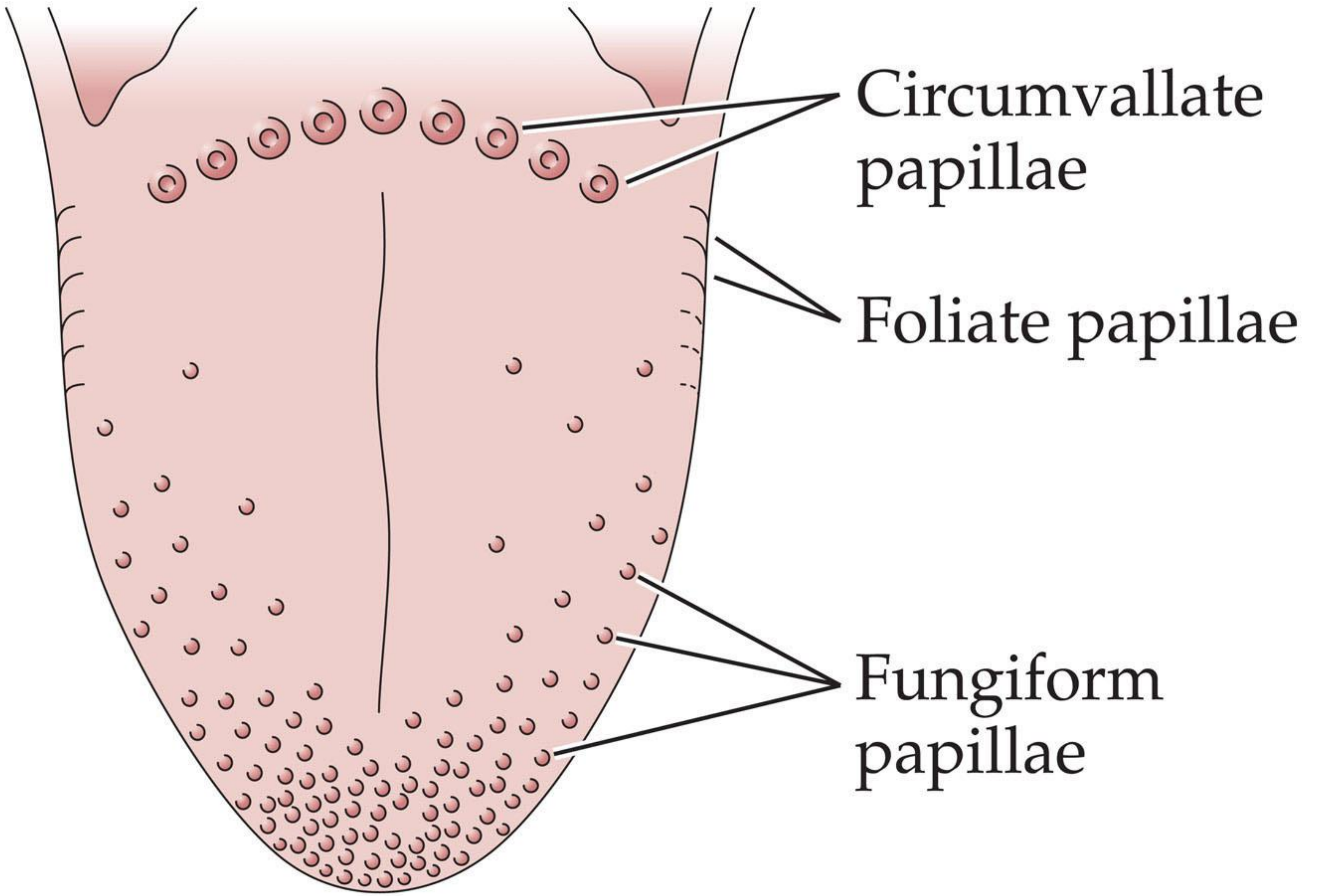
3. Foliate papillae: Folds of tissue containing taste buds. Located on the rear of the tongue lateral to the circumvallate papillae, where the tongue attaches to the mouth.
4. Circumvallate papillae: Circular structures that form an inverted *V* on the rear of the tongue (three to five on each side).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

Figure 15.2 The locations of each type of taste papilla (Part 1)



***SENSATION & PERCEPTION 4e*, Figure 15.2 (Part 1)**

Figure 15.2 The locations of each type of taste papilla (Part 2)

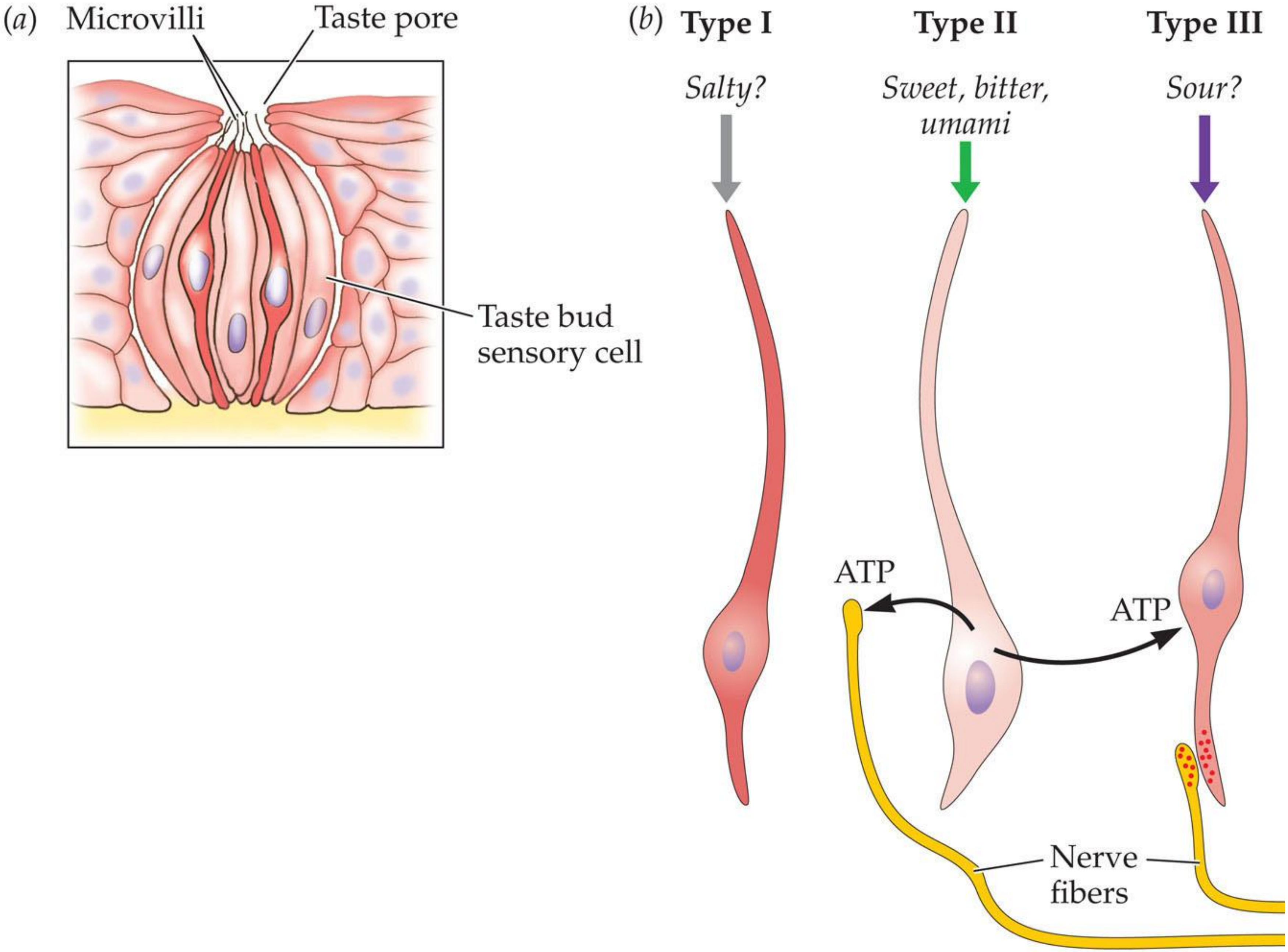


SENSATION & PERCEPTION 4e, Figure 15.2 (Part 2)

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 15.4 Taste buds



Tastant: Any stimulus that can be tasted.

Tastants can be divided into two large categories:

1. 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.

2. Other tastants are perceived via G protein-coupled receptors (GPCRs) similar to that in the olfactory system. These molecules taste sweet or bitter.

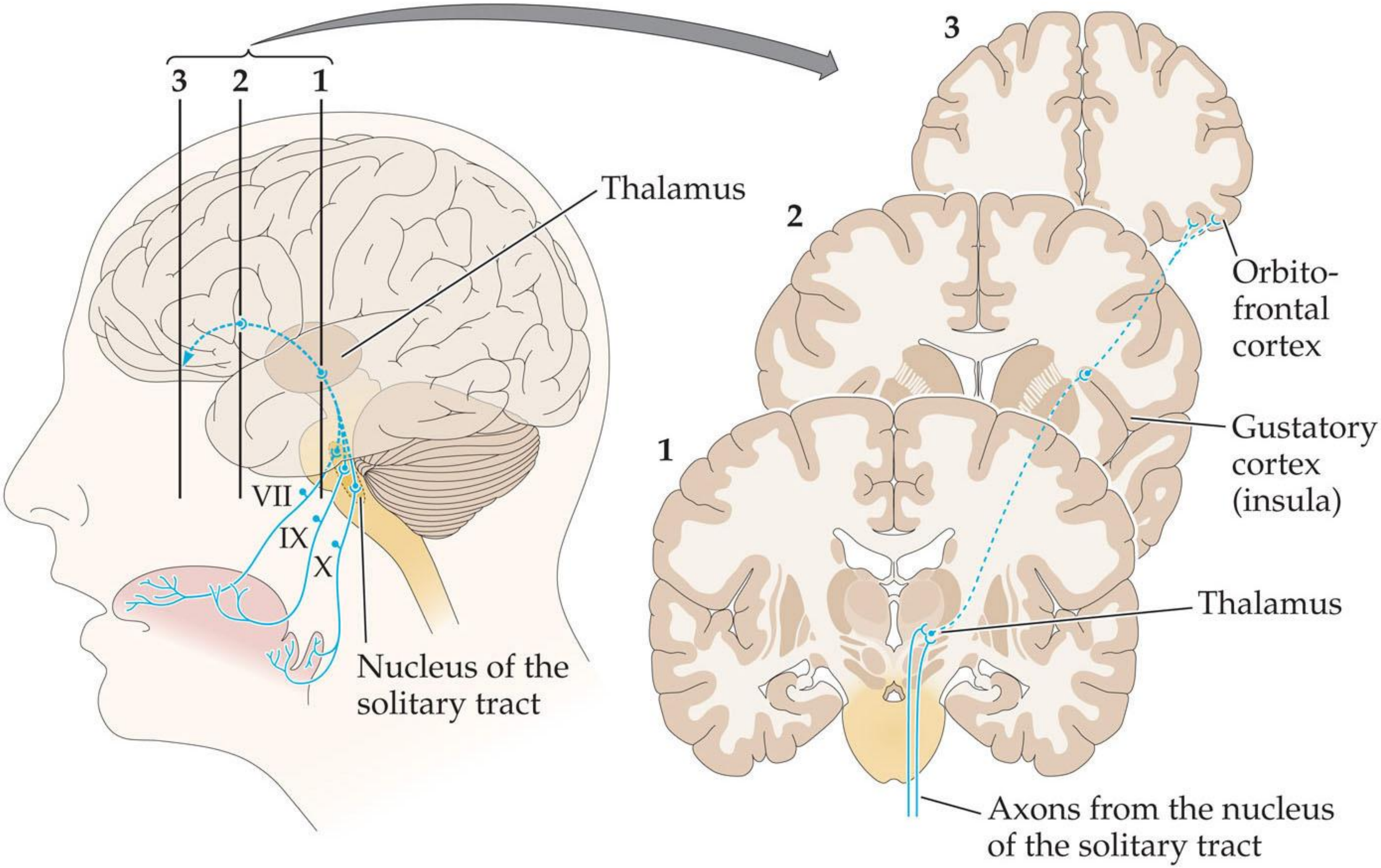
Taste processing in the central nervous system

- Pathway: Taste buds to cranial nerves to medulla and thalamus and then to cortex
- Insular cortex: Primary cortical processing area for taste. The part of the cortex that first receives taste information.

Taste processing in the central nervous system (*continued*)

- 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 15.5 The path of taste information



***SENSATION & PERCEPTION 4e*, Figure 15.5**

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 sensitivity to salty foods over time.

Salty (*continued*)

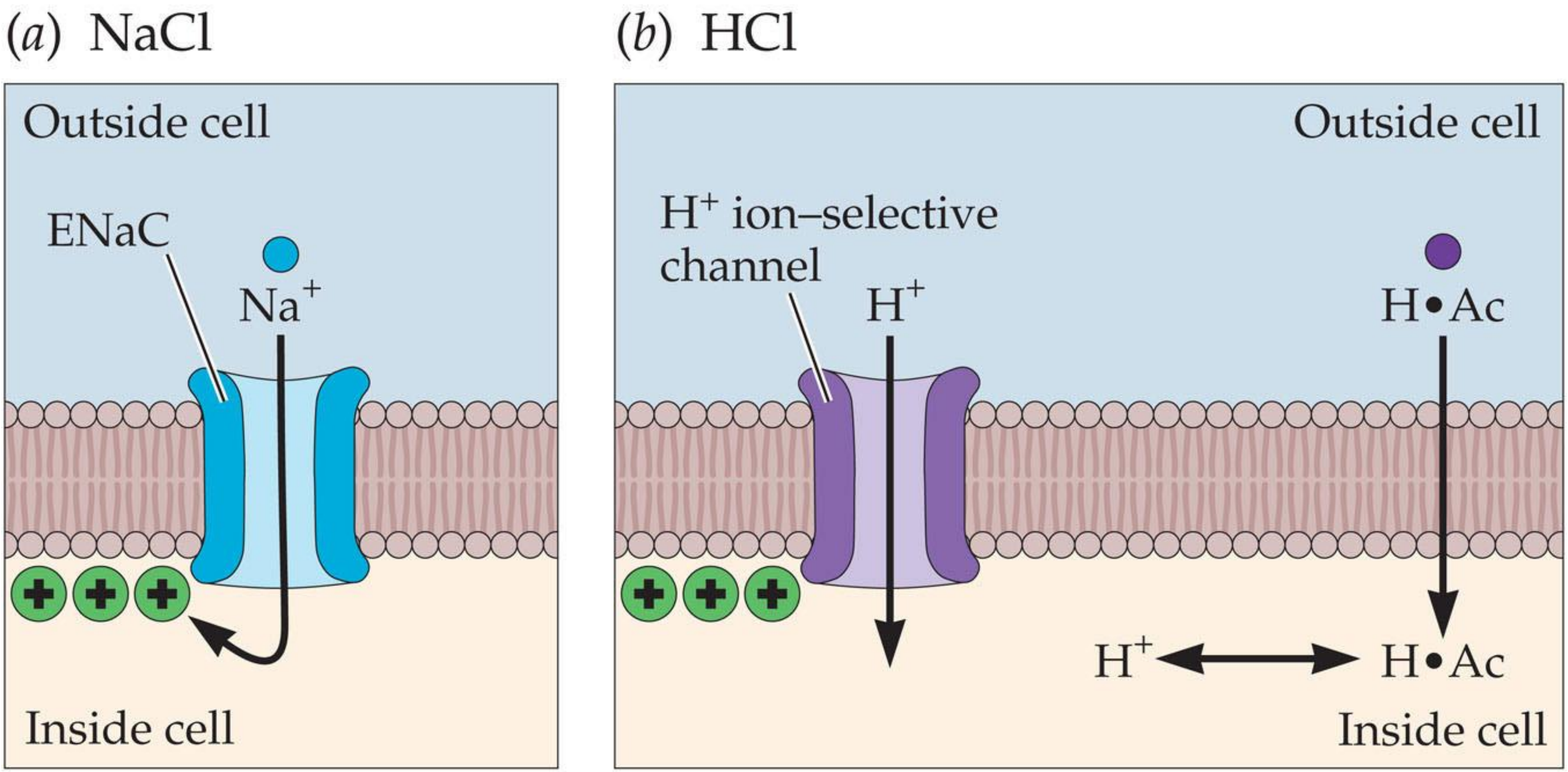
- Liking for saltiness is not static.
  - Early experiences can modify salt preference. Chloride-deficiency in childhood leads to increased preference for salty foods later.
  - Gestational experiences may affect liking for saltiness.

The Four Basic Tastes

Sour

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

Figure 15.6 Diagram of a taste receptor cell, illustrating the different receptor mechanisms for ionic stimuli



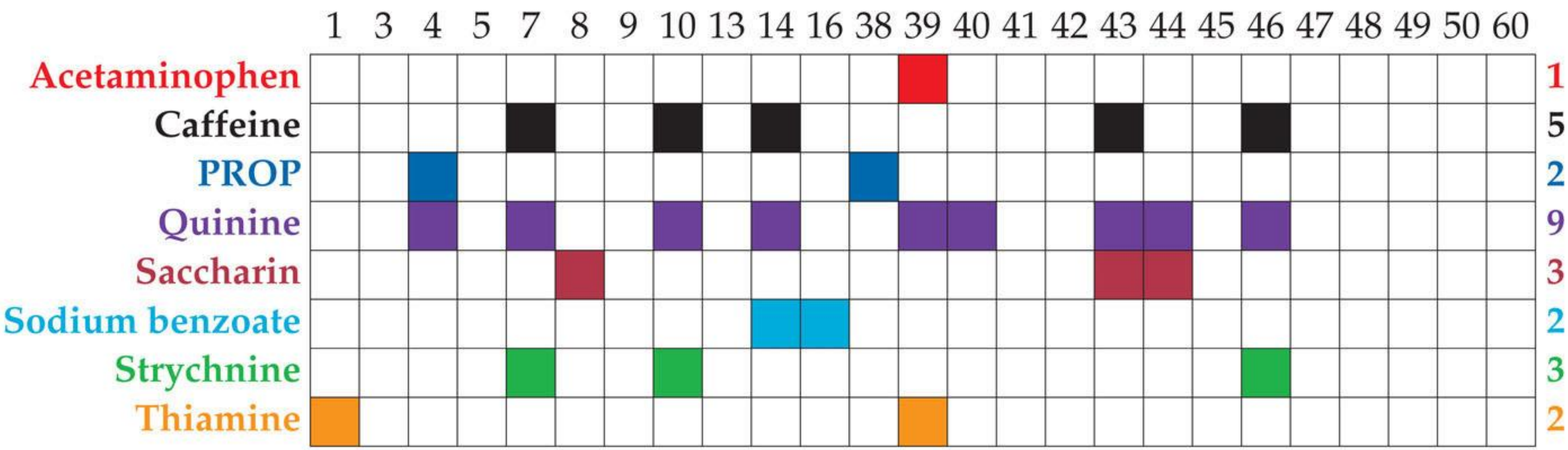
SENSATION & PERCEPTION 4e, **Figure 15.6**

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

Figure 15.7 Bitter receptors are designated by TAS2R#, where # is the number of the receptor



SENSATION & PERCEPTION 4e, **Figure 15.7**

Sweet

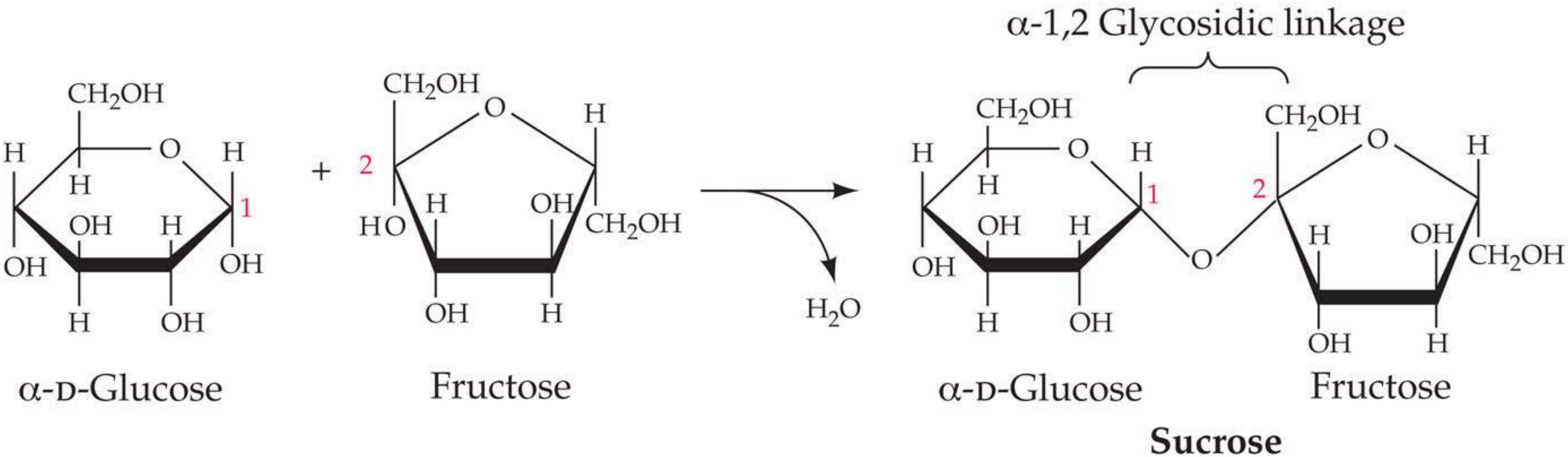
- Evoked by sugars
- Many different sugars taste sweet
  - Glucose: Principle source of energy for most animals
  - Fructose: Even sweeter than glucose
  - Sucrose: Common table sugar; combination of glucose and fructose

The Four Basic Tastes

Sweet (*continued*)

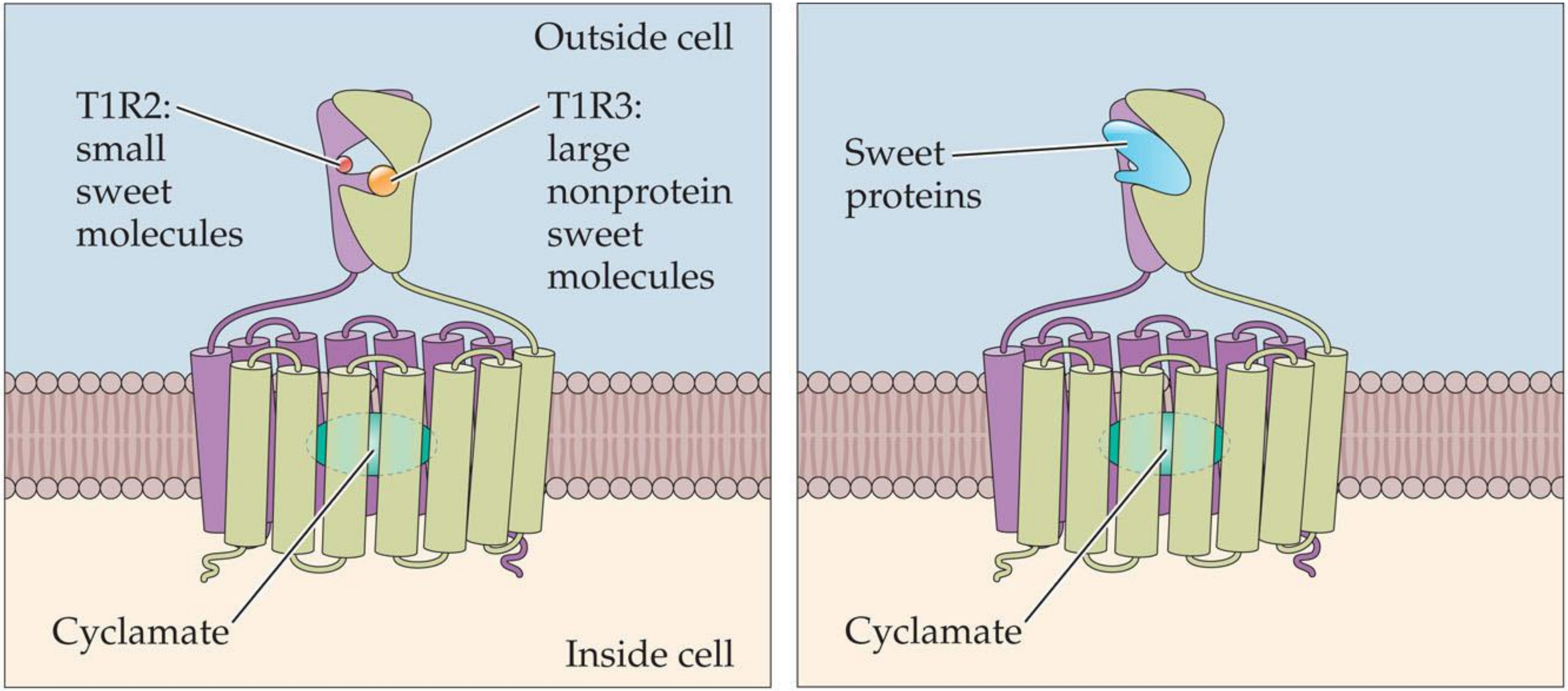
- Single receptor responsible for all sweet perception
  - Different sweeteners stimulate different parts of receptor.
  - Artificial sweeteners stimulate this receptor as well.

Figure 15.8 The molecular structure of sucrose, common table sugar



SENSATION & PERCEPTION 4e, **Figure 15.8**

Figure 15.9 Structure of the T1R2-T1R3 heterodimer sweet receptor, showing binding sites for both large and small sweet molecules



SENSATION & PERCEPTION 4e, Figure 15.9

Genetic Variation in Bitter

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

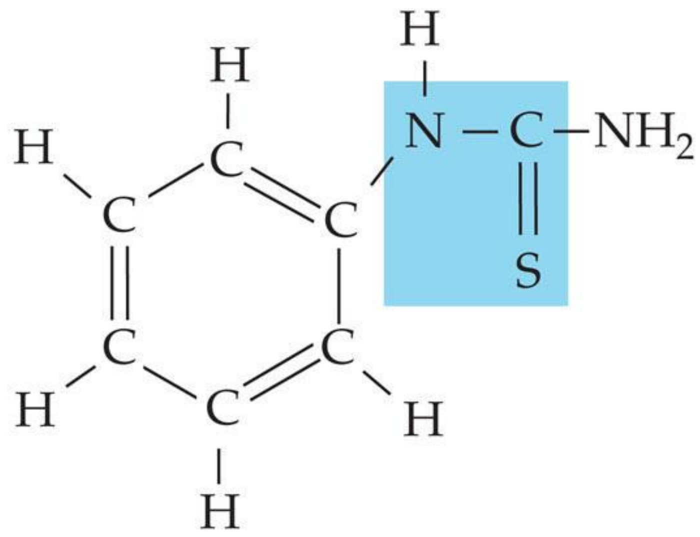
Genetic Variation in Bitter

Gene for PTC/PROP receptors discovered in 2003.

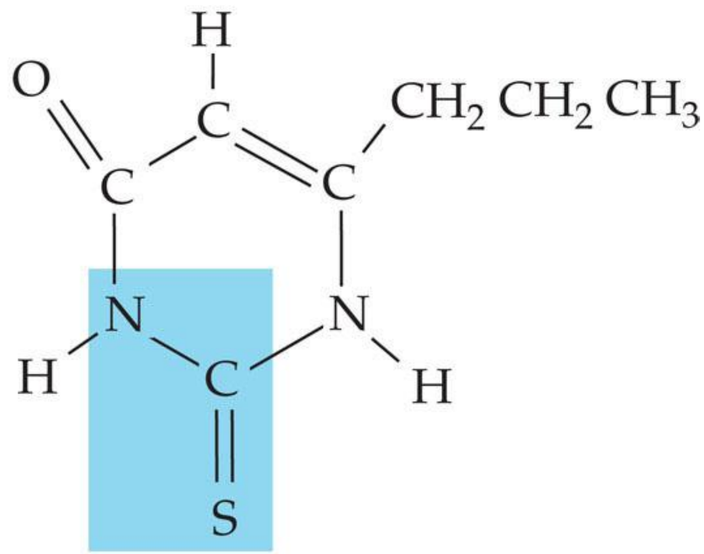
- Individuals with two recessive genes are nontasters of PTC/PROP.
- Individuals with one or more of the genes are tasters of PTC/PROP.

Figure 15.10 The chemical structures of PTC (*a*) and PROP (*b*)

(*a*) Phenylthiocarbamide



(*b*) Propylthiouracil



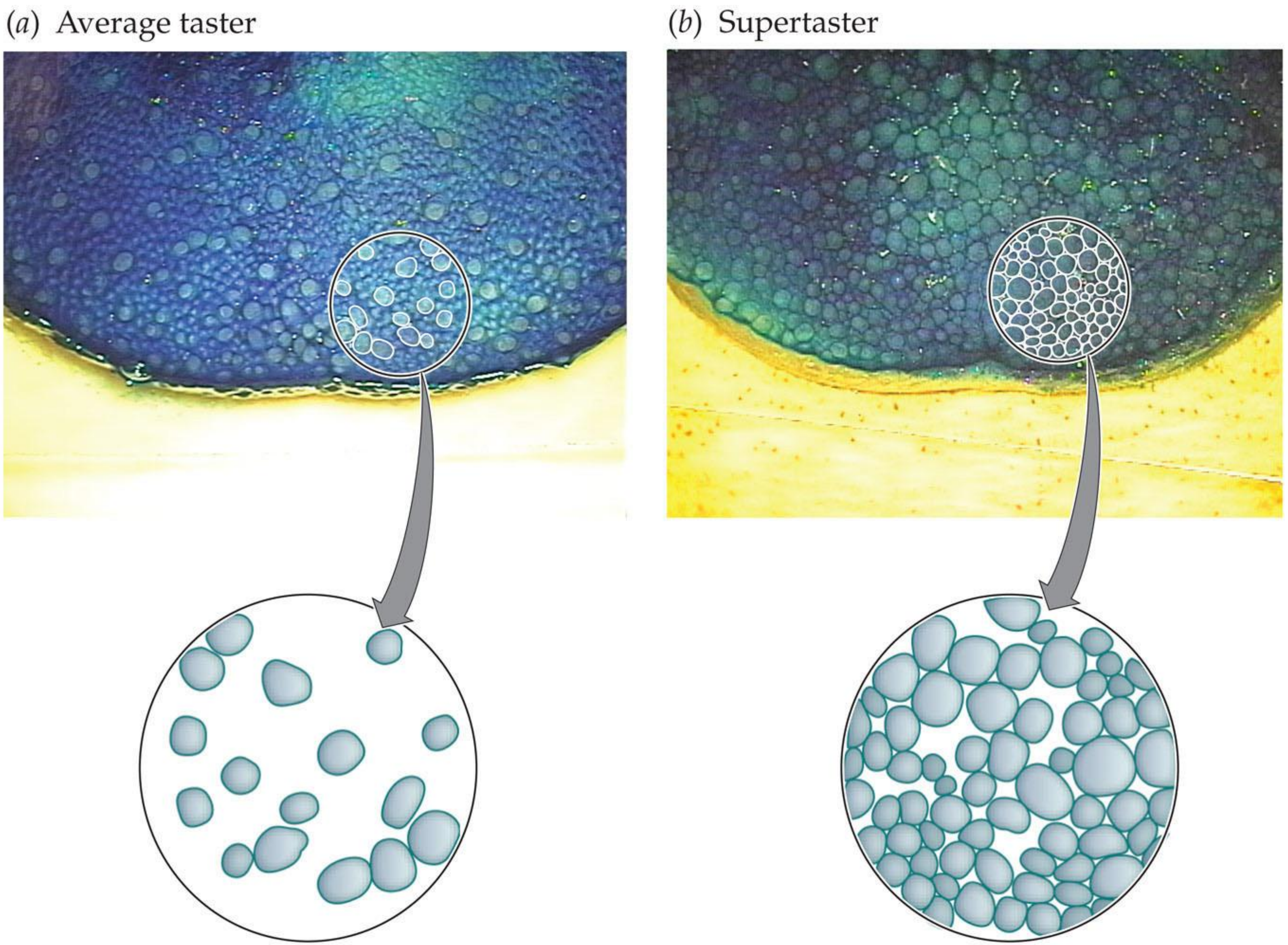
***SENSATION & PERCEPTION 4e*, Figure 15.10**

Genetic Variation in Bitter

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

- Perceives the most intense taste sensations

Figure 15.3 Examples showing typical variability in the density of fungiform papillae from one individual to the next



SENSATION & PERCEPTION 4e, Figure 15.3

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
  - Nontasters match the bitterness of PROP to the same intensity as the sound of a watch or a whisper.

Genetic Variation in Bitter

- Medium tasters match the bitterness of PROP to the same intensity as the smell of frying bacon or the pain of a mild headache.
- Supertasters match the bitterness of PROP to the same intensity as the brightness of the sun or the most intense pain ever experienced.

Genetic Variation in Bitter

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.

Health consequences of taste sensation (*continued*)

- 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.

Wisdom of the Body: How Do We Solve the “Omnivore’s Dilemma”?

Humans are omnivores and have many choices to of what to eat.

- “Omnivore’s dilemma”: Modern humans’ need to find a healthy diet amidst dizzying choices available to us today.

How do taste and smell help us choose what to eat and what not to eat?

- Smell: Helps us identify objects in the environment.
- Taste: Helps us identify nutrients and antinutrients.

Wisdom of the Body: How Do We Solve the "Omnivore's Dilemma"?

Survival value of taste

- 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

Wisdom of the Body: How Do We Solve the “Omnivore’s Dilemma”?

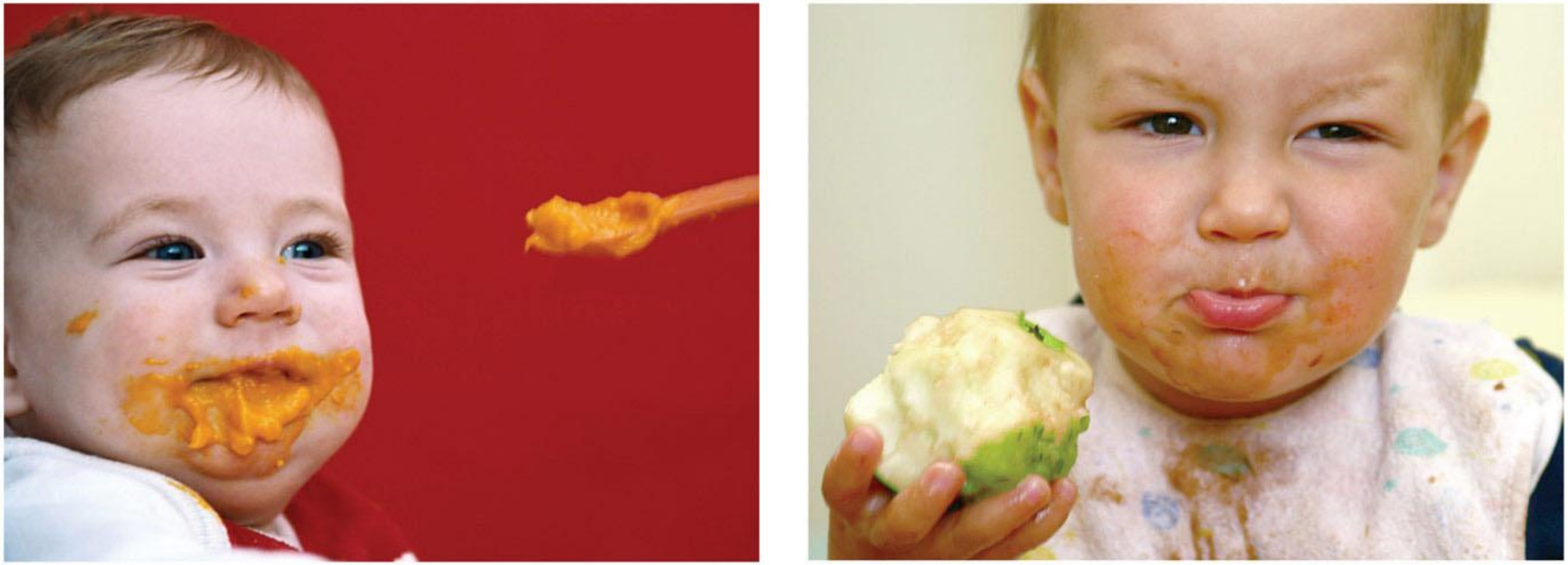
Infants’ behavior and facial expressions reveal innate preferences for certain foods.

Different flavored foods placed on tips of infants’ tongues:

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

Figure 15.12 The two toddlers' facial expressions reveal the taste qualities that they're experiencing

(*a*) (*b*)



***SENSATION & PERCEPTION 4e,* Figure 15.12**

Wisdom of the Body: How Do We Solve the "Omnivore's Dilemma"?

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.

Wisdom of the Body: How Do We Solve the “Omnivore’s Dilemma”?

Modern theories also emphasize learning: We come to like or dislike foods based on the consequences of eating them.

- “Evaluative conditioning”
- Foods with a positive or negative valence transfer to other neutral foods

We regulate our intake of food through a combination of hardwired tastes and learned responses to food flavors.

Figure 15.13 The nutrients in vegetables are, alas, largely undetectable, so we cannot develop specific hungers for them

SENSATION & PERCEPTION 4e, **Figure 15.13**

Wisdom of the Body: How Do We Solve the "Omnivore's Dilemma"?

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, sweating, and tightness in the chest if sensitive individuals consume a large amount
  - For most people, MSG does not pose a problem in small doses

Wisdom of the Body: How Do We Solve the “Omnivore’s Dilemma”?

The special case of fat

- Like protein, fat is an important nutrient.
- Fat molecules evoke tactile sensations like oily, viscous, creamy, etc.
- Rats have fatty acid receptors on their tongues and humans may, too.
- Digesting fat in the gut produces conditioned preferences for the sensory properties of the food containing fat.

The Nature of Taste Qualities

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

The Nature of Taste Qualities

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

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.

Pleasure and retronasal versus orthonasal olfaction (*continued*)

- 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

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.

Chili Peppers (*continued*)

- 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 15.14 Do these images inspire fear or delight in your mouths?

***SENSATION & PERCEPTION 4e*, Figure 15.14**