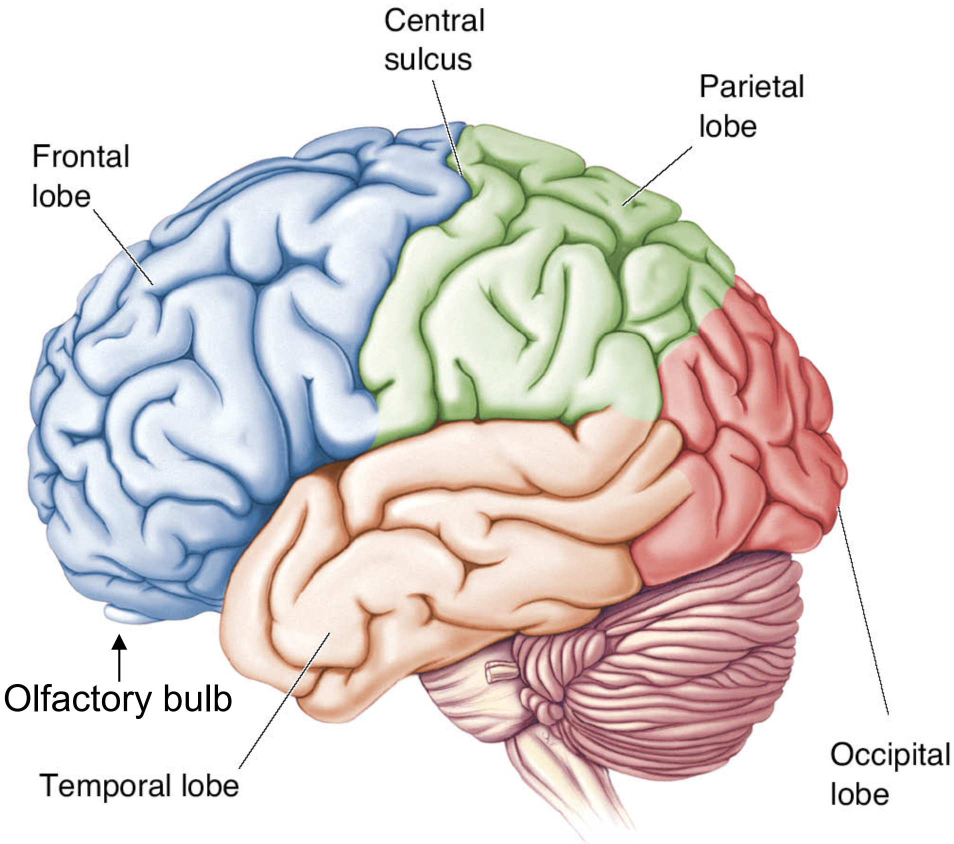
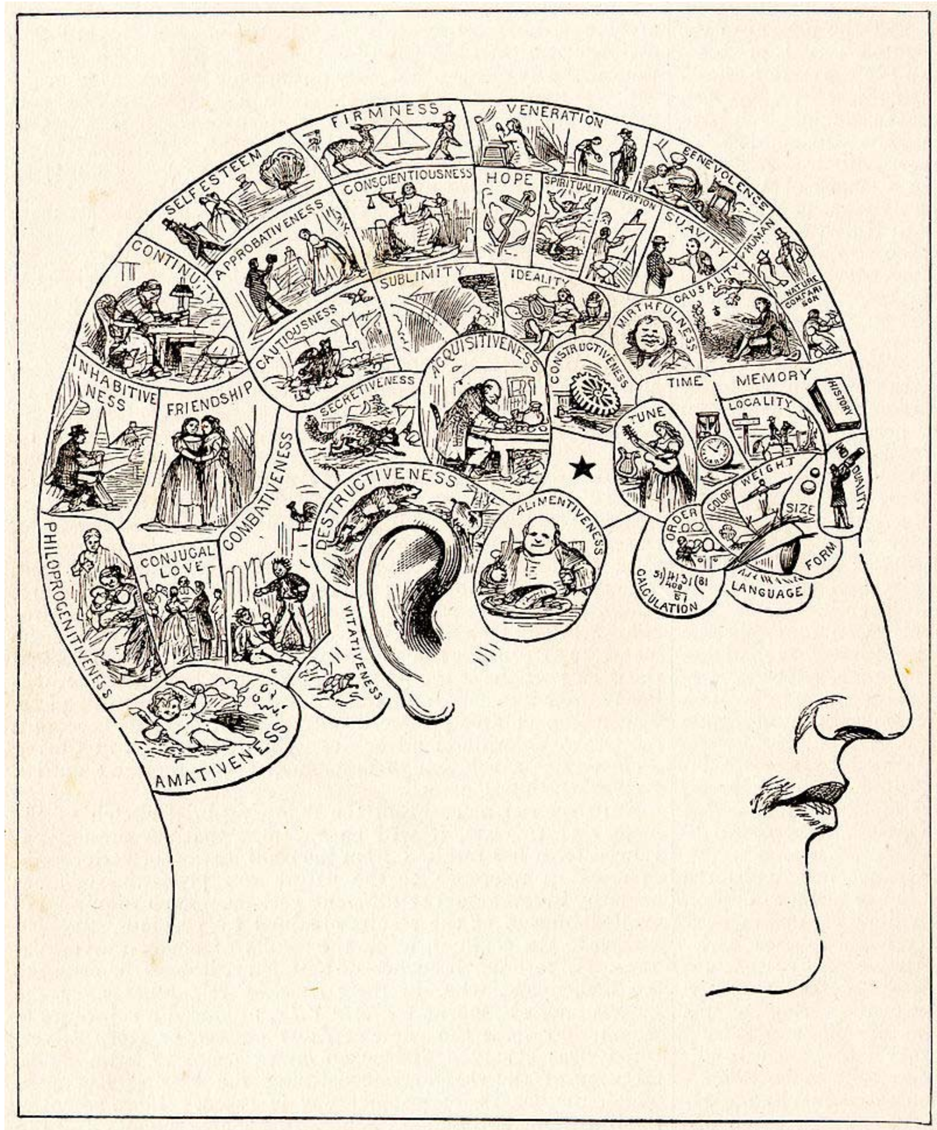
Lobes of the Human Cerebrum (CNS)



- Central nervous system
  - Cerebrum (Frontal, Parietal, Temporal, Occipital lobe)
  - cerebellum,
  - brain stem
  - Spinal cord

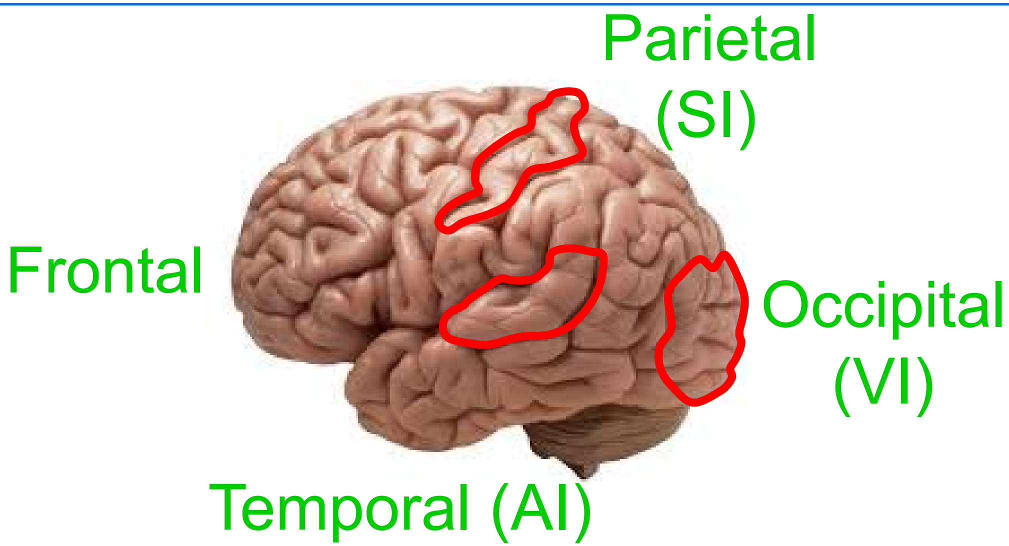
Phrenology



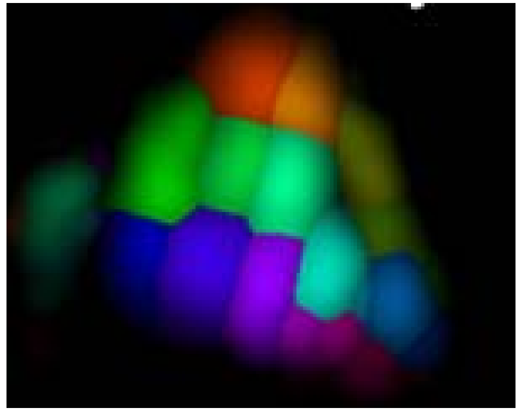
Phrenological Chart of the Faculties.

- It is based on the concept that the brain is the organ of the mind, and that certain brain areas have localized specific modules.
- Franz Joseph Gall's assumption in 1796, that character, thoughts, and emotions are located in specific parts of the brain is considered an important historical advance toward neuropsychology

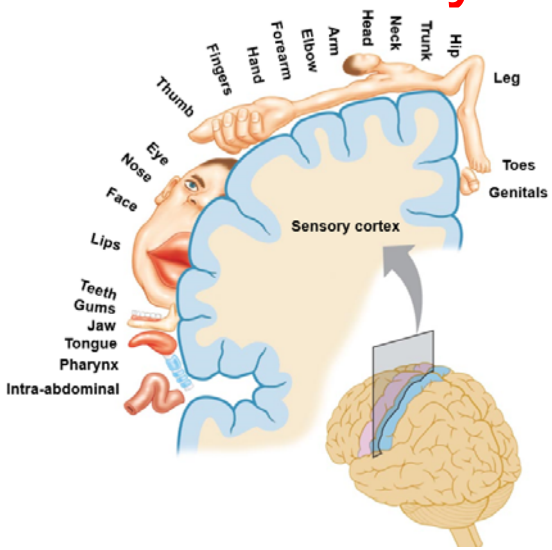
Sensory brain Map



Retinotopic map

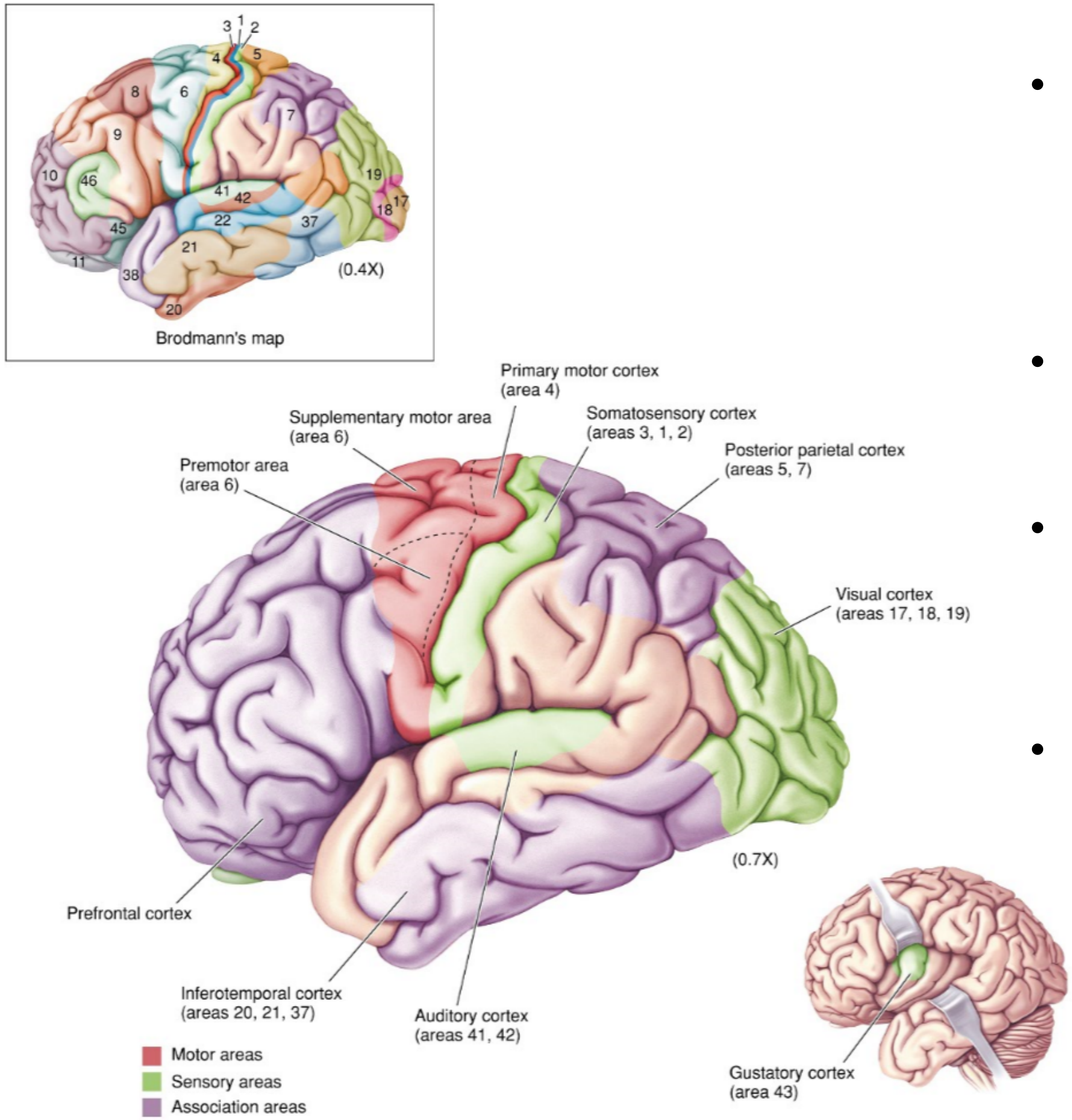


Somatosensory map



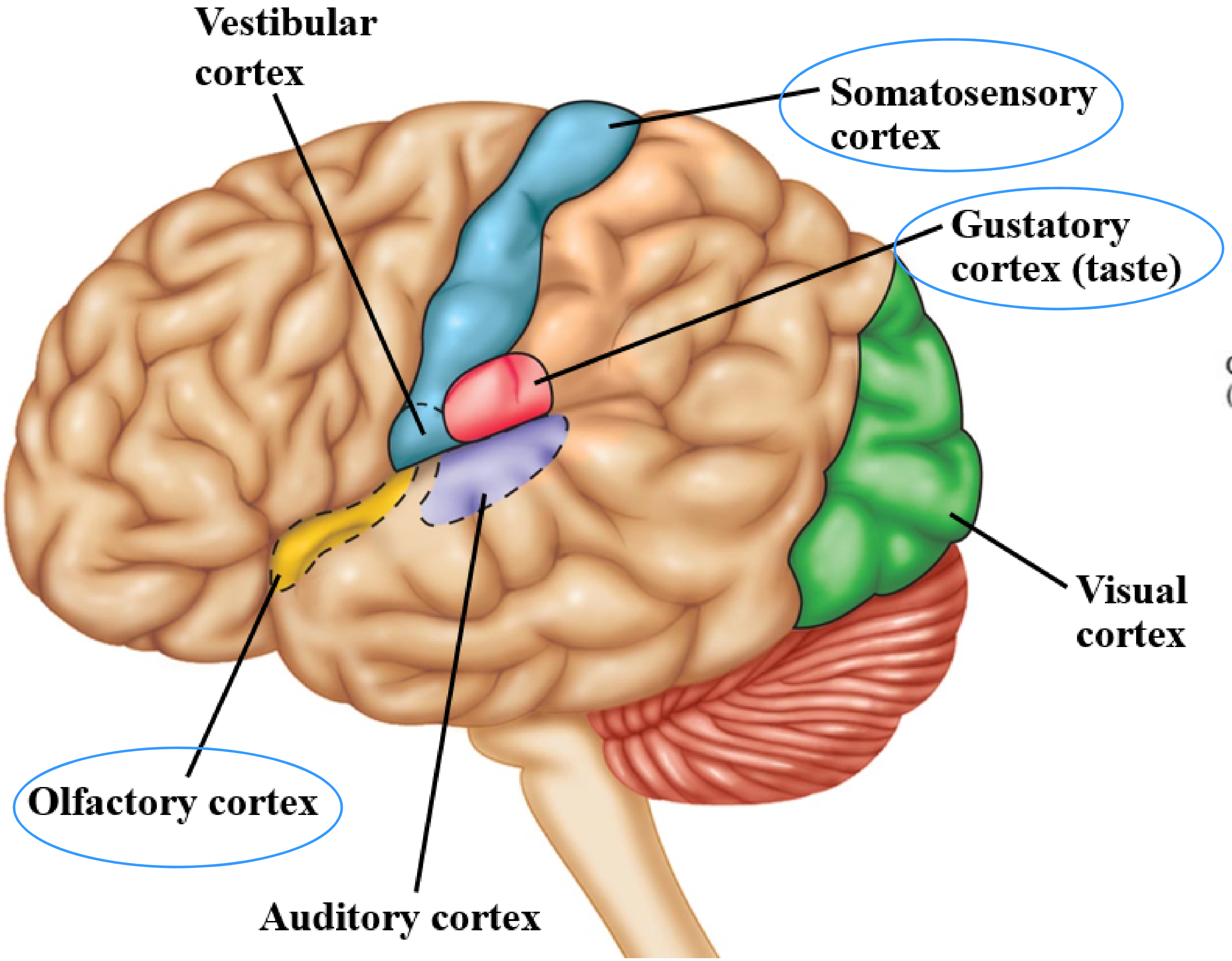
Tonotopic map

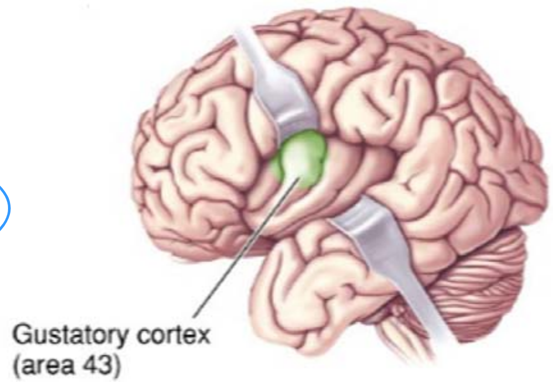
Cortical map (in CNS) with diverse sensory modalities



- Frontal: reward, attention, memory, planning, motivation, cognitive functions and voluntary movement or activity.
- Parietal: sense of touch, temperature, pain, and sense of taste
- Temporal: memory, hearing, language processing, sense of smell, and emotion.
- Occipital: visual processing

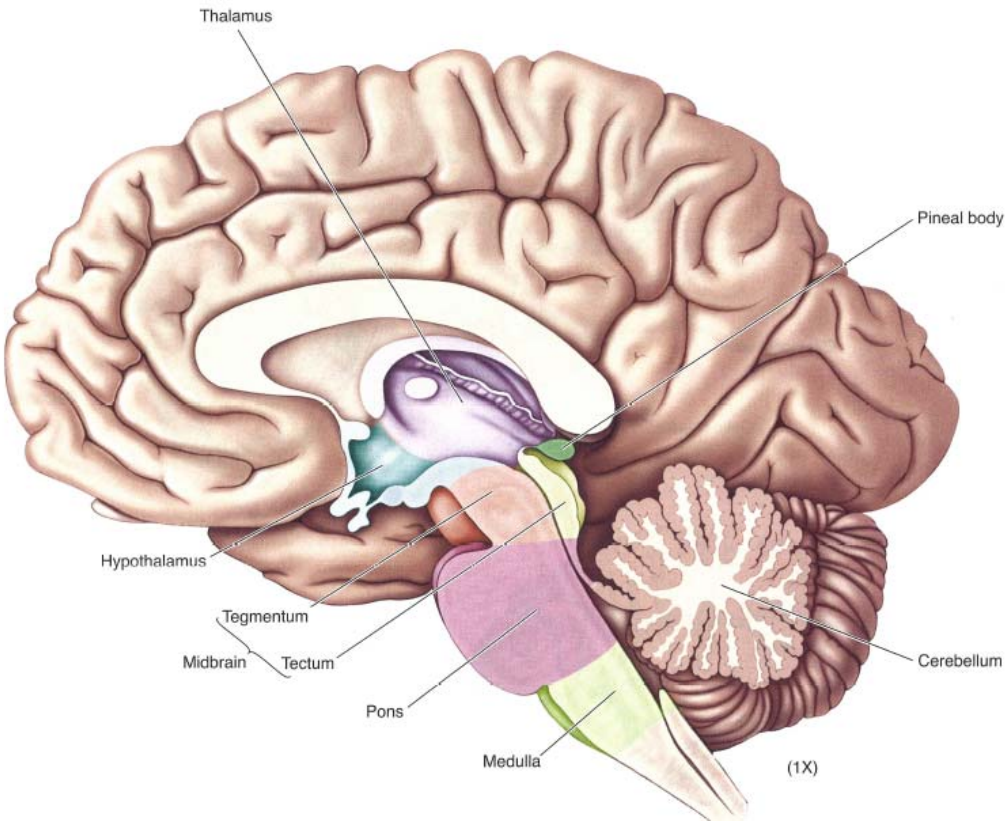
Cortical maps with diverse sensory modalities





Brain stem connected to thalamus and cortex

- Brain stem

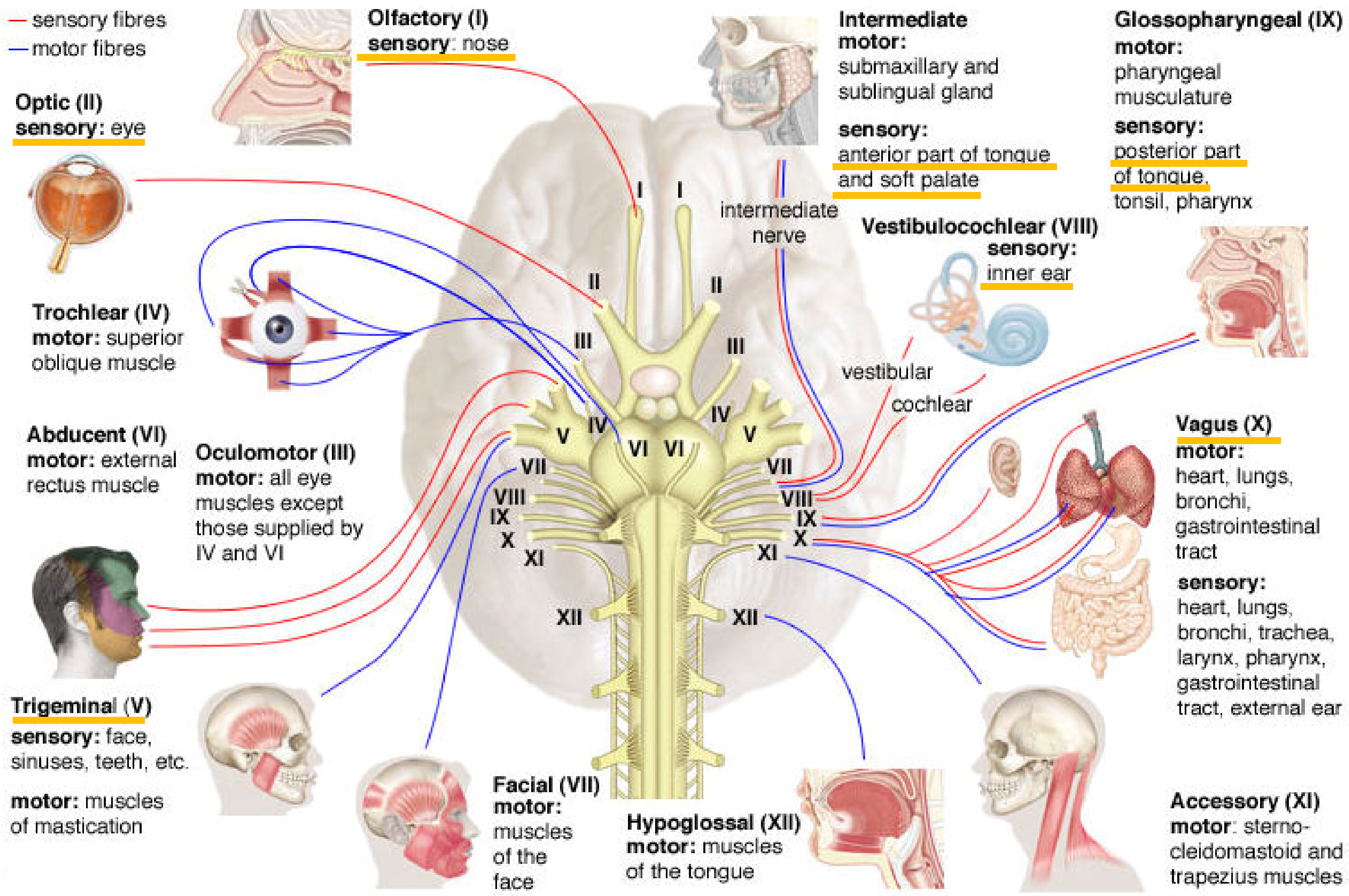


The Medial Surface of the Brain

(a) Brain Stem Structures. Splitting the brain down the middle exposes the medial surface of the cerebrum, shown in this life-size illustration. This view also shows the midsagittal, cut surface of the brain stem, consisting of the diencephalon (thalamus and hypothalamus), the midbrain (tectum and tegmentum), the pons, and the medulla. (It should be noted that some anatomists define the brain stem as consisting only of the midbrain, pons, and medulla.)

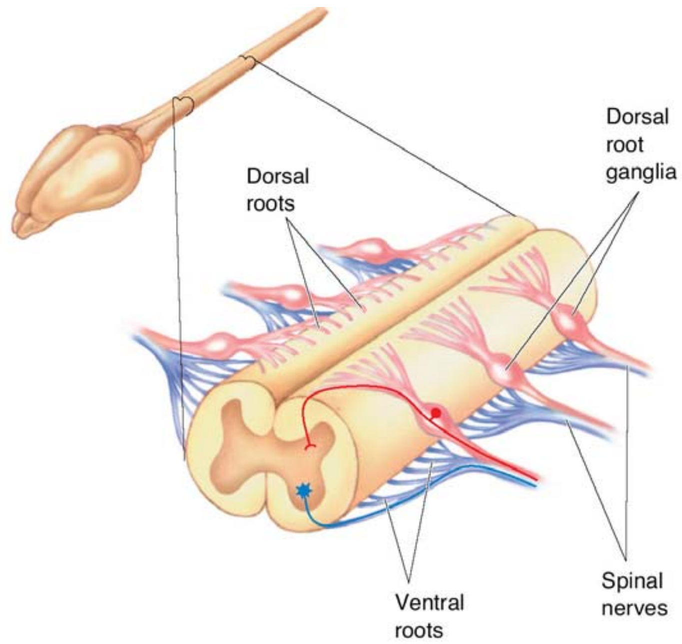
- The brainstem provides the main motor and sensory innervation to the face and neck via the cranial nerves. Of the twelve pairs of cranial nerves, ten pairs come from the brainstem.

Brain stem connected to periphery organs



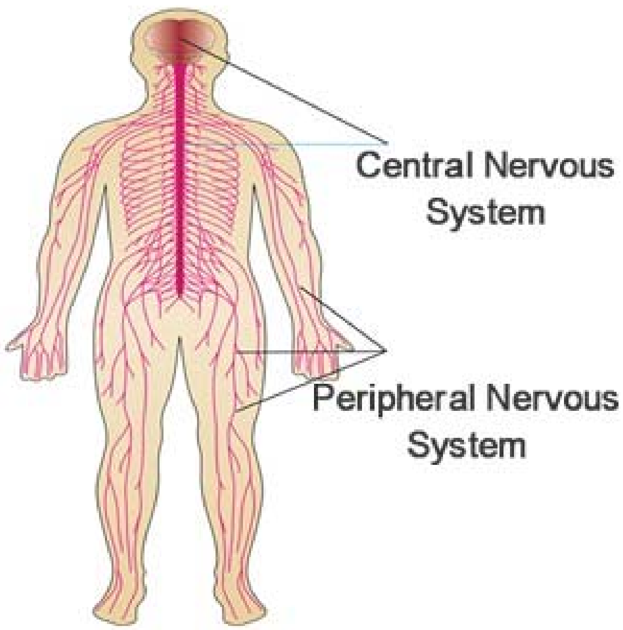
Spinal cord (CNS-PNS)

- Spinal cord
  - Location: attached to the brain stem
  - Conduit of information (brain–body)
    - Skin, joints, muscles
    - Spinal nerves
      - Dorsal root
      - Ventral root



Gross Organization (PNS)

- Peripheral nervous system
  - Nervous system outside the brain and spinal cord
  - Somatic PNS: innervates voluntary organs such as skin, joints, muscles
  - Visceral PNS: innervates internal organs and their functions such as blood circulation, hormone release, heart rate, digestion, and urination, sexual arousal.



Cortical map and perception

“My brain’s map are continuously modified by experience.”

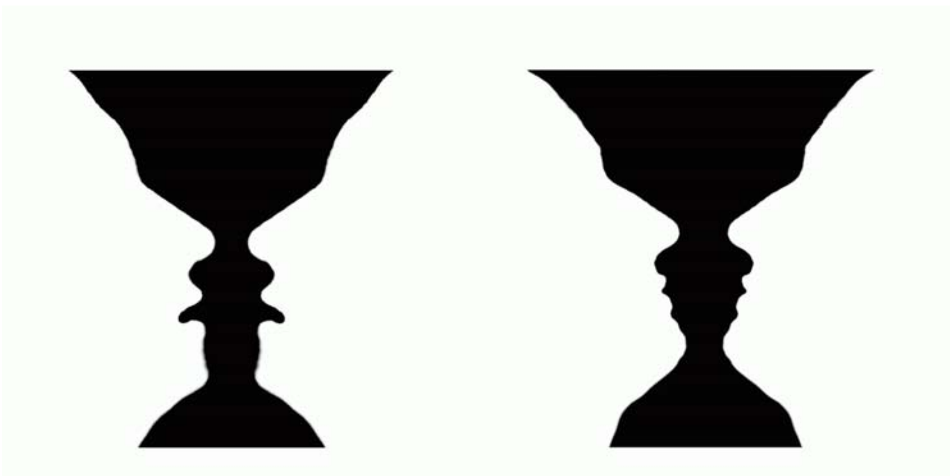
Auditory Cortex:
Larger sensitivity to violin

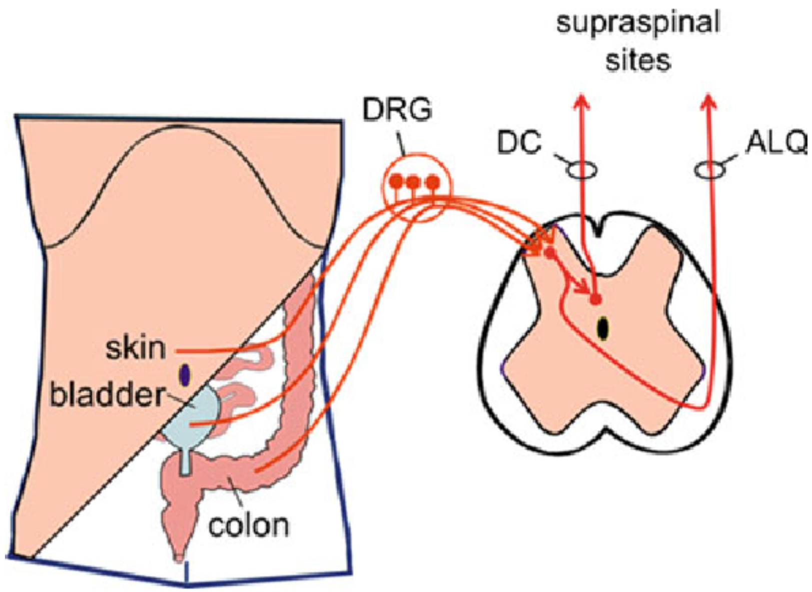
Somatosensory Cortex:
Enlarged cortical map to left-hand fingers

Elbert and Heim, 2001

General Principles of Sensory Physiology

- **Perception**: conscious interpretation of the world based on sensory systems, memory, and other neural processes
- Information is sent from the periphery to the CNS
  - External environment, Sensory
  - Internal environment, Visceral afferent





General Principles of Sensory Physiology

- Sensory systems (modality)
  - Somatosensory system (pressure and temperature)
    - Somatic: sensations of the skin
    - Proprioception: perception of limb and body positions
  - Vision (light)
  - Hearing (sound)
  - Balance and equilibrium (acceleration)
  - Taste (chemicals)
  - Smell (chemicals)
- Sensory receptors
  - Detect specific form of energy in the external environment
  - Modality: light, sound, pressure, temperature, chemicals, acceleration

A given sensory receptor is specific for each modality

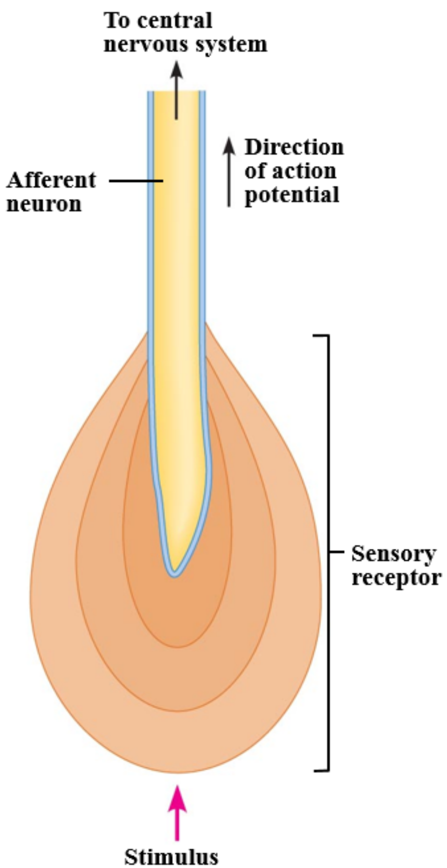
TABLE 10.1 Characteristics of Sensory Receptors

Receptor class	Sensation/visceral information	Modality
Photoreceptors	Vision	Photons of light
Chemoreceptors	Taste	Chemicals dissolved in saliva
	Smell	Chemicals dissolved in mucus
	Pain	Chemicals in extracellular fluid
Thermoreceptors		
Warm receptors	Warmth	Increase in temperatures between 30°C and 43°C
Cold receptors	Cold	Decrease in temperatures between 35°C and 20°C
Mechanoreceptors		
Pacinian corpuscle	Vibration	Pressure
Hair cells	Sound	Sound waves
	Balance and equilibrium	Acceleration

Sensory Transduction

- Conversion of stimulus energy into electrical energy
- Receptor (or graded) potentials
  - Opening or closing of ion channels/receptors
  - Triggered by sensory stimuli
- If the receptor potential exceeds threshold, it can generate an action potential

Sensory Transduction



Afferent neurons with sensory receptors

- Dorsal root ganglion in spinal cord (Somatosensation)
- Olfactory receptor cells in nasal cavity (Smell)
- Hair cells in cochlear (sound)
- Rod/Cone cells in retina (Vision)
- Taste receptor cell in taste bud (Taste)

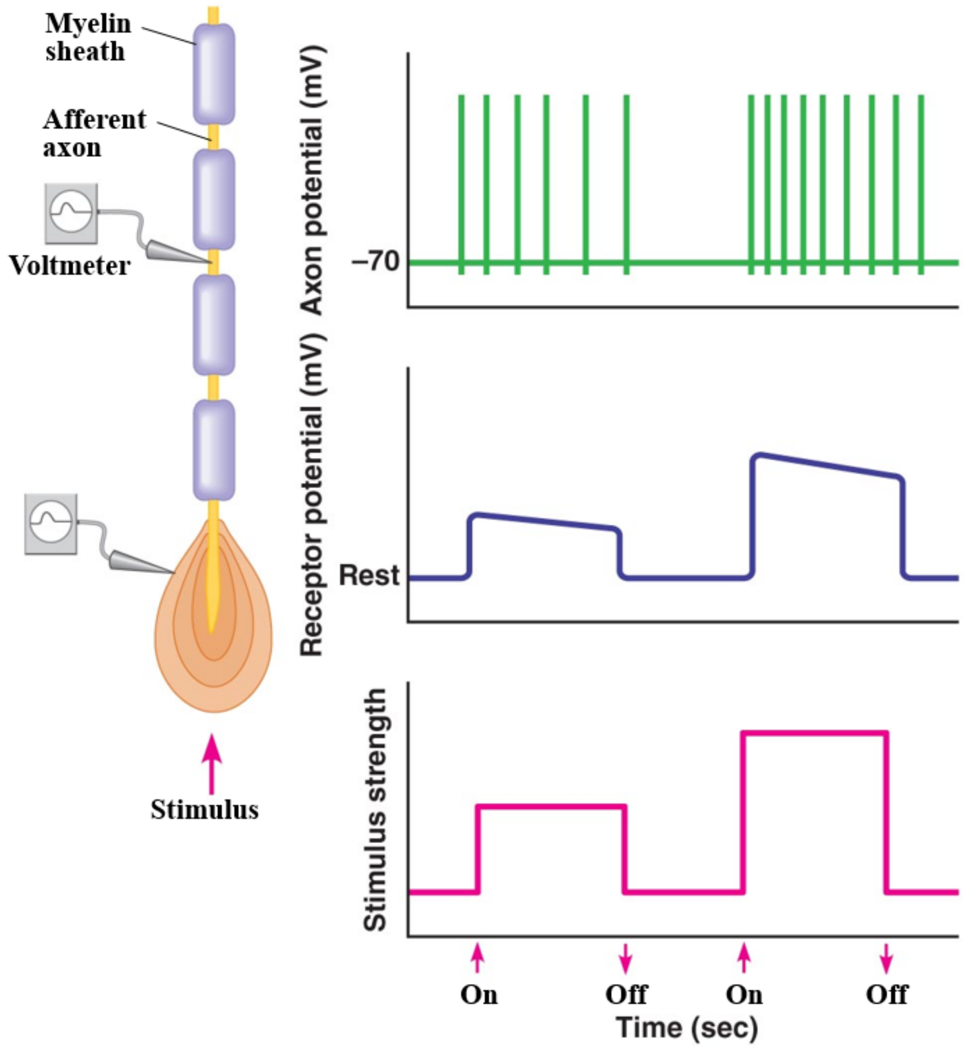
Sensory Pathways

- Specific neural pathways transmitting information of a specific modality
- Sensory unit
  - All receptors are of similar type within a modality
  - Action potential may result from activation of receptors in sensory cells
  - Receptive field: area in which a sensory unit is activated

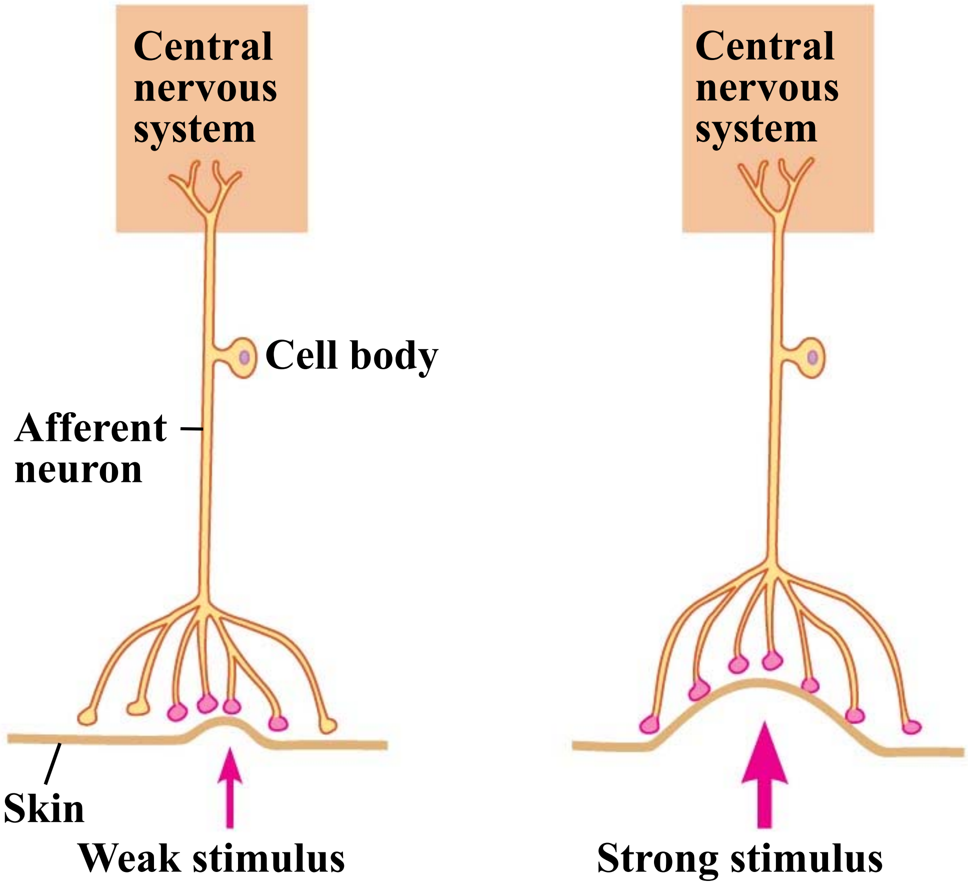
Sensory coding: stimulus intensity

- Coding for stimulus intensity
  - Frequency of action potentials
  - Number of receptors or units activated (population coding)

- Stronger stimulus activates more receptors or more sensory units

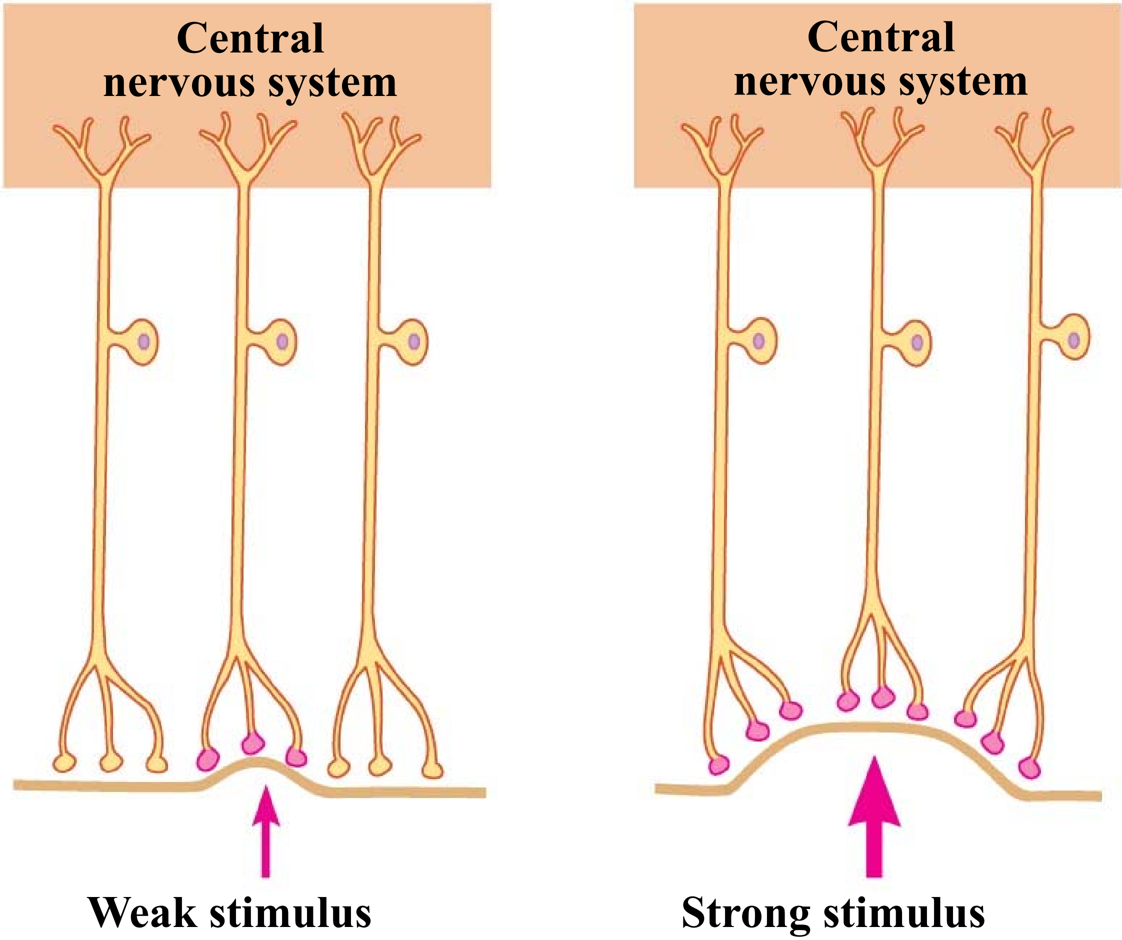


Coding of stimulus intensity (The number of receptors)



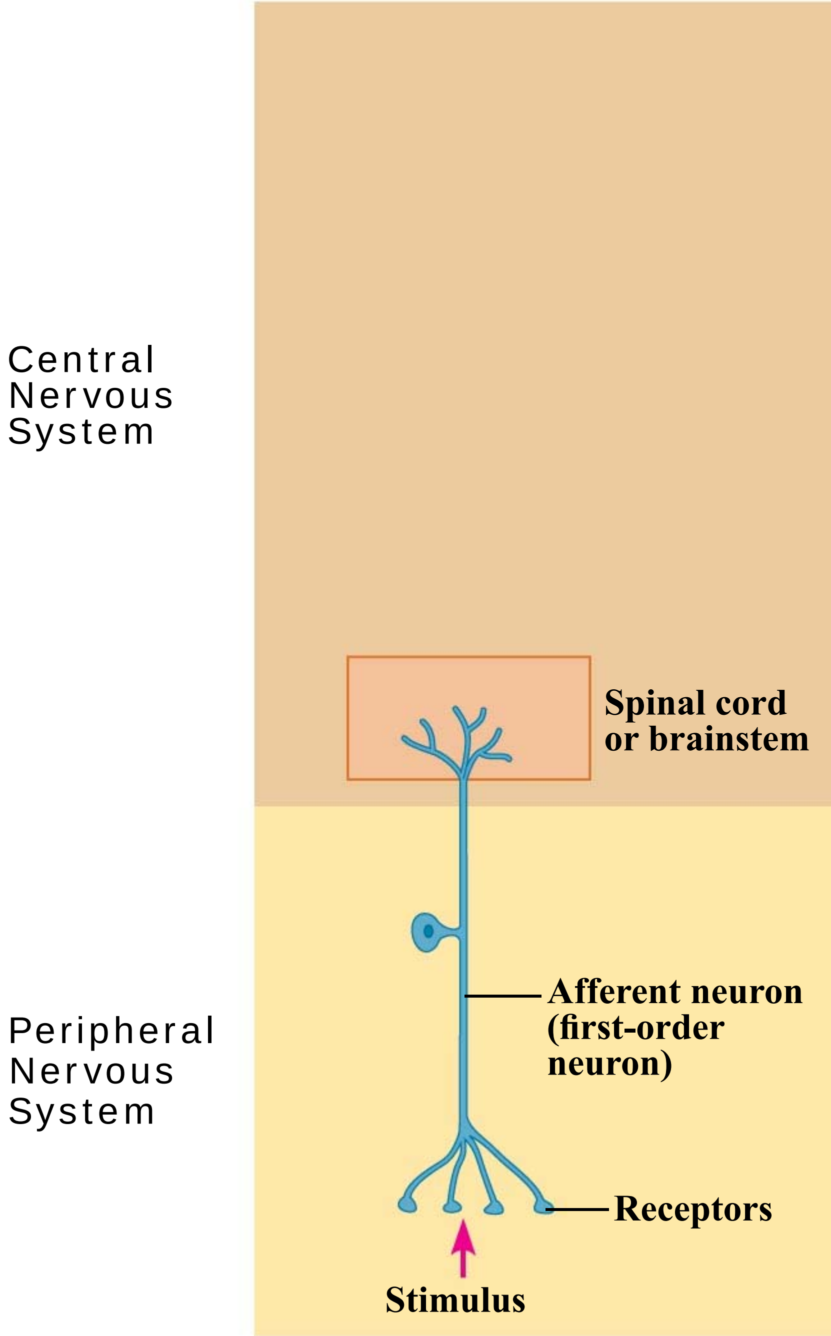
(a) Single sensory unit stimulated

Coding of stimulus intensity (The number of receptor cells or units)



(b) Multiple sensory units stimulated

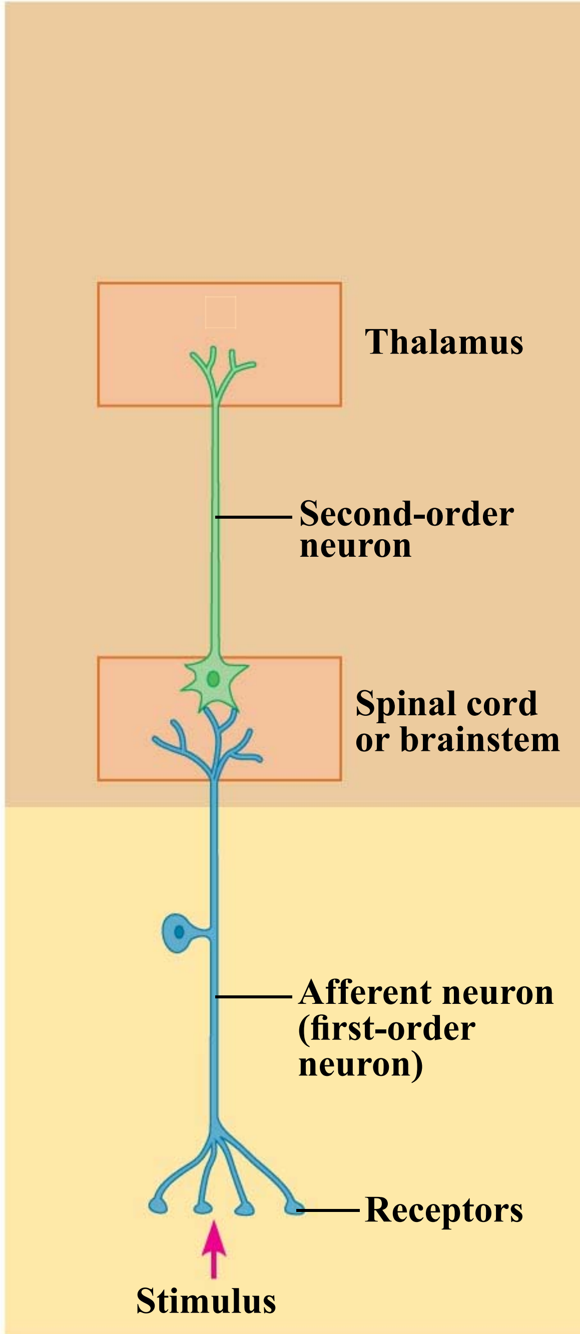
Generalized pathway for sensory systems



Generalized pathway for sensory systems

Central Nervous System

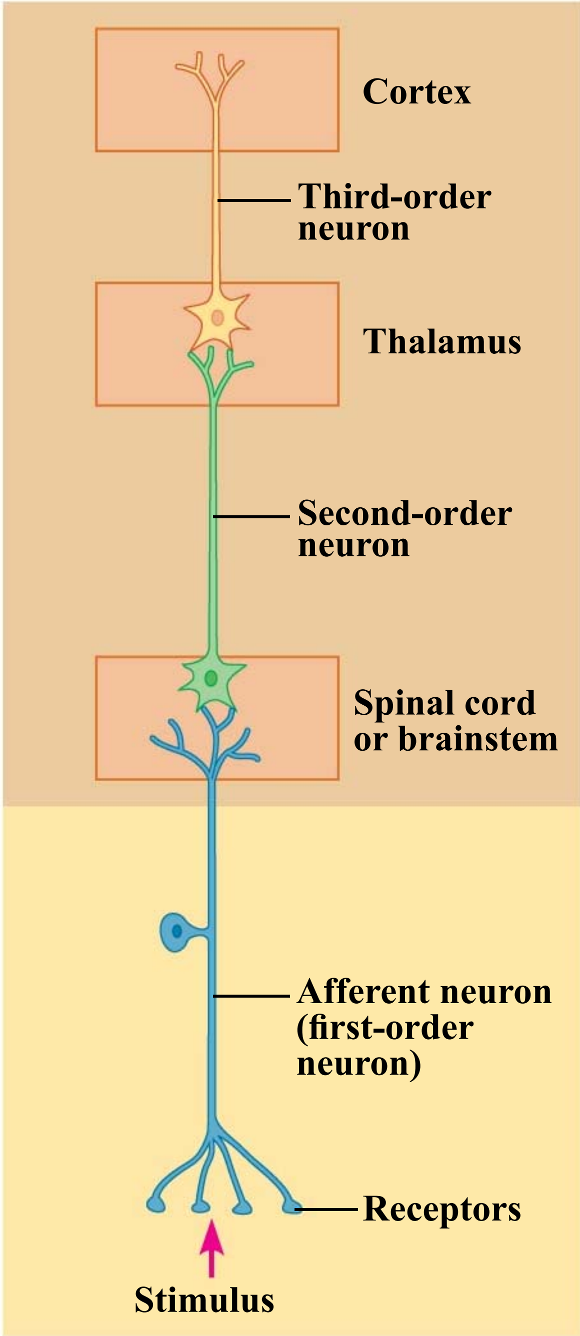
Peripheral Nervous System



Generalized pathway for sensory systems

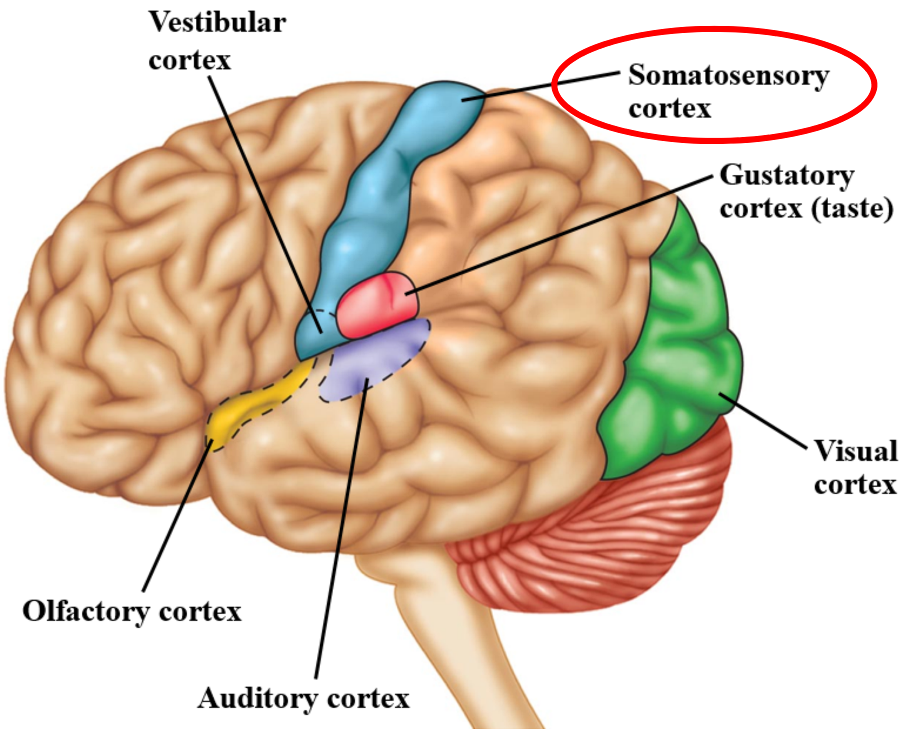
Central Nervous System

Peripheral Nervous System

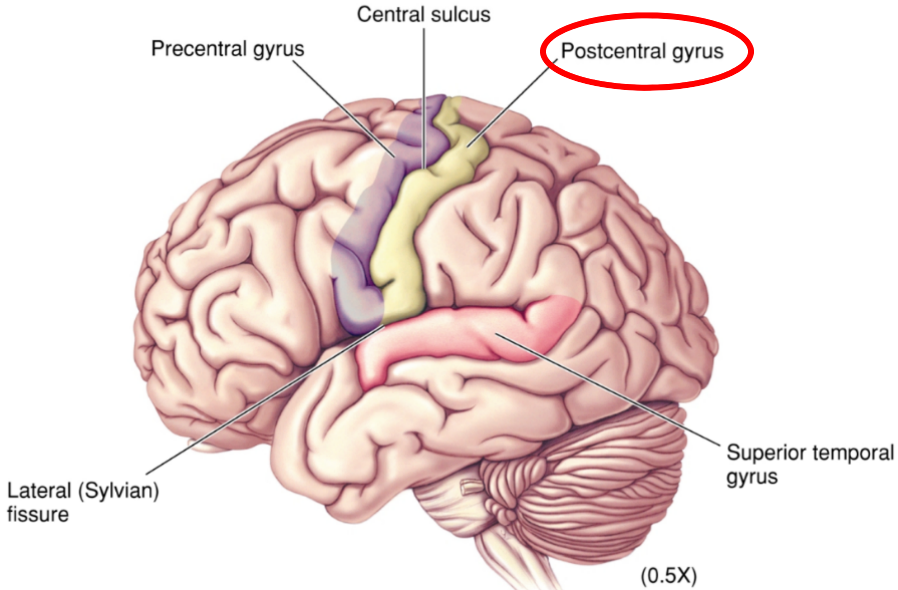


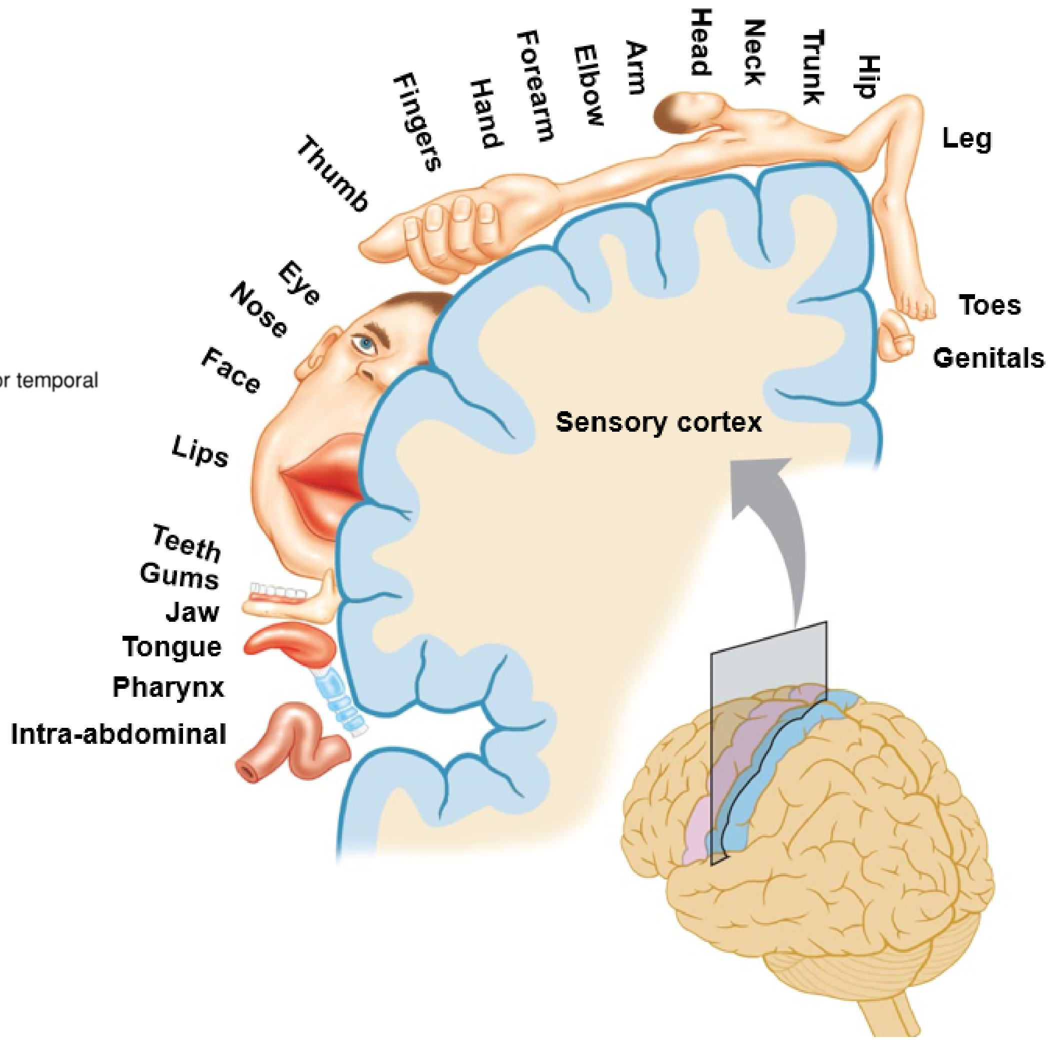
Sensory anatomy and physiology

- Somatosensory System
- Taste
- Olfaction



Somatosensory cortical map

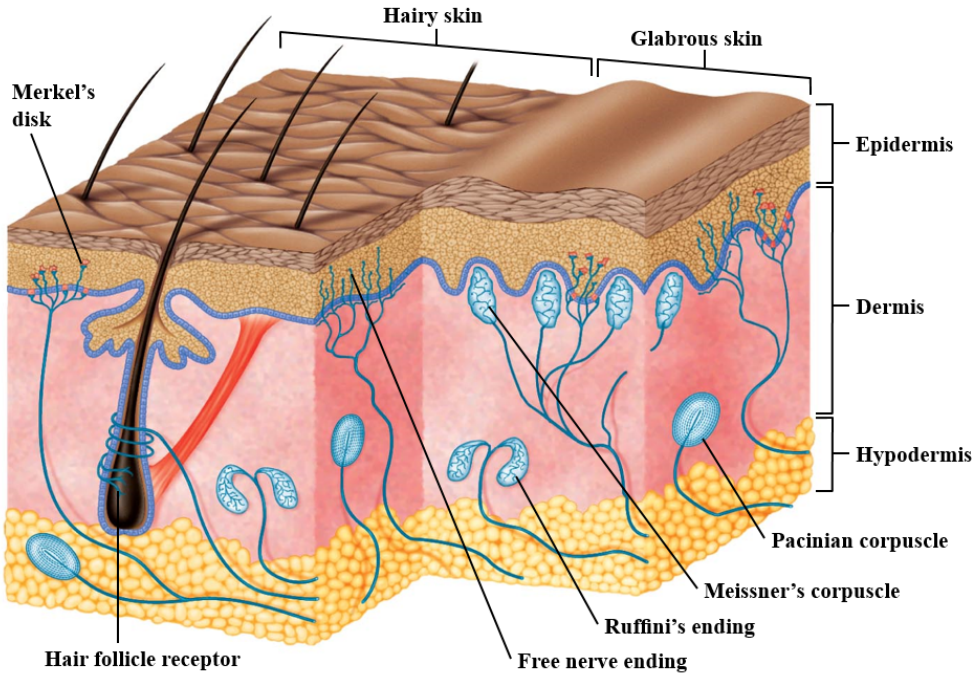




The Peripheral Somatosensory System

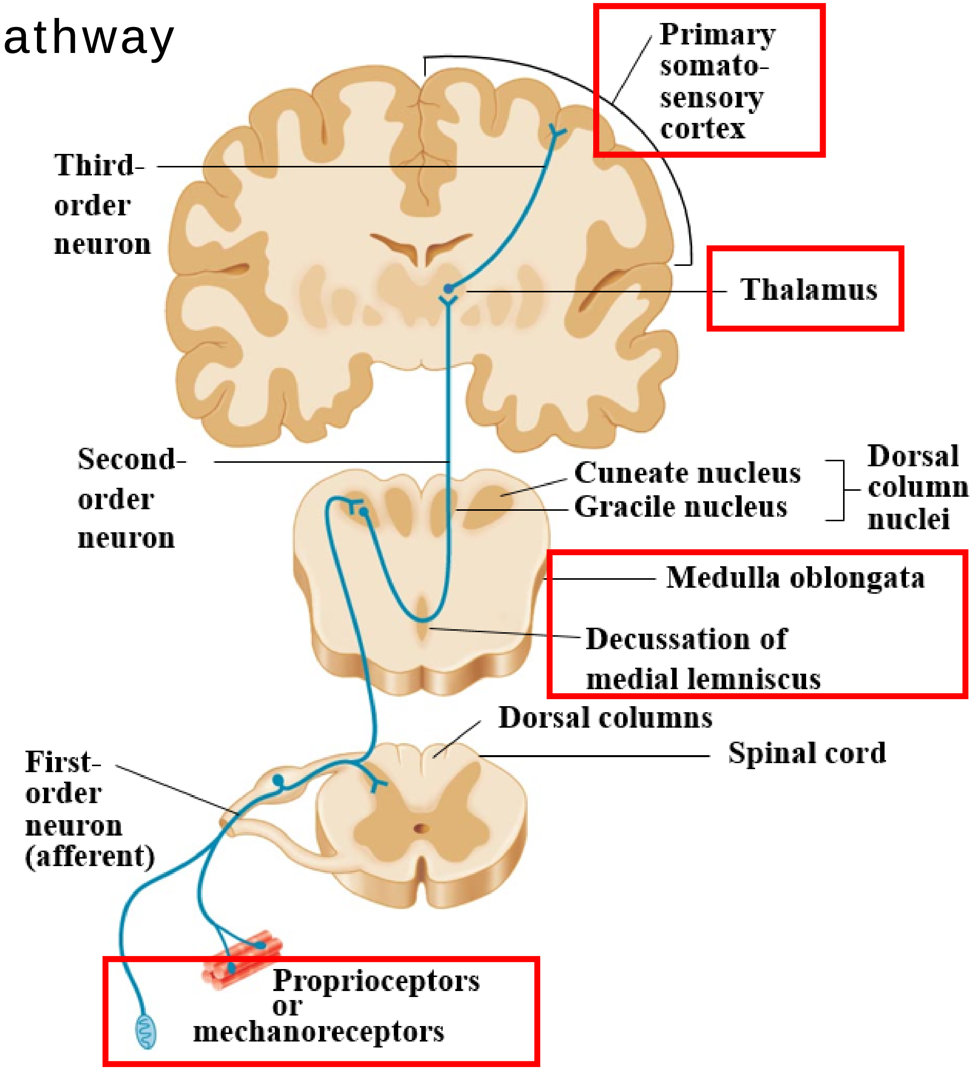
Somatosensory receptors

- **Proprioceptors**, position of the limb in space (joint angle, muscle length, muscle tension), Ruffini endings and Pacinian corpuscles
- **Mechanoreceptors**, sensation of mechanical pressure or distortion in Corpuscles, Hair follicle receptor, and Merkel's endings
- **Thermoreceptors**, sensation of relative changes in temperature in Ruffini's ending
- **Nociceptors**, pain sensation by damaging stimuli in Free nerve ending



Somatosensory lemniscal Pathways

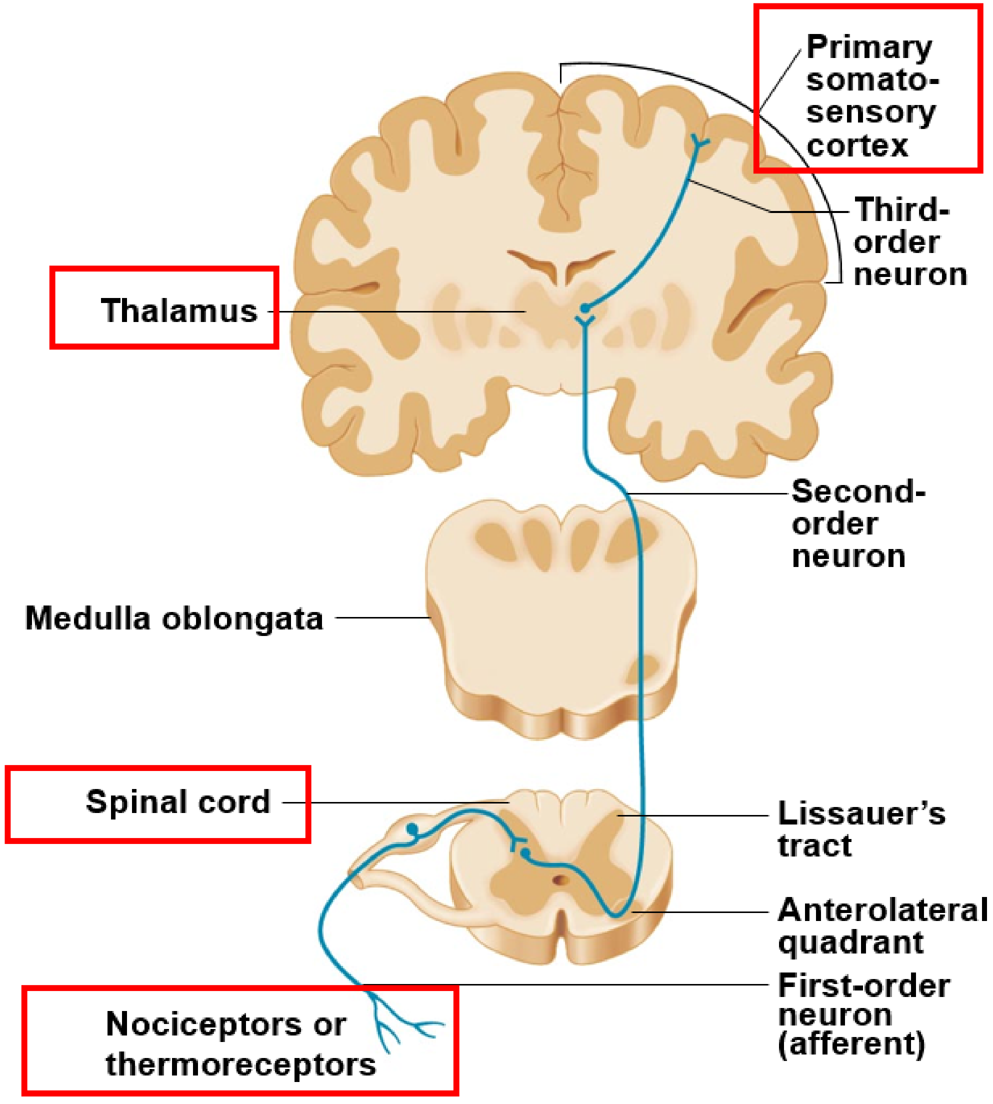
- Dorsal column–medial lemniscal pathway
  - Somesthetic sensations
    - Touch and pressure
    - Proprioception



Dorsal column–medial lemniscal pathway

Somatosensory spinothalamic Pathways

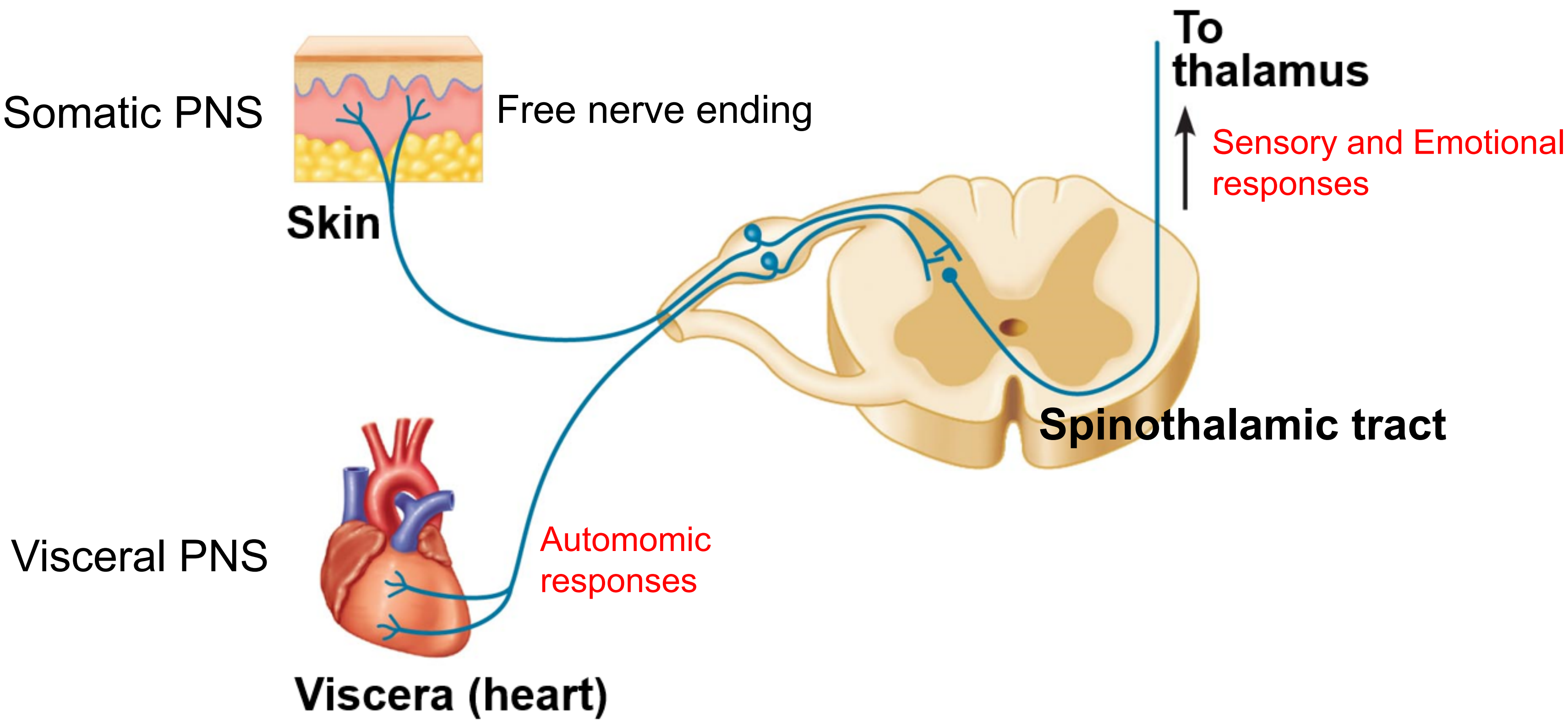
- Spinal cord-thalamus pathway
  - Spinothalamic tract
    - Temperature
    - Tissue-damaging stimuli



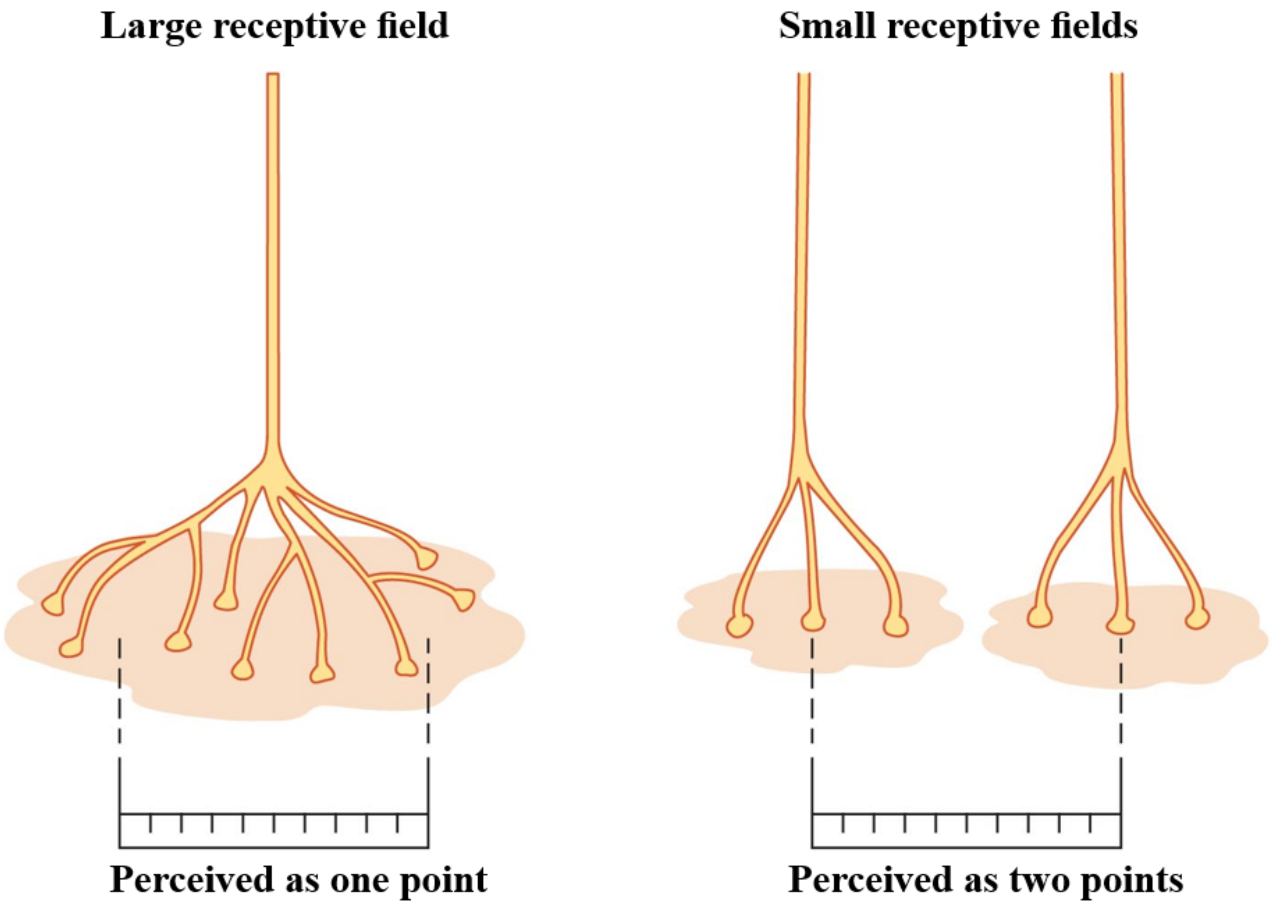
Spinothalamic tract

Pain Perception

- The pain response
  - Sensation produced by tissue-damaging stimulus
  - Pain elicits autonomic responses (e.g., increased blood pressure, sweating)
  - Pain elicits emotional responses (e.g., fear, anxiety)



Two point discrimination



Receptive field: area in which a sensory unit is activated

Coding of Stimulus Location

- Two-point discrimination: sensory acuity
  - Ability to perceive two points on the skin
  - two-point discrimination is a widely used technique for determining tactile agnosia
  - Two-point threshold: The smallest distance between two points that still results in the perception of two distinct stimuli is recorded as the two-point threshold
  - Tactile acuity: The keenness or sharpness of the sense of touch, usually measured by the two-point threshold

TABLE 10.2 Two-Point Discrimination Thresholds for Selected Areas of the Body

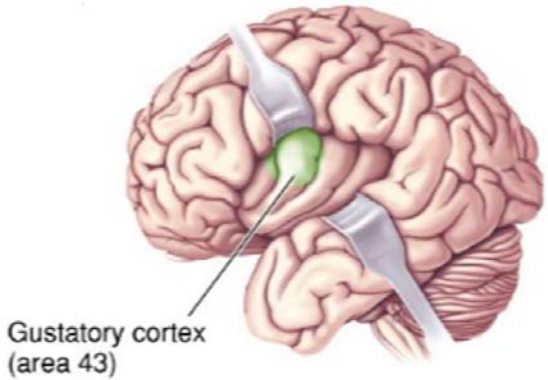
Body region	Two-point discrimination threshold (mm)*
Lips (greatest acuity)	1
Index finger	2
Thumb	3
Palm of hand	10
Big toe	10
Forehead	18
Sole of foot	22
Breast	31
Abdomen	36
Shoulder	38
Back	42
Thigh	46
Upper arm	47
Calf (least acuity)	48

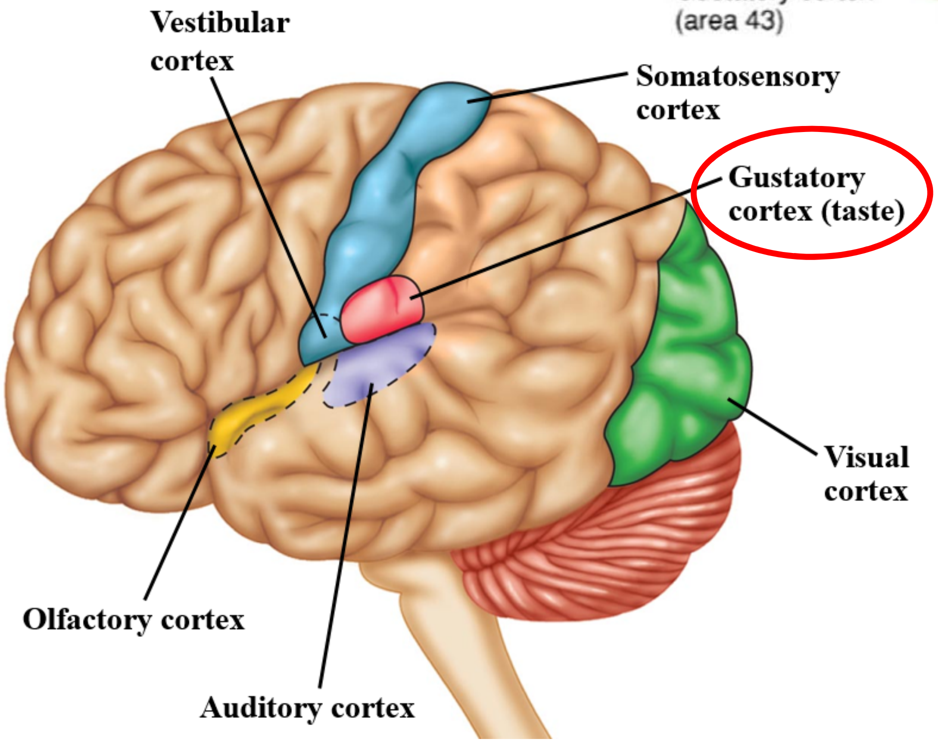
*Smaller distances indicate greater tactile acuity.

Source: Weinstein and Kenshalo, editors, *The Skin Senses,* copyright 1968. (Table: Two-Point Discrimination Thresholds for Selected Areas of the Body.) Courtesy of Charles C. Thomas Publisher, Ltd., Springfield, Illinois.

Sensory Anatomy and Physiology

- Somatosensory System
- Taste
- Olfaction





Taste buds (in PNS) in the tongue

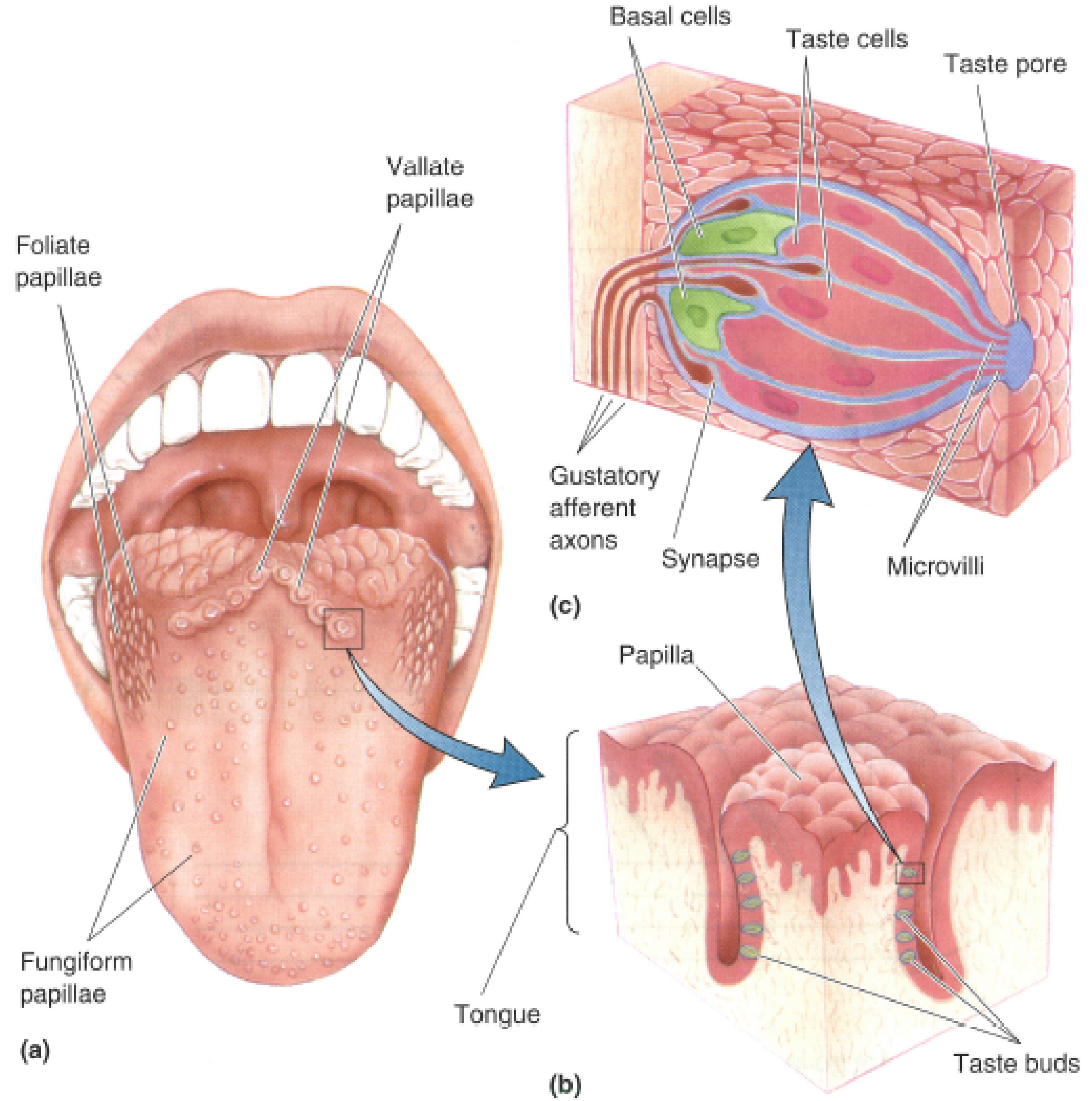


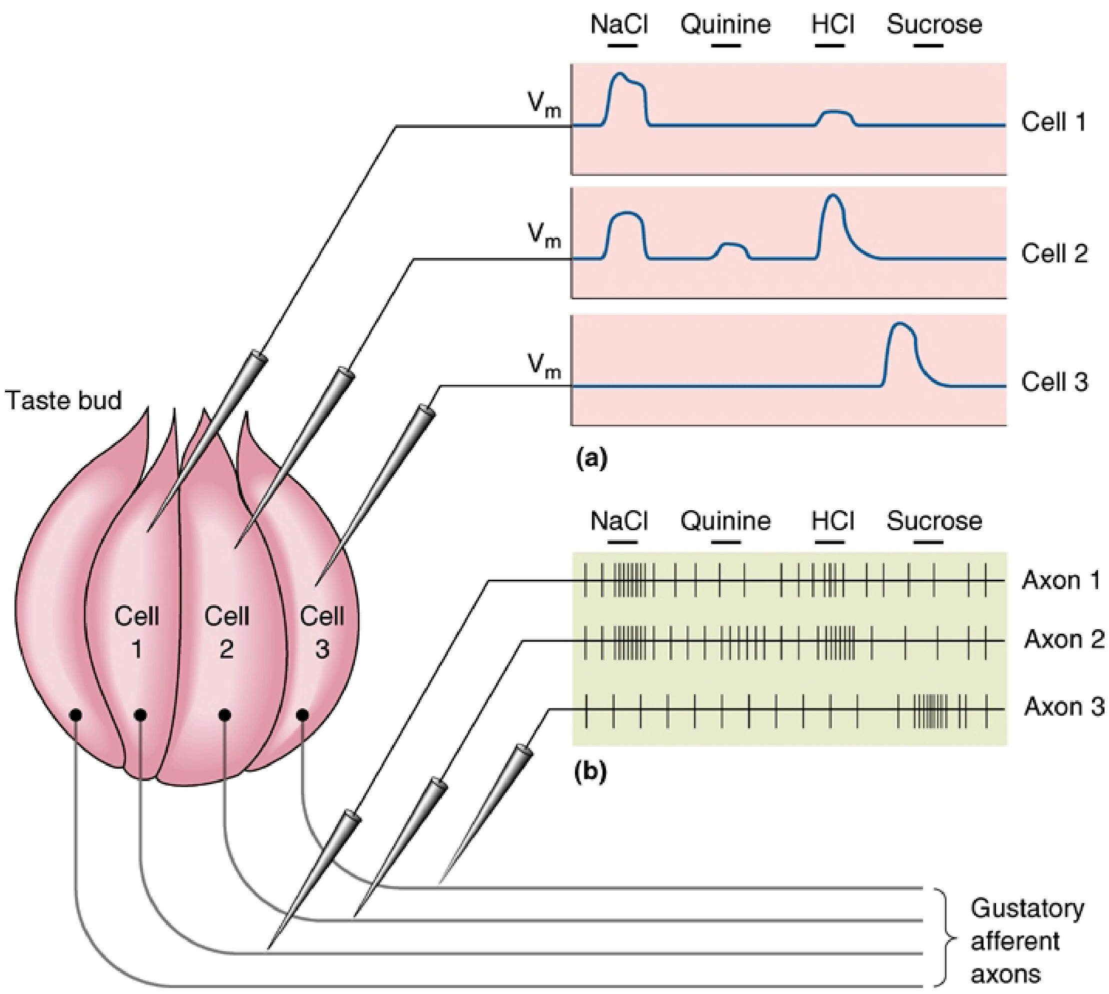
FIGURE 8.2
The tongue, its papillae, and its taste buds. (a) Papillae are the taste-sensitive structures. The largest and most posterior are the vallate papillae. Foliate papillae are elongated. Fungiform papillae are relatively large toward the back of the tongue and much smaller along the sides and tip. (b) A cross-sectional view of a vallate papilla, showing the locations of taste buds. (c) A taste bud is a cluster of taste cells (the receptor cells), gustatory afferent axons and their synapses with taste cells and basal cells. Microvilli at the apical end of the taste cells extend into the taste pore, the site where chemicals dissolved in saliva can interact directly with taste cells.

Taste

- Taste buds
  - More than 10,000 taste buds
  - Taste pore exposed to saliva in mouth
  - 50–150 taste receptors cells per taste bud
    - Respond to tastants, that give food its flavor

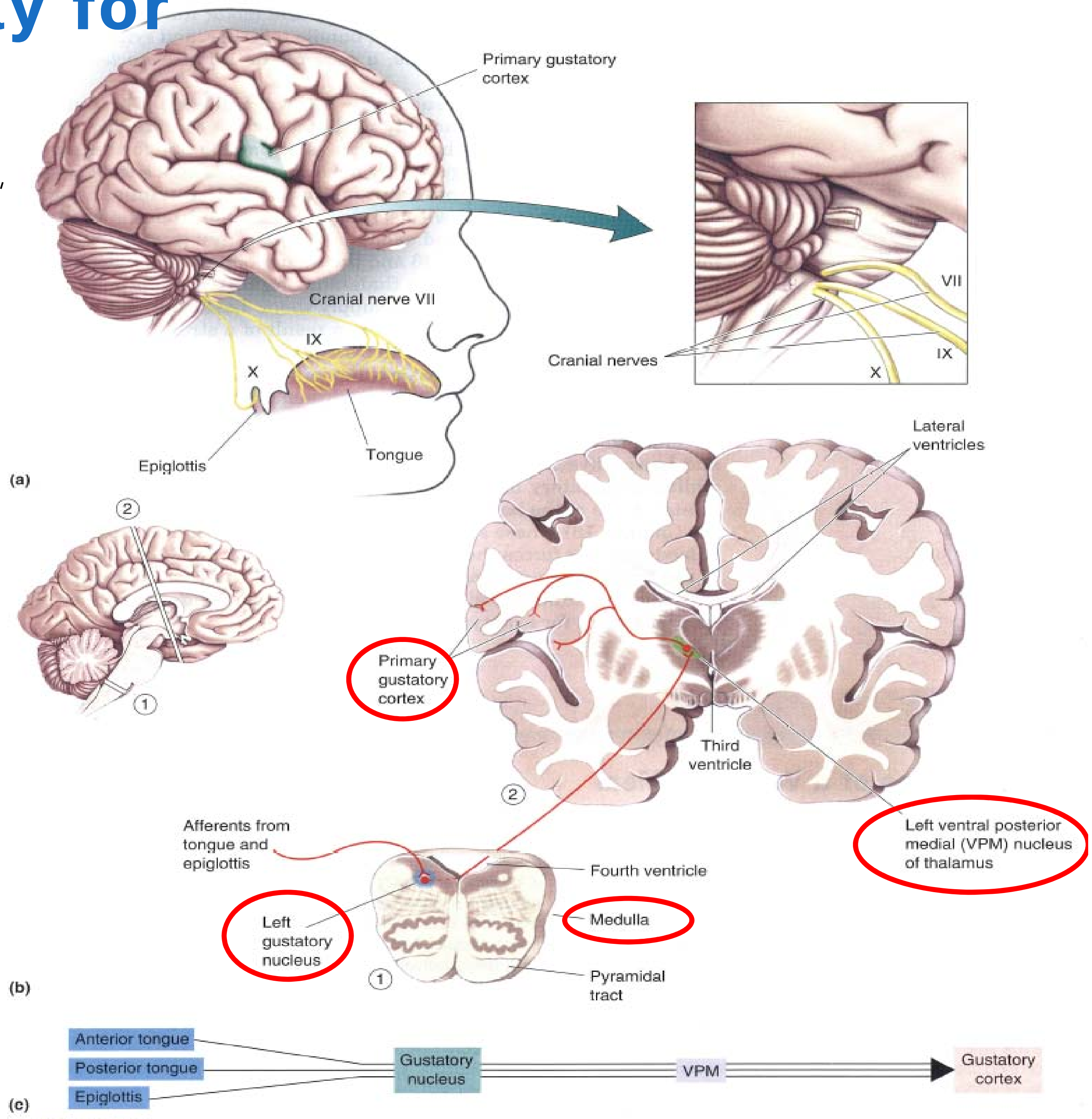
Signal Transduction in Taste

- Four primary tastes
  - Sour: due to H^+,
  - Salty: due to Na^+,
  - Sweet: due to ligands (e.g. sugar)
  - Bitter: due to ligands (e.g. quinine)
- Each taste receptor cell responds to all four primary tastes
  - Receptor cells generally respond to one taste more strongly than the others
- Different types of receptor cells located within a taste bud



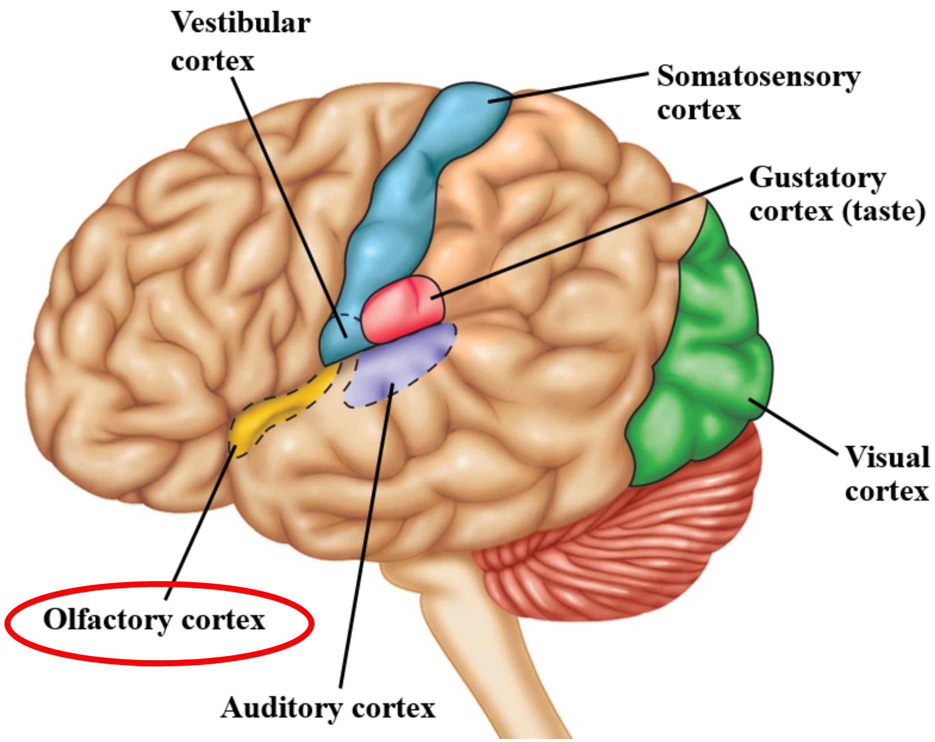
Neural Pathway for Taste

- Sensory neurons = cranial nerves VII, IX, and X
- Terminate in brainstem gustatory nucleus
- To thalamus
- To gustatory cortex in parietal lobe



Sensory Anatomy and Physiology

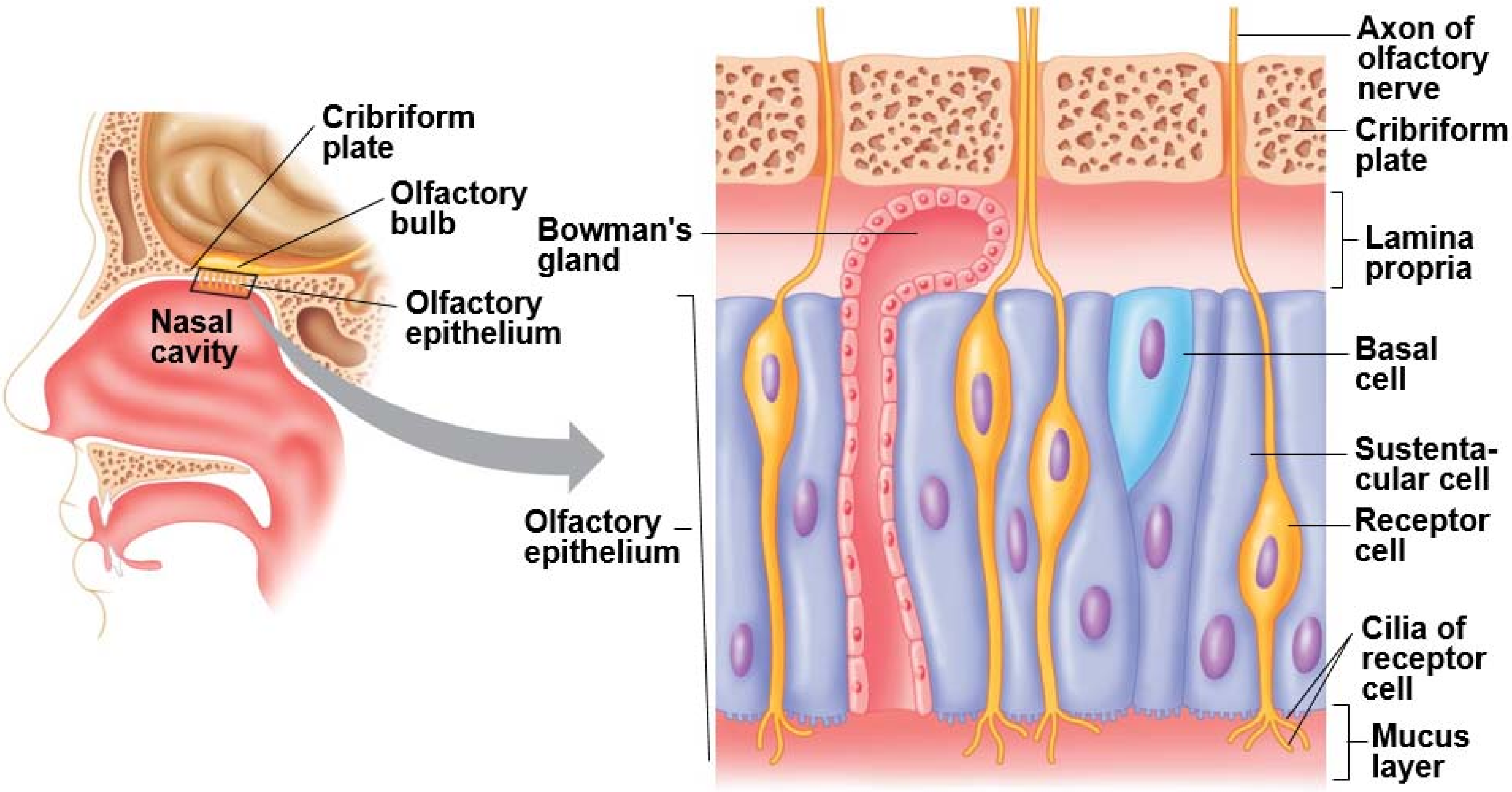
- The Somatosensory System
- Taste
- Olfaction



Olfactory Epithelium

- Olfaction depends on chemicals in air that bind to chemoreceptors in the olfactory epithelium
- Located in nasal cavity
- Three cell types
  - Receptor cells
    - Neurons that respond to odorants
  - Basal cells
    - Precursor cells for new receptor cells
  - Sustentacular
    - Maintain extracellular environment

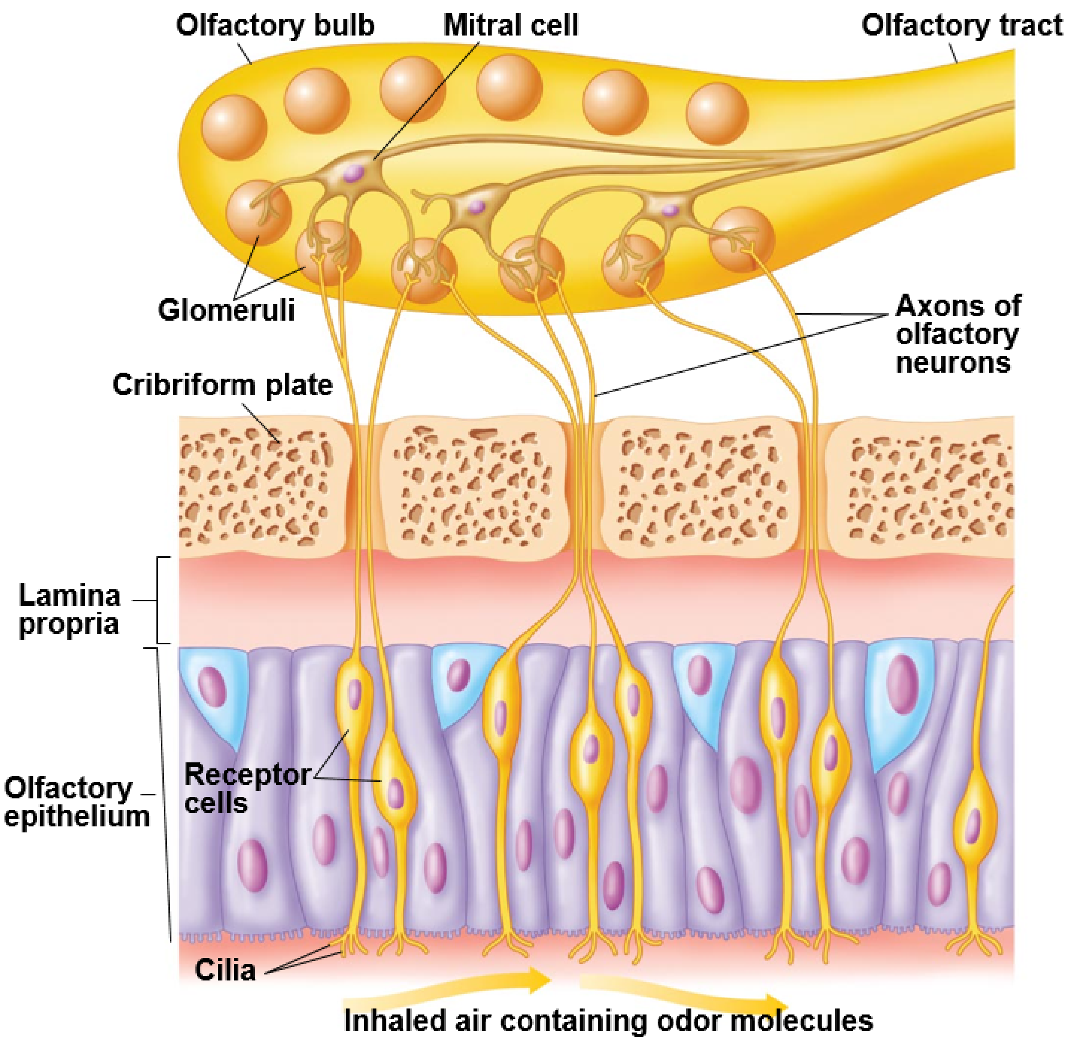
Olfactory Epithelium



Olfactory Receptor Cells

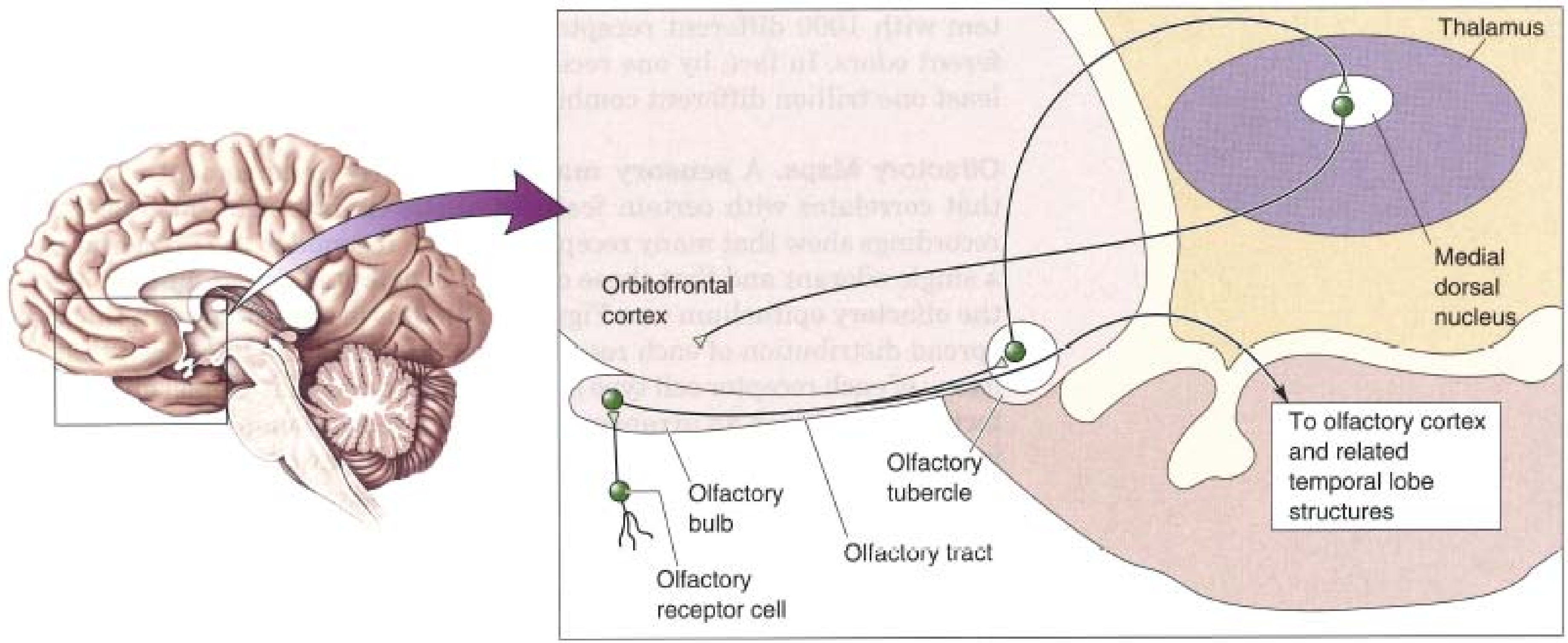
- The neurons that are replaced continuously
- Cilia project into mucus
  - Have chemoreceptors
- Olfactory binding proteins
  - Located in mucus
  - Transport odorants to receptors

Neural Pathway for Olfaction



- Axon of receptor cells comprises cranial nerve I, the olfactory nerve
- Communication between mitral cells and olfactory neuron in glomeruli
- Relay in olfactory tubercle to cerebral cortex

Neural Pathway for Olfaction



▲ FIGURE 8.17

Central olfactory pathways. Axons of the olfactory tract branch and enter many regions of the forebrain, including the olfactory cortex. The neocortex is reached only by a pathway that synapses in the medial dorsal nucleus of the thalamus.