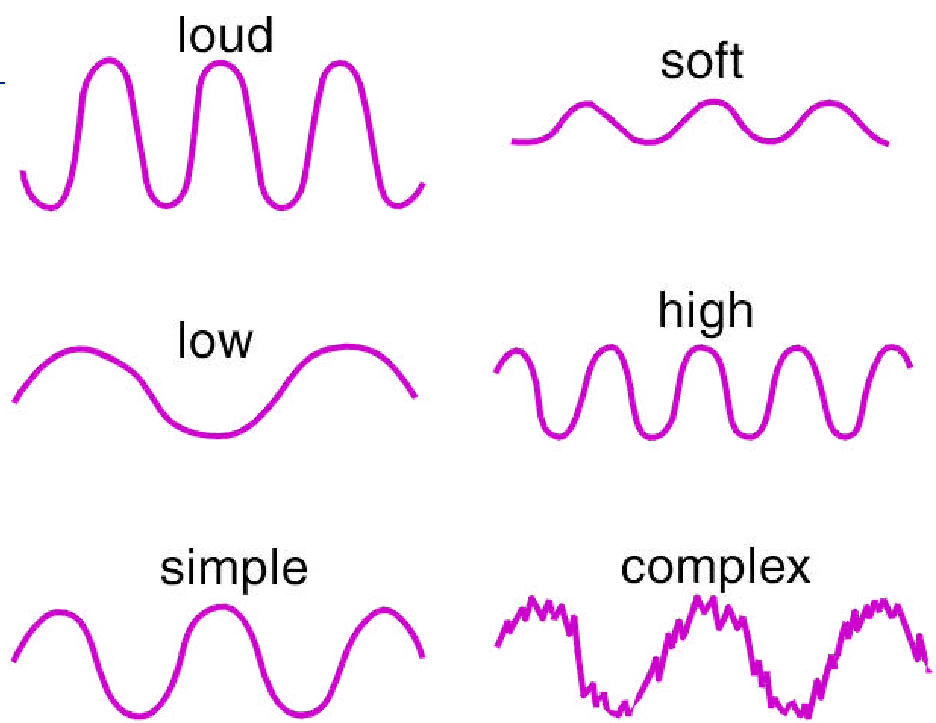
Carlson (7e)

PowerPoint Lecture Outline

Chapter 7: Audition, the Body Senses, and the Chemical Senses

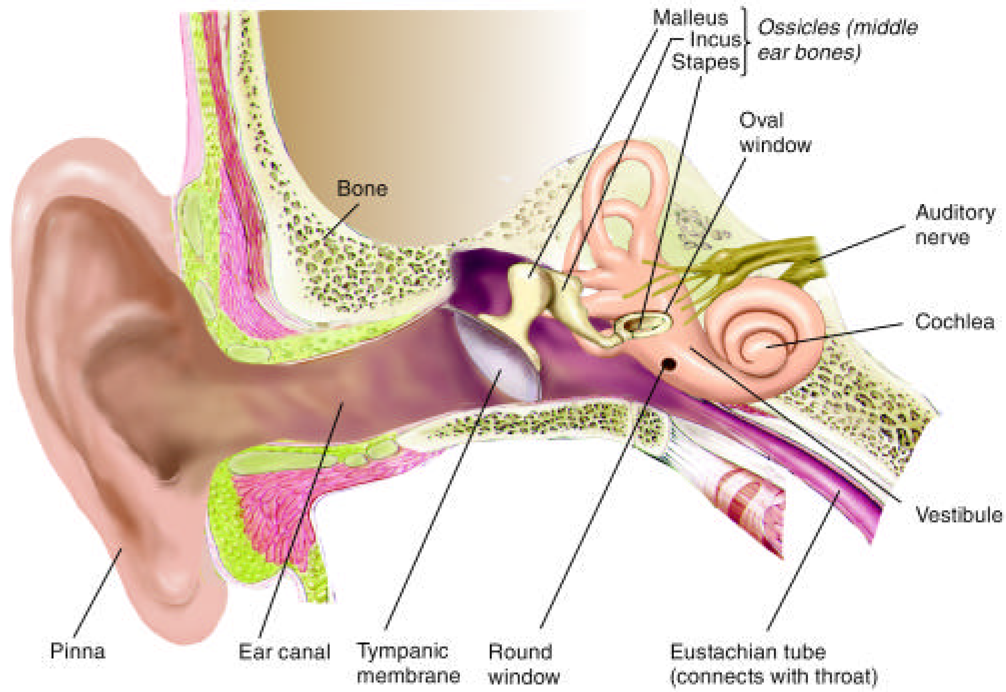
Sound Waves

Physical Dimension	*Perceptual Dimension*
Amplitude (intensity)	Loudness
Frequency	Pitch
Complexity	Timbre



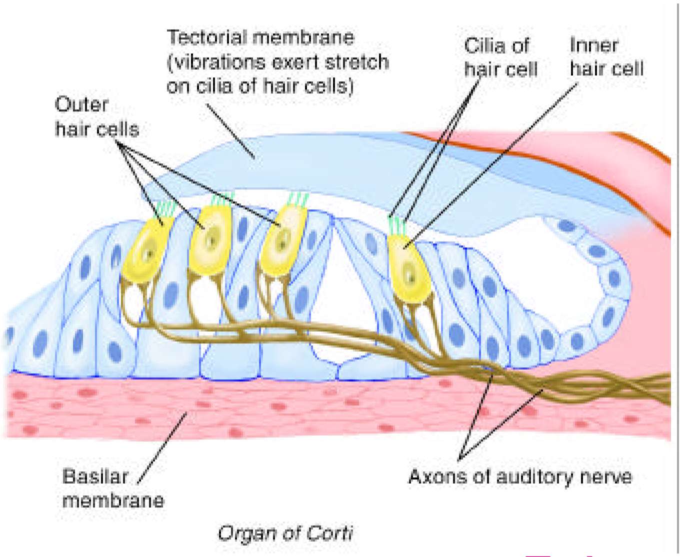
Divisions of the Ear

- Outer ear:
  - Channel to tympanic membrane
- Middle ear:
  - Ossicles
- Inner ear:
  - Cochlea



The Cochlea

- The cochlea is formed from three chambers:
  - Scala vestibuli and scala media are separated by a membrane
  - Scala tympani and scala media are separated by the basilar membrane
- Hair cells within the organ of Corti transduce sound waves into nerve impulses
- The organ of Corti consists of
  - Basilar membrane (forms the base)
  - Tectorial membrane (forms the roof)
  - Hair cells in between



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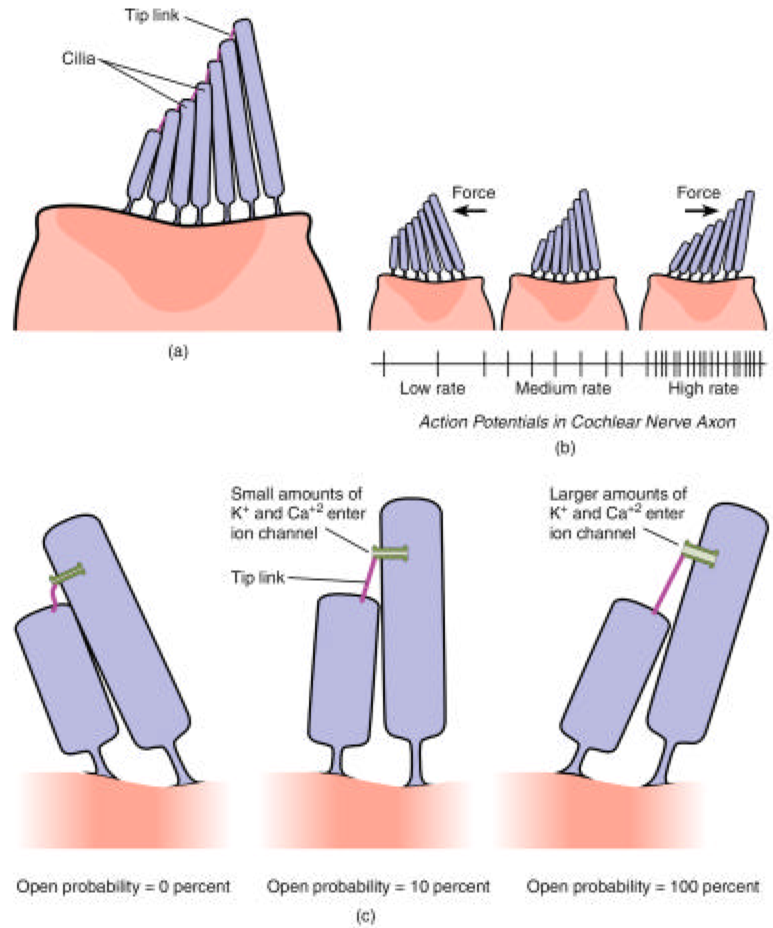
Auditory Hair Cells

- Two types of hair cells are located within the human organ of Corti
  - Inner hair cells (approximately 3500) form a single line of cells along the basilar membrane
    - Destruction of inner hair cells eliminates hearing
  - Outer hair cells (approximately 12,000) are arranged in three rows along the basilar membrane
    - Outer hair cells serve a structural function
  - Cilia project from the top of each hair cell
    - The tectorial membrane is attached to the outer hair cell cilia
    - When sound waves move the basilar and tectorial membranes, the cilia bend in one direction or the other
    - Shear of the cilia generates a receptor potential that releases a neurotransmitter

Auditory Transduction

- Cilia tips are joined by a fiber link
- Cilia movement produces tension of the link which opens an ion channel in the adjacent tip
- Calcium and potassium ions flow into the cilia and produce a depolarization



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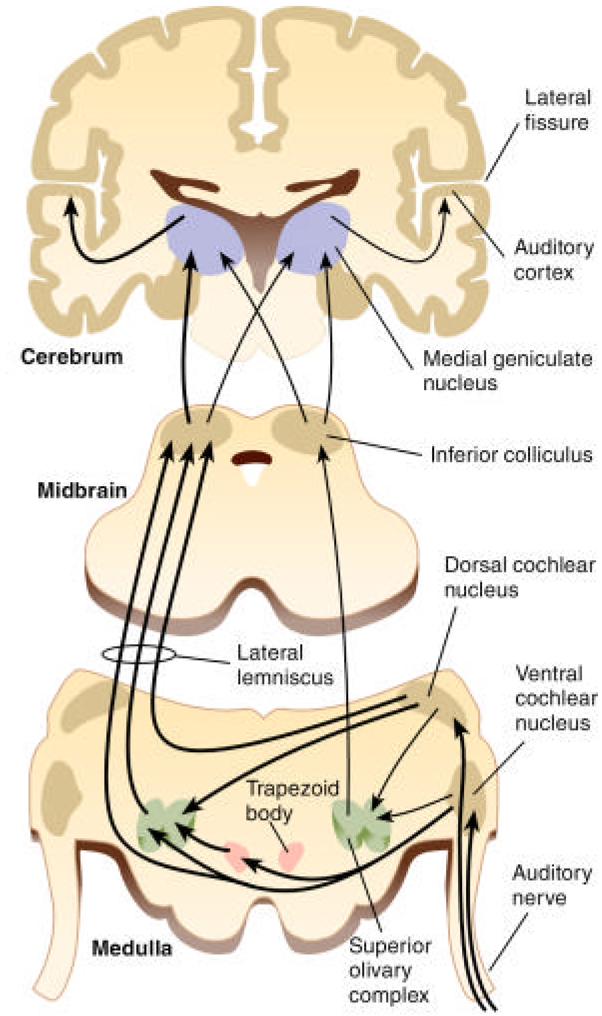
Auditory Pathways

- Afferent pathways:
  - Through cochlear nuclei
    - To superior olivary nuclei
    - To inferior colliculus
    - To medial geniculate
    - To auditory cortex
- Efferent pathway:
  - Olivocochlear bundle

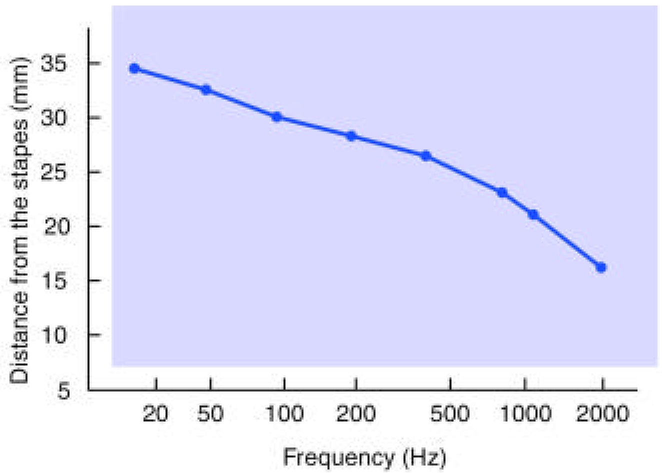


Place Coding of Pitch

- Different frequencies produce maximal distortion of basilar membrane
  - Sound vibration produces a traveling wave
    - High frequency: near base of basilar membrane
    - Moderate frequency: near apex of basilar membrane
  - Different regions of the basilar membrane project to different areas of auditory cortex
  - Throughout the auditory system there is a tonotopic representation in which adjacent neurons receive signals from adjacent areas of the basilar membrane
- Place coding can account for medium to high sound frequencies, low frequency sounds are coded by rate of firing

Support for Place Theory

- Observations of traveling waves by von Bekesy
  - Different frequencies produce maximal displacement at different points along the basilar membrane
- Antibiotics
  - Induce hair cell loss first at base of basilar membrane, which produces a loss of hearing for high frequency sounds
- Cochlear implants restore speech perception by stimulating different regions of the basilar membrane



Analysis of the Auditory System

- The various components of the auditory system detect sounds, determine sound location, and recognize sound identity
- Lesions placed at different levels of the auditory system:
  - Bilateral auditory cortex: animal can detect pitch, intensity diff, but not “tunes”
  - Brachium of inf. colliculus: animal cannot detect frequency or intensity differences
  - Lateral lemniscus: animal is deaf

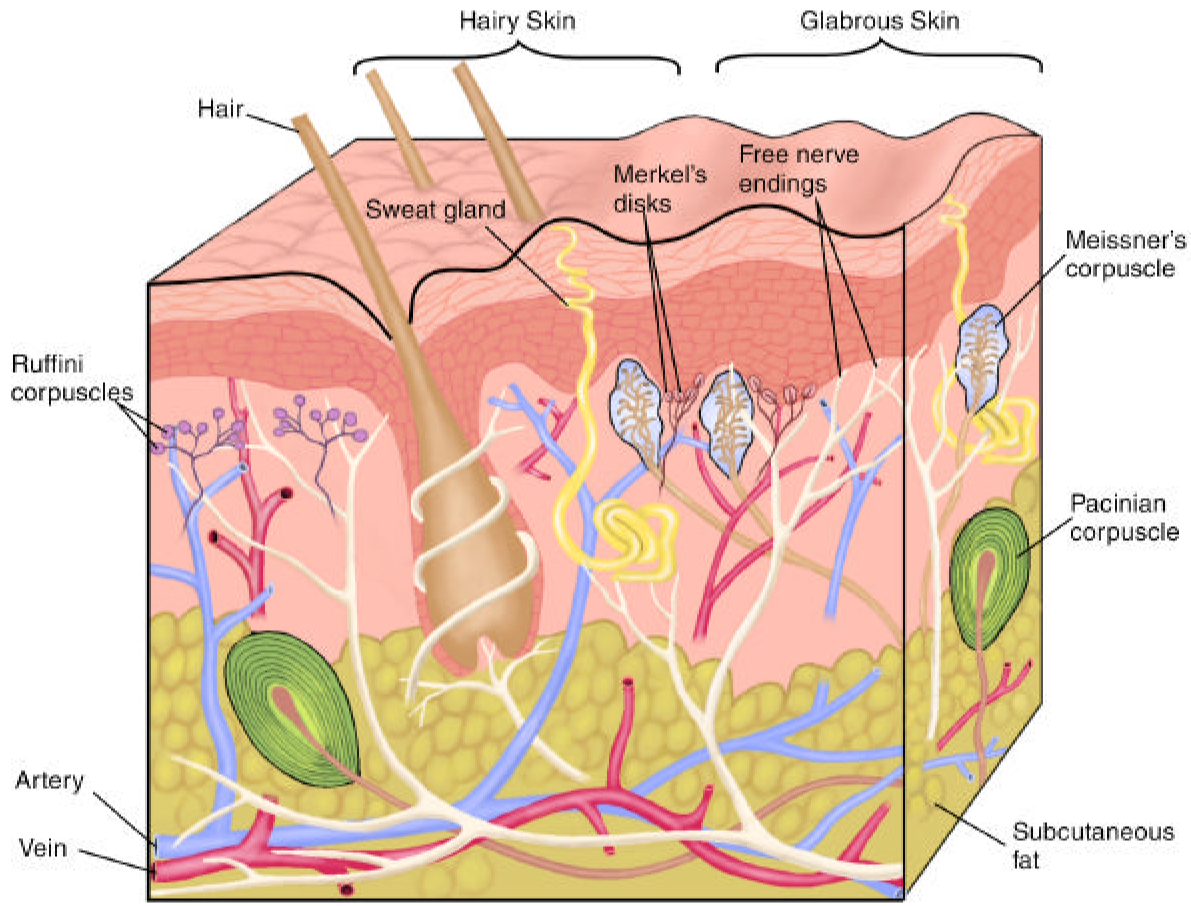
Somatosenses

- The somatosenses provide information relating to events on the skin and to events occurring within the body
  - The cutaneous senses receive various signals from the skin that form the sense of touch
    - Pressure
    - Vibration
    - Heating/cooling
    - Stimuli that damage tissue (and produce pain)
  - Kinesthesia provides information about the body position and movement
    - Kinesthetic signals arise from receptors located within the joints, tendons, and muscles

Morphology of Skin

Epidermis

Dermis



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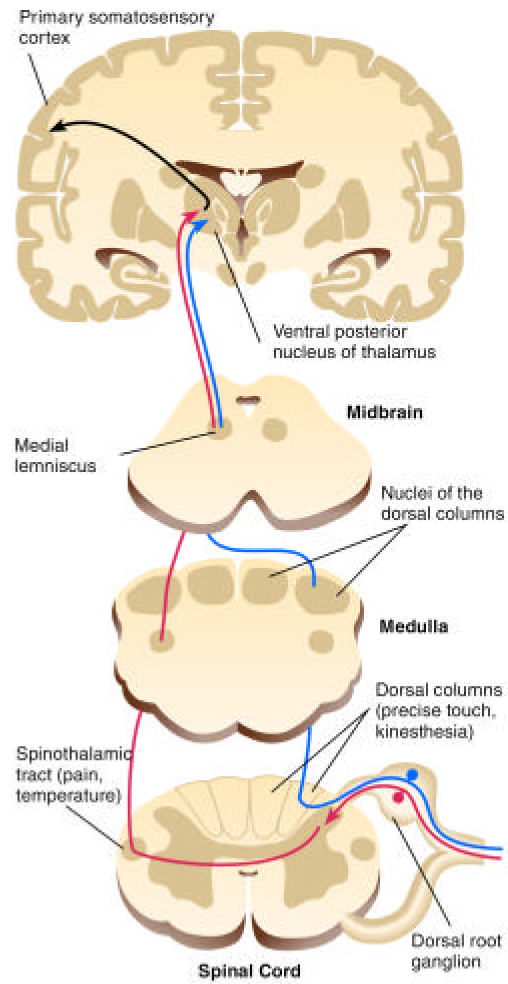
Cutaneous Senses

- Three different sensations are reported to the brain by receptors localized within skin
  - Touch involves perception of pressure and vibration of an object on the skin
    - Pacinian corpuscles detect deformation of the skin
  - Temperature is detected by warmth and cold receptors
    - Receptor activation is relative to the baseline temperature
    - The receptors lie at different levels of the skin (cold are close to the surface of the skin)
  - Pain is associated with skin tissue damage

Somatosensory Pathways

- The dorsal columns carry information related to touch (precisely localized)
- The spinothalamic tract carries pain and temperature signals (poorly localized)
- Somatosensory cortex is organized into columns
  - There may be 5-10 cortical maps of the body surface



Pain

- Pain serves a functional role for survival
  - Persons lacking pain receptors are at great risk
- Pain stimuli induce species-typical escape and withdrawal responses
  - Pain is a motivational force that can activate behavior
- Pain involves tissue destruction induced by
    - Thermal stimuli
    - Mechanical force
- Pain reception is poorly localized (as is temperature)
- Pain involves an emotional component (that can be used to modify the magnitude of pain perception)

Pain Receptors

- Receptors for pain (nociceptors)
  - Free nerve endings networks within the skin that respond to intense pressure
  - Free nerve endings that respond to heat, acids, and capsaicin (the active ingredient in chili peppers)
  - Receptors that are sensitive to ATP
- Pain receptors are found in:
  - Skin
  - Sheath around muscles, internal organs
  - Cornea of the eye
  - Pulp of the teeth
- Pain receptors are activated by mechanical, chemical stimulation

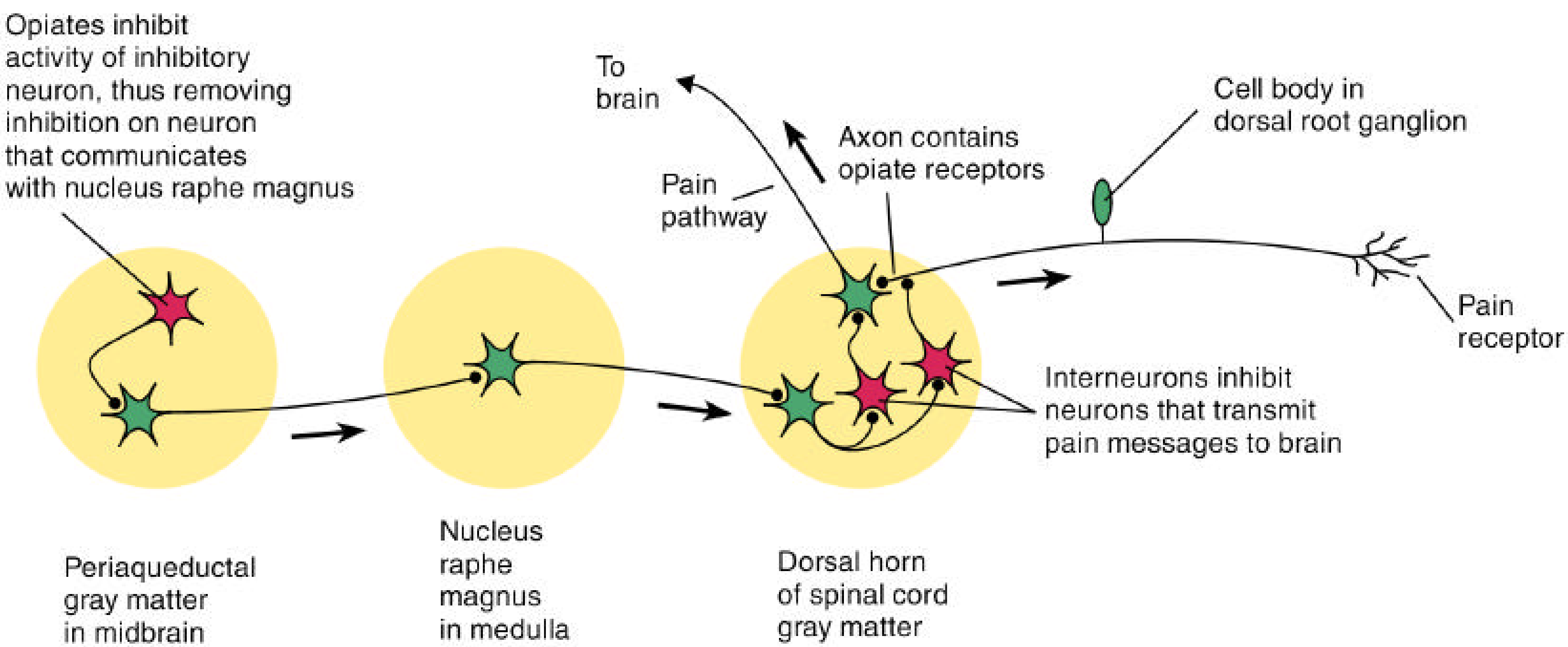
Analgesia

- Analgesia refers to the reduction of the perception of pain
- Analgesia can be induced by external and internal stimuli
  - Hypnosis
  - Massage
  - Acupuncture
  - Opiates
  - Placebo
  - Attention shifts
- Pain stimuli activate primary somatosensory cortex and the anterior cingulate cortex
  - The anterior cingulate cortex is involved in the aversiveness of pain (hypnosis and PET scanner study)

Opiates and Pain

- Exogenous opiates reduce pain reactivity
- Brain produces several endorphins
- Naloxone reverses opiate activity
  - Naloxone reversibility is taken as an indication of opiate involvement
- Focal brain stimulation can reduce pain
    - PAG in particular is effective
    - Brain stimulation activates a descending pathway that modulates pain (Basbaum and Fields model)

Opiate-Induced Analgesia Circuit



Gustation

- Gustation is related to eating foods and drinking liquids
  - Molecules within the food dissolve in saliva and activate one of four receptor types
  - Each receptor type provides information about a food
    - Sweet: safe foods
    - Salty: source of sodium ions
    - Bitter: poisonous foods
    - Sour: spoiled foods
- Flavor involves a mixture of taste and olfaction

Transduction of Taste

- Taste molecules bind with a receptor, alter membrane potential, and induce receptor potentials
  - Saltiness: best stimulus is sodium chloride
    - Receptor for saltiness may be a simple sodium channel
  - Sourness receptors respond to hydrogen ions present in acid solutions
  - Bitterness: typical stimulus is an alkaloid (e.g. quinine)
    - Receptors involve a hydrophobic residue
  - Sweetness: typical stimulus is a sugar
    - Receptors have a hydrogen ion site

Gustatory Processing

- Gustatory information is transmitted through cranial nerves 7 (anterior tongue), 9 (posterior tongue), and 10 (palate and epiglottis)
  - First relay station for taste information is the nucleus of the solitary tract (medulla)
  - Taste information is then transmitted to primary gustatory cortex, to the amygdala, and to the hypothalamus
- Recordings from chorda tympani (7^{th} cranial nerve) indicate that taste fibers respond to more than one taste quality and to temperature
  - In cortex, the major groups of taste-sensitive neurons were salty and sweet