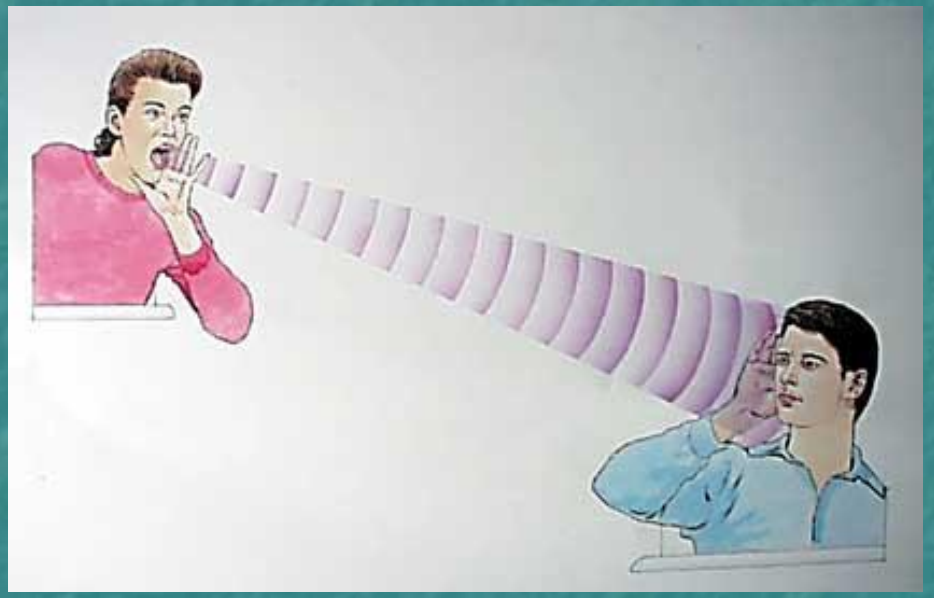
SENSE ORGANS

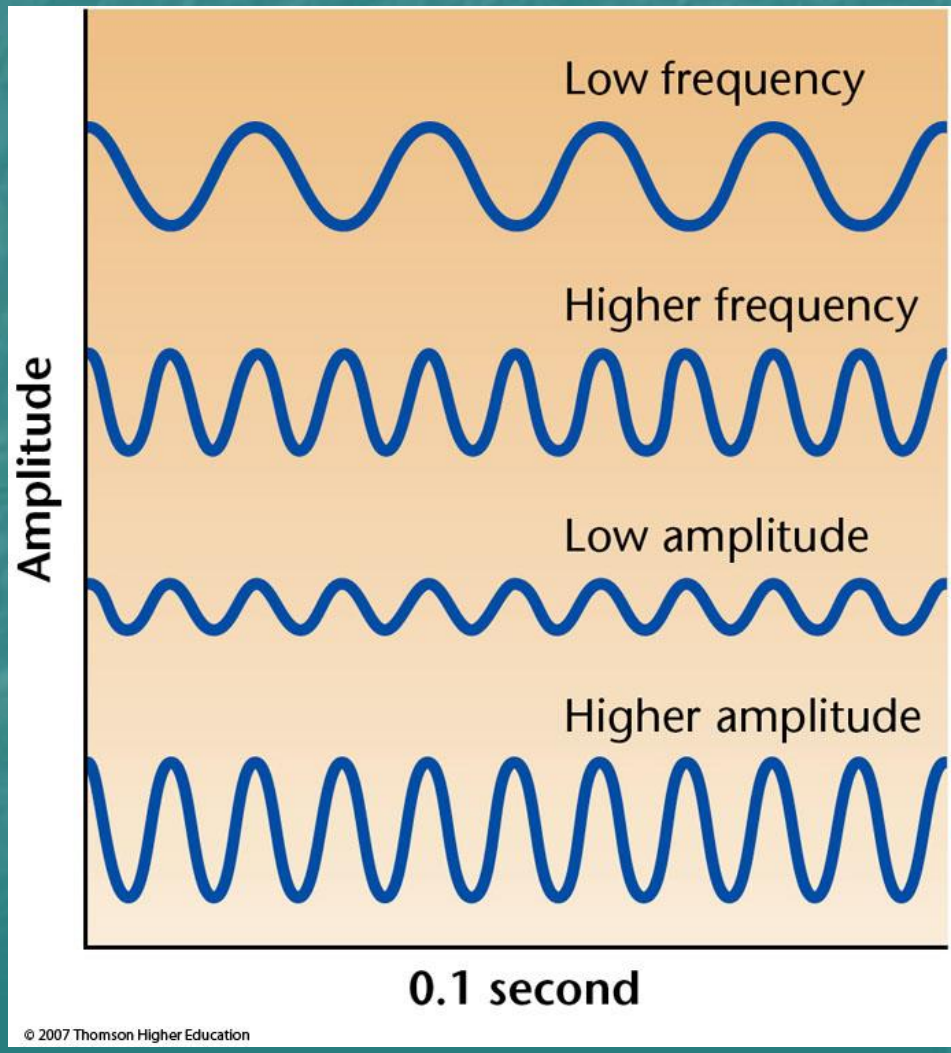
The Sense of Hearing

- Physical stimulus: sound waves
- Sound waves are periodic compressions of air, water or other media.
- Sound waves are "transduced" into action potentials sent to the brain.



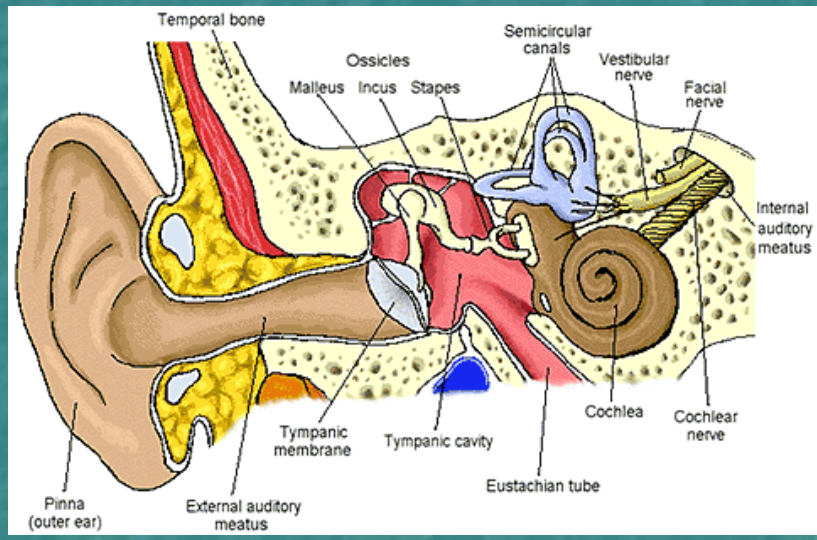
Audition

- Amplitude refers to the height and subsequent intensity of the sound wave.
- Loudness refers to the perception of the sound wave.
  - Amplitude is one factor.
- Frequency refers to the number of compressions per second and is measured in hertz.
  - Related to the pitch (high to low) of a sound.

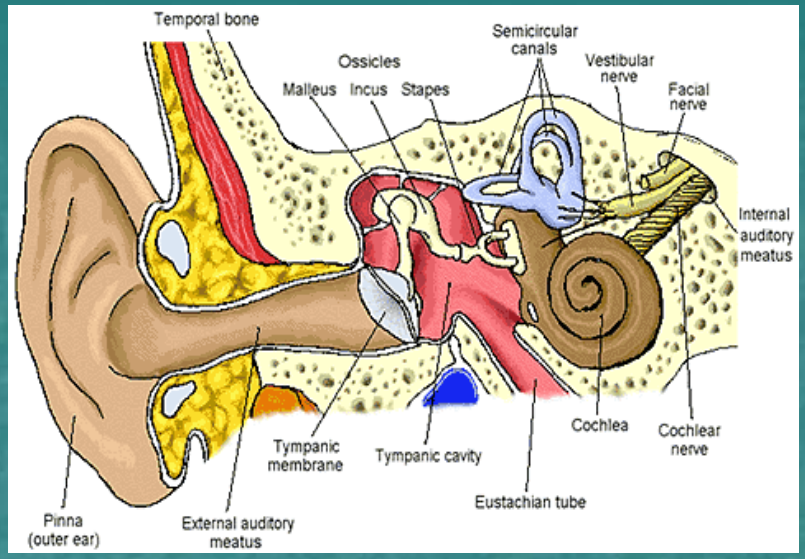


Anatomy of the Ear

- The ear is divided into 3 parts:
  - Outer ear
  - Middle ear
  - Inner ear
- The outer ear includes:
  - pinna (pl: pinnae) (A):
    - focus sound waves into middle ear
    - help locate the source of a sound
  - external auditory canal (B):
    - pathway to middle ear
- The middle ear includes:
  - Tympanic membrane (C) (eardrum)
    - vibrates when struck by sound waves
  - 3 middle ear bones transmit information to the inner ear:
    - malleus (D)
    - incus (E)
    - stapes (F)

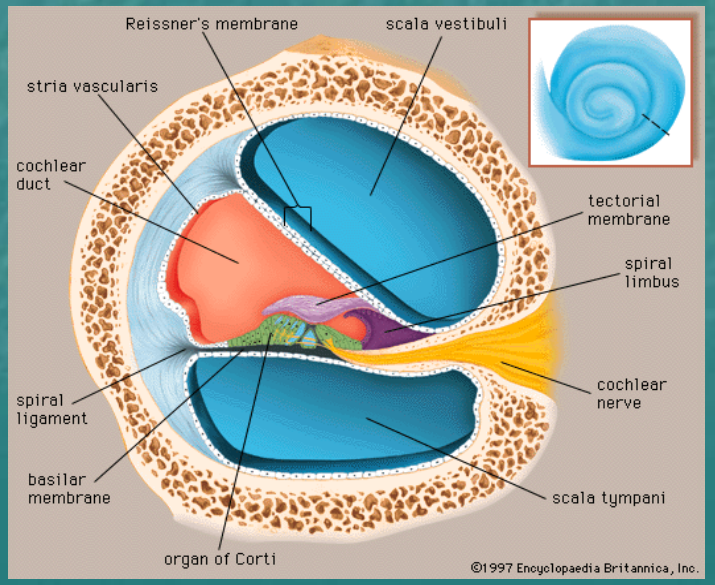


- The inner ear includes:
  - Oval window (G): a second membrane, like the eardrum
  - Semicircular canals (H): part of the vestibular system, involved in balance and equilibrium



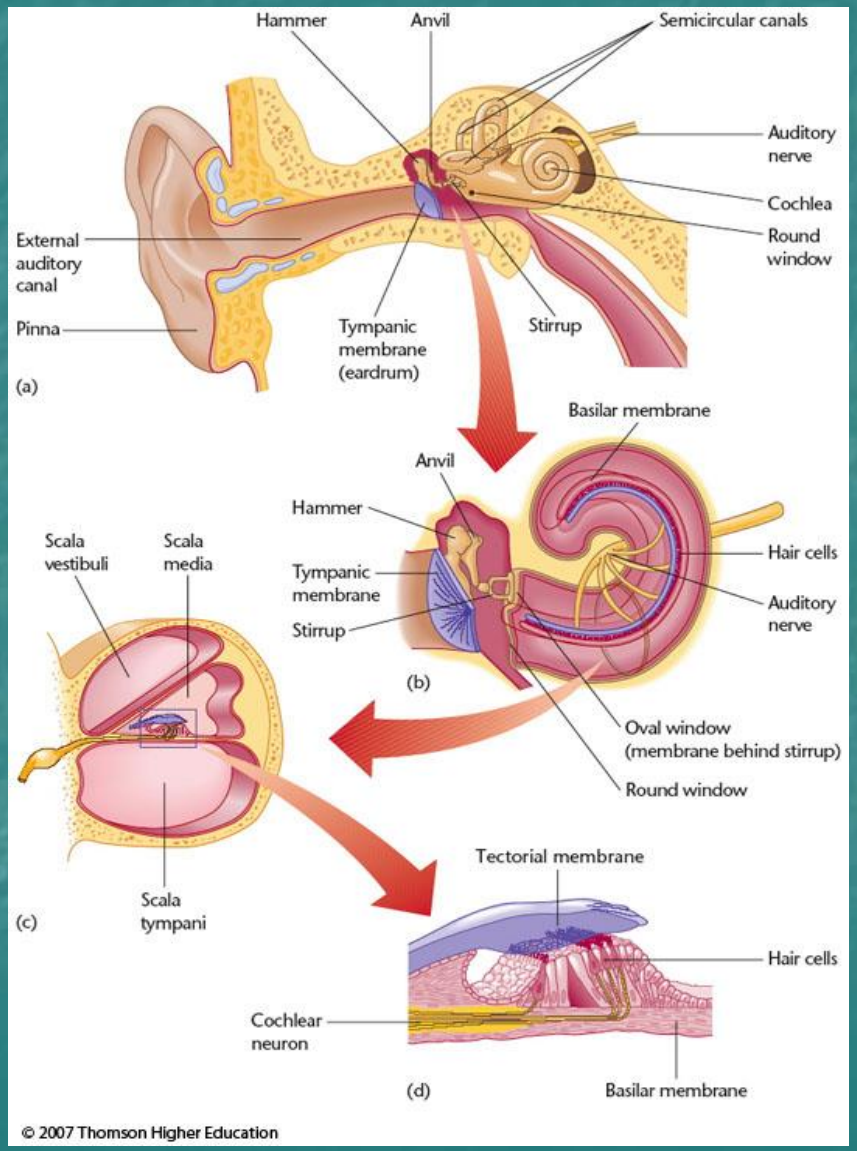
- Cochlea (I): a snail shaped structure containing
  - three fluid-filled tunnels
  - auditory receptors (hair cells)

- Organ of Corti (K)
  - Hair cells and two surrounding membranes in the cochlea



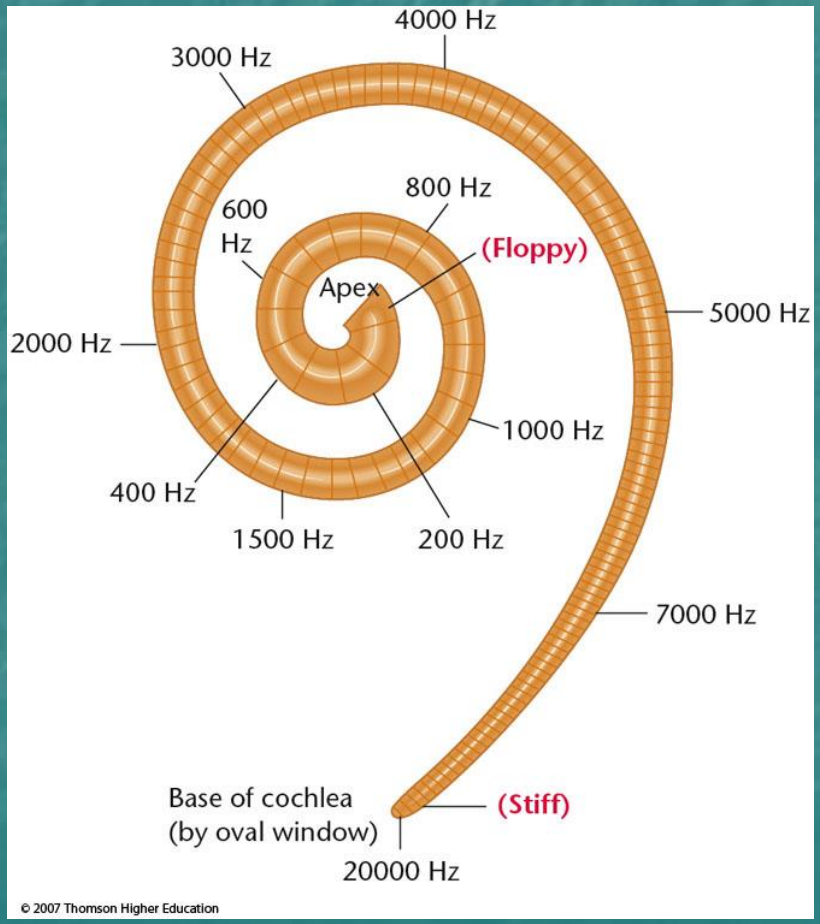
Audition

- Auditory nerve (M)
  - exits the inner ear and carries information about sound to the auditory cortex



Theories of Pitch Perception

- Frequency theory - the basilar membrane vibrates in synchrony with the sound and causes auditory nerve axons to produce action potentials at the same frequency.
- Place theory - each area along the basilar membrane is tuned to a specific frequency of sound wave.



Audition

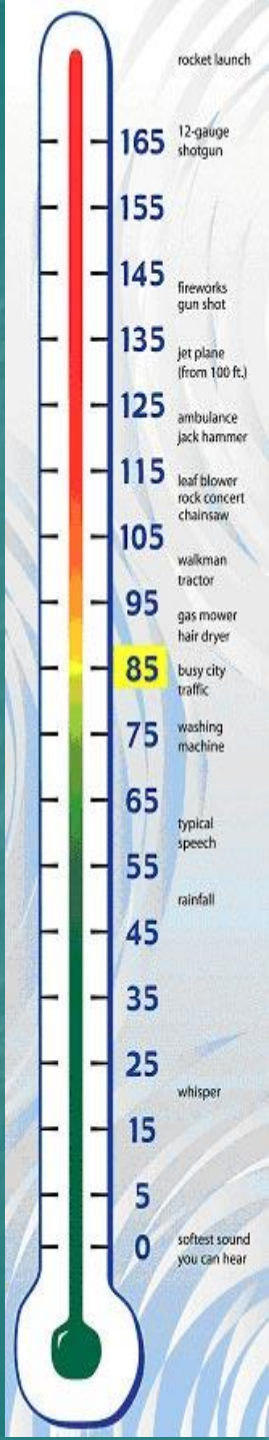
- Primary auditory cortex located in the superior temporal cortex
- Each hemisphere receives most of its information from the opposite ear.
- The primary auditory cortex provides a tonotopic map
  - cells are responsive to preferred tones
- Damage can lead to deficits processing auditory info:
  - loss of ability to identify a song or voice
- It does not result in a loss of hearing

Hearing Loss

- About 99% of hearing impaired people have at least some response to loud noises.
- Two categories of hearing impairment include:
  1. Conductive or middle ear deafness
  2. Nerve deafness

Sounds that cause hearing loss

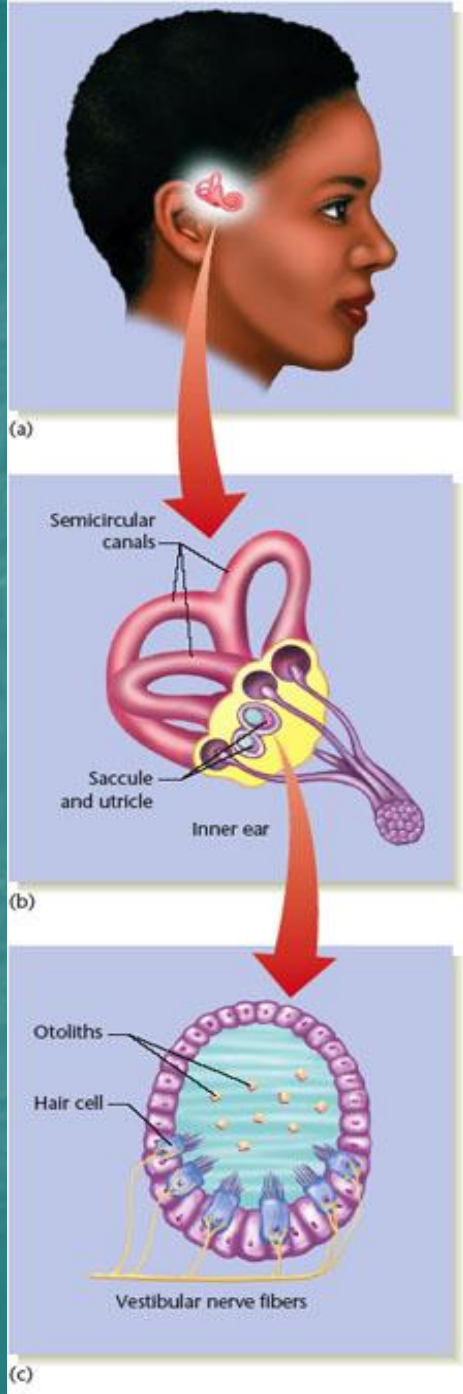
- Heavy city traffic = 90 decibels
- Car horn = 110 decibels
- Headphones = 120 decibels (common volume)
- Jackhammer = 130 decibels
- Rock band at close range = 140 decibels
- Rocket launching = 180 decibels



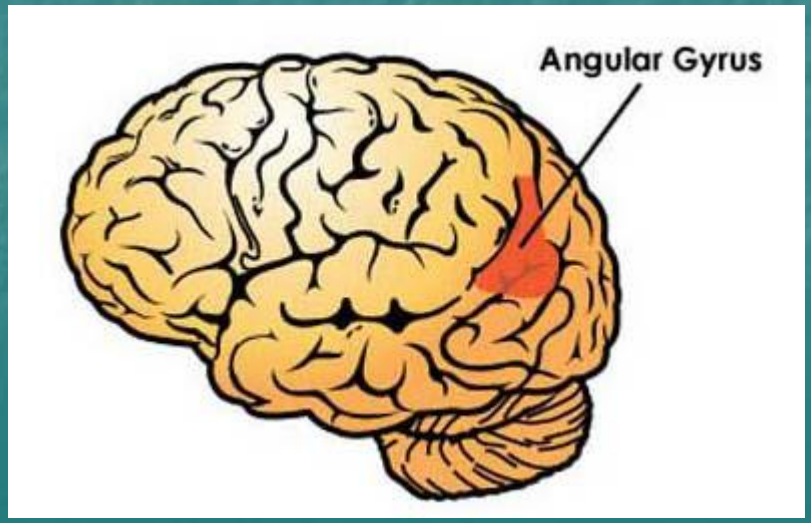
The Mechanical Senses

- Mechanical senses respond to pressure, bending, or other distortions of a receptor.
- Mechanical senses include:
  - Vestibular sensation (balance)
  - Touch
  - Pain
  - Other body sensations

- The vestibular sense refers to the system that detects the position and the movement of the head.
  - Directs compensatory movements of the eye and helps to maintain balance.
- Vestibular organ: in inner ear, adjacent to cochlea, consists of:
  - two otolith organs
    - calcium carbonate particles (otoliths) activate hair cells when head tilts
  - three semicircular canals
    - oriented in three different planes
    - filled with jellylike substance that activates hair cells when the head moves

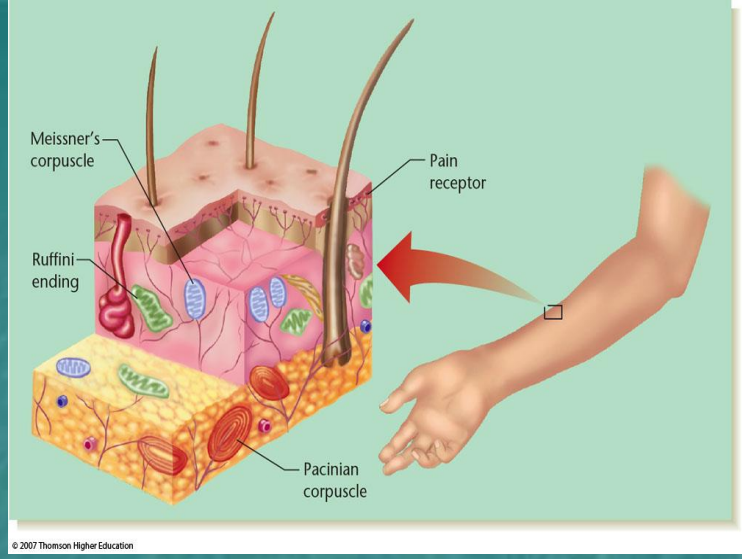


- Part of the brain which helps process information about our vestibular sense
  - Angular gyrus
    - integrates balance and movement info with other sensations
    - Located at border between parietal and temporal cortex



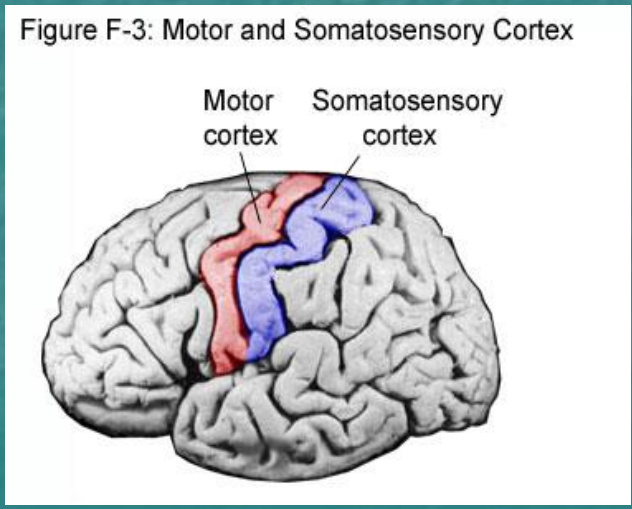
- Somatosensory system refers to sensation of the body and its movements and includes:
  - discriminative touch
  - deep pressure
  - cold
  - warmth
  - pain
  - itch
  - tickle
  - position and movement of joints

- Touch receptors can be:
  - simple bare neurons
  - elaborated neuron ending
  - bare ending surrounded by non-neural cells that modify its function



Part of the brain which helps process information about touch:

- Somatosensory cortex of parietal lobe
- Info from touch receptors in head enters CNS through cranial nerves
- Info from receptors below head enters spinal cord and travels through spinal nerves to brain



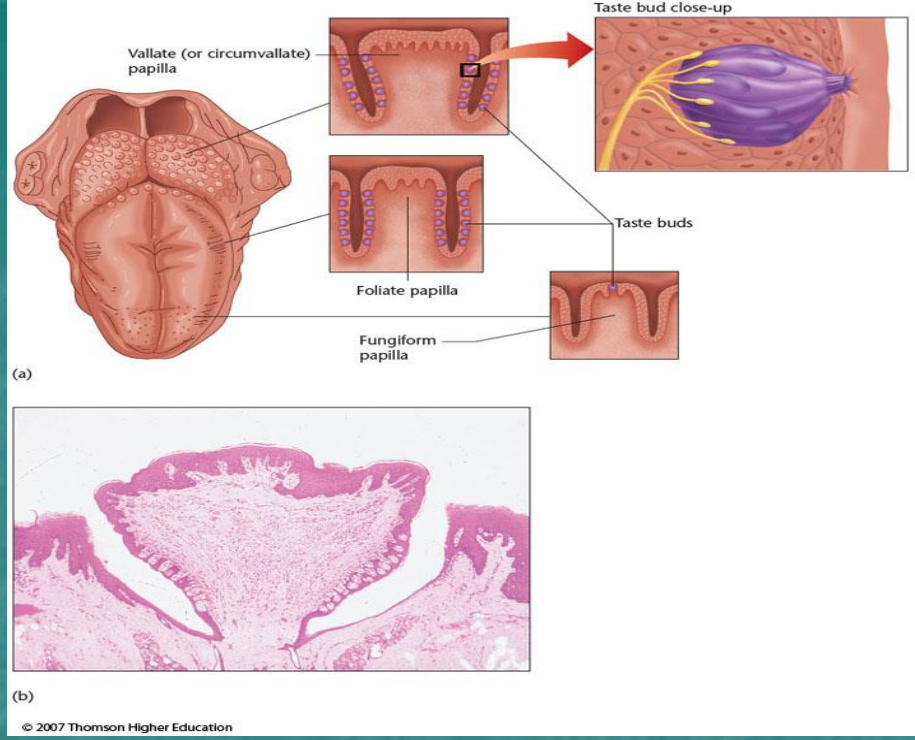
PAIN

- Pain depends on many axon types, neurotransmitters, and brain areas.
- Mild pain triggers the release of glutamate.
- Strong pain triggers the release of glutamate and substance P.
  - Substance P results in the increased intensity of pain.
  - Morphine and opiates block pain by blocking these neurotransmitters.

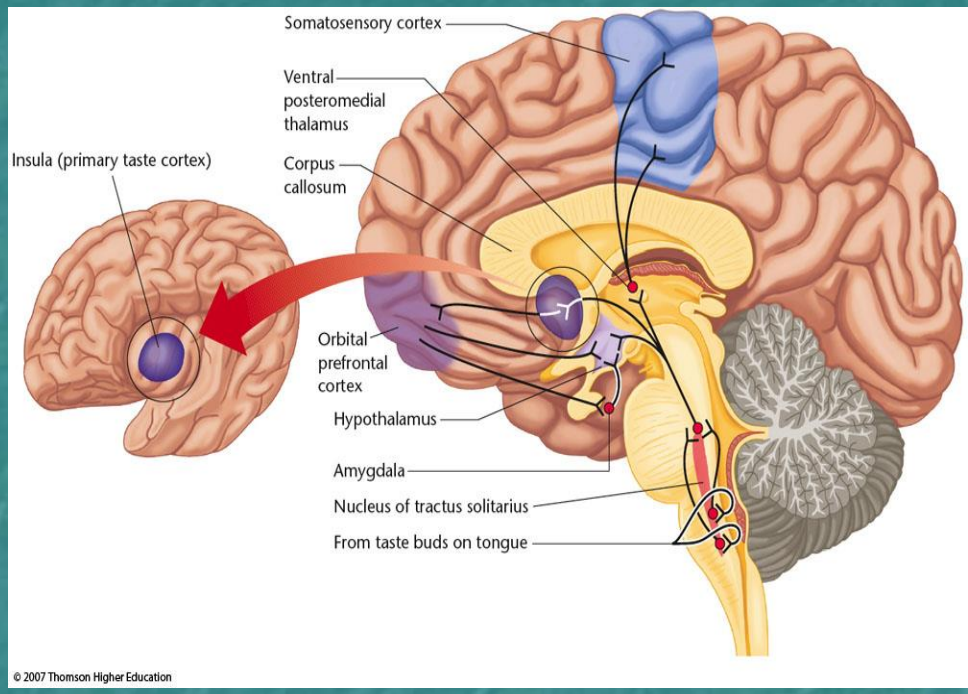
The Chemical Senses: Taste

- Taste refers to the stimulation of taste buds by chemicals.
- Our perception of flavor is the combination of both taste and smell.
  - Taste and smell axons converge in the endopiriform cortex.
- Taste receptors:
  - modified skin cells
  - excitable membranes release neurotransmitters and excite neighboring neurons
  - replaced every 10 to 14 days

- Papilla(e): structure(s) on surface of tongue that contain up to 10 taste buds
- Each taste bud contains approx. 50 receptors
- Most taste buds are located along the outside of the tongue in humans.
- Western societies have traditionally described sweet, sour, salty and bitter tastes as the "primary" tastes and four types of receptors.
- Evidence suggests a fifth type of glutamate receptor.

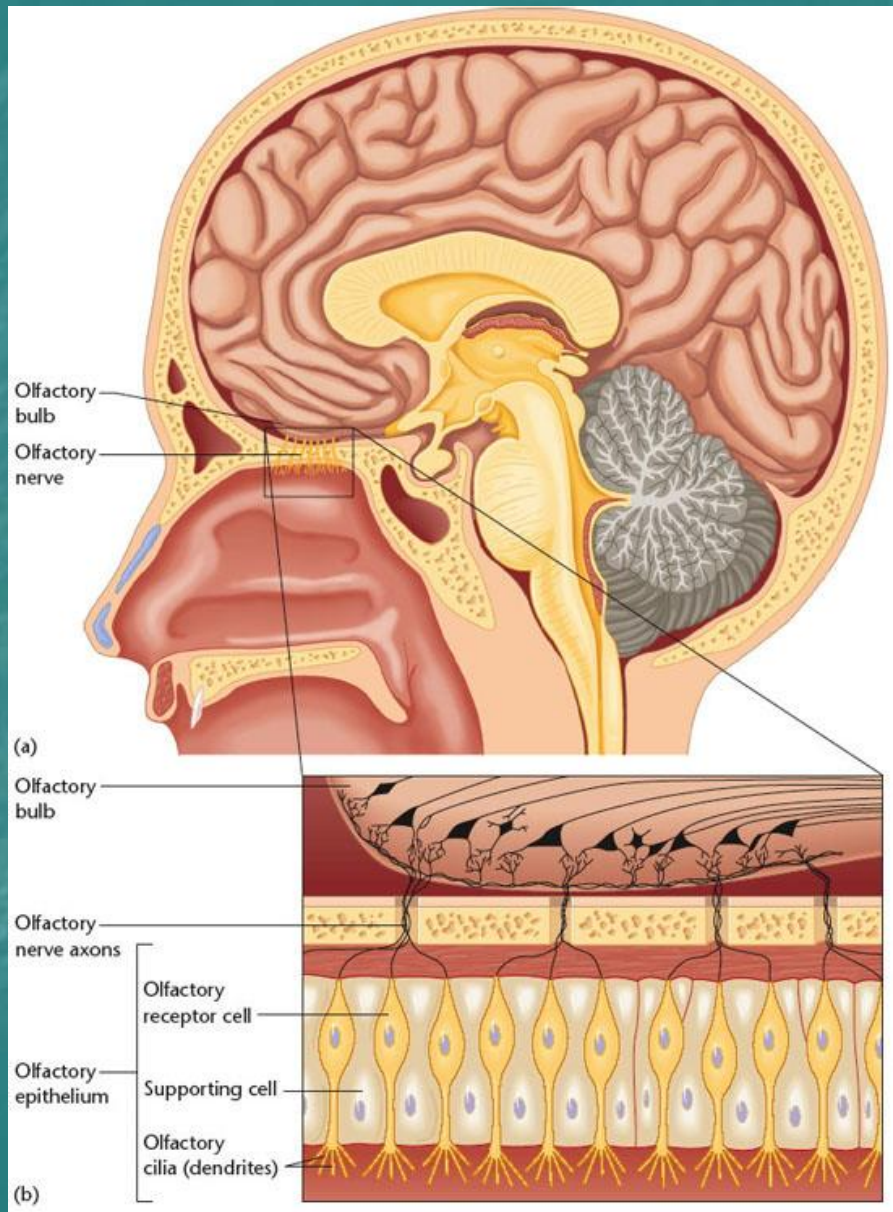


- Various areas of the brain are responsible for processing different taste information.
  - Somatosensory cortex responds to the touch aspect of taste
  - The insula is the primary taste cortex.



The Chemical Senses: Smell

- **Olfaction:** detection and recognition of chemicals that contact membranes inside the nose
- **Olfactory cells:** receptor cells for smell
- **Olfactory epithelium:**
  - membrane in rear of nasal passage
  - Contains olfactory cells



- Which part of the brain helps process information about smell?
  - Axons from olfactory receptors carry information to the olfactory bulb in the brain.
  - The olfactory bulb sends axons to many areas of the cerebral cortex.
  - Coding in the brain is determined by which part of the olfactory bulb is excited.

Vomeronasal organ

- Vomeronasal organ (VNO): set of receptors located near the olfactory receptors that are sensitive to pheromones
- Pheromones: chemicals released by an animal to affect the behavior of others of the same species
  - The VNO and pheromones are important for most mammals, but less so for humans
  - It is tiny in human adults and has no receptors.
  - Humans unconsciously respond to some pheromones through receptors in the olfactory mucosa.
    - Example: synchronization of menstrual cycles

Integration of the Senses

- Synesthesia is the experience of one sense in response to stimulation of a different sense.
  - Suggests some axons from one area have branches to other cortical regions.