The Special Senses

Hearing and Equilibrium

The Ear

- The organ of hearing and equilibrium
  - Cranial nerve VIII - Vestibulocochlear
  - Regions
    - External ear
    - Middle ear
    - Internal ear (labyrinth)

External Ear

- Two parts
  - Pinna or auricle (external structures)
  - External auditory meatus (ear canal)
    - Site of cerumen (earwax) production
    - Waterproofing, protection
  - Separated from the middle ear by the tympanic membrane (ear drum)
    - Vibrates in response to sound waves

Middle Ear

- Tympanic cavity
  - Air-filled chamber
    - Openings
      - Tympanic membrane – covers opening to outer ear
      - Round and oval windows – openings to inner ear
      - Epitympanic recess – dead-end cavity into temporal bone of unknown function
    - Auditory tube
      - AKA Eustachian tube or pharyngotympanic tube
Middle Ear

- Auditory tube (Eustachian tube)
  - Connects the middle ear to the nasopharynx
  - Equalizes pressure
    - Opens during swallowing and yawning

- Otitis Media

Middle Ear

- Contains auditory ossicles (bones)
  - Malleus
  - Incus
  - Stapes
- Middle ear is air-filled; inner ear is fluid-filled
- Sound is mostly reflected from a liquid medium

- Sound waves cause tympanic membrane to vibrate
- Ossicles help transmit vibrations into the inner ear
  - Reduce the area where force is applied
  - Increases the pressure of the force enough to transfer most of the energy into the liquid
  - Reflexive muscle action restricts the movement of the bones during loud noises

Inner Ear

- Contains functional organs for hearing & equilibrium
  - Bony labyrinth - filled with perilymph
  - Membranous labyrinth – functional component
  - Filled with endolymph
  - Location of various inner ear receptors
Inner ear - Labyrinth

- Labyrinth is modified to form 3 distinct regions
  - Vestibule
    - Gravity
    - Head position
    - Linear acceleration and deceleration (changes in speed)
  - Semicircular canals
    - Angular acceleration and deceleration (changes in direction)
  - Cochlea
    - Vibration

* Note: It is always the membranous labyrinth that contains the receptors

**Figure 15.27**

Inner Ear

- The cochlea
  - A spiral, conical, bony chamber
  - Still 2 portions of bony labyrinth enclosing a portion of membranous labyrinth

**Figure 15.28a**

Inner ear

- Cavity of the cochlea is divided into 3 chambers
  - Vestibular canal (scala vestibuli)
  - Cochlear duct (scala media)
    - Basilar membrane supporting Organ of Corti
    - Organ of hearing
  - Tympanic canal (scala tympani)

**Figure 15.28b**
Physiology of Hearing

- Transduction of sound
  - Mechanical energy in middle ear
  - Fluid pressure wave in inner ear
  - Nerve impulse

This is from your textbook

Physiology of Hearing in a Nutshell

Sounds set up vibrations in air that beat against the eardrum that pushes a chain of tiny bones that press fluid in the internal ear against membranes that set up shearing forces that pull on the tiny hair cells that stimulate nearby neurons that give rise to the impulses that travel to the brain – and you hear.

(This is from your textbook)
Sound waves from the external auditory canal travel through the tympanic membrane and drum. The vibrations are transmitted through the ossicles (malleus, incus, stapes) to the oval and round windows.sounds with frequencies below hearing travel through the helicotrema and do not excite hair cells.

High-frequency sounds displace the basilar membrane near the base. Middle-frequency sounds displace the basilar membrane near the apex. Low-frequency sounds displace the membrane vibrating in the oval window. Sounds in the hearing range go through the cochlear duct, exciting the basilar membrane and deflecting hairs on inner hair cells.

Movement of the basilar membrane bends the hair cells.
Localization of Sound

- **Timing comparison**
  - Side nearest sound detects sound first
- **Comparison of volume**
  - High pitched = blocked by head
    - Perceived as loudest in ear nearest the source
  - Low pitched = curve around head
    - Perceived as equally loud in both ears

Abnormalities of hearing

- **Conductive deafness**
  - Interference in movement of middle ear bones
    - Impacted earwax, perforated eardrum or otosclerosis of the ossicles (overgrowth of bone)
- **Sensorineural deafness**
  - Damage to the neural structures
    - Aging, prolonged exposure to loud sounds

Abnormalities of hearing

- **Otitis media**

Abnormalities of hearing

- **Otosclerosis**

Abnormalities of hearing

- **Meniere’s Disease**
  - Episodes of vertigo
  - Progressive hearing loss
  - Tinnitus
  - Feeling of fullness or pressure in ear
  - Usually only in one ear

Abnormalities of hearing

- **Tinnitus**
  - Ringing, clicking, hissing, or roaring
  - Sometimes can be heard with a stethoscope (objective tinnitus)
  - May occur in the same rhythm as the heartbeat
  - Caused by noise-induced hearing loss, ear infections, diseases of blood vessels, head injury, neurological problems, brain tumors, earwax...
Physiology of Equilibrium

- Information about position and movement of head
  - Vestibular apparatus
    - Utricle
    - Saccule
    - Semi-circular canals

Vestibule

- Macula = receptor
  - Utricle
    - Horizontal movements
      - Tilting the head side to side
  - Saccule
    - Vertical movements

Semi-Circular canals

- Crista ampullaris
  - Sensory receptor for dynamic equilibrium
  - One in the ampulla of each semicircular canal
  - Major stimuli are rotatory movements

Equilibrium

- Motion Sickness
  - Conflicts between eye movements and equilibrium
- Nystagmus
  - Physiologic
    - Involuntary eye movement, part of a reflex
    - Preserves clear vision during rotation of the head
  - Pathologic
    - Abnormal eye movement – eyes move as though the head is rotating while the head is still
    - Caused by damage to any part of the vestibular system