Hearing
• Range of human hearing is 20Hz-20kHz (20,000 Hz).
• Hz= Hertz= cycles per second, a measure of frequency of sound vibrations.
• Male range: 18 Hz-18kHz.
• Female: 22 Hz-22 kHz.
• This is a mechanoceptive sense.
• The ear detects the vibrations in the air (sound) and converts the sound into nerve impulses.
Ear

- **Outer**
  - Structures associated with the external surface of the head.
- **Functions.**
  - 1) Collect sound from the air.
  - 2) Funnel sound into the middle ear.
  - 3) Helps locate a sound source in the environment
1) Auricle/pinna
- The external structure we normally associate with the "ear."
- Fan or cup shaped, cartilaginous.
- Function: is to collect sound from the environment.
- The larger the size of the pinna the more sound energy that can be collected.
- Because the pinna faces laterally and slightly anteriorly it aids in locating sound sources.
- That is how you can "hear" sounds behind you.
2) concha
- means "shell" shaped.
- It is the expanded lateral end of the auditory canal.
- Helps to funnel sound into the canal.

3) auditory canal
- The tube that carries sound to the tympanic membrane.
- Focusing the sound waves from the larger outer pinna into the smaller auditory canal compresses the sound energy into a smaller area, increasing the volume.
4) cerumenous glands
- Produce cerumen or ear wax.
- Function: the sticky cerumen traps particles (and bugs) in the auditory canal before they reach the tympanic membrane.
- Cerumen also retards the growth of microorganisms
Ear  Outer Structures

6) tympanic membrane
- Also called the ear drum.
- A thin, skin-like membrane stretched taut across the medial end of the auditory canal.
- It vibrates in response to sound pressure waves that strikes its surface.
Middle Ear

An air filled cavity just medial to the tympanic membrane.

Function

1) Transmits sound vibrations to the inner ear
2) Amplifies sound
3) Equalizes air pressure between outer and middle ear

In this warm, moist cavity infections are common (particularly in infants)

This is called otitis media.
Middle Ear Structures

1) Eustachian tubes
   - A tube that extends from the middle ear cavity to the pharynx (throat).
   - If there is any air pressure difference across the tympanic membrane it will cause the membrane to deform:
     - inwards if the pressure is lower in the middle ear or outward if the pressure is greater.
     - The Eustachian tube equalizes the pressure across the membrane by opening a pathway from the middle ear to the external atmosphere.
   - If the pressure not equalized properly, the ear drum can rupture when there is a large pressure difference.
Middle Ear Structures

2) auditory ossicles

The tiny "ear bones" of the middle ear.

Functions:

1. to transmit sound to the inner ear.
2. Amplify or dampen the sound energy
Middle Ear Structures

There are three bones

a) malleus or hammer rests on the medial surface of the tympanic membrane. It is attached medially to the incus.

b) incus or anvil is the middle ear bone. Carries sound to the stapes.

c) stapes or stirrup passes sound energy into the inner ear.

- It rests on a membrane covered opening called the oval window which allows vibrations to enter the inner ear.
Middle Ear Structures

Muscles

a) tensor tympani
   • Originates on the petrous portion of the temporal bone and inserts on the malleus.
   • When the muscle contract it pulls on the tympanic membrane and stiffens it.
   • The membrane moves less and transmits less sound energy into the middle ear.

b) stapedius
   • This muscle inserts on the stapes.
   • Has a similar function as the tympani.
Inner Ear

A fluid filled cavity made of spaces and tubes embedded within the petrous portion of the temporal bone.

Function

1) Convert sound pressure waves to nerve impulses.
2) Detects the static equilibrium (head position)
3) Detects dynamic equilibrium (linear and rotational movement)
Inner Ear Structures

- Labyrinth is a maze-like series of bony tubes within the inner ear
- The tubes contain membrane lined ducts filled with a CSF-like fluid called endolymph.
- Endolymph conducts sounds pressure waves into the cochlea of the inner ear.
- There are three structures that are a part of the labyrinth
  - 1) Vestibule
  - 2) Semicircular canals
  - 3) Cochlea
1) Vestibule
   - Bulbous spaces between the tubes of the semicircular canals and the cochlea.
   - The vestibule detects static and dynamic equilibrium; that is, the sense of head position and linear acceleration.
   - The latter is a term referring to the acceleration of the head (and presumably) and body through space in a straight line.
   - The two structures that detect these states are called
     A. Utricle
     B. Saccule

Inner Ear Structures
Inner Ear Structures

2) Semicircular ducts and canals
   - Three tubes oriented in the three axes of 3D space (x, y and z)
   - These detect dynamical or rotational movement of the head and body.
Inner Ear Structures

3) Cochlea

- A long tube curled into a shape that resembles a snail's shell.
- Its function is to convert sound waves into nerve impulses.
Inner Ear Structures

3) Cochlea

- a. vestibular duct
  - The oval window leads to a long curled duct called the vestibular duct.
  - It is filled with a fluid called perilymph.
  - The floor of the vestibular duct is formed by the vestibular membrane.

- b. cochlear duct
  - A duct which extends the length of the cochlea.
  - Contains endolymph and the spiral organ of Corti
Inner Ear Structures

3) Cochlea

c. tympanic duct

As the vestibular duct rounds the tip of the Cochlear duct it transitions into the tympanic duct, also filled with perilymph.

The roof of the tympanic duct is formed by the basilar membrane.

d. spiral organ of Corti

A structure made of several membranes and collections of cells which extends the length of the cochlear duct.
Inner Ear Structures

3) Cochlea
e. tectorial membrane
Projects into cochlear duct.
Rests on top of the hairs of hair cells.
Inner Ear Structures

3) Cochlea
   f. hair cells
   Project hairs upward into the inferior surface of the tectorial membrane.
Physiology of hearing

1) Sounds waves are collected by the pinna and focused into the auditory canal.

The vibrations pass down the canal and strike the tympanic membrane.
Physiology of hearing

2) Membrane vibrates in response to the sounds waves and moves the malleus.
Physiology of hearing

3) Malleus moves incus which in turn moves the stapes. The stapes rests on the membrane across the oval window. This membrane vibrates in response to the vibrations carried by the stapes.
Physiology of hearing

4) Oval window transmits sound into the vestibular duct
Physiology of hearing

5) perilymph in vestibular duct

Carries sound waves down the length of the duct rounds the corner into the tympanic duct.
Physiology of hearing

6) vibrations cross the vestibular membrane. Pass into the endolymph of the cochlear duct.
Physiology of hearing

7) The tectorial membrane picks up the sound pressure waves in the endolymph and pushes down on the hairs of the hair cells.
8) Hair cells generate nerve impulses which are conducted by the vestibulocochlear nerve to the auditory cortex.
Physiology of hearing

9) Compression in tympanic duct

The perilymph carries sound energy from the vestibular duct to the round window.
Physiology of hearing

10) The sound energy passes out of the inner ear into the middle ear and is dissipated down the Eustachion tube.
Physiology of hearing

The hair cells closest to the middle ear are sensitive to higher sound frequencies.

The hair cells at the end of the spiral organ detects low vibrations.
Vestibular apparatus and equilibrium

1) Static equilibrium

Structures in the vestibule which detect static equilibrium
- utricle
- Saccule

These structures contain called the macula which, in turn, have hair cells.
Vestibular apparatus and equilibrium

The hairs projected upward into a layer of gel-like material.

Resting on the gel layer are rocklike particles called otoliths or otoconia.

As the head tilts one way or another, the otoliths "roll" down hill and drag the gel layer with them.

The embedded hair bend and generate nerve impulses.
Vestibular apparatus and equilibrium

2) Dynamic equilibrium
   - Rotational movement.
   - 3 semicircular ducts
Vestibular apparatus and equilibrium

- Contain a fluid. The base of each canal contains a space called an ampulla.
- Each contains a structure called the crista ampullaris
  - Made of a gelatinous flap called the cupulla
  - The hairs of hair cells project into the cupulla
Vestibular apparatus and equilibrium

- As the head rotates, the fluid lags behind and pushes on the cupulla.
- The cupulla bends and deforms the hair cells.
- Nerve signals are sent to the brain to be decoded as rotational movement.
- When the rotational information from the vestibular apparatus and vision do not coincide this results in a condition called sensory mismatch.
- Otherwise known as motion sickness.
Taste

Sweet
sour
salty
bitter
meaty (umami.)
BTW, the taste map shown here is not correct.
Actually taste sensations are more evenly distributed across the tongue.
Discovered by Dr. Kikunae Ikeda, of the Tokyo Imperial University, in 1907.

"There is a taste which is common to asparagus, tomatoes, cheese and meat but which is not one of the four well-known tastes of sweet, sour, bitter and salty."

Found in broth made from Kombu, a type of seaweed.

Isolated the chemical responsible for the taste; glutamate

Now known as monosodium glutamate or MSG.

Enhances the original flavor of food.
The End