Hearing

Audition – The sense or act of hearing

The Stimulus Input: Sound Waves

Sound waves are composed of changes in air pressure unfolding over time.

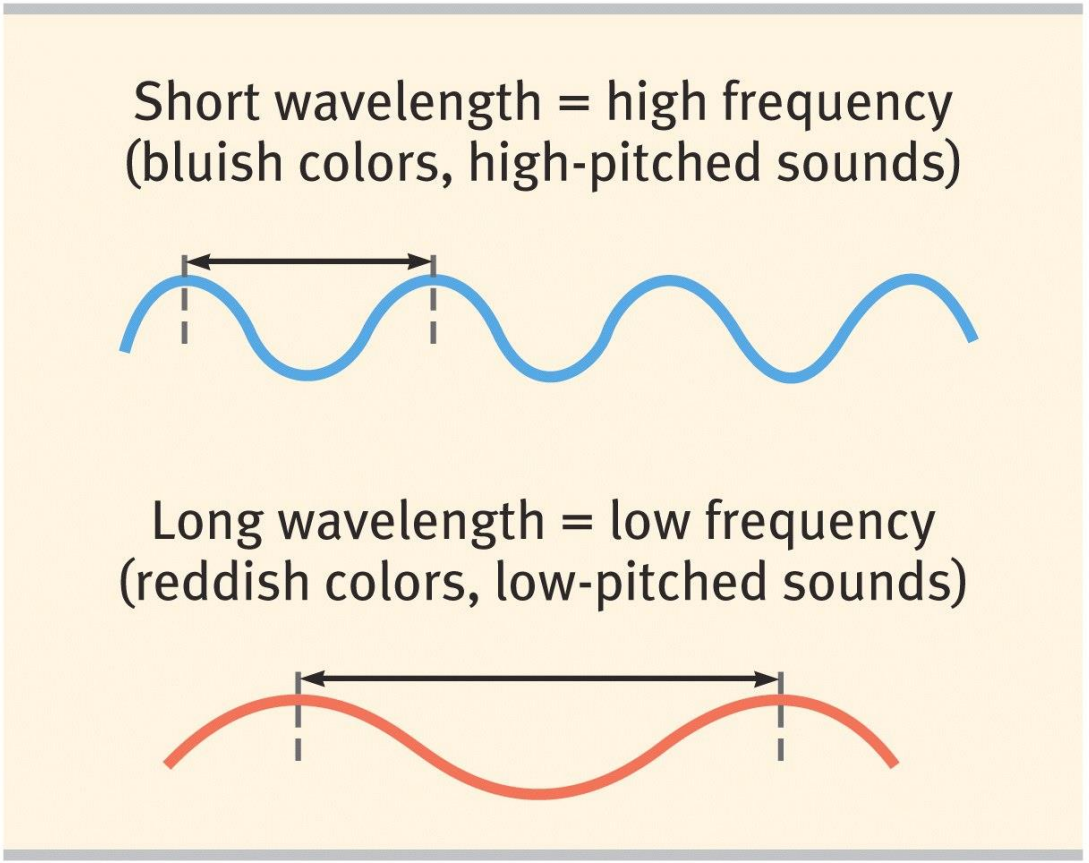
Acoustical transduction: Conversion of sound waves into neural impulses in the hair cells of the inner ear.

Frequency (Pitch)

Frequency (pitch): The dimension of frequency determined by the wavelength of sound.

- Measured in **Hertz (Hz)**

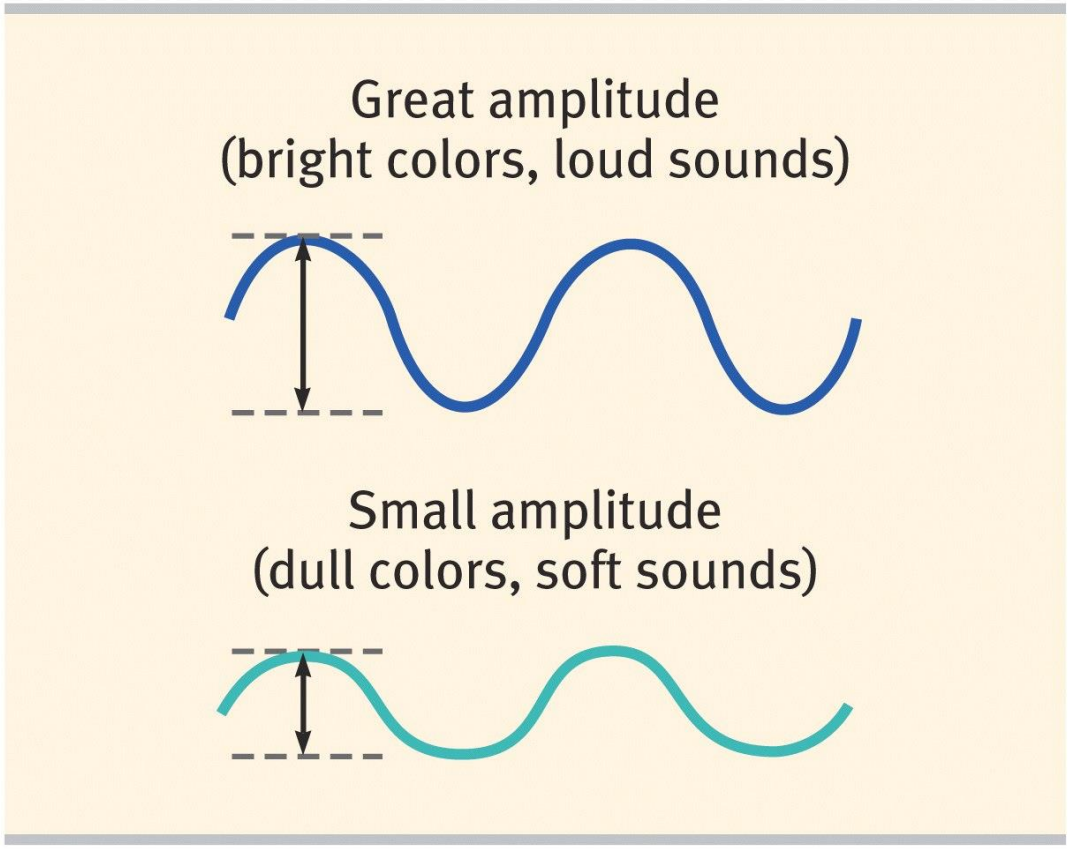
Wavelength: The distance from the peak of one wave to the peak of the next.



Intensity (Loudness)

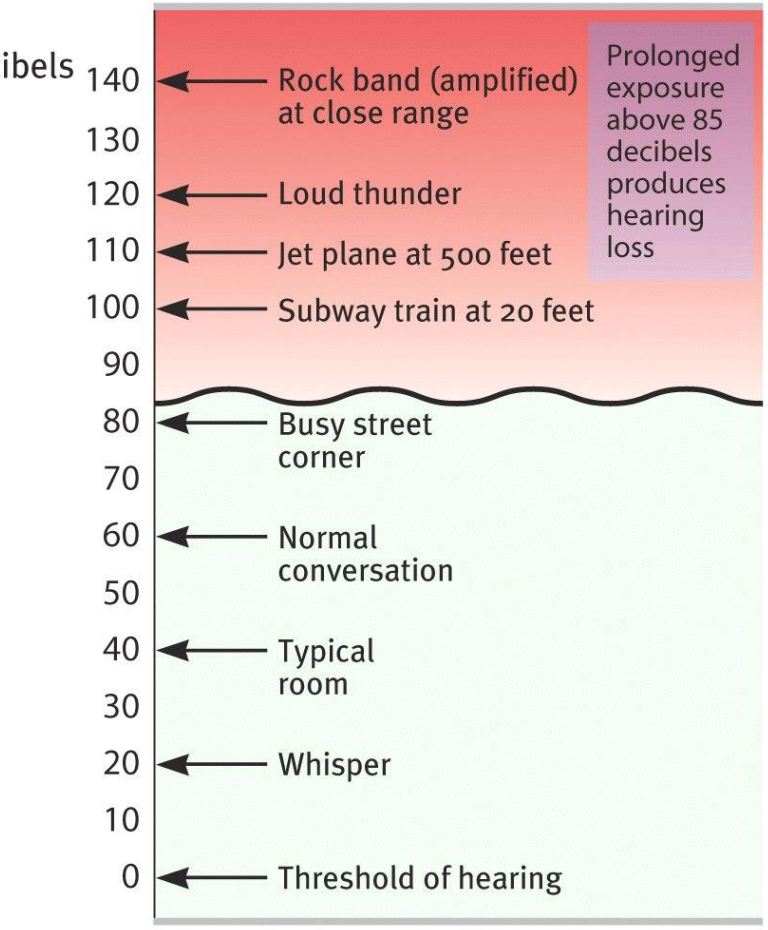
Intensity (Loudness): Amount of energy in a wave, determined by the amplitude, relates to the perceived loudness.

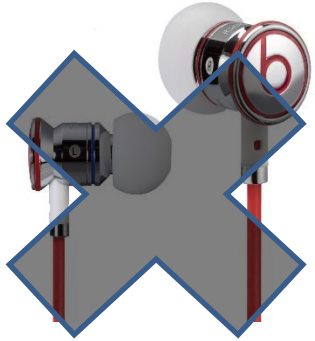
- Measured in **Decibels (dB)**



Loudness of Sound

120dB





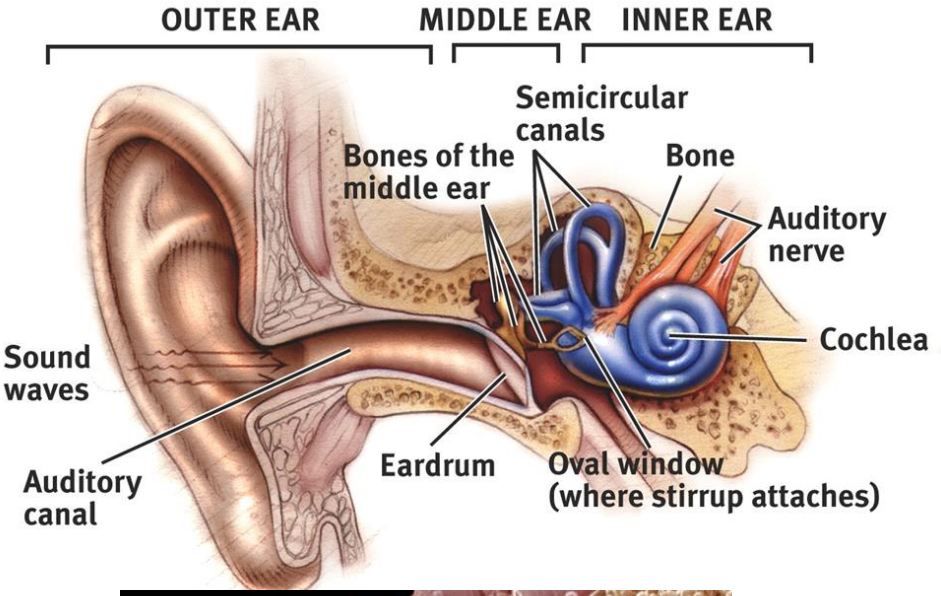
70dB

Tinnitus: the perception of sound within the human ear when no external sound is present. (So, another example of???)

- Latin for "ringing"
- "ringing" is only one of the sounds one may perceive.
- Result of prolonged exposure to loud sounds.

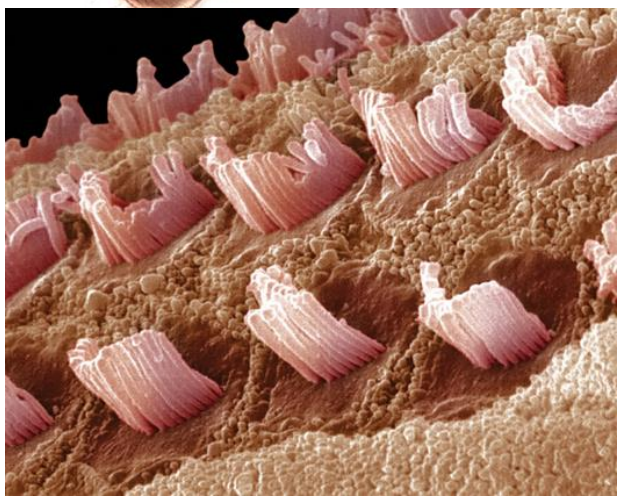
Tinnitus simulation

The Ear



Outer Ear: Pinna. Collects sounds.

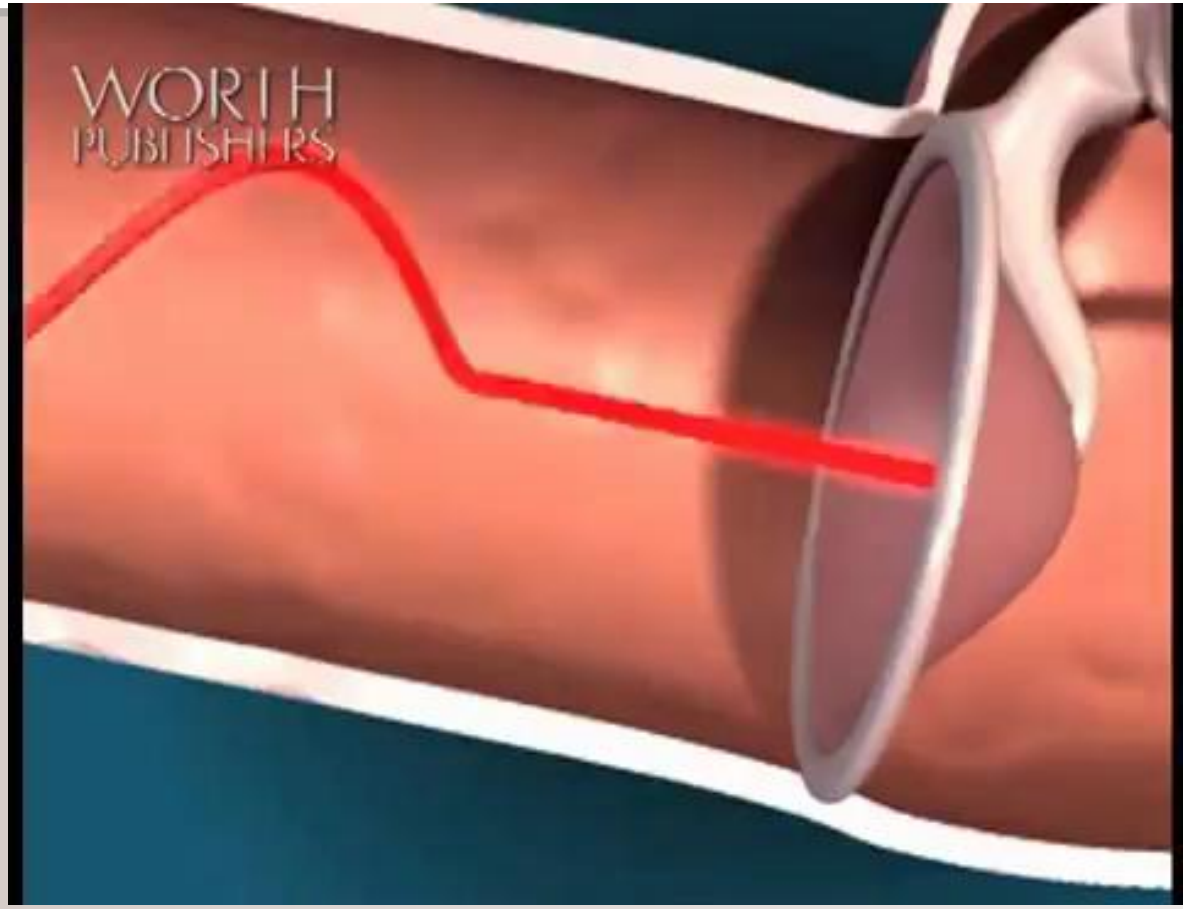
Middle Ear: Chamber between eardrum and cochlea containing three tiny bones (hammer, anvil, stirrup) that concentrate the vibrations of the eardrum on the cochlea's oval window.



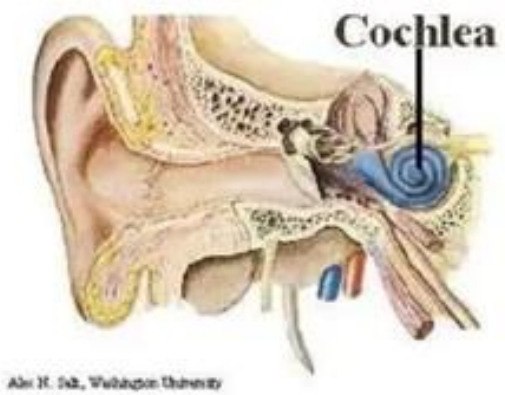
Inner Ear: Innermost part of the ear, containing the cochlea, semicircular canals, and vestibular sacs.

Converting Sound Waves into Neural Signals, Part 1

What happens to initiate neural signals for sound?



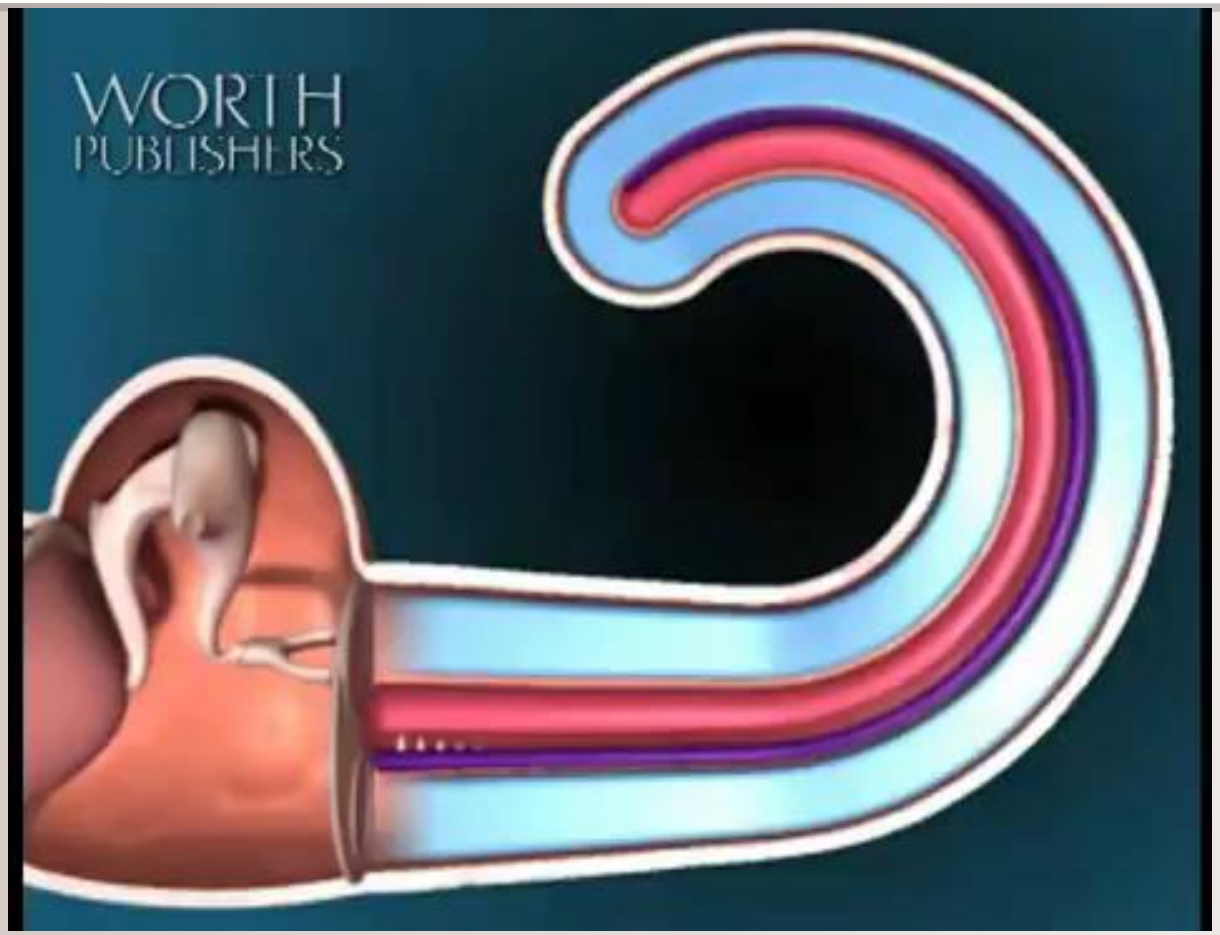
Cochlea: Coiled, bony, fluid-filled tube in the inner ear that transforms sound vibrations to auditory signals.



Basilar membrane – Thin strip of tissue, contains hair cells that are sensitive to vibrations

Converting Sound Waves into Neural Signals, Part 2

How does the process of initiating neural signs for sound conclude?



Hair Cells

- Cochlea has 16,000 hair cells
- Can turn neural current on/off 1000 times/second
- Cilia can whither or fuse in response to noise
- Brain detects loudness from # of cells responding
- Can still hear loud sounds if you lose sense of soft sounds
- Compressed sound – soft sounds amplified
- Most hearing loss comes from damage to hair cells
- Hair cells send neural messages to auditory cortex
- Auditory nerve created by bending of hair cells

Normal Hair Cells

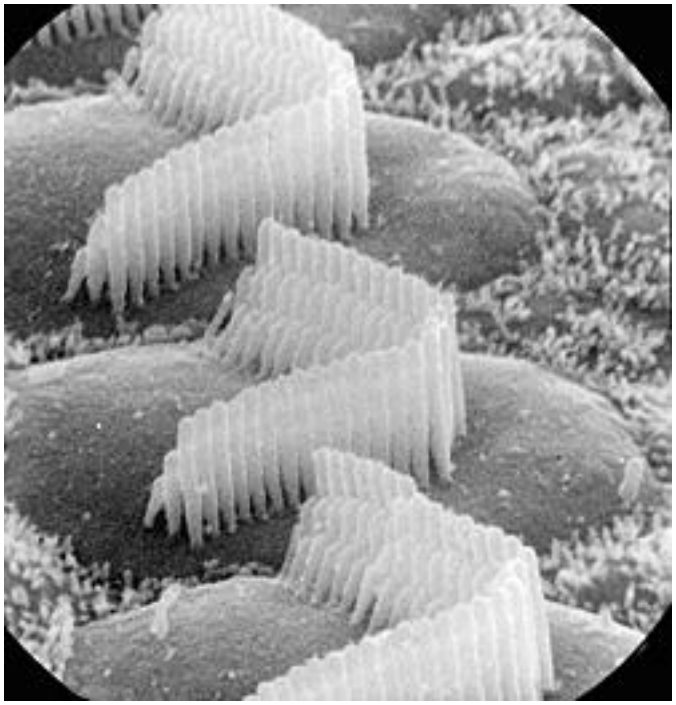
Damaged Hair Cells

Transduction in the ear

- Sound waves hit the **eardrum** then **anvil** then **hammer** then **stirrup** then **oval window**.
- Everything is just vibrating.
- Then the **cochlea** vibrates.
- The **cochlea** is lined with mucus called **basilar membrane**.
- In **basilar membrane** there are hair cells. When hair cells vibrate they turn vibrations into neural impulses which are called **organ of Corti**.
- These signals are then sent to thalamus up the auditory nerve.

It is all about the vibrations!!!

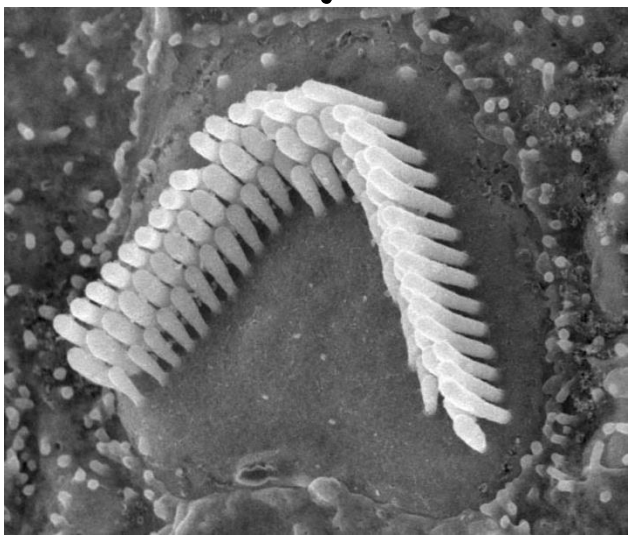
Place Theory



- Different hairs vibrate in the cochlea when they process different pitches.
- So some hairs vibrate when they hear high and other vibrate when they hear low pitches.

Frequency Theory

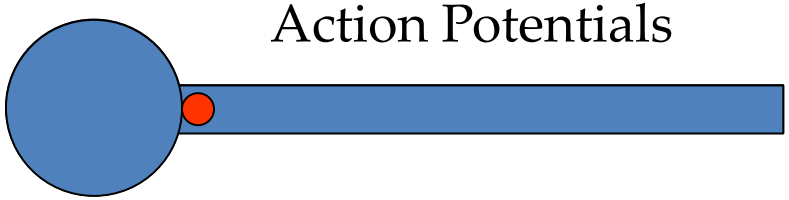
- All the hairs vibrate but at different speeds.



Sound Frequency

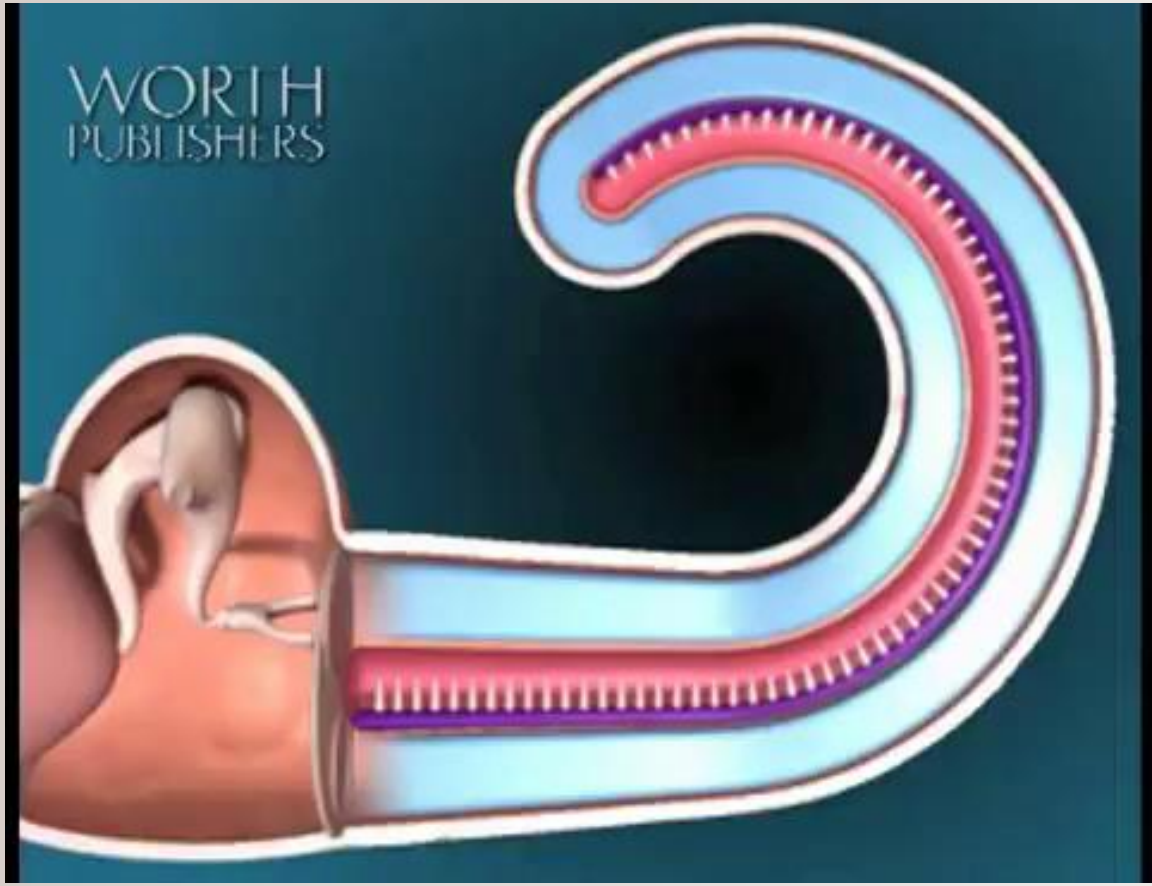
200 Hz

Auditory Nerve Action Potentials



Distinguishing Differences in Pitch

What are the highs and lows of sound?



Deafness

Conduction Deafness

- Something goes wrong with the sound and the vibration on the way to the cochlea.
- You can replace the bones or get a hearing aid to help.

Nerve (sensorineural) Deafness

- The hair cells in the cochlea get damaged.
- Loud noises can cause this type of deafness.
- NO WAY to replace the hairs.
- Cochlea implant is possible.