

# 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)

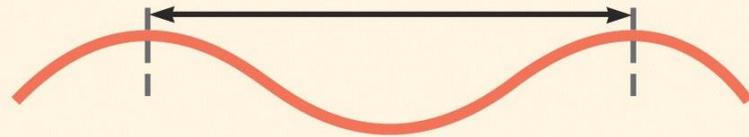
**Frequency (pitch):** The dimension of frequency determined by the wavelength of sound.  
- Measured in Hertz (Hz)

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

Short wavelength = high frequency  
(bluish colors, high-pitched sounds)



Long wavelength = low frequency  
(reddish colors, low-pitched sounds)



# Intensity (Loudness)

## Intensity (Loudness):

Amount of energy  
in a wave,  
determined by the  
amplitude, relates  
to the perceived  
loudness.

- Measured in  
Decibels (dB)

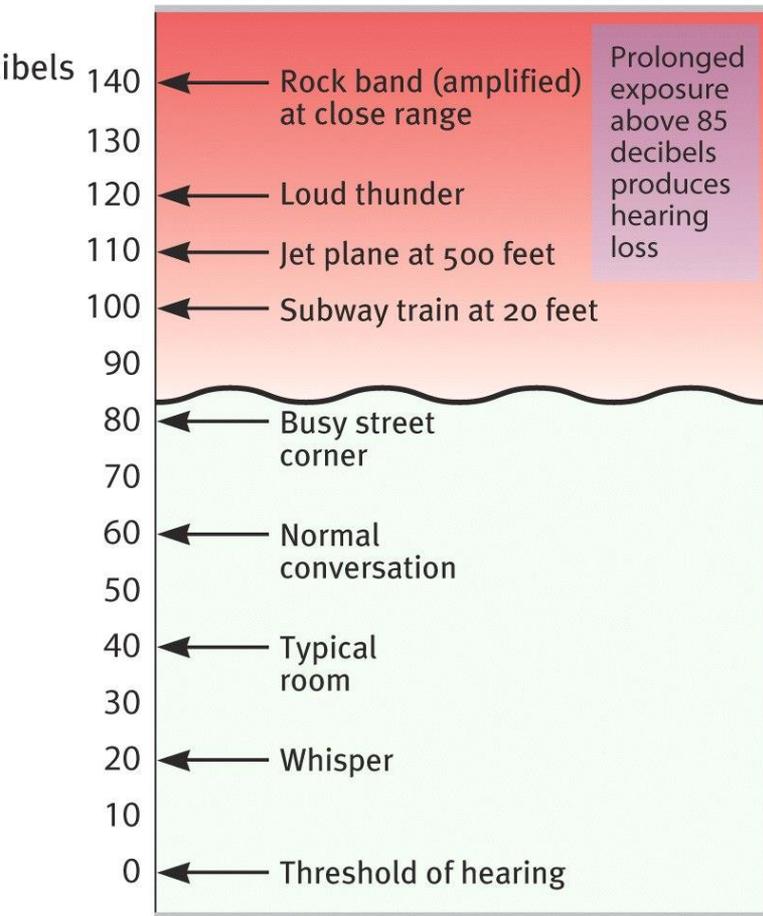
Great amplitude  
(bright colors, loud sounds)



Small amplitude  
(dull colors, soft sounds)

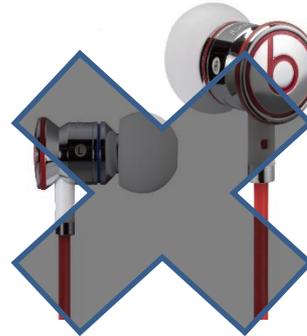


# Loudness of Sound



Tinnitus simulation

120dB



70dB



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

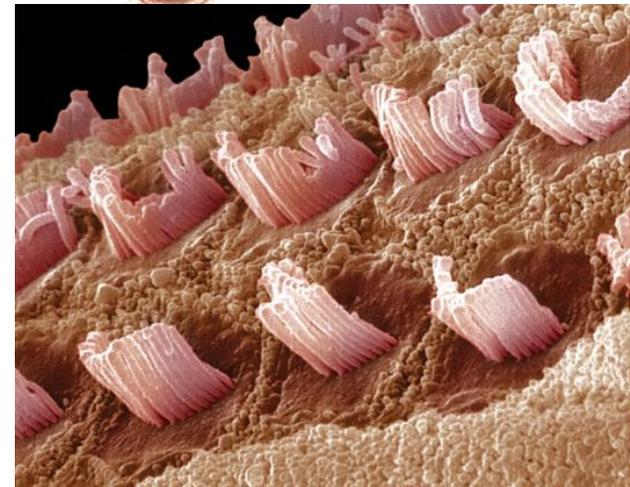
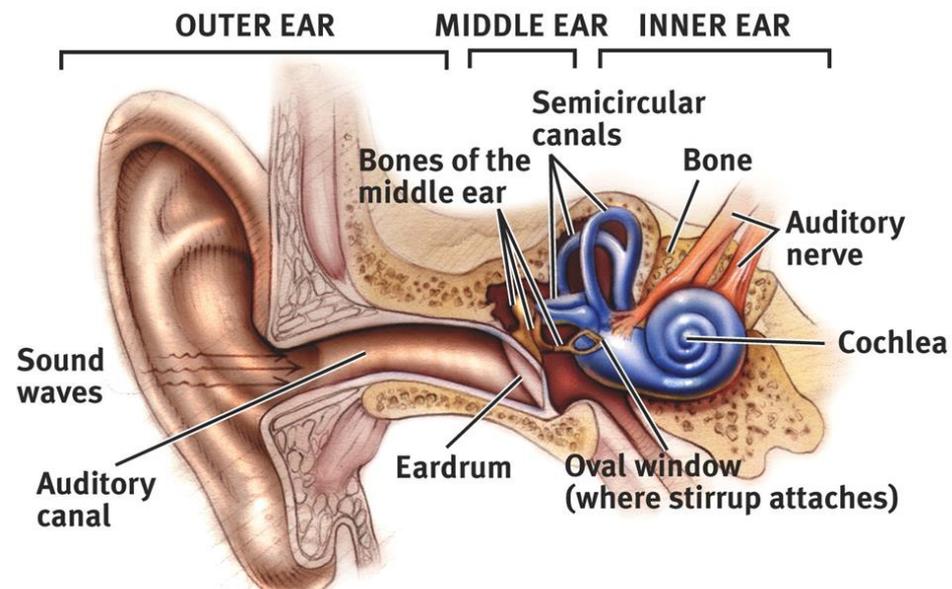
- Latin for "ringing"
- "ringing" is only one of the sounds one may perceive.
- Result of prolonged exposure to loud sounds.

# The Ear

**Outer Ear:** Pinna. Collects sounds.

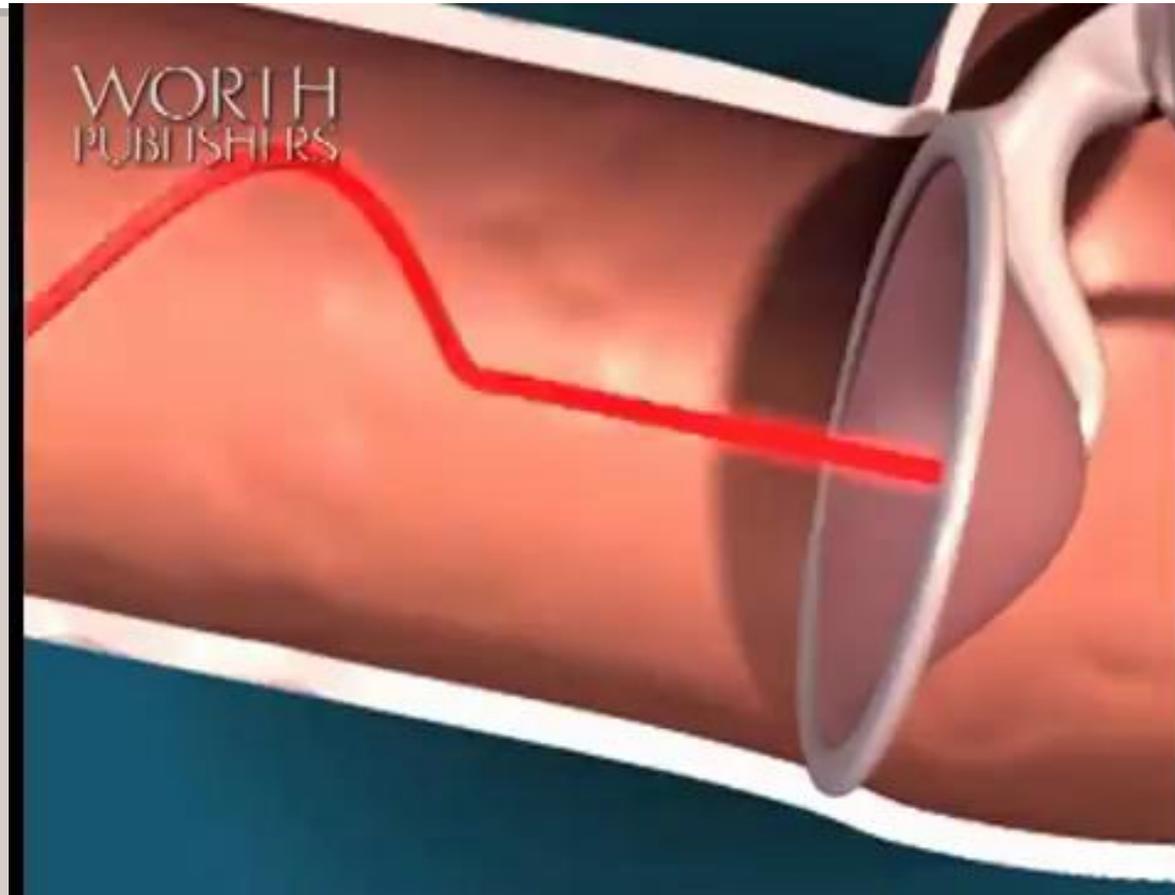
**Middle Ear:** Chamber between eardrum and cochlea containing three tiny bones (hammer, anvil, stirrup) that concentrate the vibrations of the eardrum on the cochlea's oval window.

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

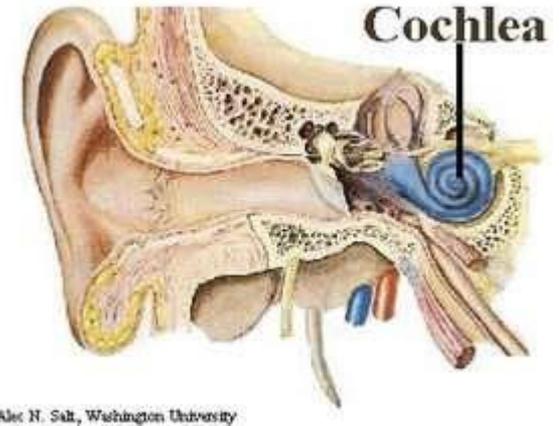
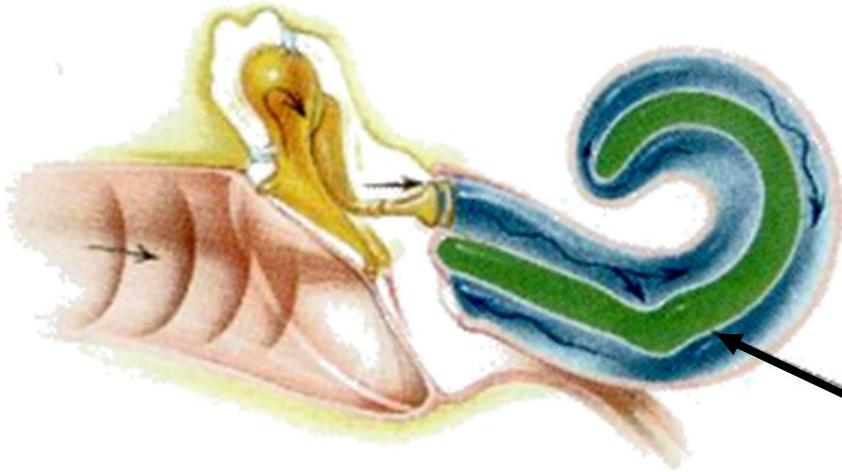


# Converting Sound Waves into Neural Signals, Part 1

*What happens to  
initiate neural  
signals for  
sound?*



**Cochlea:** a bony, spiral-shaped, fluid-filled tube in the inner ear through which sound waves travel and trigger nerve impulses.



Alex N. Salt, Washington University

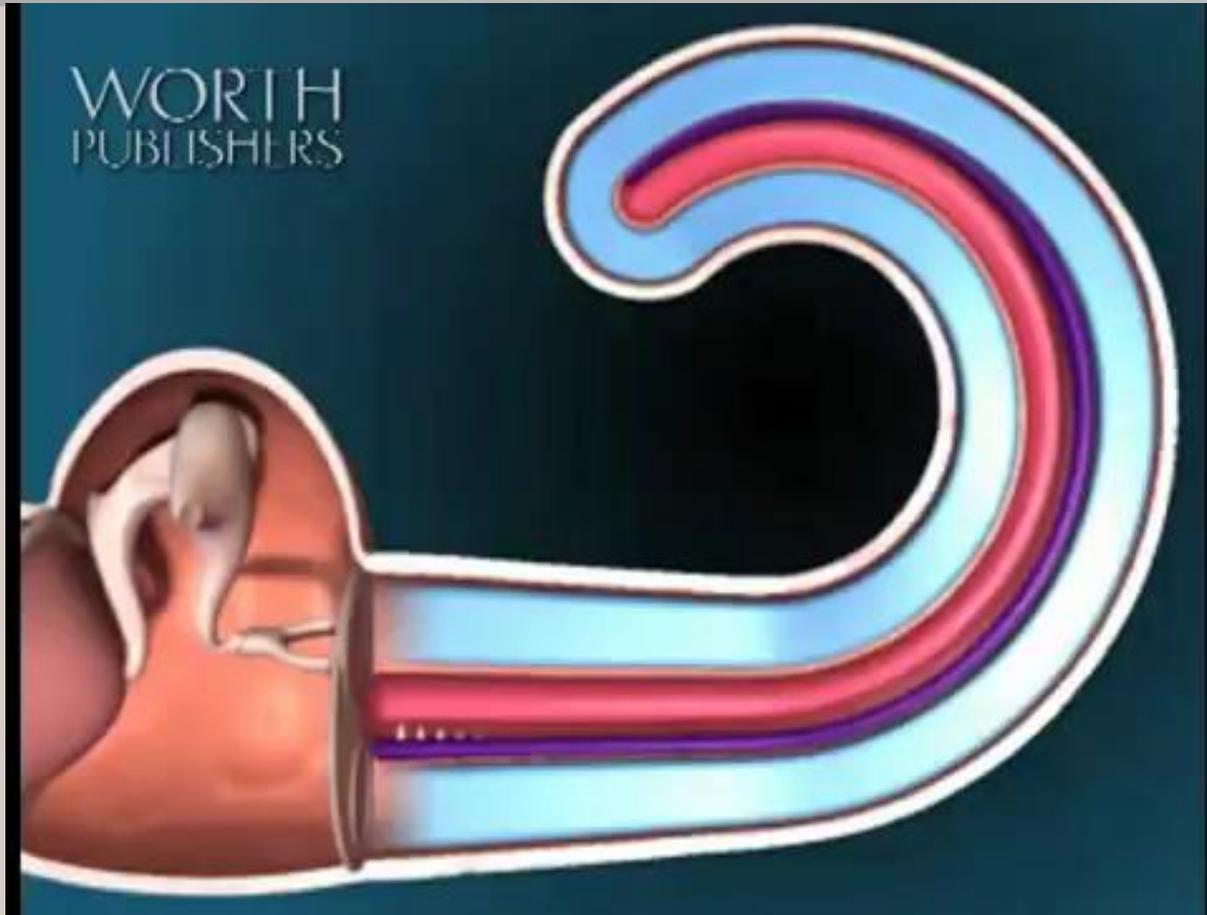


*Basilar membrane* –

Thin strip of tissue, contains hair cells that are sensitive to vibrations and transduce sound waves into neural signals

# Converting Sound Waves into Neural Signals, Part 2

*How does the  
process of  
initiating neural  
signals for sound  
conclude?*



# Hair Cells

- Sensory receptors embedded in basilar membrane
- Transduce the physical vibration of sound waves into neural impulses.
- As hair cells bend, they stimulate the cells of the auditory nerve.
- Cilia can wither or fuse in response to noise
- Brain detects loudness from # of cells responding
- Hair cells send neural messages to auditory cortex



Normal Hair Cells

Damaged Hair Cells

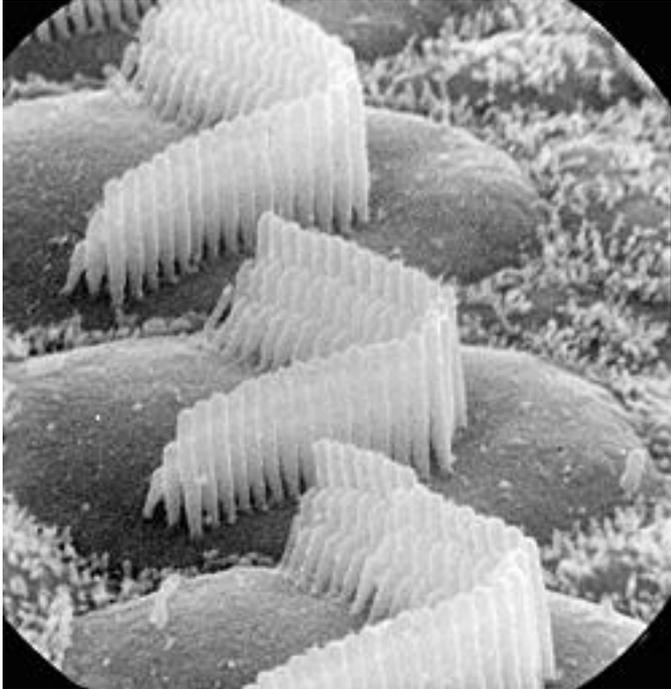
# Transduction in the ear

- Sound waves enter the pinna and travel down the auditory canal where they hit the **eardrum**.
- The eardrum pushes against the **anvil**, then the **hammer**, followed by the **stirrup**, which pushes against the **oval window**. (*This all happens through vibrations.*)
- Next, the the **cochlea** vibrates.
- The **cochlea** is lined with mucus called **basilar membrane**.
- In the **basilar membrane** there are hair cells. When the hair cells vibrate they turn vibrations into neural impulses which are called **organ of Corti**.
- These signals are then sent to the **thalamus** via the auditory nerve.



It is all about the vibrations!!!

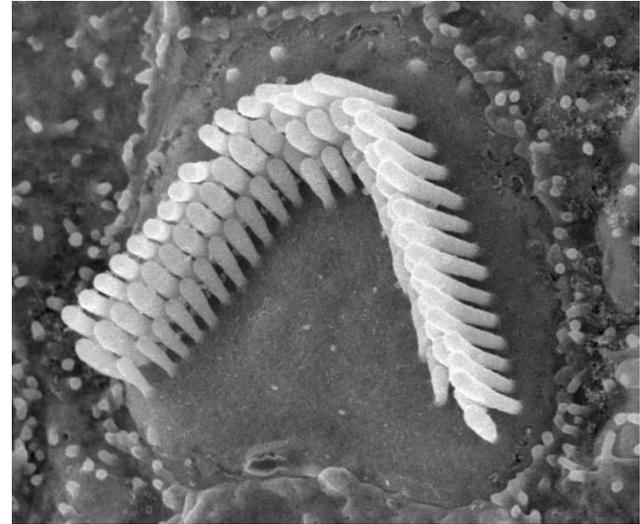
# Place Theory



- 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.



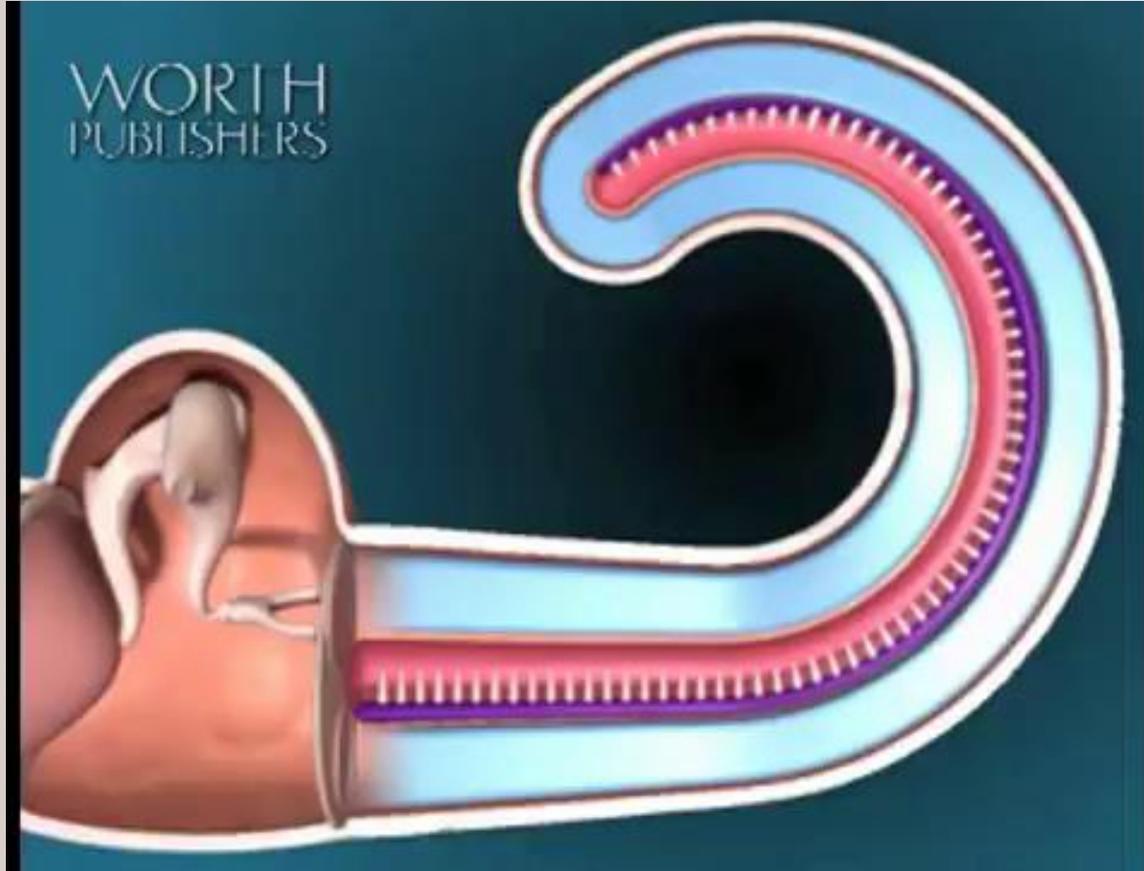
Sound  
Frequency  
200 Hz



Auditory Nerve  
Action Potentials

# Distinguishing Differences in Pitch

*What are the  
highs and lows of  
sound?*



# Deafness

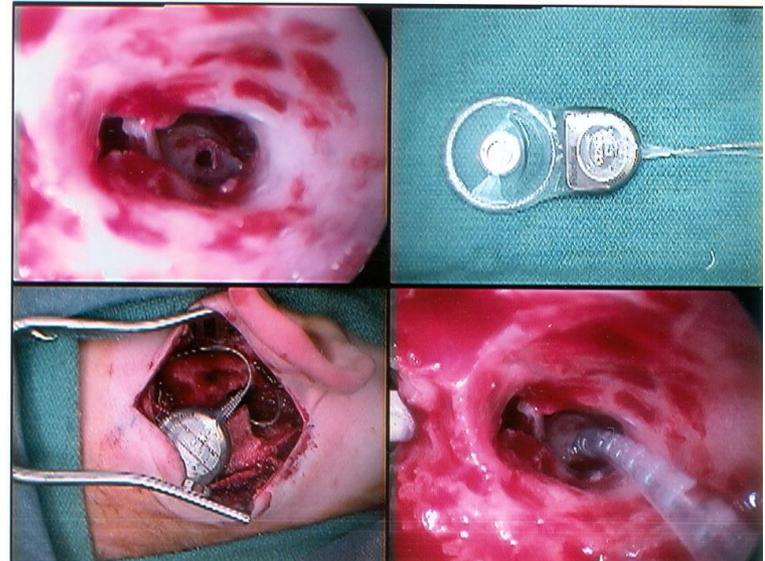
## Conduction Deafness

- Something goes wrong with the sound and the vibration on the way to the cochlea. (problem in outer or middle ear.)
- You can replace the bones or get a hearing aid to help.



## Nerve (sensorineural) Deafness

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

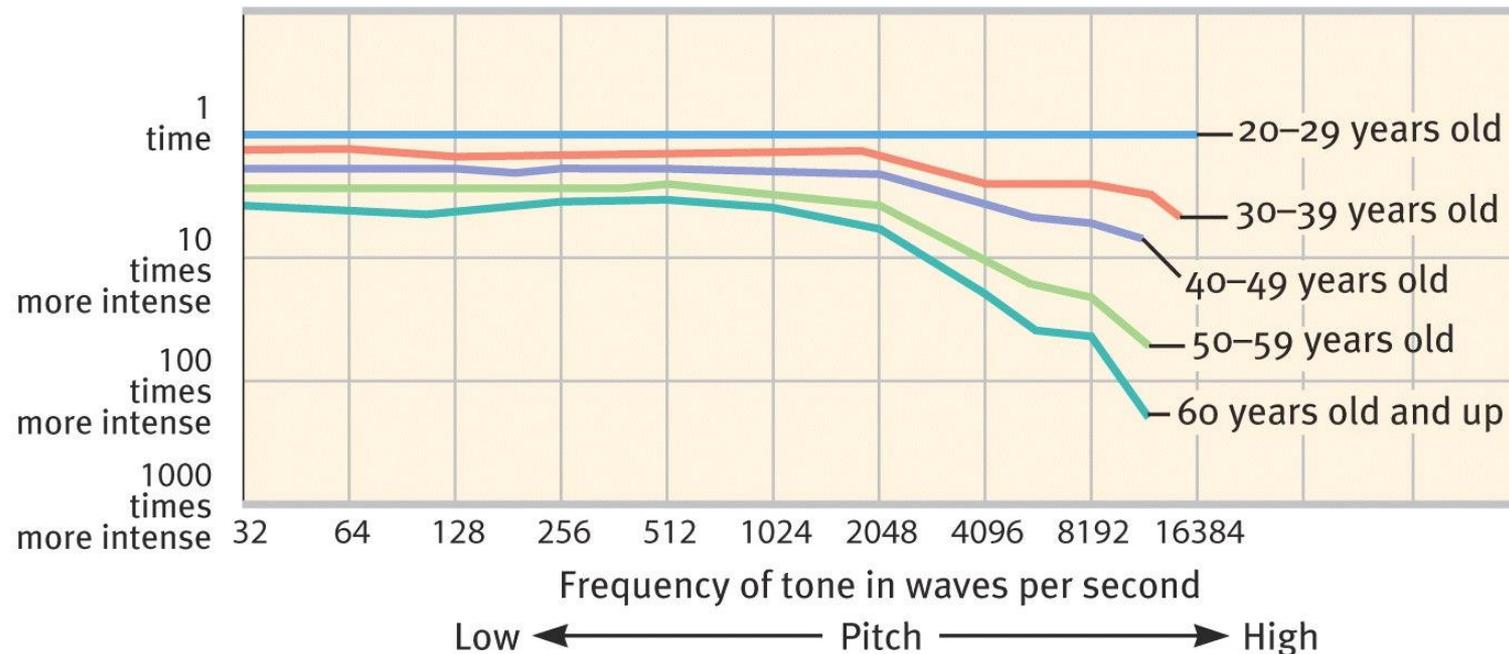


# Hearing Deficits



Older people tend to hear low frequencies well but suffer hearing loss when listening for high frequencies.

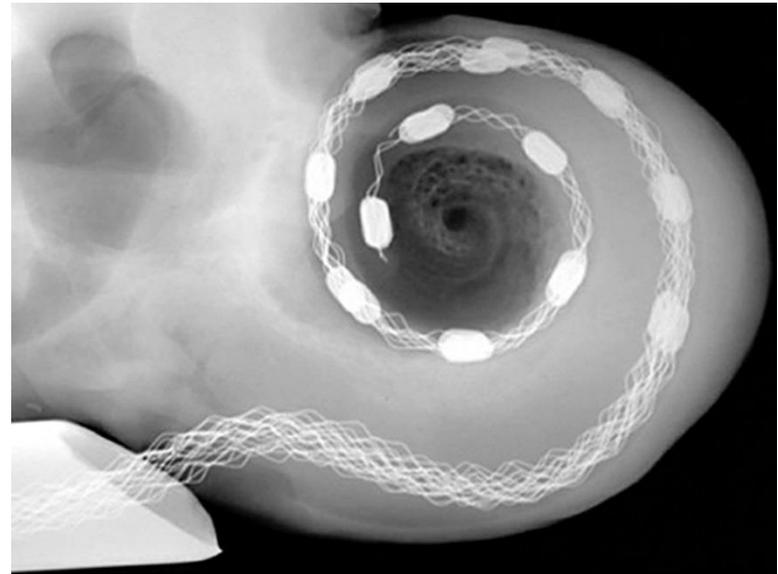
Amplitude (intensity) required for perception relative to 20–29-year-old group



A [cochlear implant](#) is an electronic medical device that replaces the function of the damaged inner ear. Unlike hearing aids, which make sounds louder, [cochlear implants](#) do the work of damaged parts of the inner ear (**cochlea**) to provide sound signals to the brain.

[Hotly debated in deaf culture.](#)

Cochlear implants perpetuate the idea that deaf people need to be "fixed" — and a lot of deaf people take issue with that.



Cochlear Implant

# Cochlear Implants

