



Introduction to Cochlear Implant

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Neural Prosthetic Device

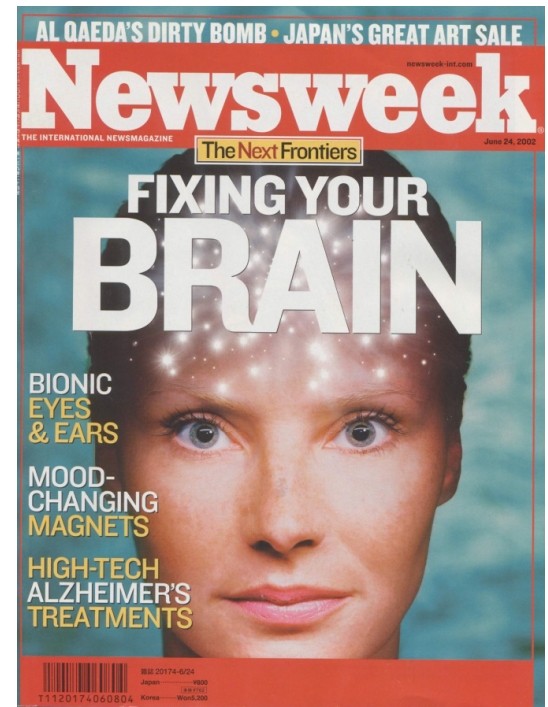
A artificial device that connects directly with the nervous system to replace/supplement sensory or motor functions.



In 1970's, it was
in SF movies.



Now it is a science.



And it is newsworthy.

Definition of Sound

Sound : a vibratory energy
by an object possessing
both inertia and elasticity

pure tone vs.
complex tone

Fourier transform



Sound

Three components of a sinusoid

<u>physical terms</u>	<u>range</u>	<u>subjective terms</u>
frequency	16 - 20000 Hz	pitch
intensity	0 - 120 dB	loudness
phase		location of sound

Typical Noise Levels (SPL)

threshold : 0 dB

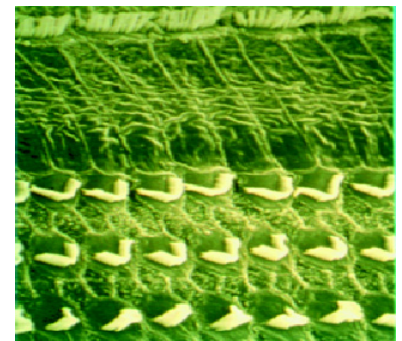
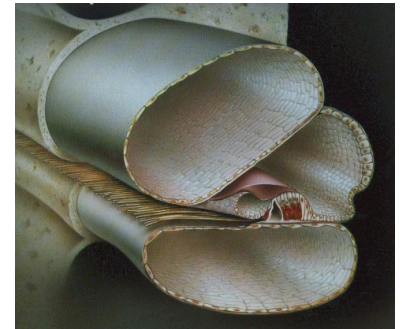
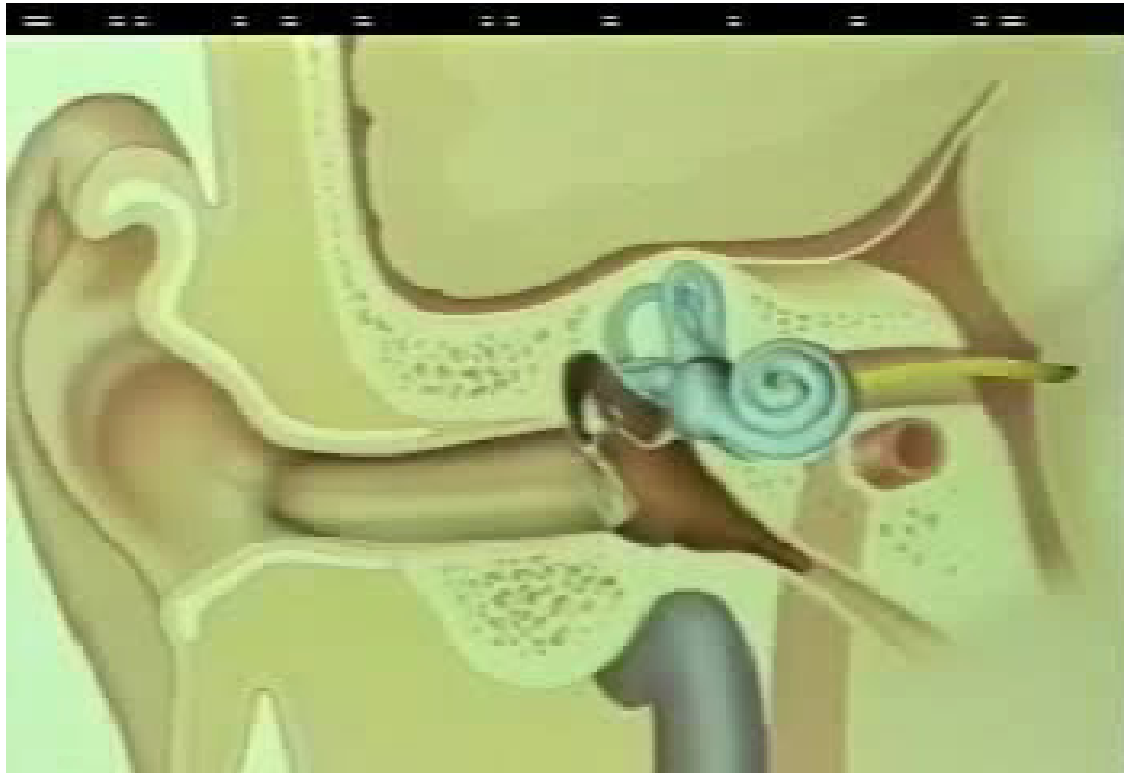
subway : 90 dB

normal speech : 60 dB

jet airplane : 105 dB

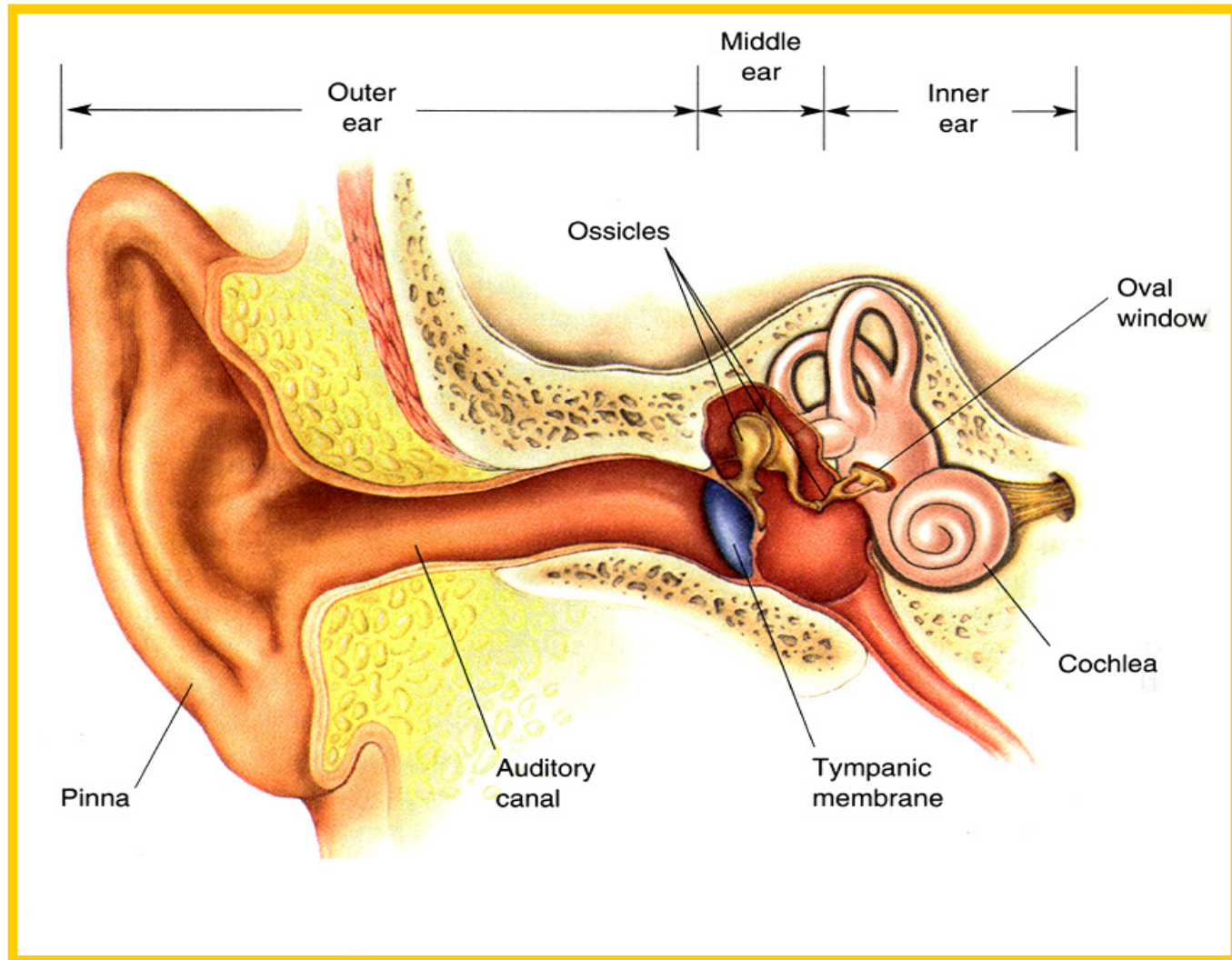
How Ear Works

The cochlea is a Fourier Analyzer !

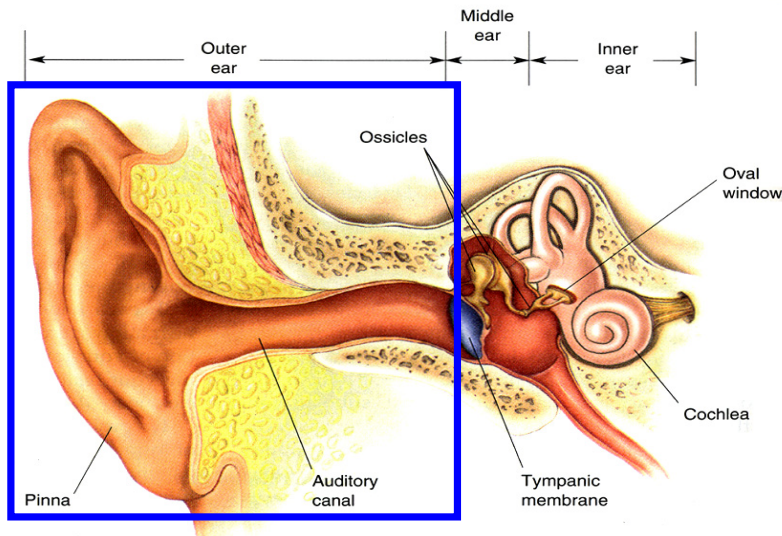


Advanced Bionics Corp., USA

Anatomy of the Ear



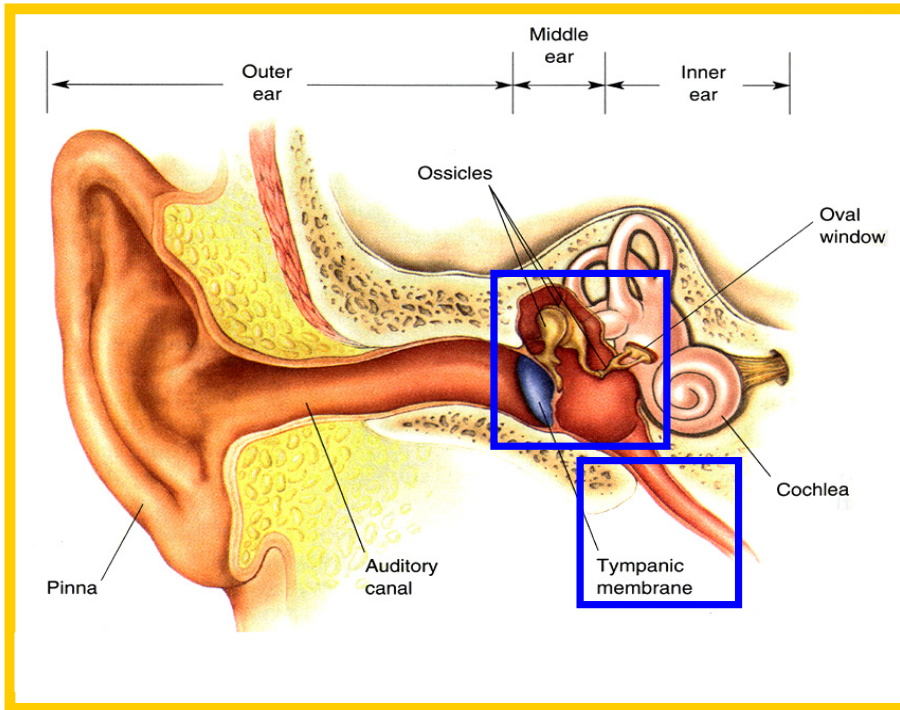
Outer Ear



Pinna : sound collection (6 dB)

External Auditory Canal
resonant frequency : 2.5 kHz
amplification
(10-15 dB, 1.5-7 kHz)

Middle Ear

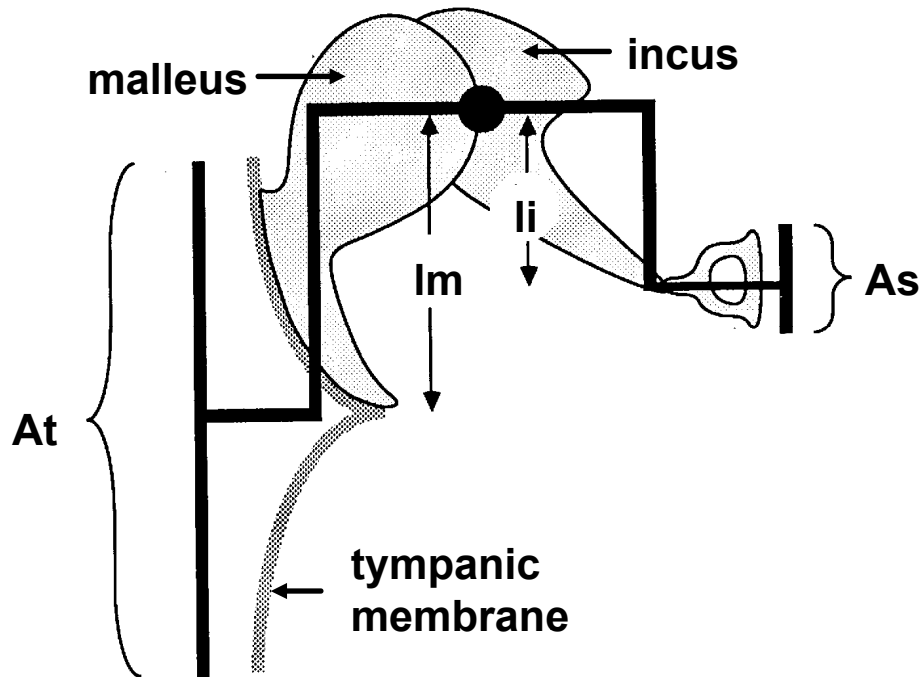


Tympanic Membrane (Ear drum)
vibration
protection

Middle Ear : bone (ossicles) + air
mechanical energy
impedance matching
amplification (34 dB)

Eustachian tube : ventilation

Middle Ear as a Transformer

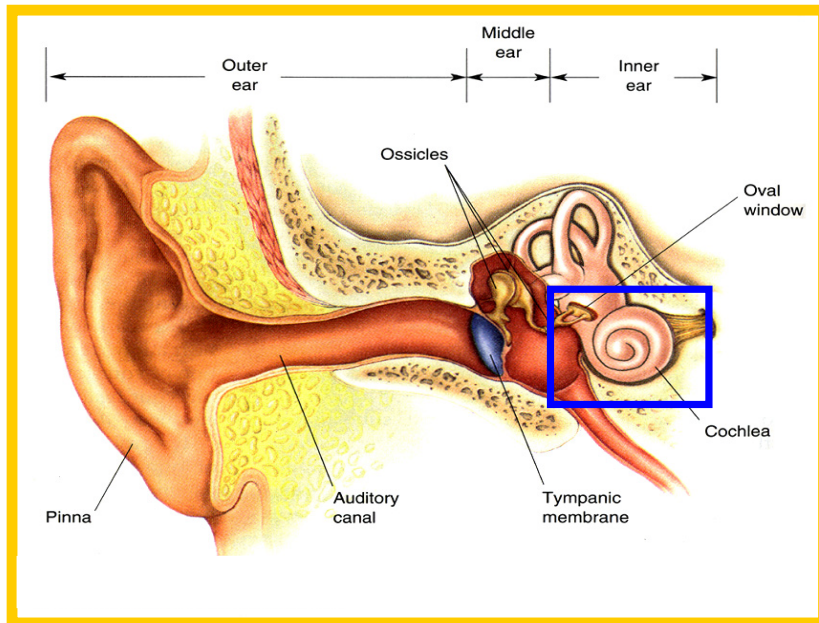


Impedance matching
air(EAC) vs. fluid(IE)

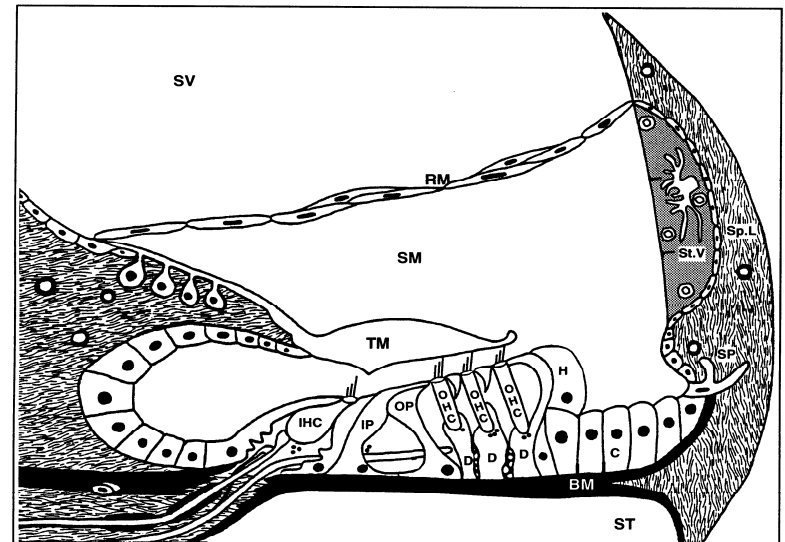
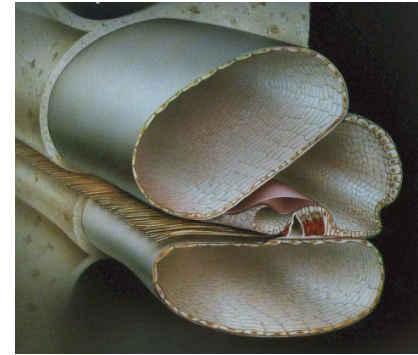
Amplification
area ratio = A_t/A_s
lever ratio = l_m/l_i

The effective area changes
with frequency.

Inner Ear



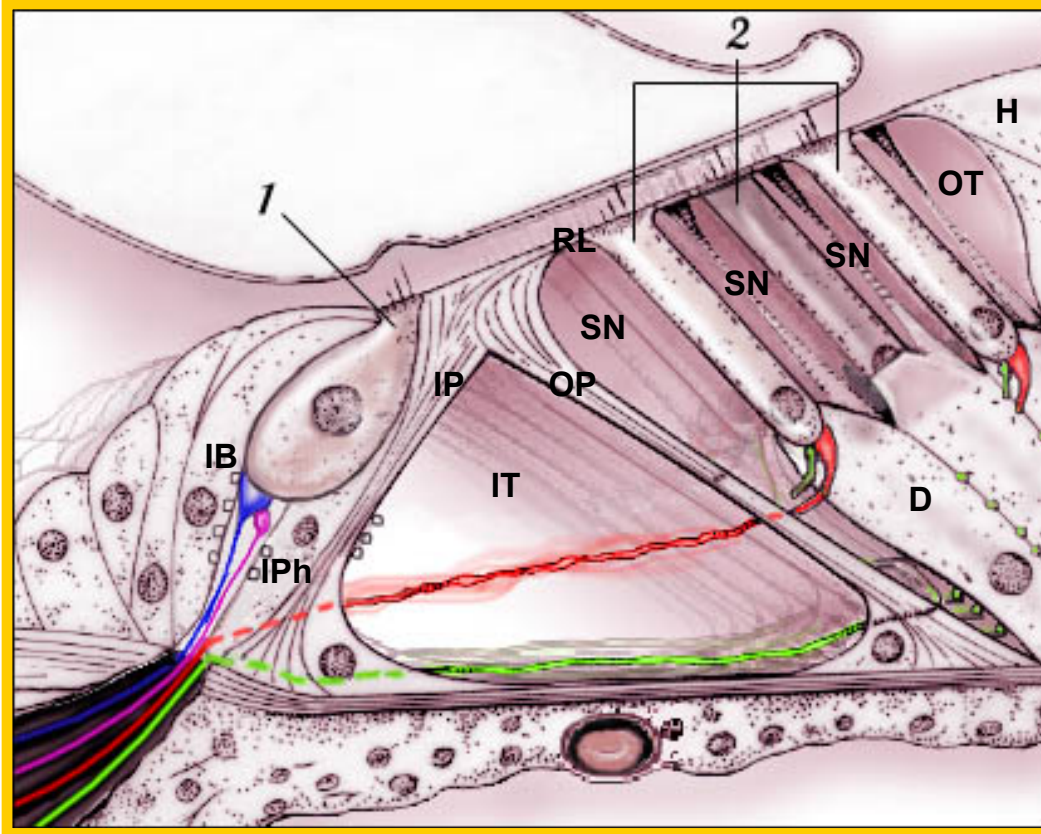
Cochlea : analyzer



Hydraulic energy

Organ of Corti : OHCs & IHCs

Organ of Corti & Surrounding Structures



H: Hensen's cell

OT: outer tunnel of Corti

D: Deiters' cell

SN: space of Nuel

2: outer hair cell(OHC)

OP: outer pillar cell

IT: inner tunnel of Corti

IP: inner pillar cell

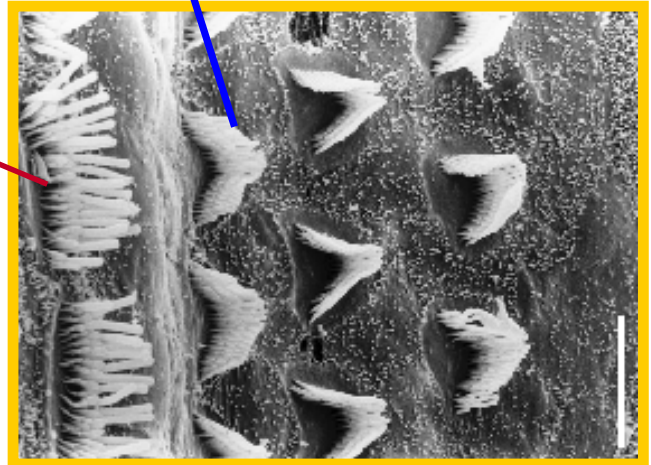
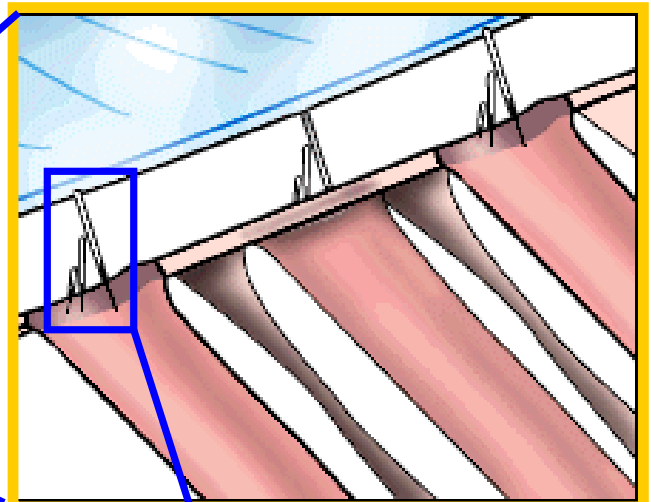
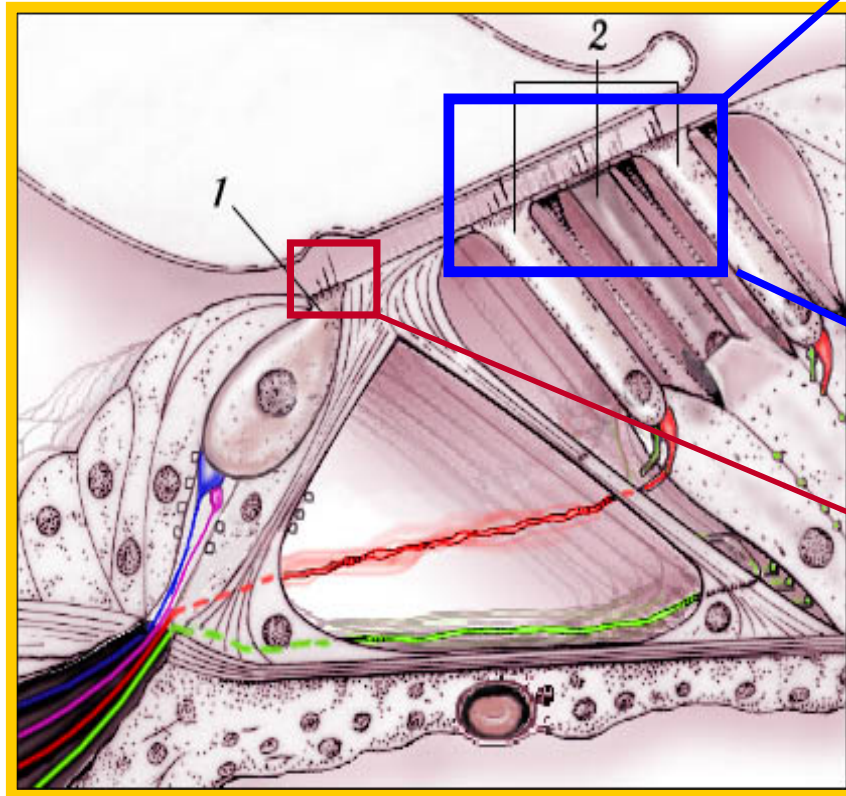
IPh: inner phalangeal cell

1: inner hair cell(IHC)

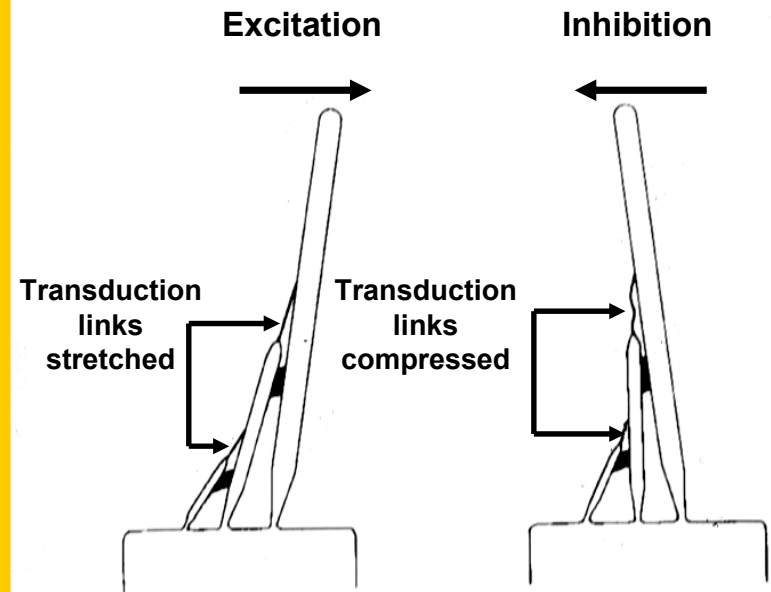
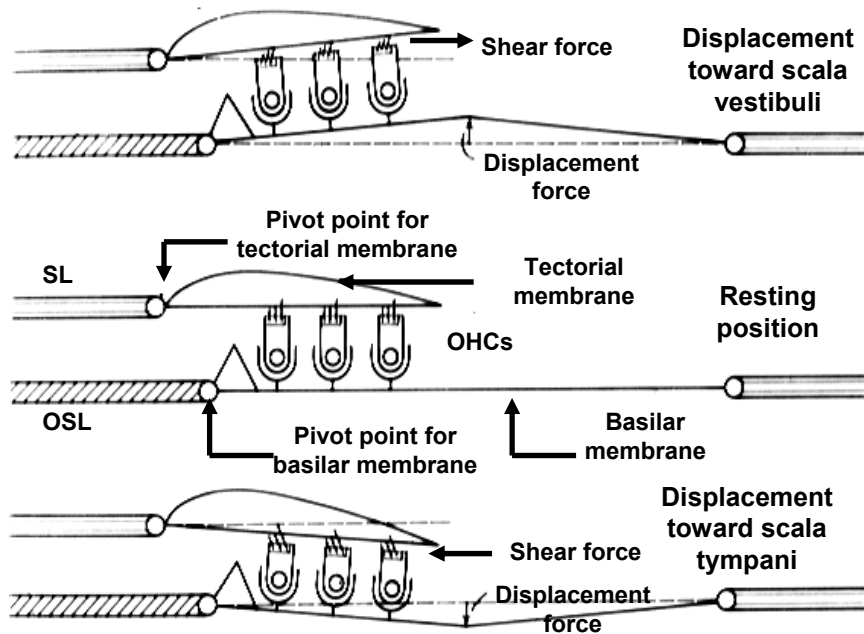
IB: inner border cell

RL: reticular lamina

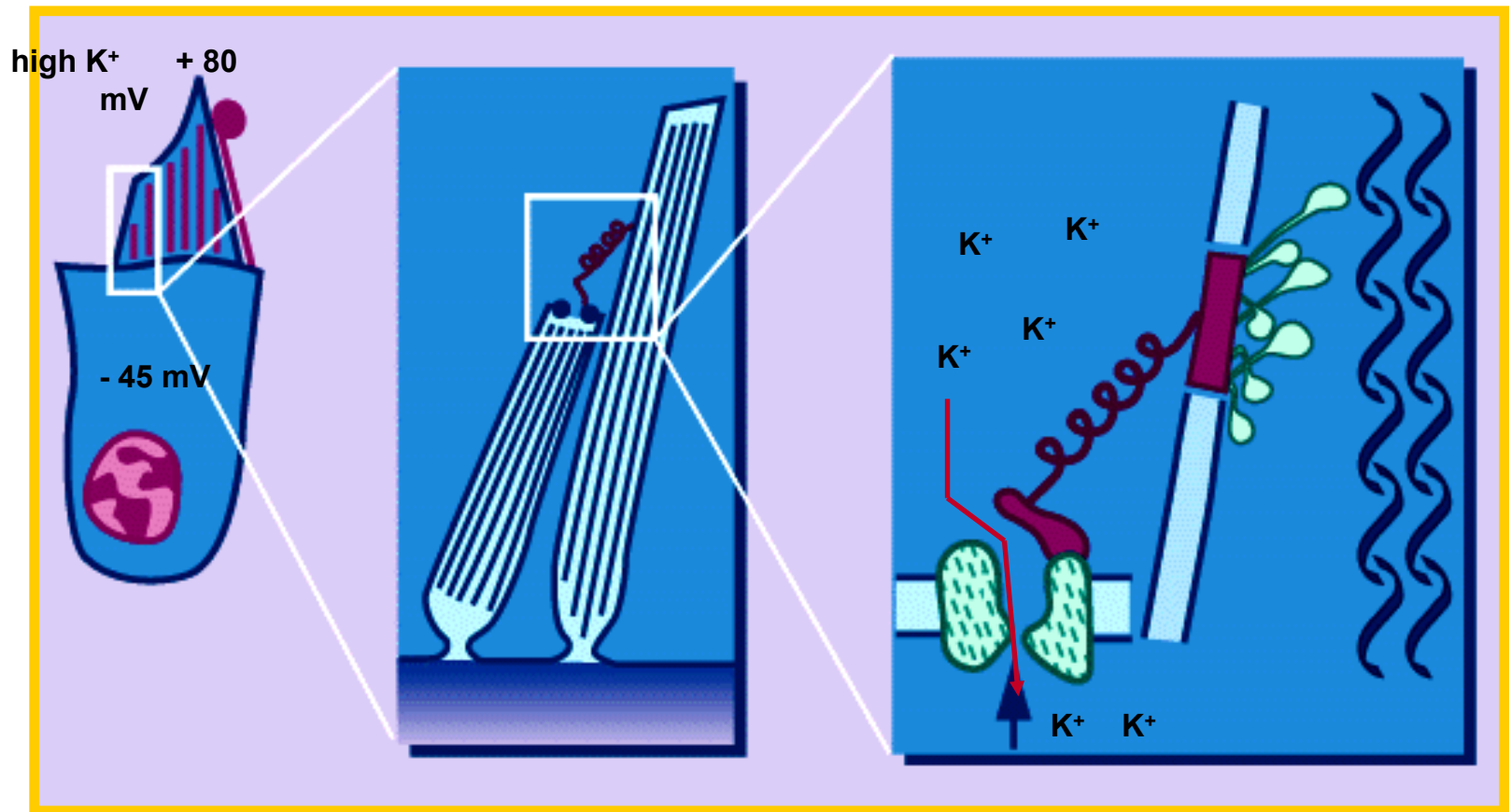
Stereocilia



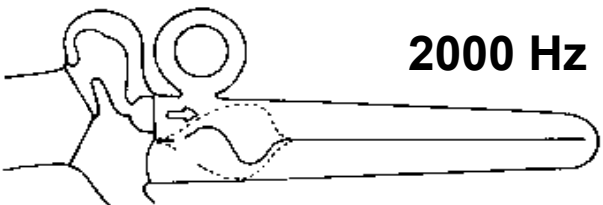
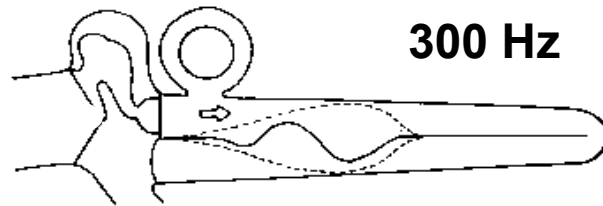
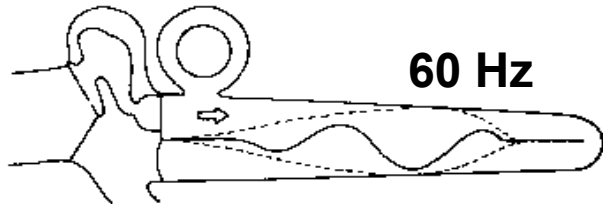
Function of Stereocilia



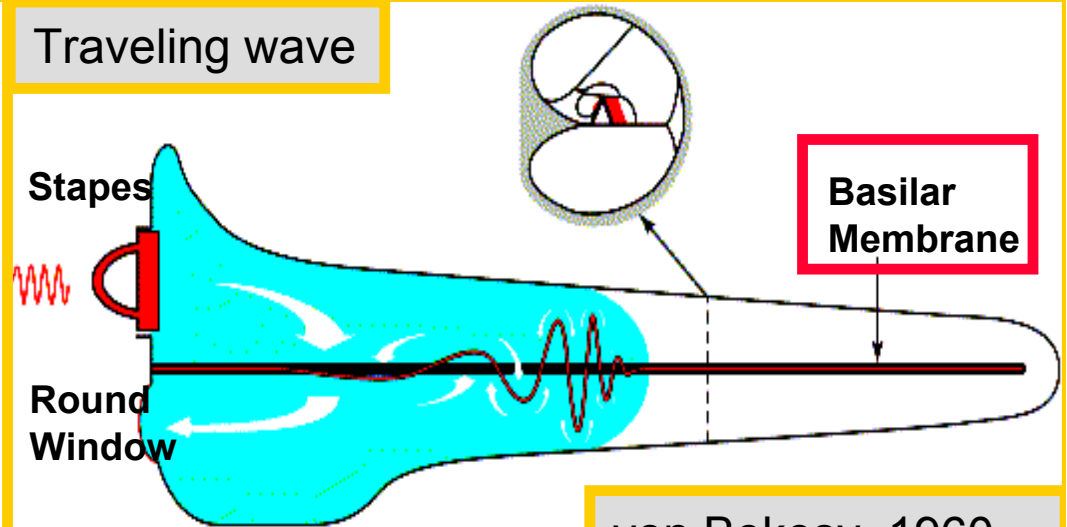
Mechanoelectrical Transduction



Frequency Selectivity - Passive Process



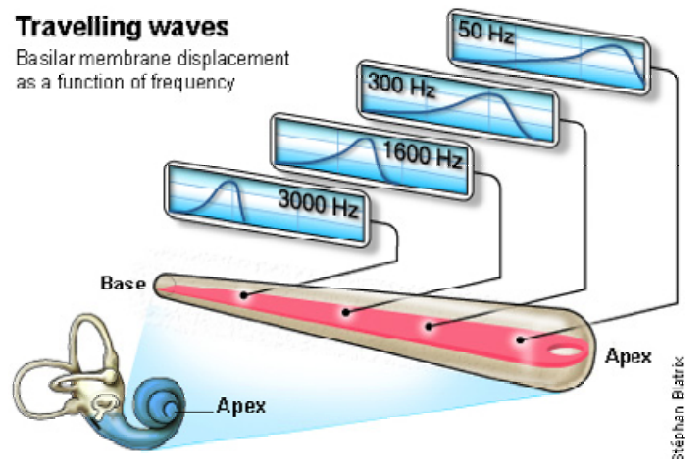
Traveling wave



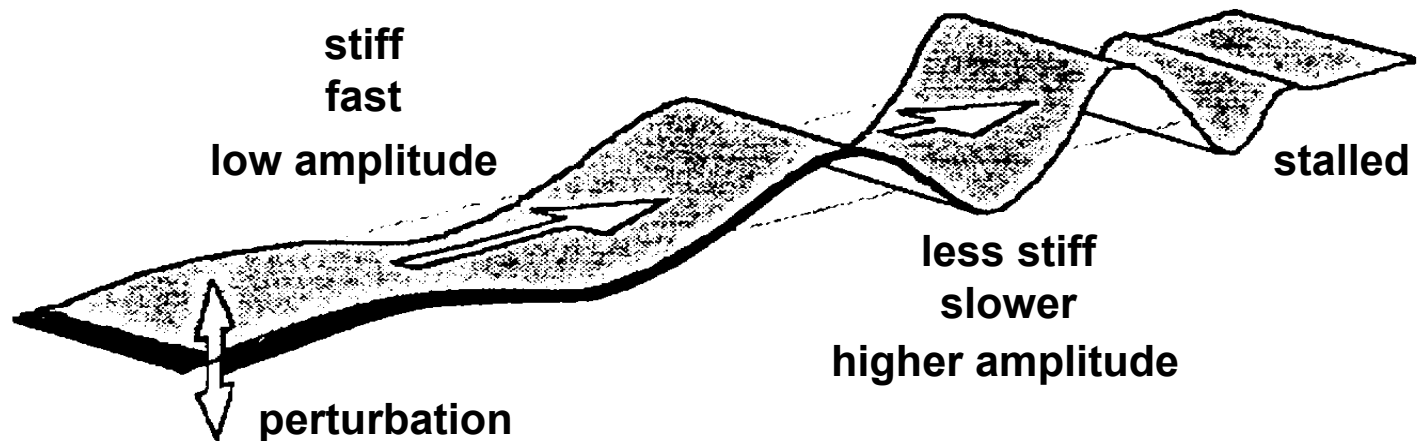
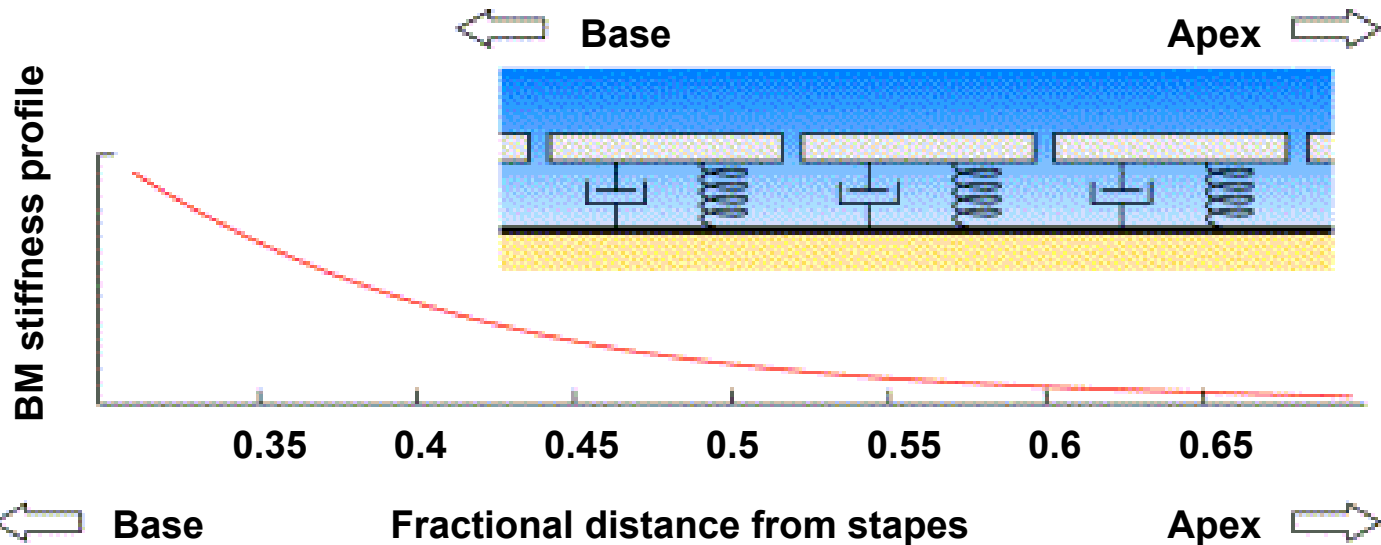
von Békésy, 1960

Travelling waves

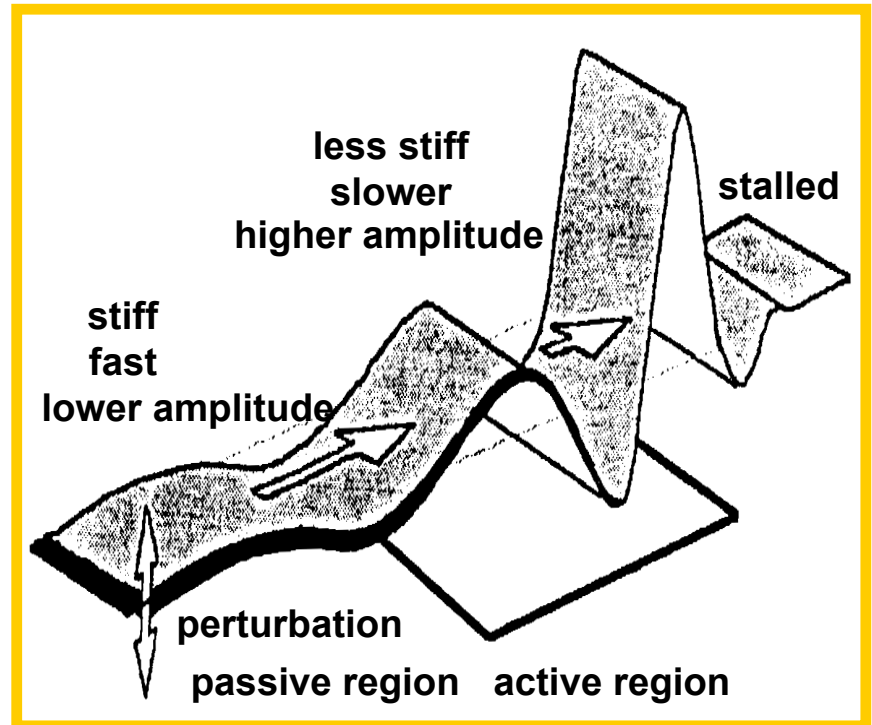
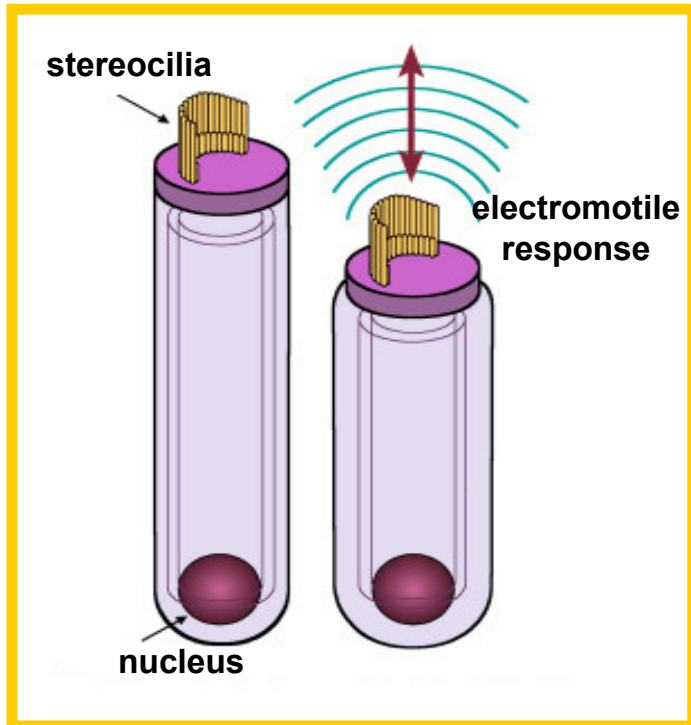
Basilar membrane displacement as a function of frequency



Basilar Membrane Movement

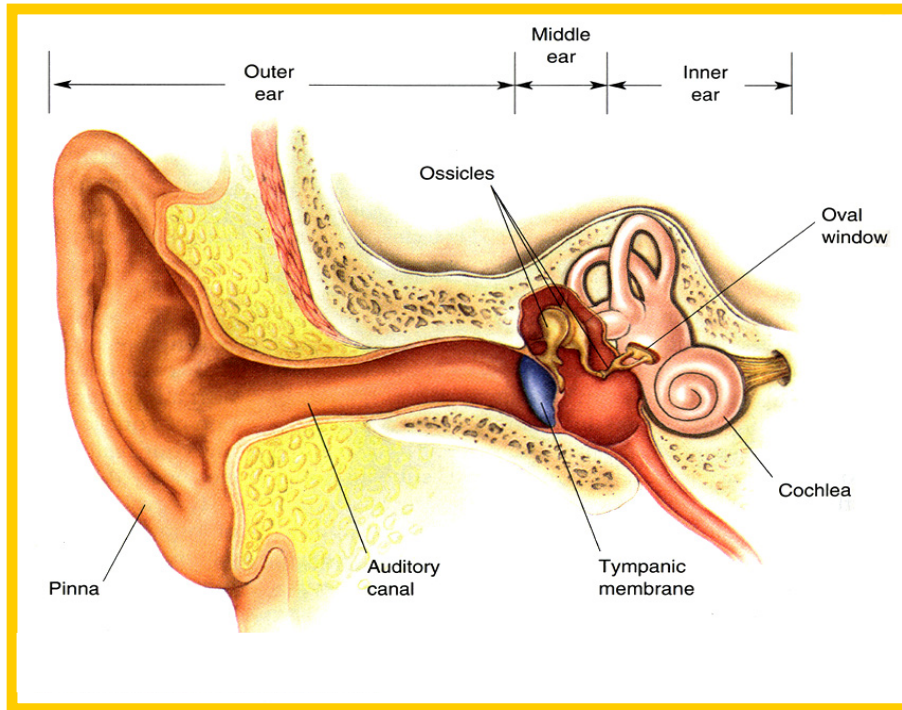


Frequency Selectivity - Active Process



Electromotility of OHC

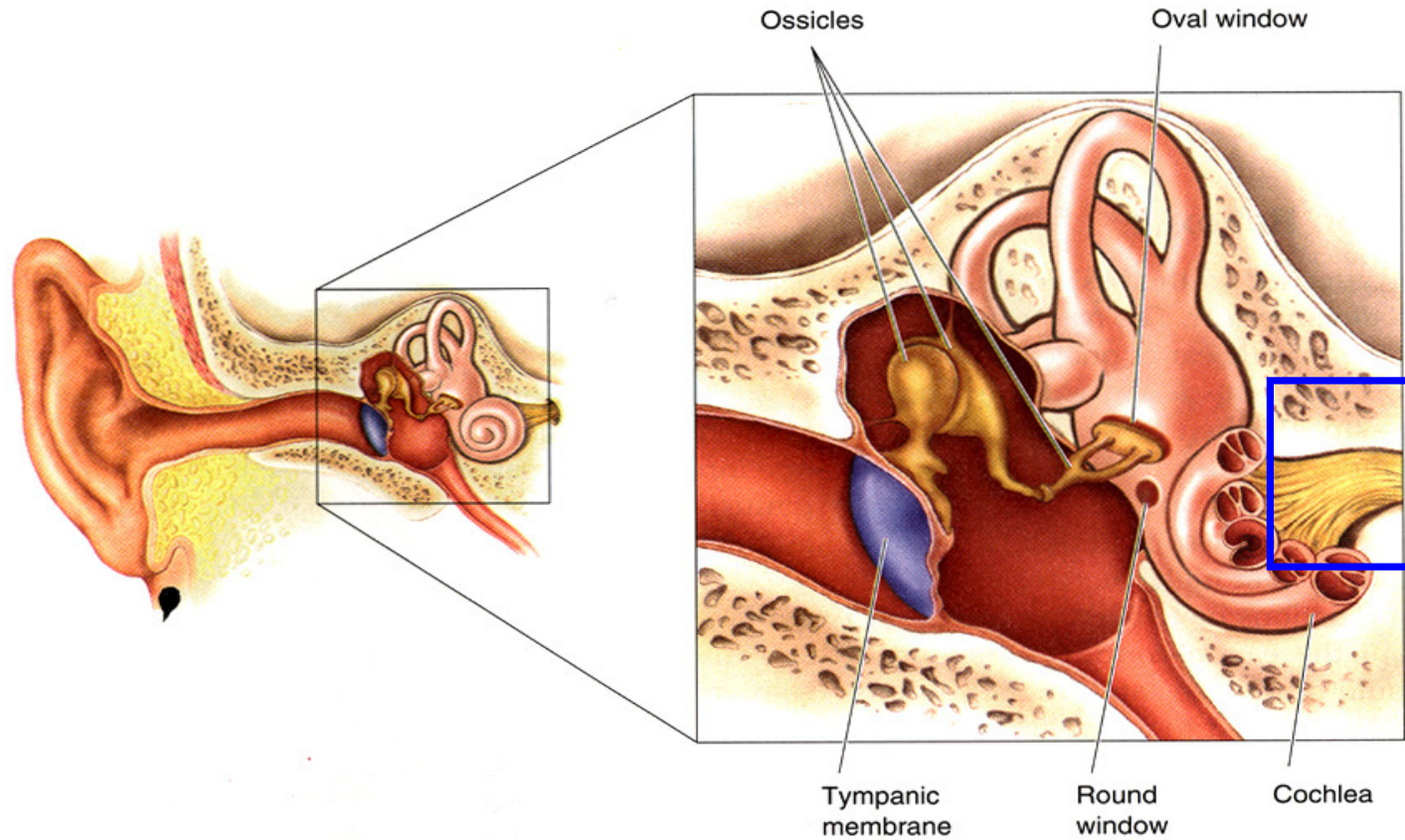
Conduction of the Sound



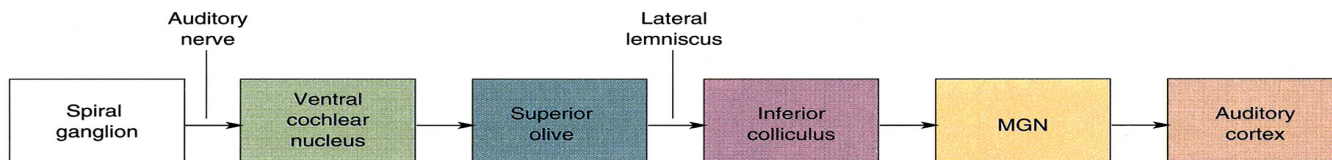
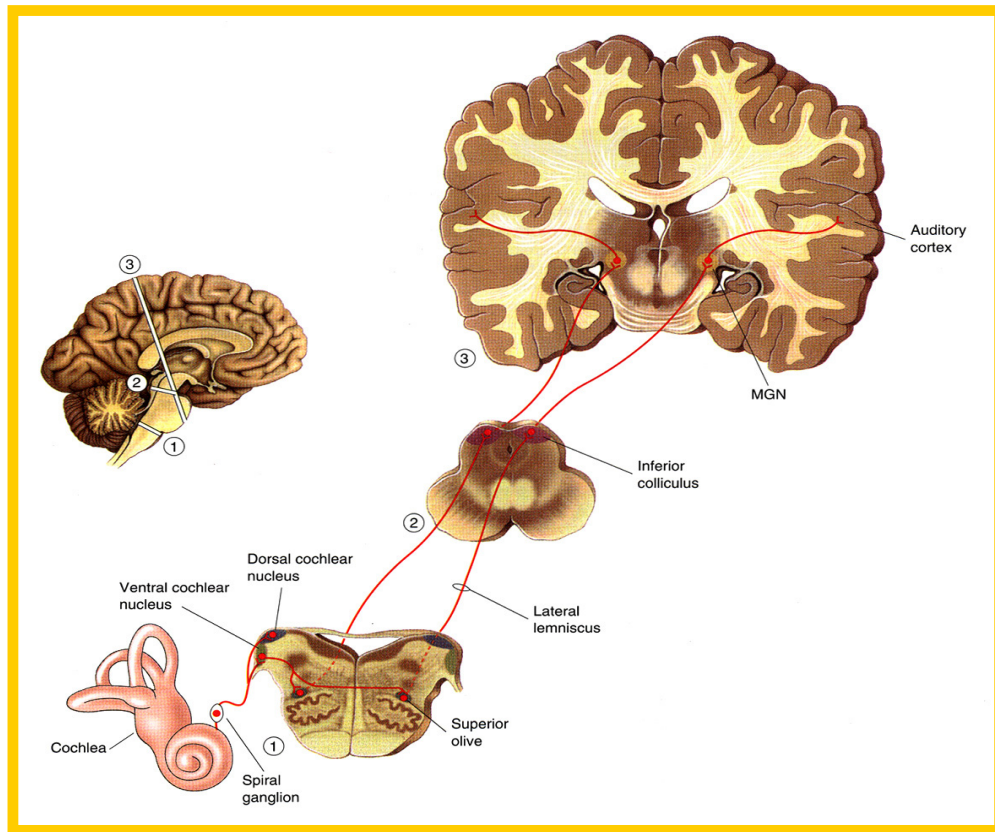
Air Conduction (AC)
Pinna - EAC - TM -
Ossicles- Cochlea

Bone Conduction (BC)
Vibration of the skull and
temporal bone - Cochlea

Auditory Nerve



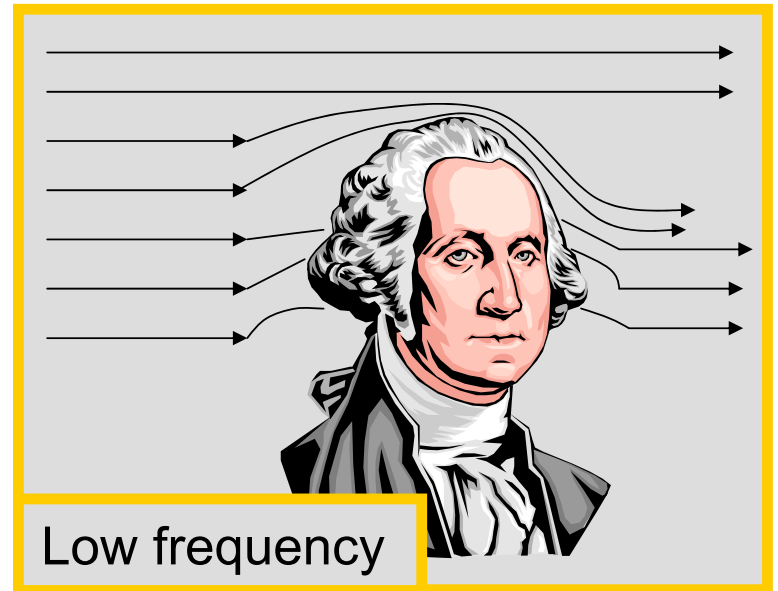
Central Pathways



Bilateral Hearing (Localization)

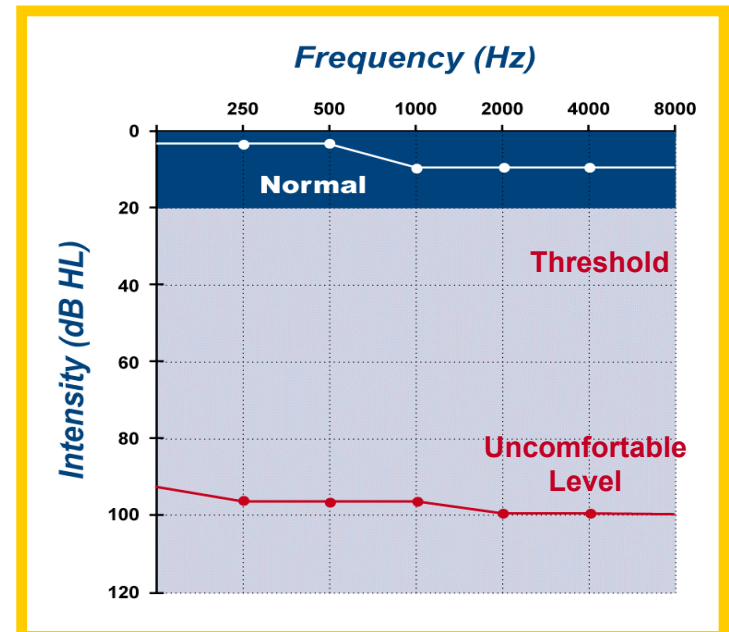
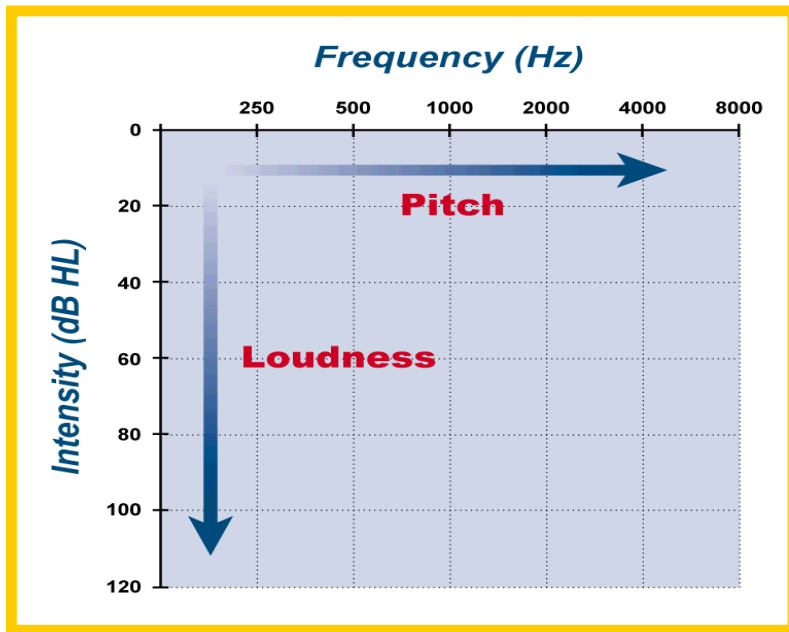


Interaural Level Difference



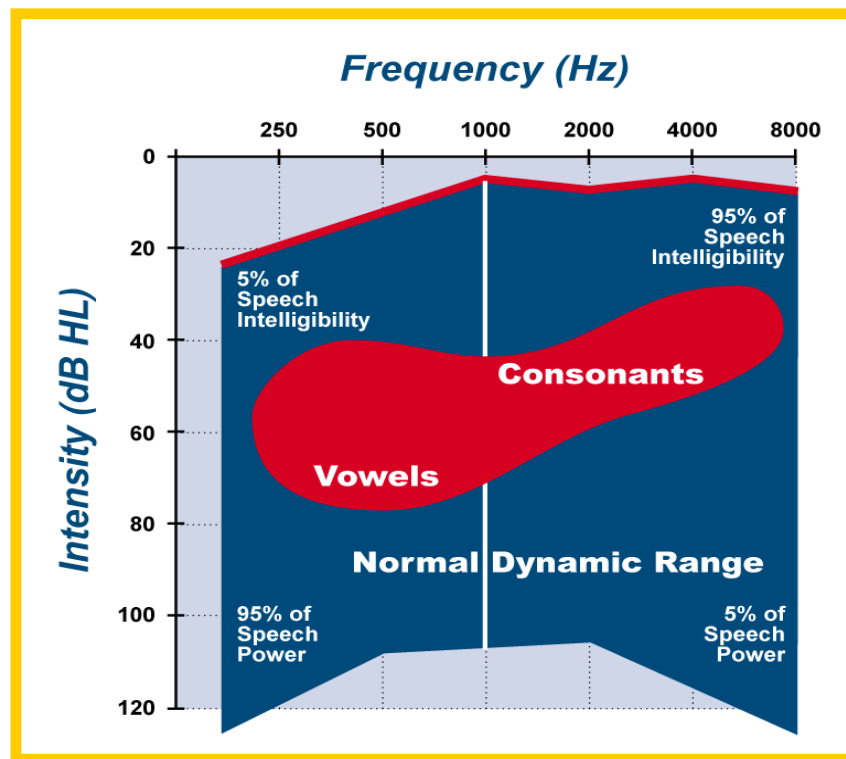
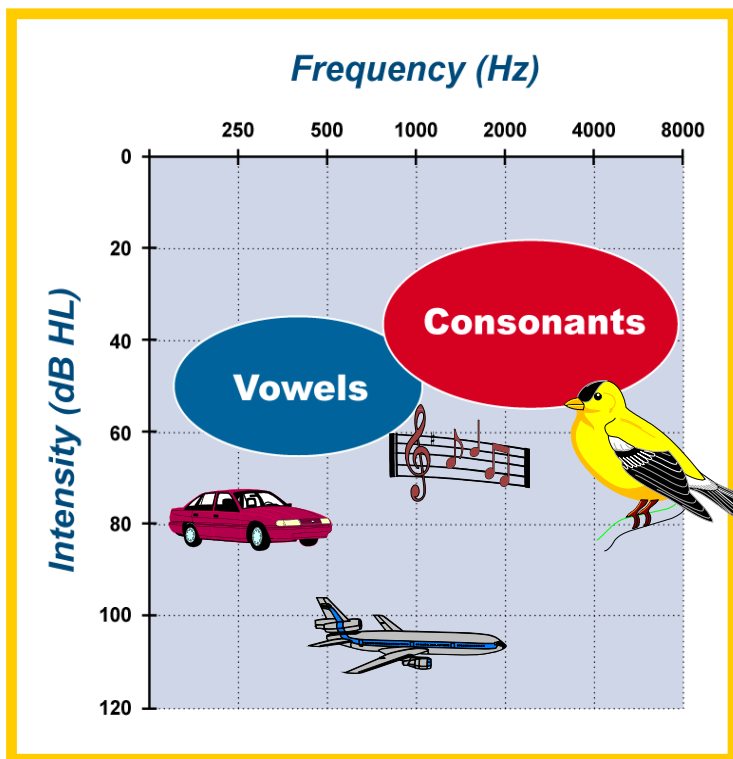
Interaural Time Difference

Pure Tone Audiometry

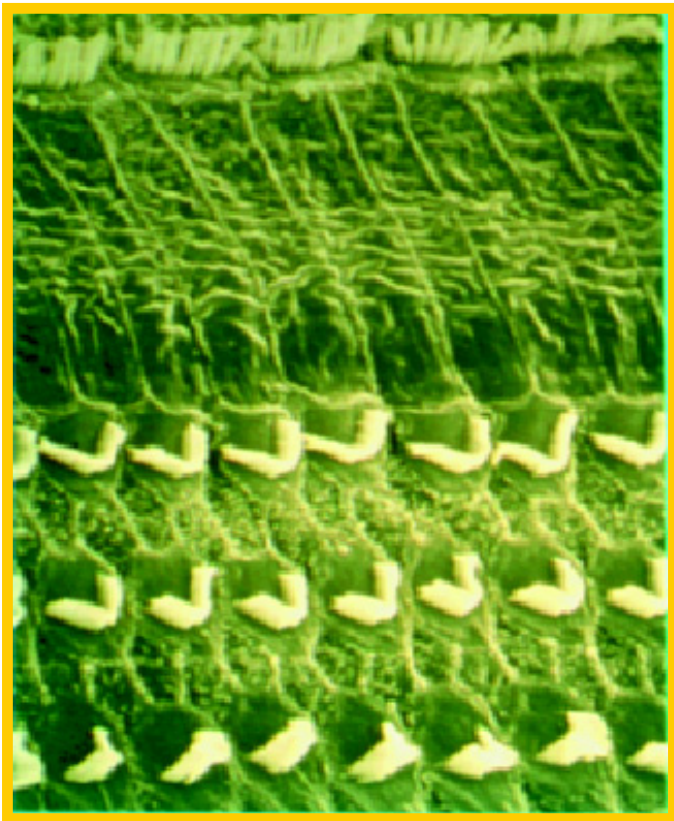


Measures ability to hear tones of different pitch and loudness

Range of Hearing

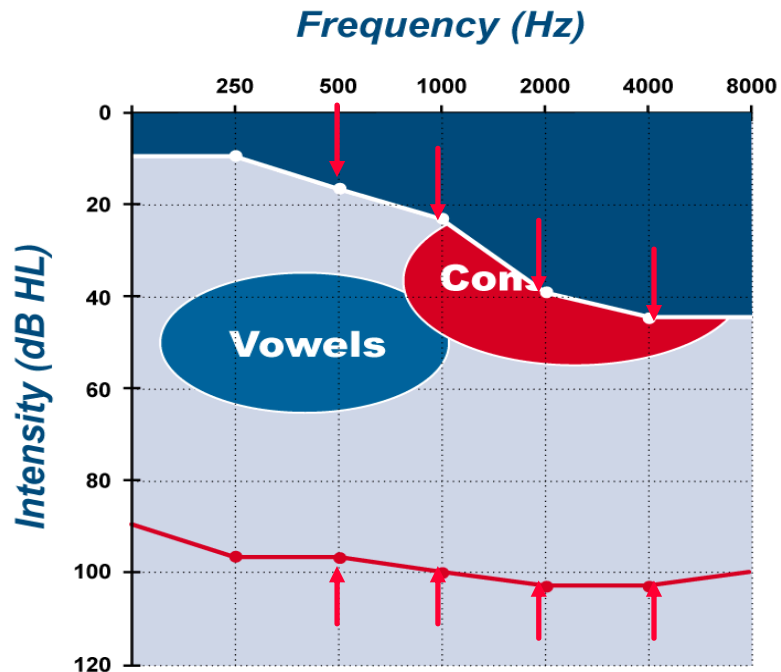


Partial Cochlear Damage

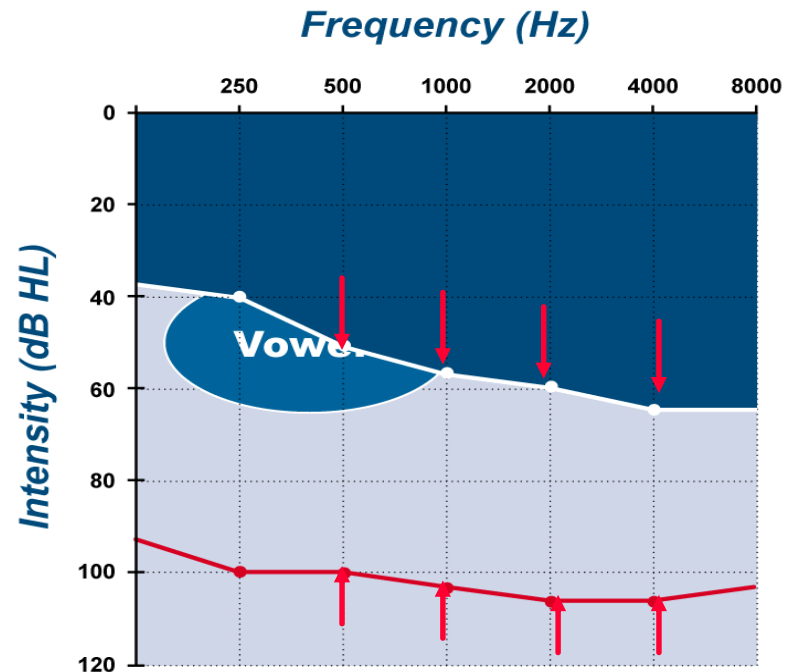


Cochlear Damage

Mild

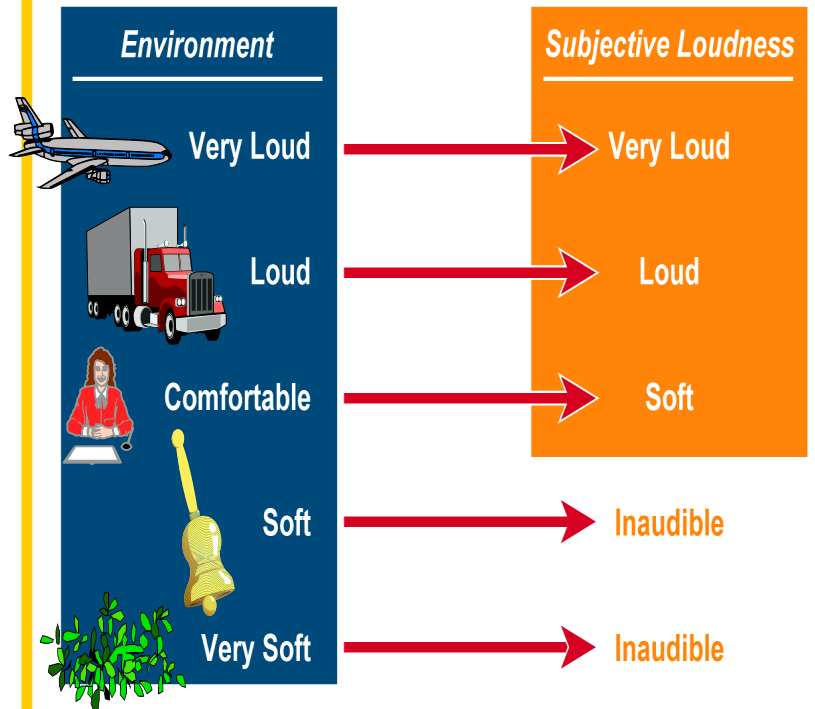
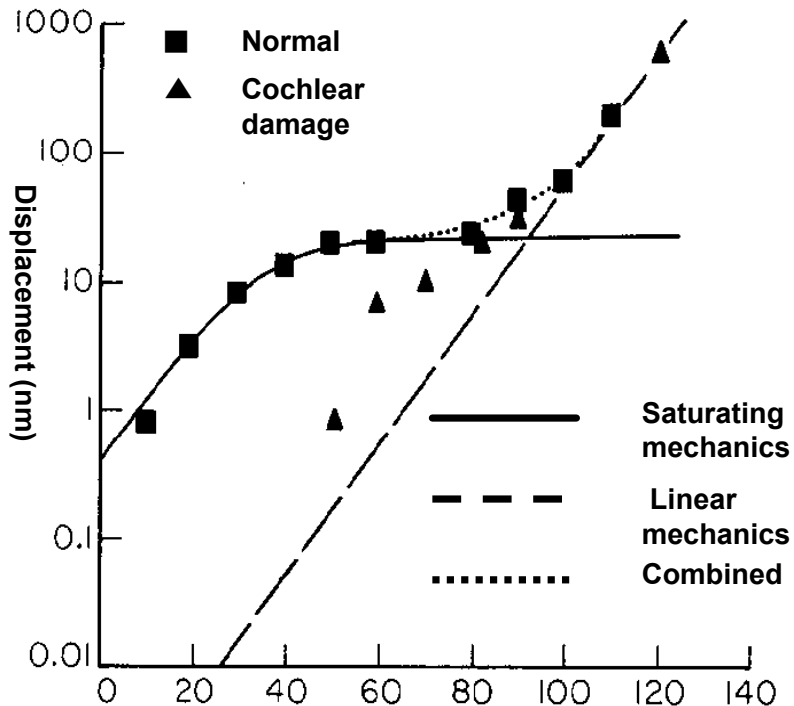


Moderate

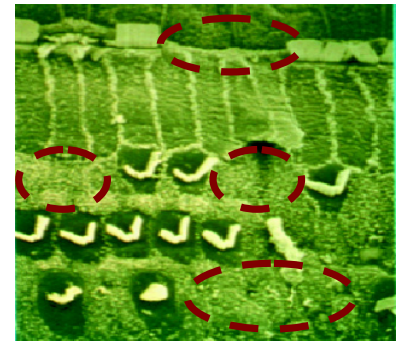
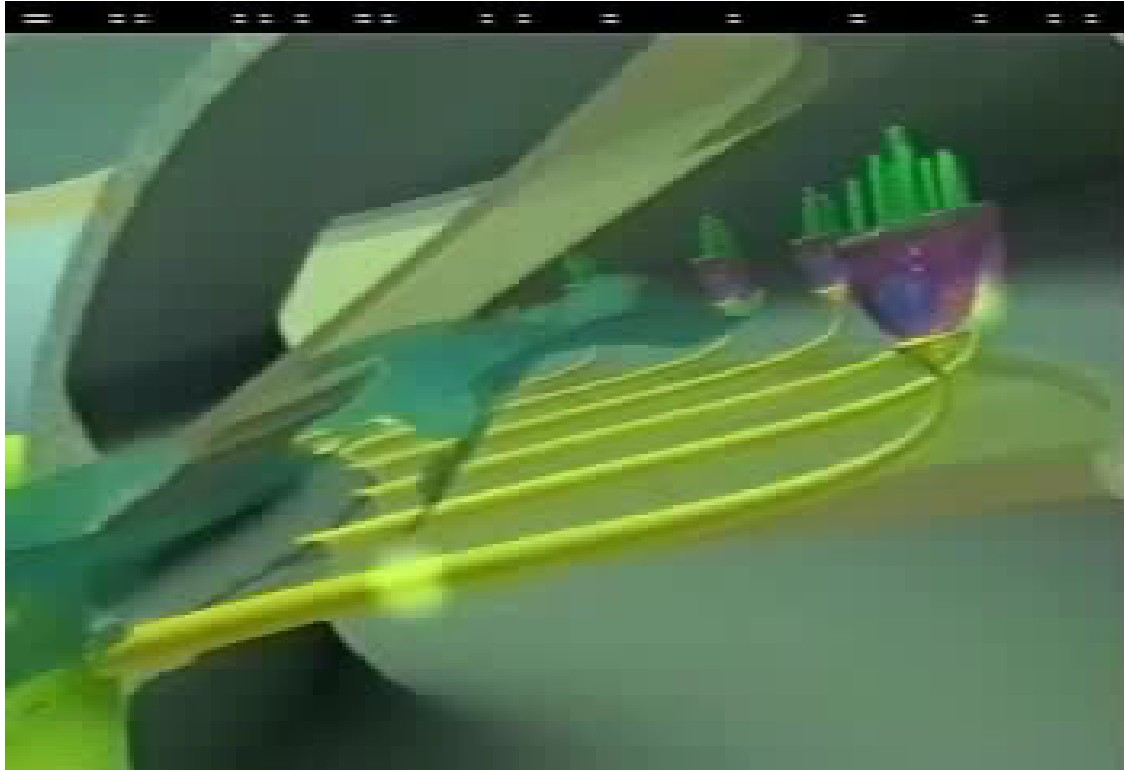


- Increased threshold
- Reduced dynamic range

Loss of Compressive Function and Reduction of Dynamic Range

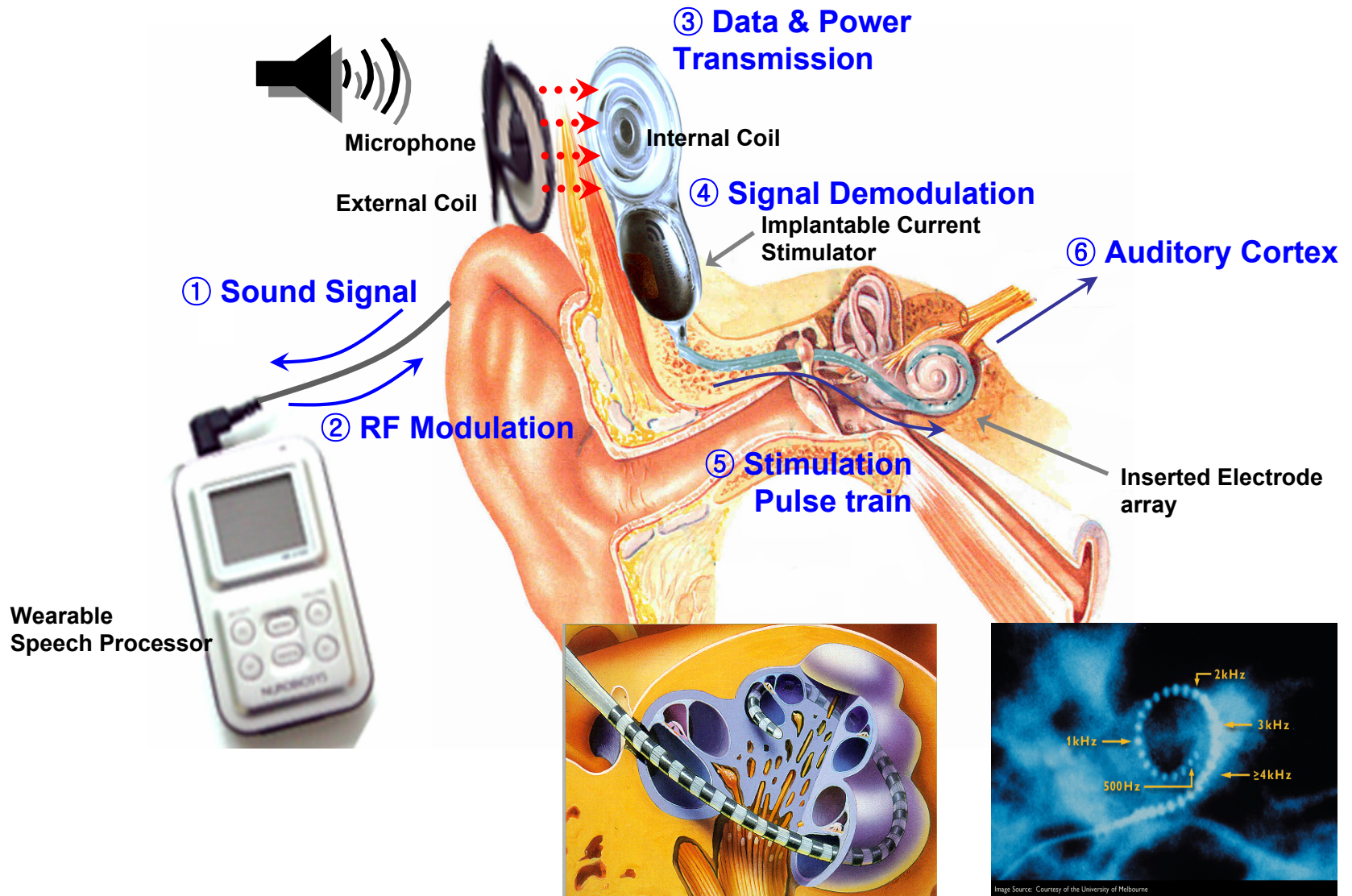


Restoring the Auditory Sensation



Advanced Bionics Corp., USA

Cochlear Implant (CI) System



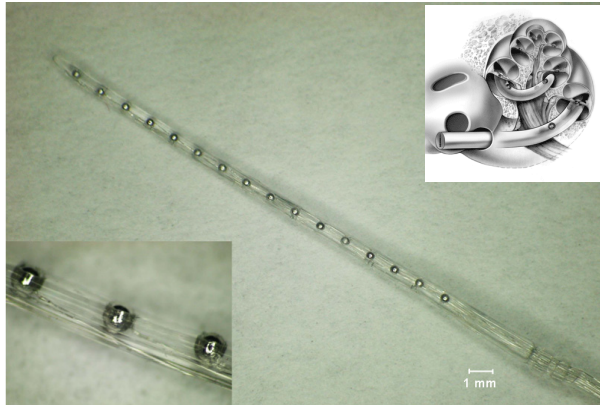
How CI System Works



Li Xu, Ohio State Univ.

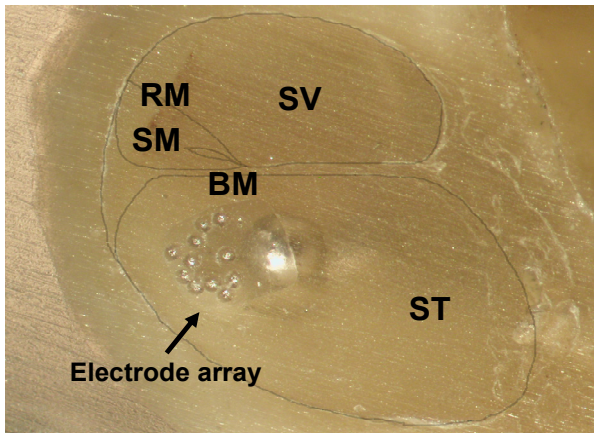
1 2 4 6 8 16 24 32 64 N

Intra-cochlear electrode array



◆ Intra-cochlear electrode array

- **simple** to fabricate.
- **reliable connection** between contacts and lines.



Possibilities for the future

- ◆ Further development and refinement of bilateral electrical stimulation and of combined EAS
- ◆ Closer mimicking of processing in the normal cochlea
- ◆ Representation of “fine structure” or “fine frequency” information with implants
- ◆ A “cognitive neuroscience” or “top down” approach to implant design
- ◆ Availability of low cost – but still highly effective – implant systems for widespread application in India, China and other developing countries
- ◆ Controlled delivery of neuro-protective or neurotrophic drugs to the implanted cochlea