MUNI
MED

MUNI
MED

8

Auditory and vestibular system

Auditory system

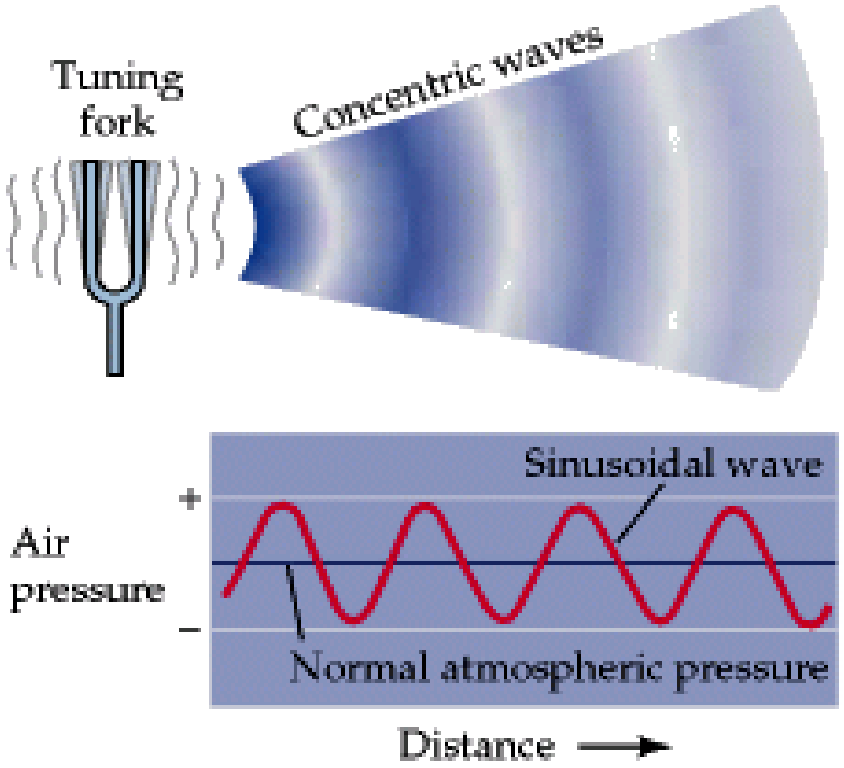
- Transduction of sound waves to the receptor and the action potential
- Transmission to CNS
- Signal processing
  - Sound decoding
  - Interpretation

MUNI MED

Auditory system

- Transduction of sound waves to the receptor and the action potential generation
- Transmission to CNS
- Signal processing
  - Sound decoding
  - Interpretation

Sound is audible mechanical vibration of an elastic medium such as air

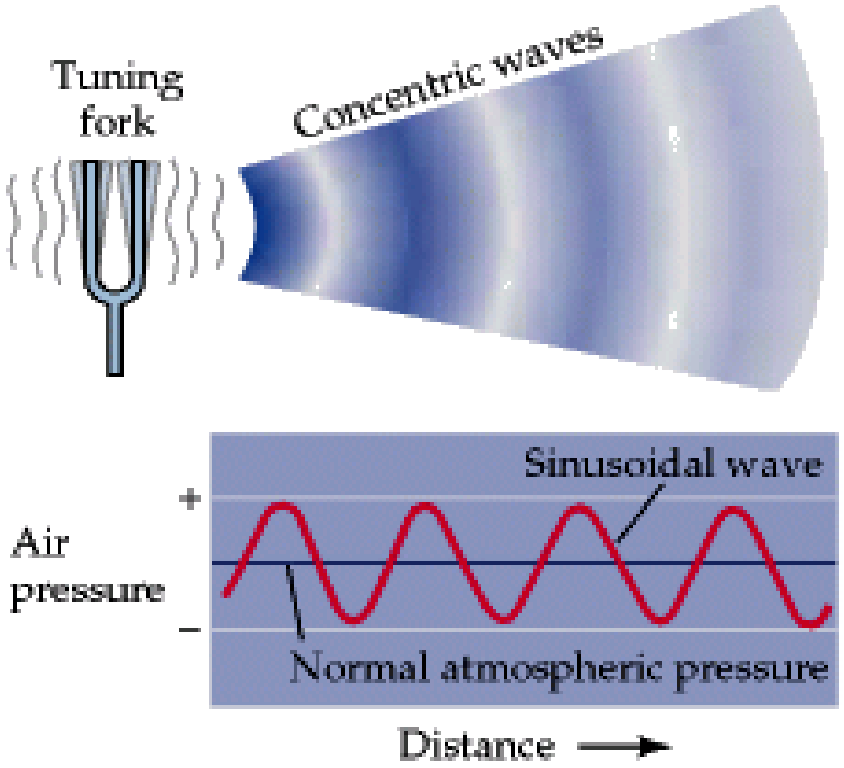


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Auditory system

- Air/water vibration caused by solid object
- Sound characteristics
  - Frequency – pitch
  - Amplitude – intensity
  - Timbre – given by representation of harmonic frequencies of the oscillation
- Pure tone
- Complex sound

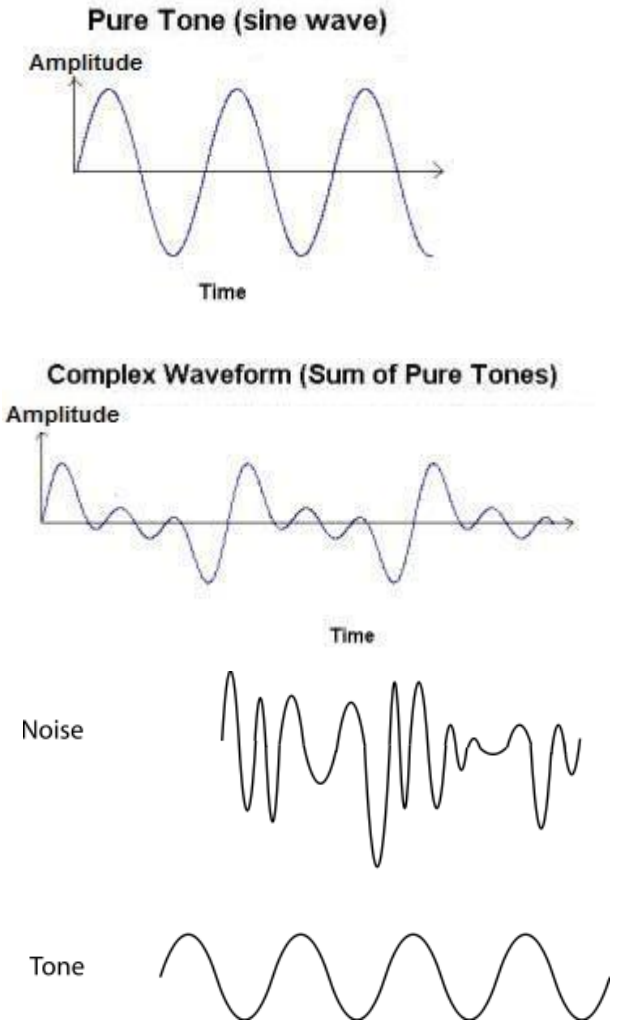


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

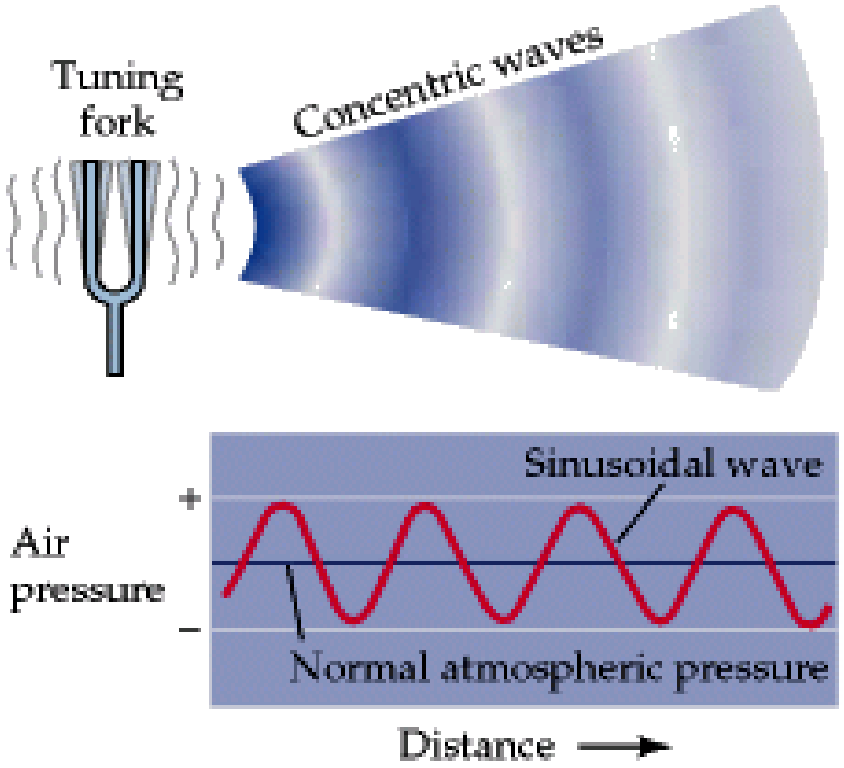
Sound

- Pure tone
  - Determined by frequency
- Complex sound
  - Sum of pure tones
    - Harmonic (musical)
      - periodic
    - Disharmonic (noise)
      - aperiodic



http://www.earmaster.com/music-theory-online/ch03/chapter-3-2.html

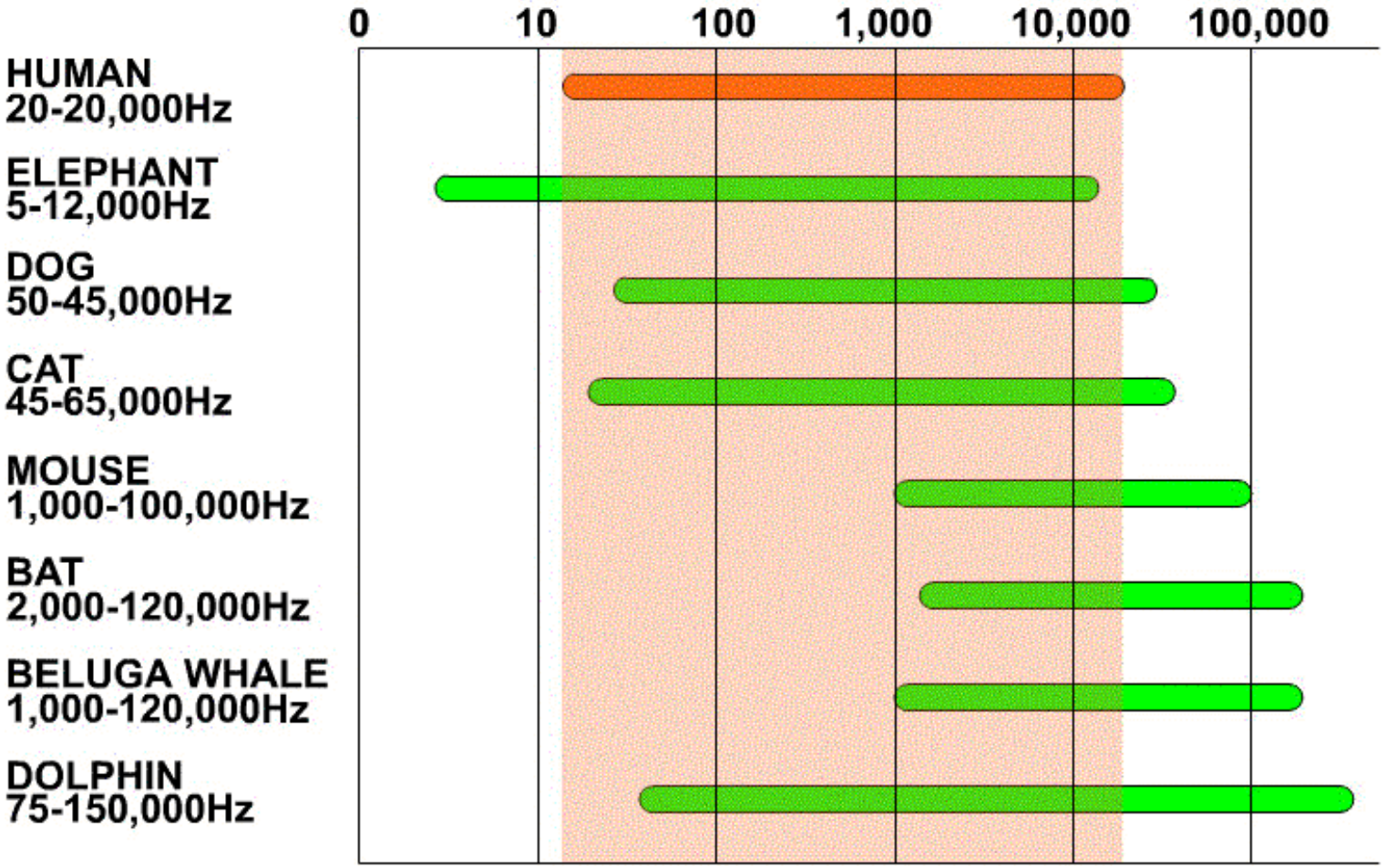
http://www.acoustics.salford.ac.uk/acoustics_info/sound_synthesis/



http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Audible spectrum

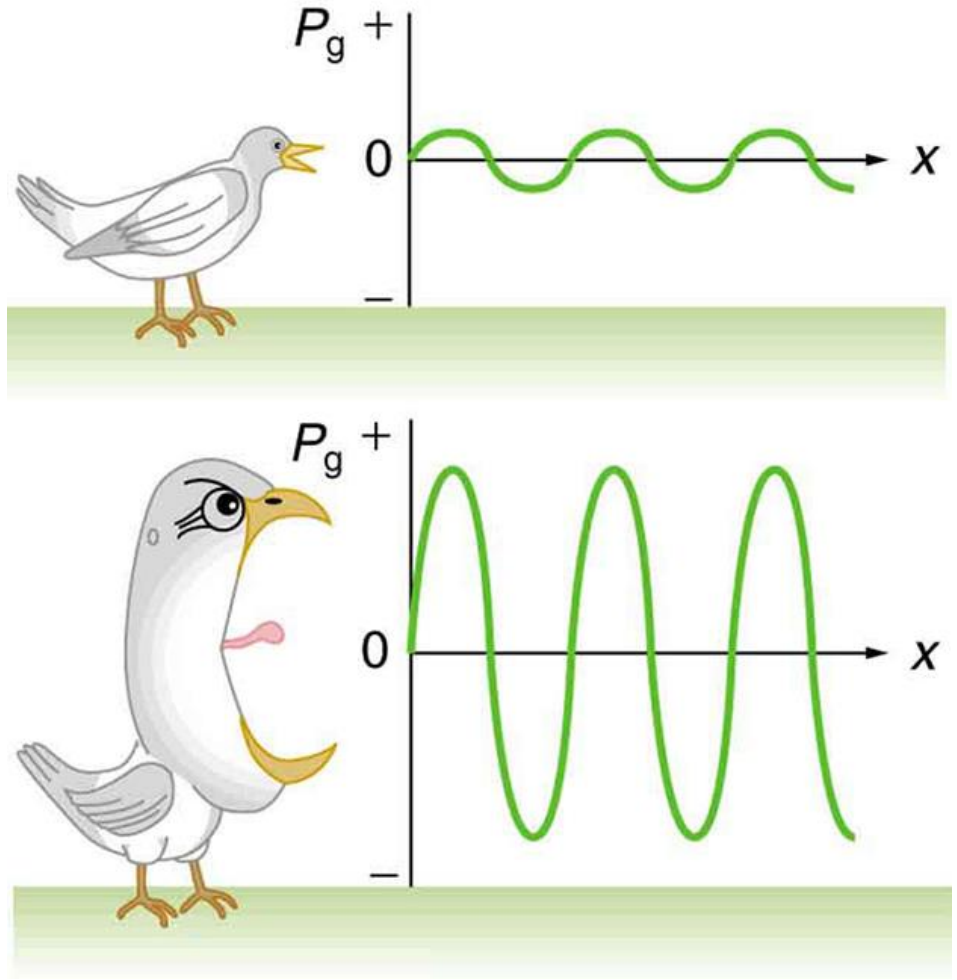


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

The intensity and volume of sound

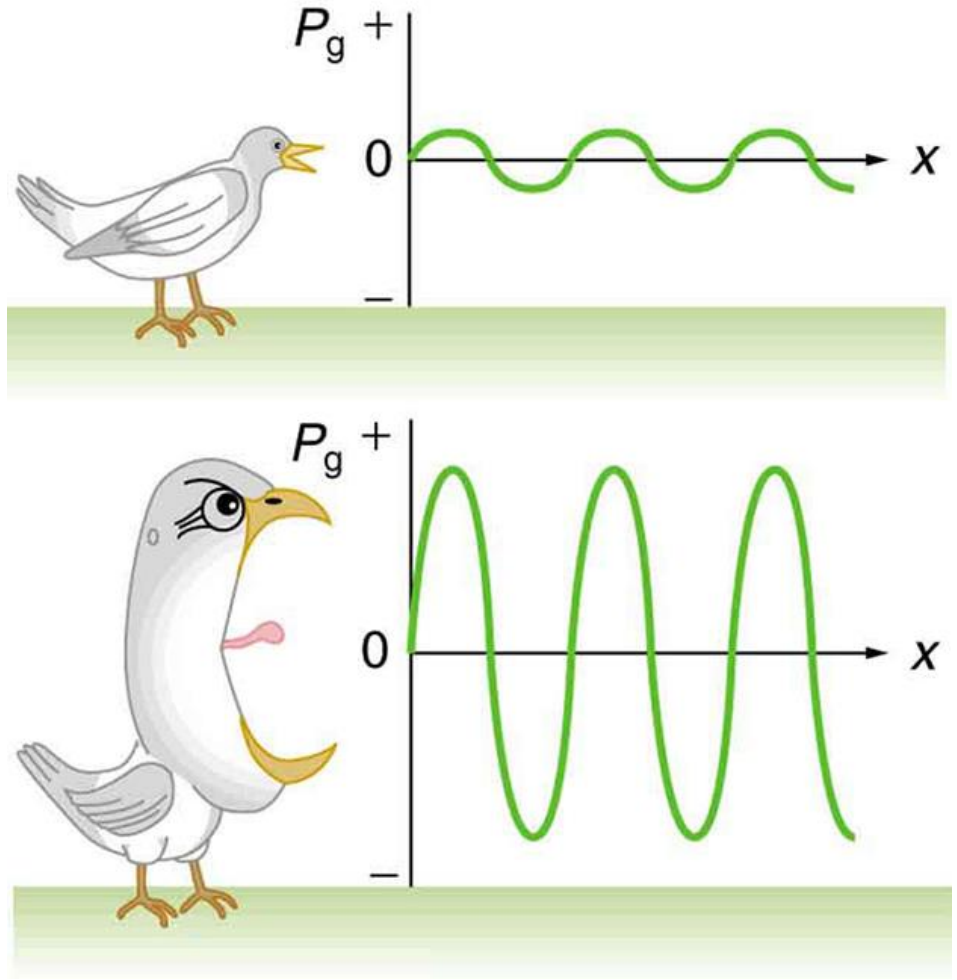
- Intensity of sound
  - Amplitude
    - Whisper – 20 dB
    - Speaking - 65 dB
    - Jet engine – 100 dB
    - Pain treshold – 120 dB



MUNI MED

The intensity and volume of sound

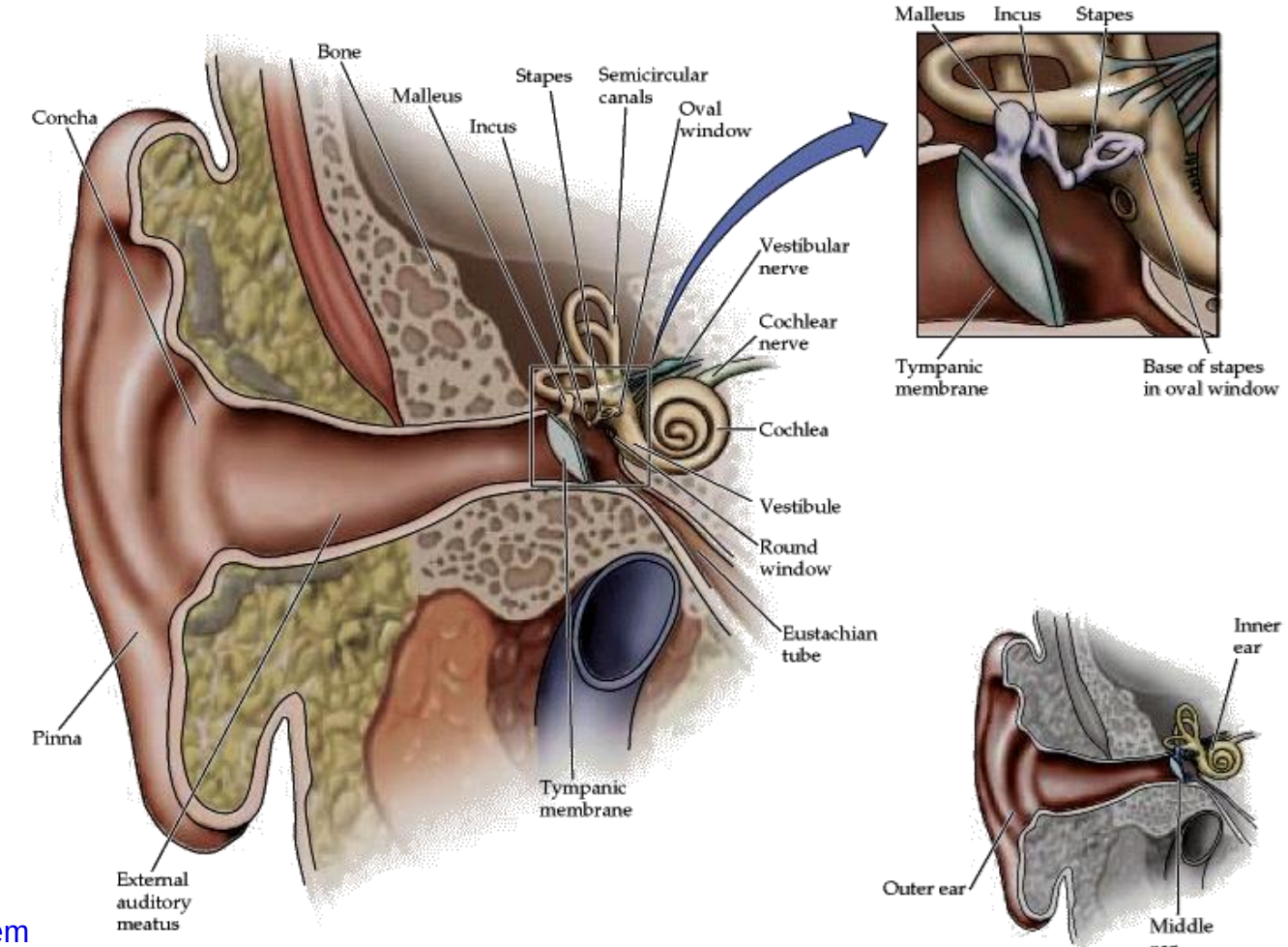
- Intensity of sound
  - Amplitude
    - Whisper – 20 dB
    - Speaking - 65 dB
    - Jet engine – 100 dB
    - Pain treshold – 120 dB
- Volume
  - Subjectively perceived intensity



MUNI MED

External ear

- ✓ Transmission of acoustic signal from environment to the tympanic membrane

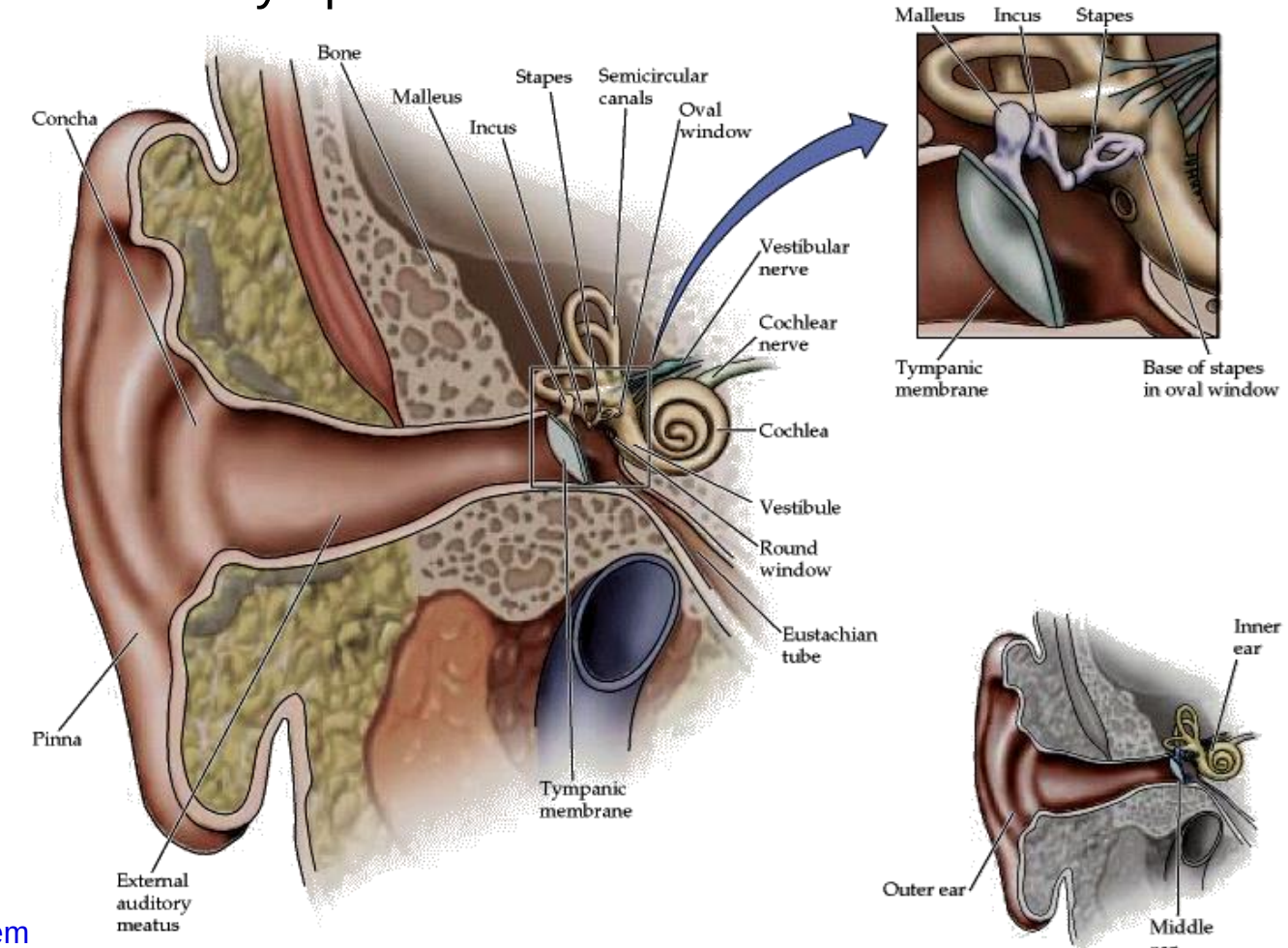


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Middle ear

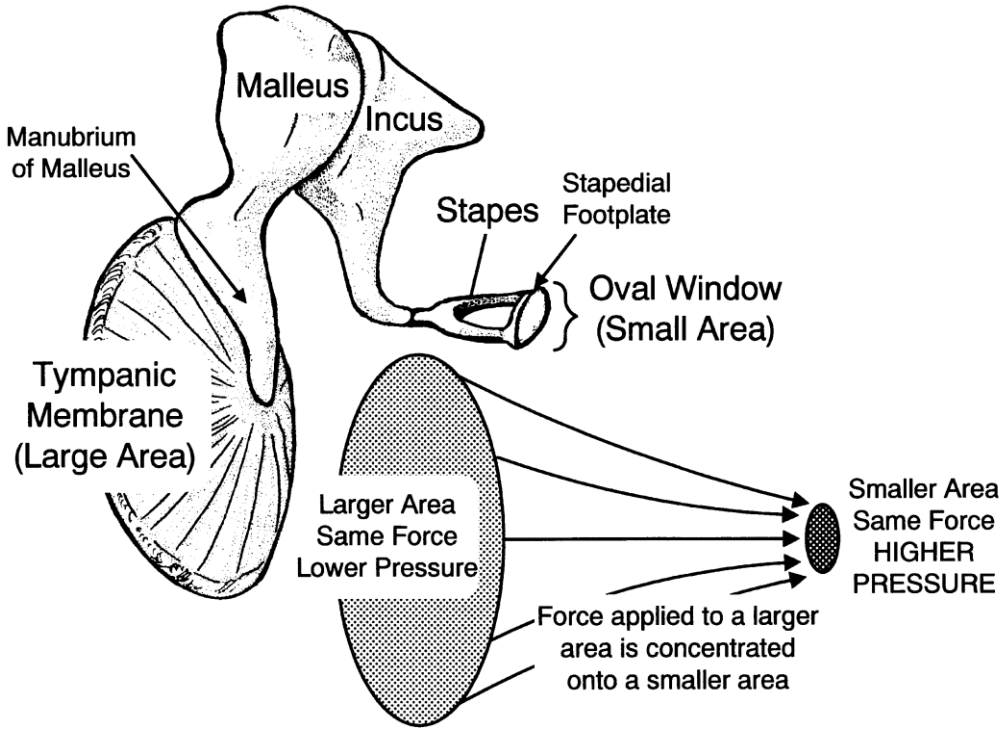
- ✓ Transmission of acoustic signal from the tympanic membrane to the oval window and endolymph/basilar membrane –ossicular vs bone conduction



MUNI MED

Middle ear

- A significant difference in acoustic impedance between air and endolymph
- Signal amplification
  - Tympanic membrane area/oval window area
  - Ossicles
- Protective function
  - m.stapedius and tensor tympani
  - Eustachian tube

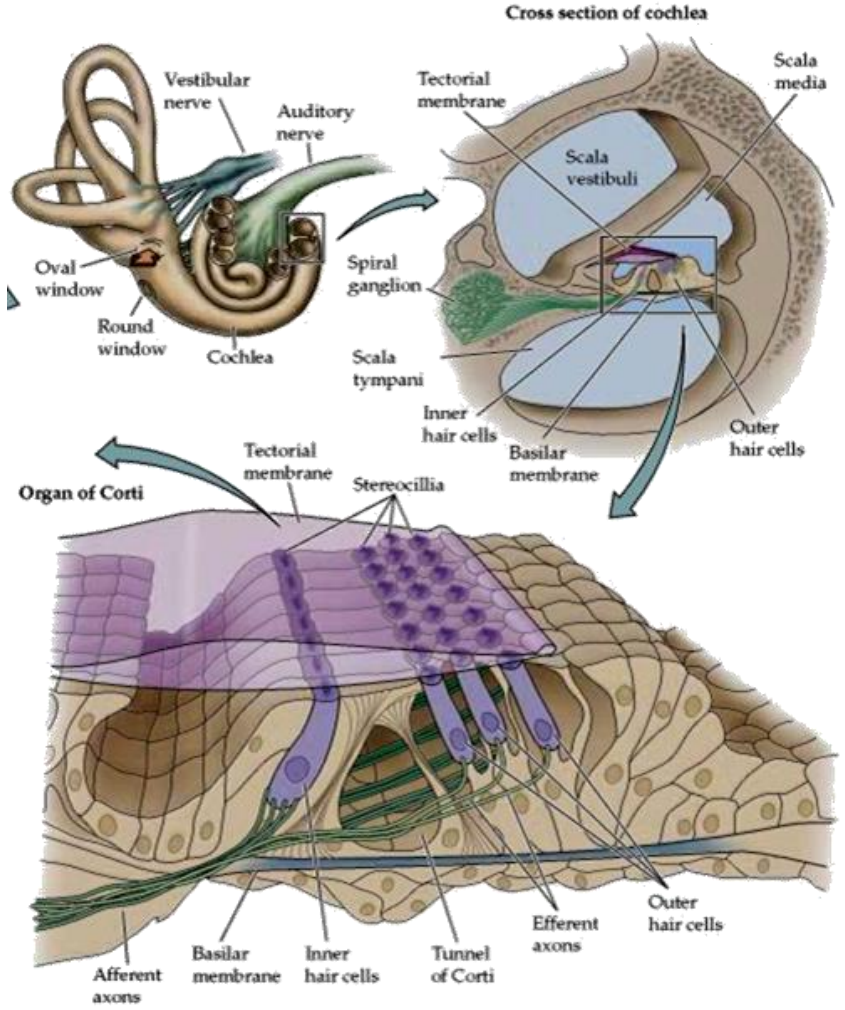


http://slideplayer.com/slide/3433153/

MUNI MED

Inner ear

- ✓ Transduction of endolymph/basilar membrane vibrations to receptor and action potential

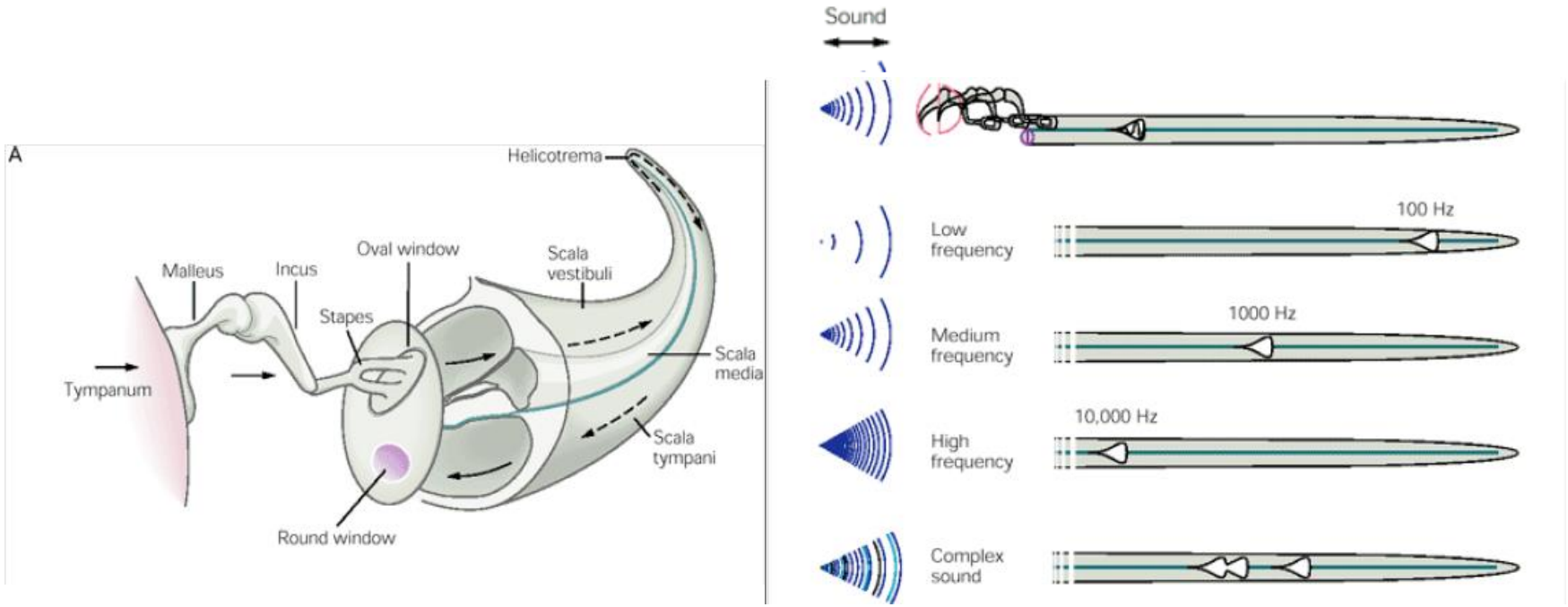


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Tonotopic arrangement

- Proximal part
  - high frequency
- Distal part
  - low frequency



http://www.slideshare.net/drpsdeb/presentations

MUNI MED

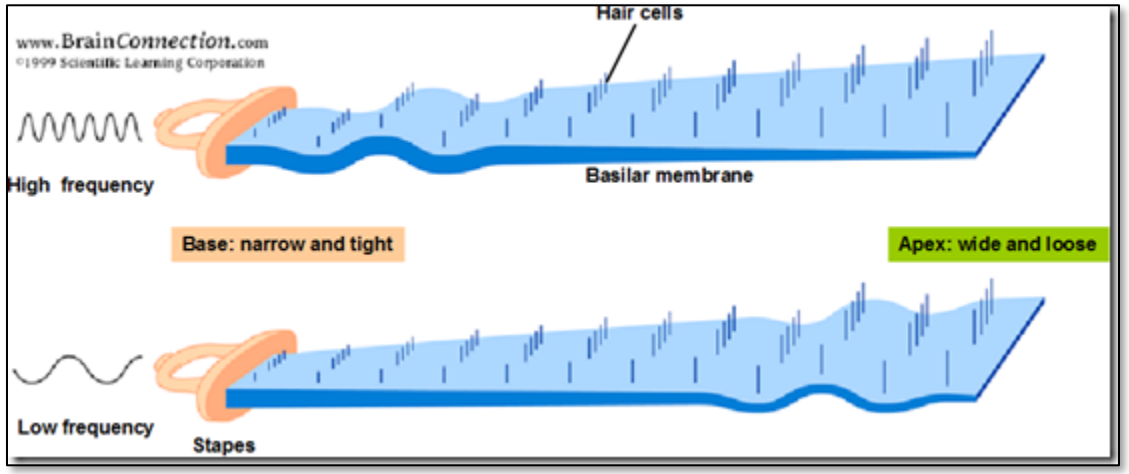
Basilar membrane

- Basal part
  - Narrow and tight

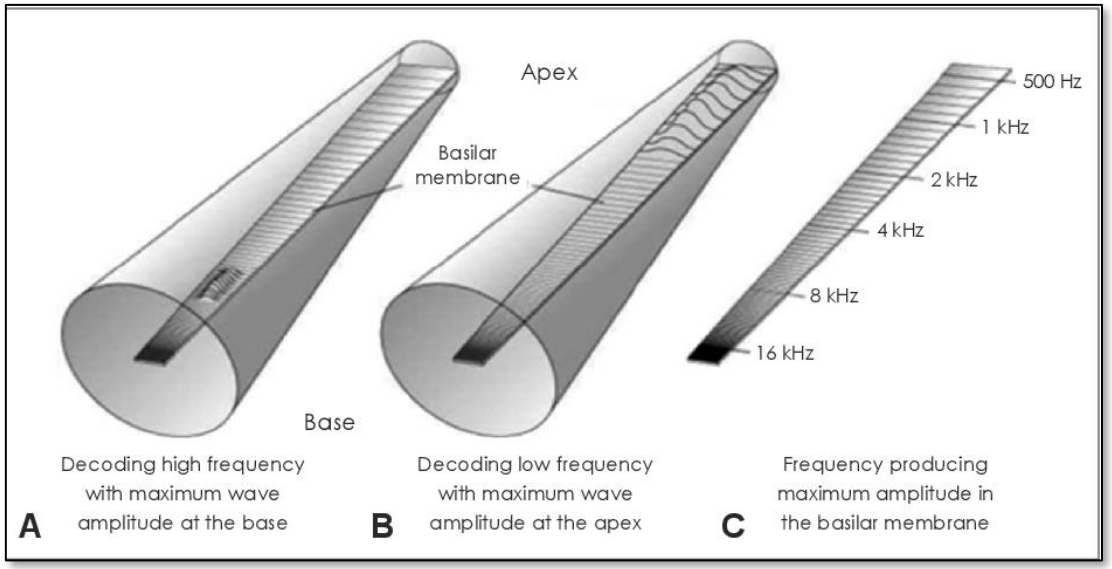
  High frquencies

- Apical part
  - Wide and loose

  Low frequencies



http://lh6.ggpht.com/_RIjx_Mg4ZVM/TNeYbcwJOYI/AAAAAAAACmA/9S_7HaZu5DI/s1600-h/image%5B62%5D.png

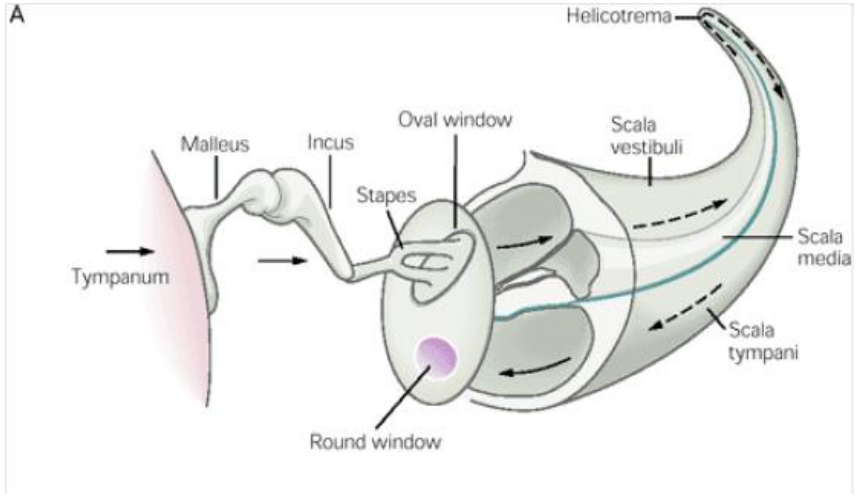


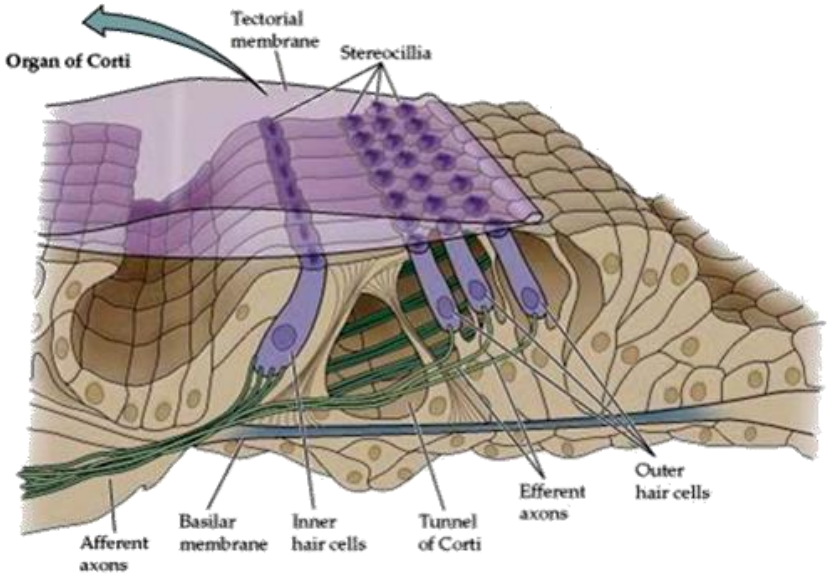
https://www.semanticscholar.org/paper/Mass-and-Stiffness-Impact-on-the-Middle-Ear-and-the-Kim-Koo/16a2a6b5ffd1c963efd906cea109277bfbf0d7e3/figure/3

MUNI MED

Organ of Corti

- Inner hair cells
  - aprox. 3 500
- Outer hair cells
  - aprox. 12 000
- Tectorial membrane



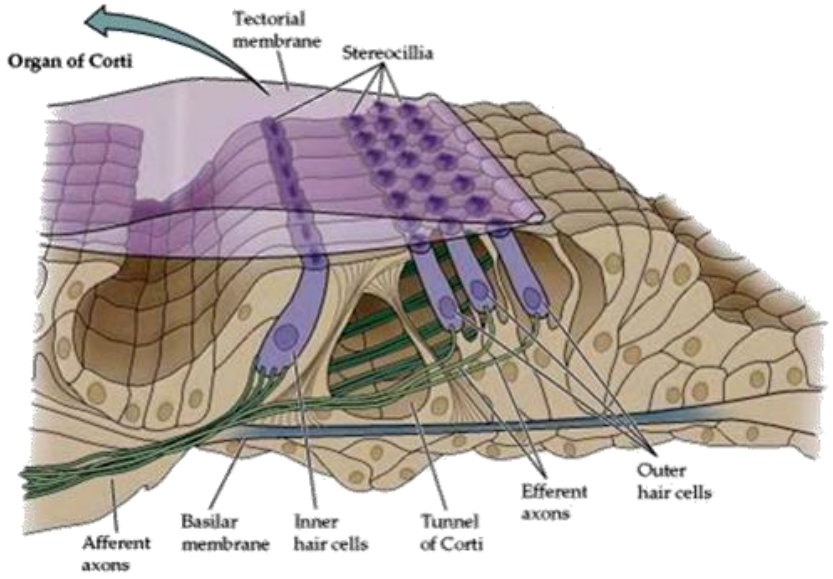


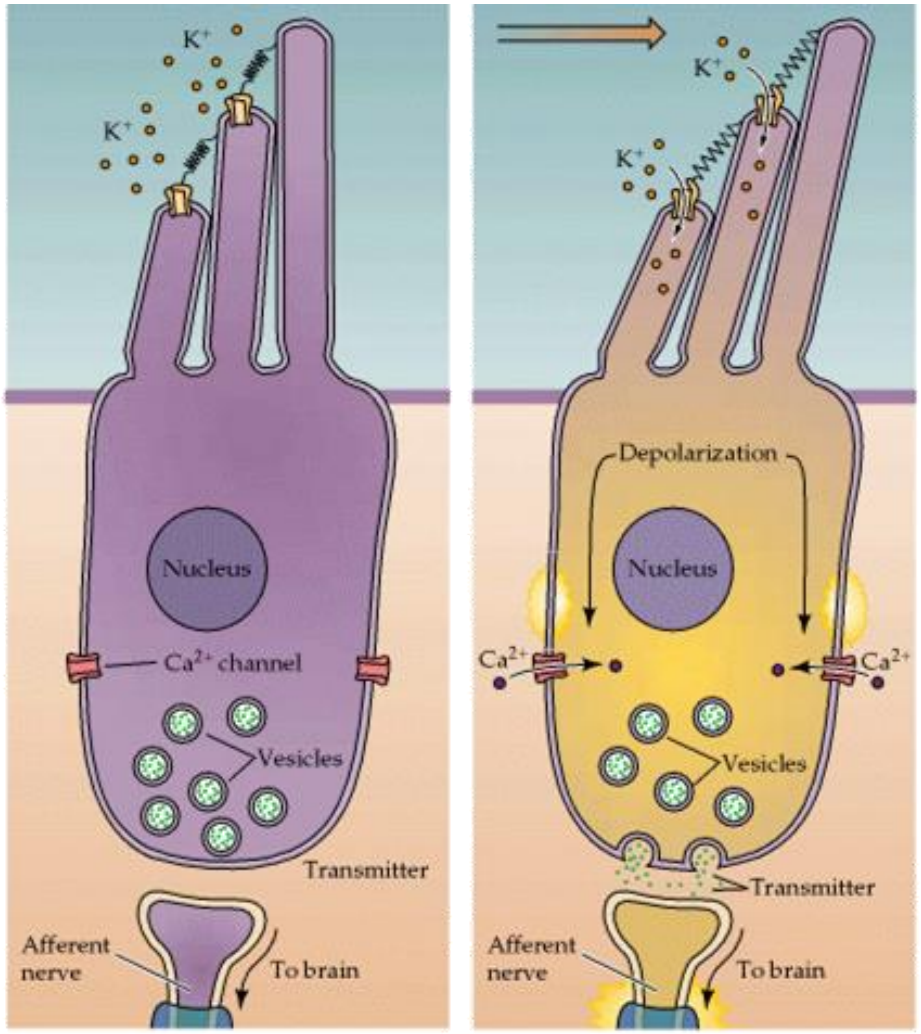
http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Inner hair cells

- Sensory function



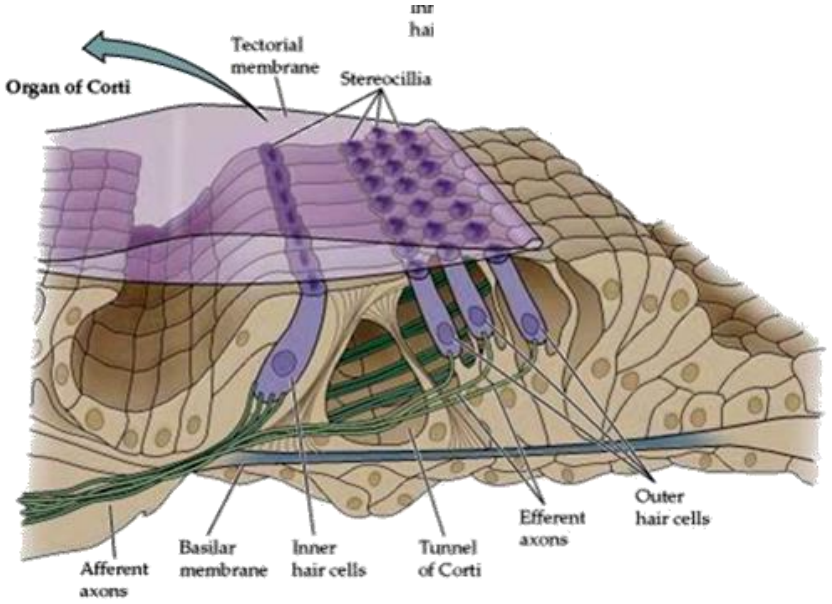


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Outer hair cells

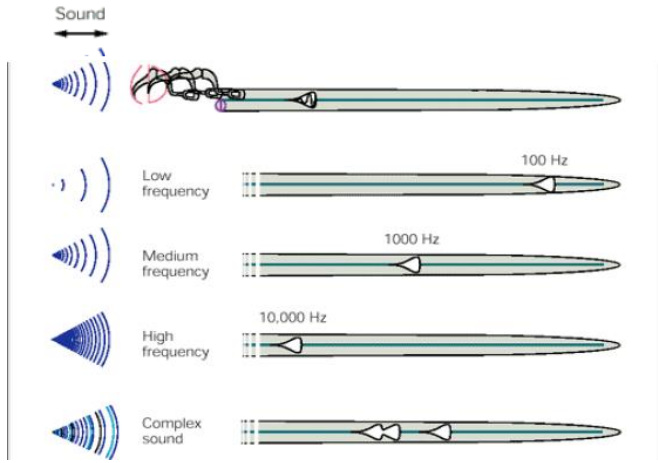
- Modulation of the signal
  - ✓ Amplification of required frequencies
- The number increases towards apex (low frequencies)

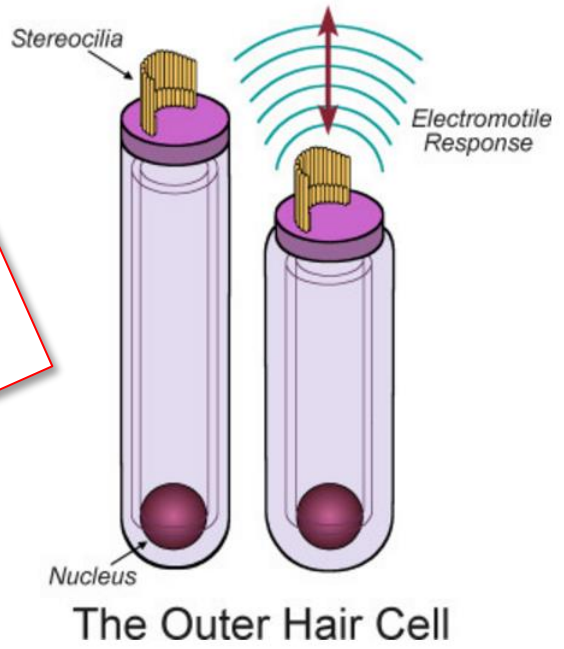


http://www.slideshare.net/drpsdeb/presentations

Their action may be detected

Otoacustic emissions

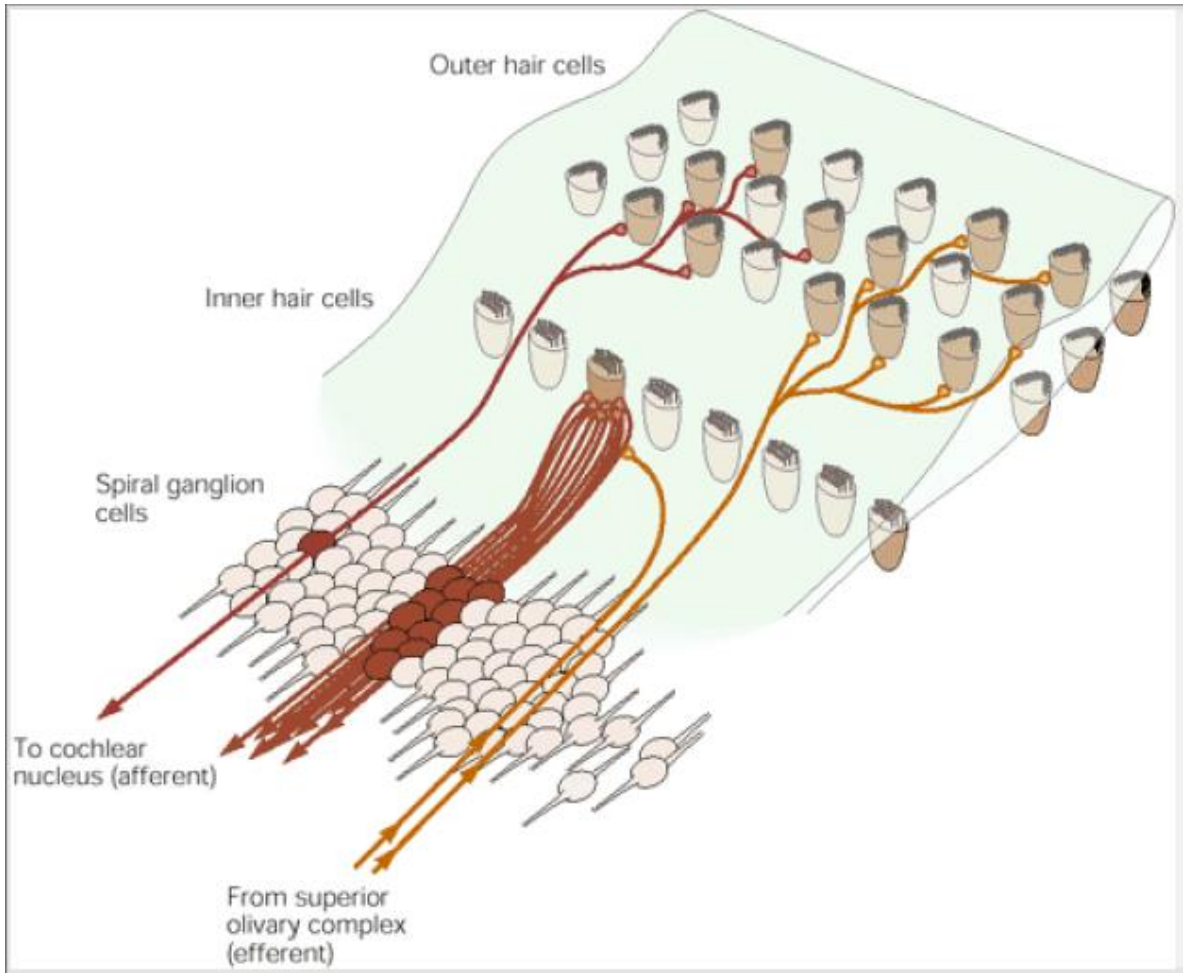




http://www.neurophys.wisc.edu/auditory/johc.html

MUNI MED

Inervation of the organ of Corti

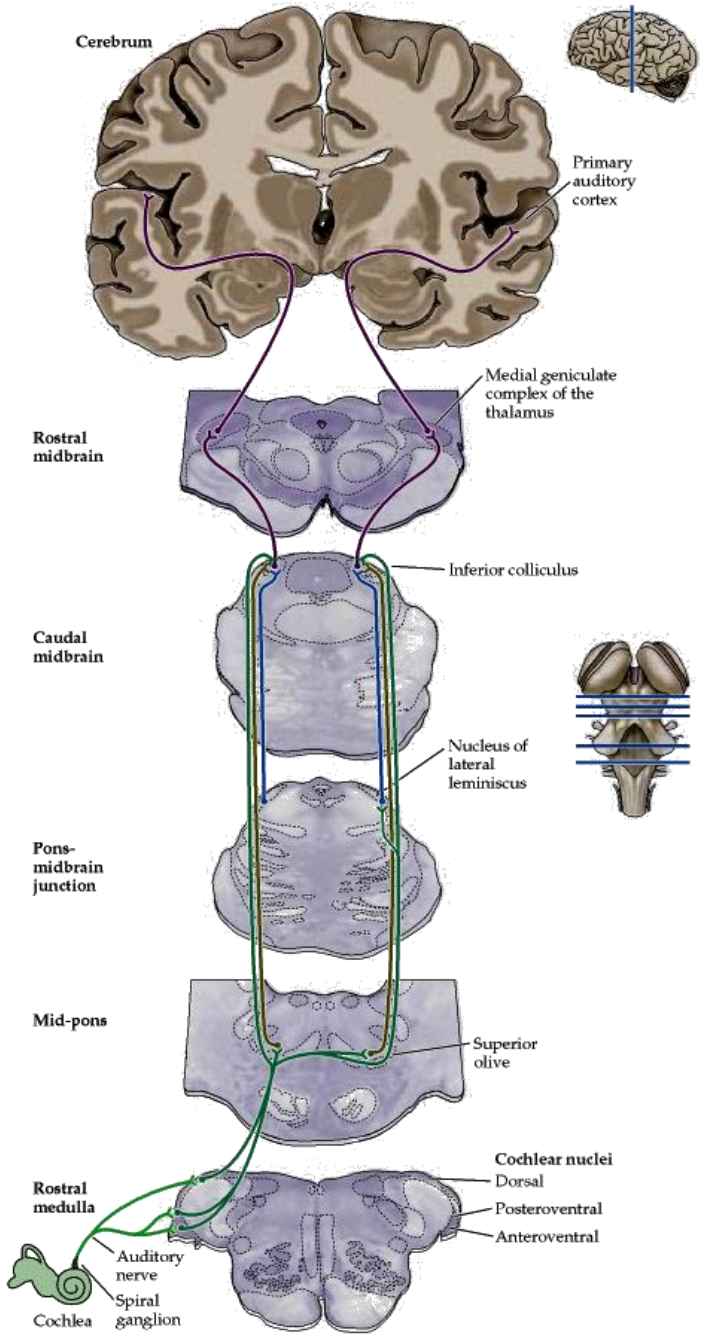


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Sound processing

- Nucleus spiralis cochleae
- Nucleus cochlearis ventralis
  - Information about intensity
  - Time delay – the sound direction
- Nucleus cochlearis dorsalis
  - Information about frequency
- Olivary nuclei
  - Analysis of direction
  - Modulation (increase) of the outer hair cells sensitivity
- Colliculi inferiores
  - Integration of information from the lower structures
  - Centre of acoustic reflexes
- N. corporis geniculati medialis
  - Thalamus
- Auditory cortex

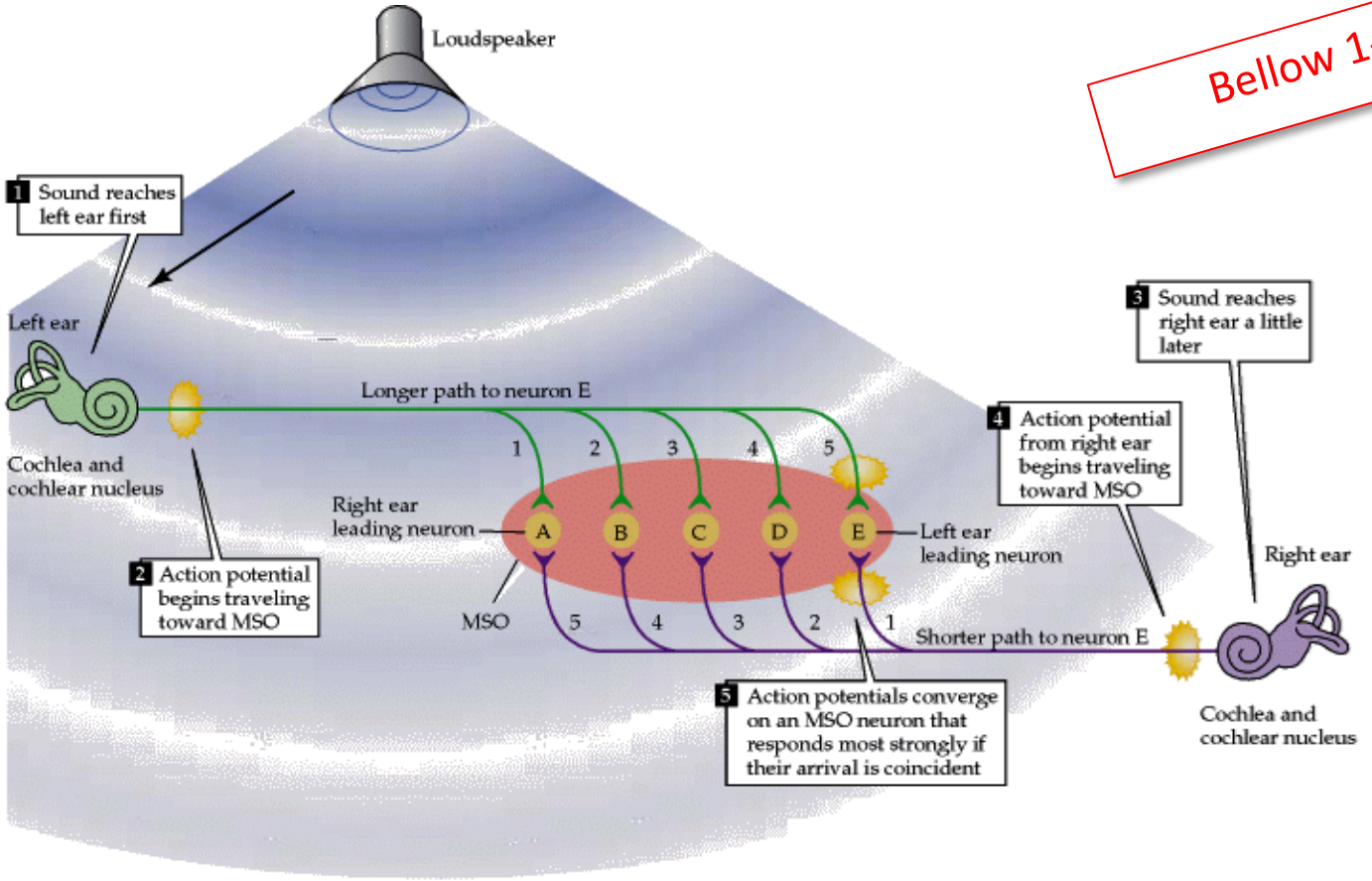


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Nucleus olivaris superior medialis

✓ Time delay based sound localization



Bellow 1-3 kHz

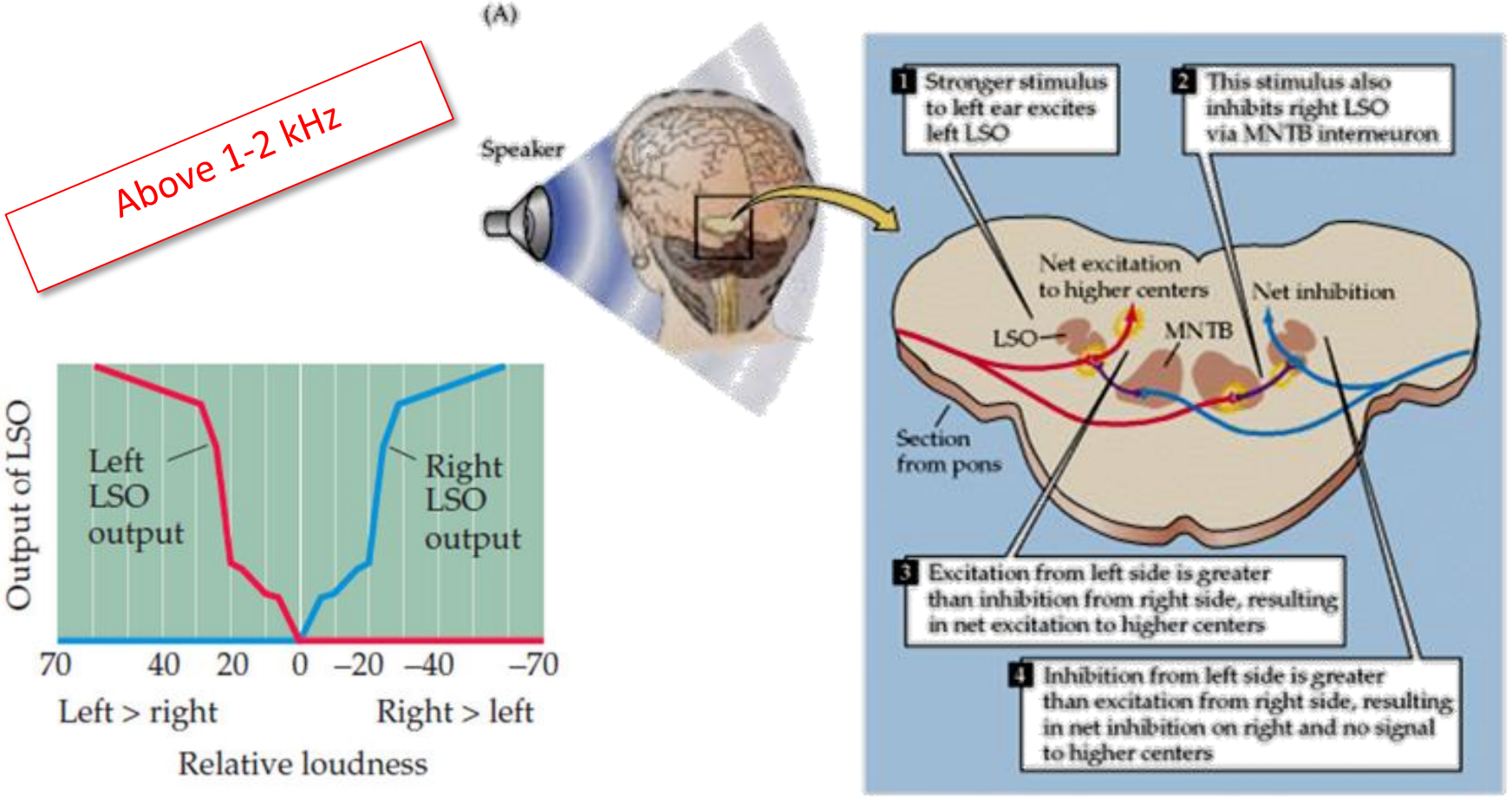
http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Nucleus olivaris superior lateralis

✓ Intensity analysis based sound localization

Above 1-2 kHz



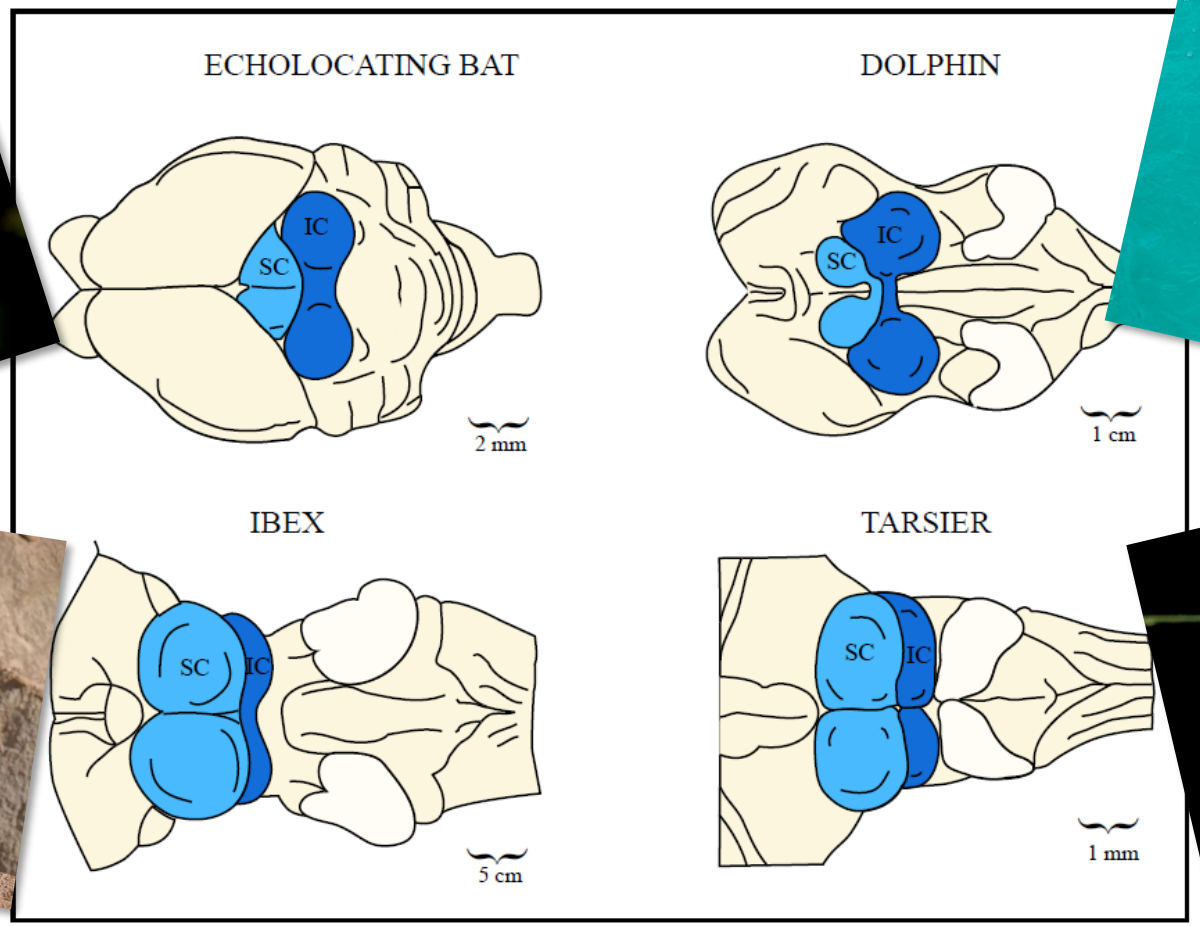
http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Colliculi inferiores in various animal species

https://www.earth.com/news/bats-mammal-longevity/

https://en.wikipedia.org/wiki/Nubian_ibex



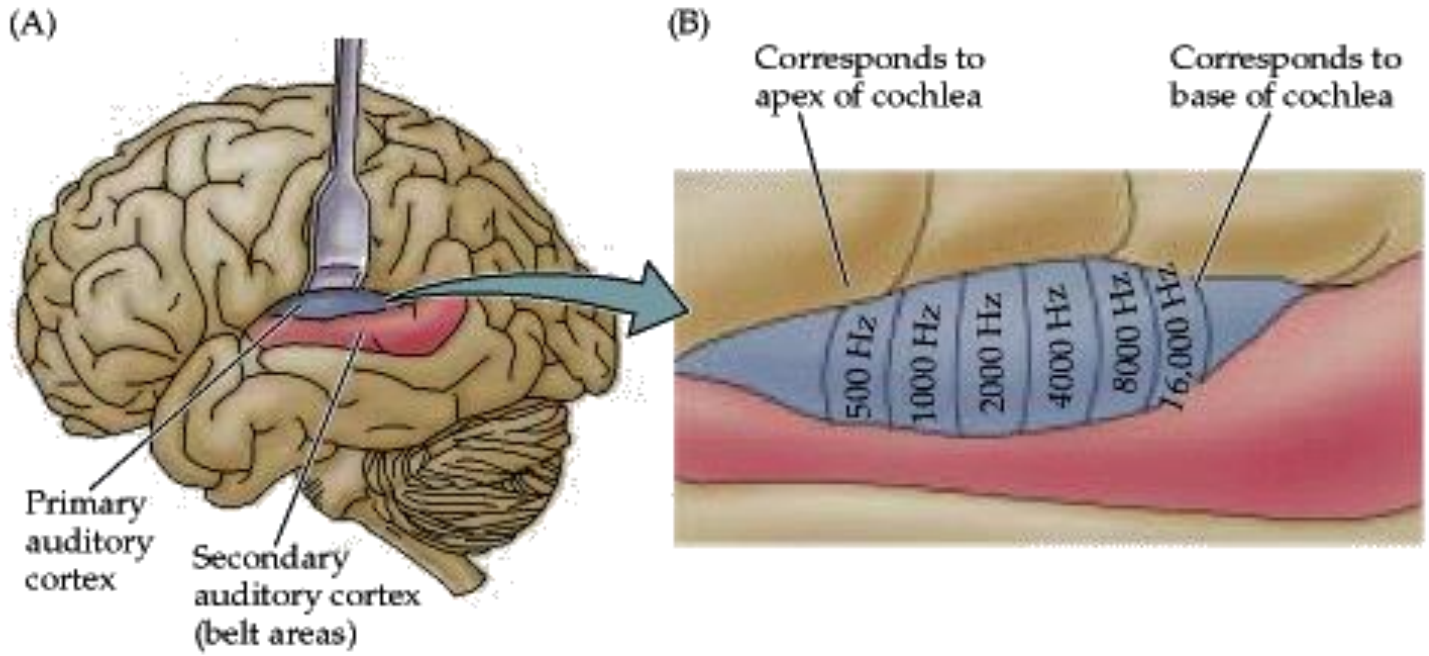
https://www.thesun.co.uk/tech/3543919/humans-communicate-with-dolphins-by-2021/

https://www.animalfactsencyclopedia.com/Tarsier-facts.html

Gerald Schneider. *9.14 Brain Structure and Its Origins, Spring 2014.* (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed). License:Creative Commons BY-NC-SA

MUNI MED

Auditory cortex

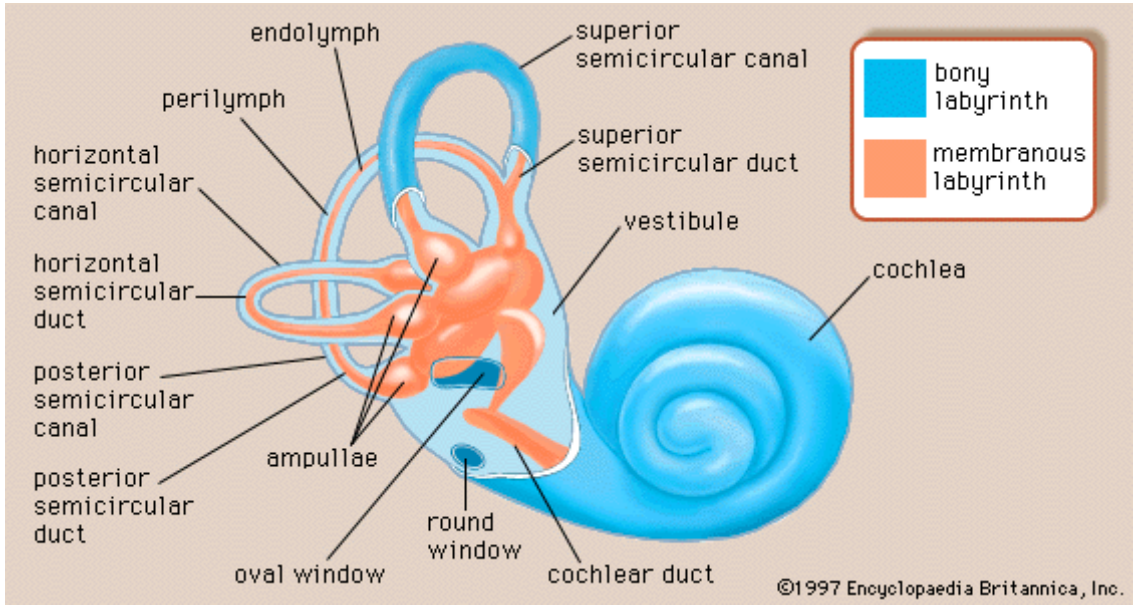


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

Vestibular system

- Associated with auditory system
  - Anatomic localization
  - Hair cells
- Information about
  - ➢ Position
  - ➢ Acceleration
    - ✓ Linear
    - ✓ Angular

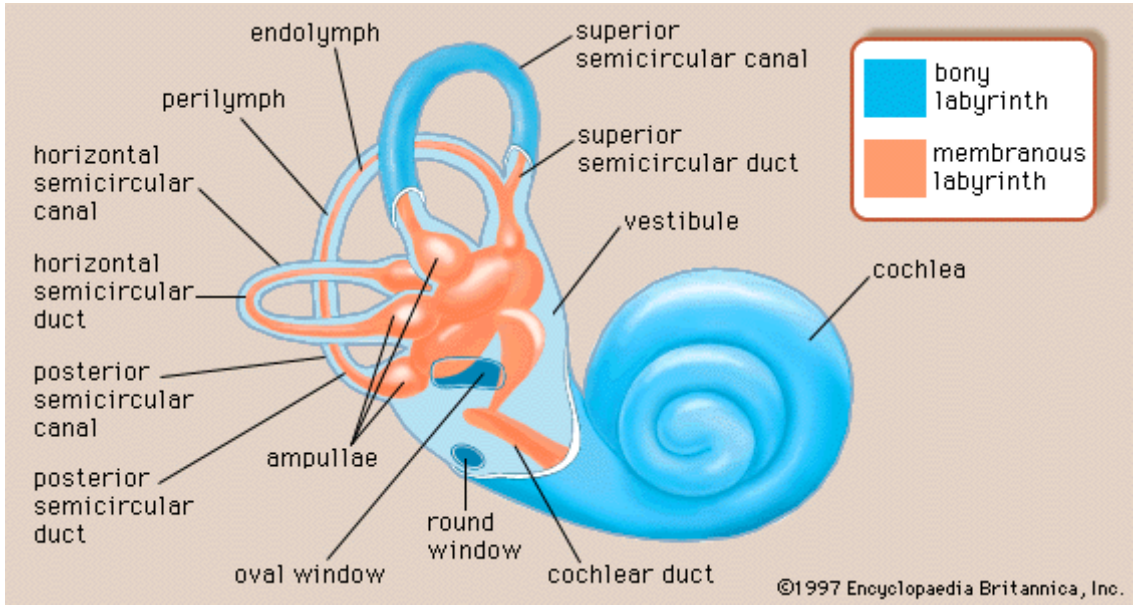


http://www.slideshare.net/CsillaEgri/presentations

MUNI MED

Vestibular system

- Associated with auditory system
  - Anatomic localization
  - Hair cells
- Information about
  - ➢ Position
  - ➢ Acceleration
    - ✓ Linear
    - ✓ Angular



http://www.slideshare.net/CsillaEgri/presentations

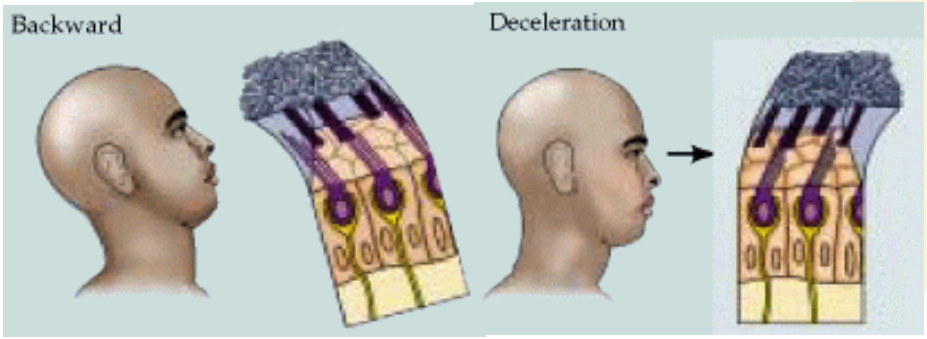
Maintenance of the balance
Muscle tone modification

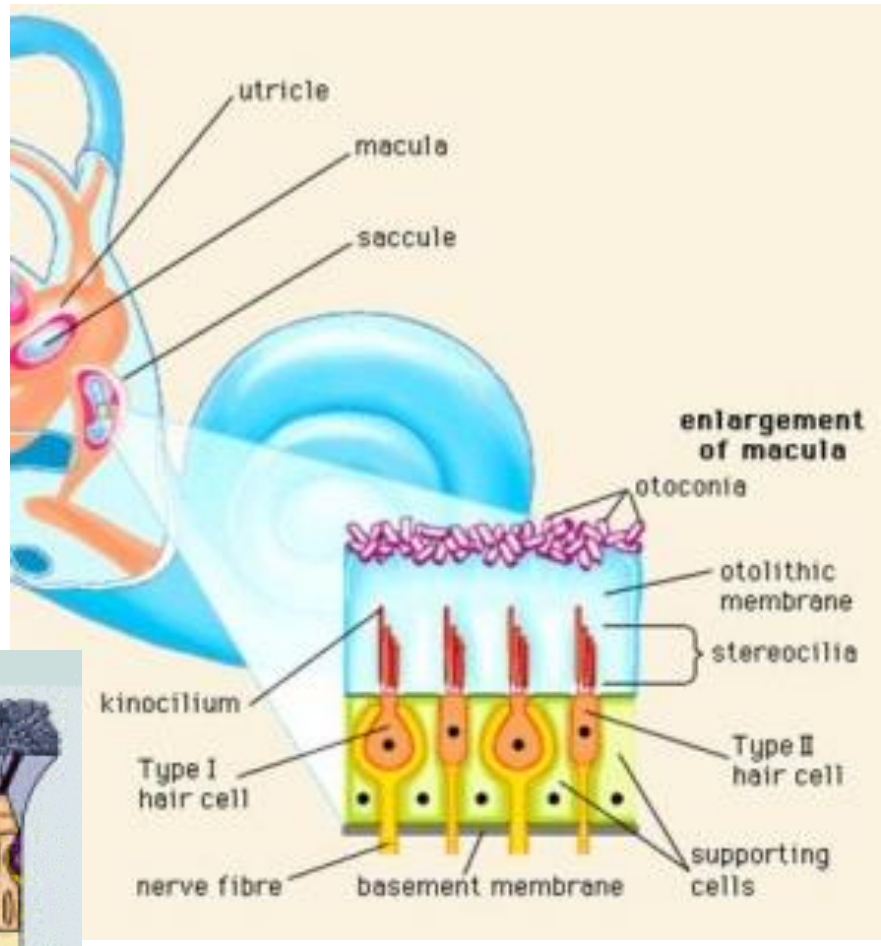
„Maintenance of the balance“ of the sight
Vestibuloocular reflexes (VOR)

MUNI MED

Information about position and linear acceleration

- Macula
  - $CaCO_3$ crystals
- Utriculus
  - Horizontal macula
- Sacculus
  - Vertical macula



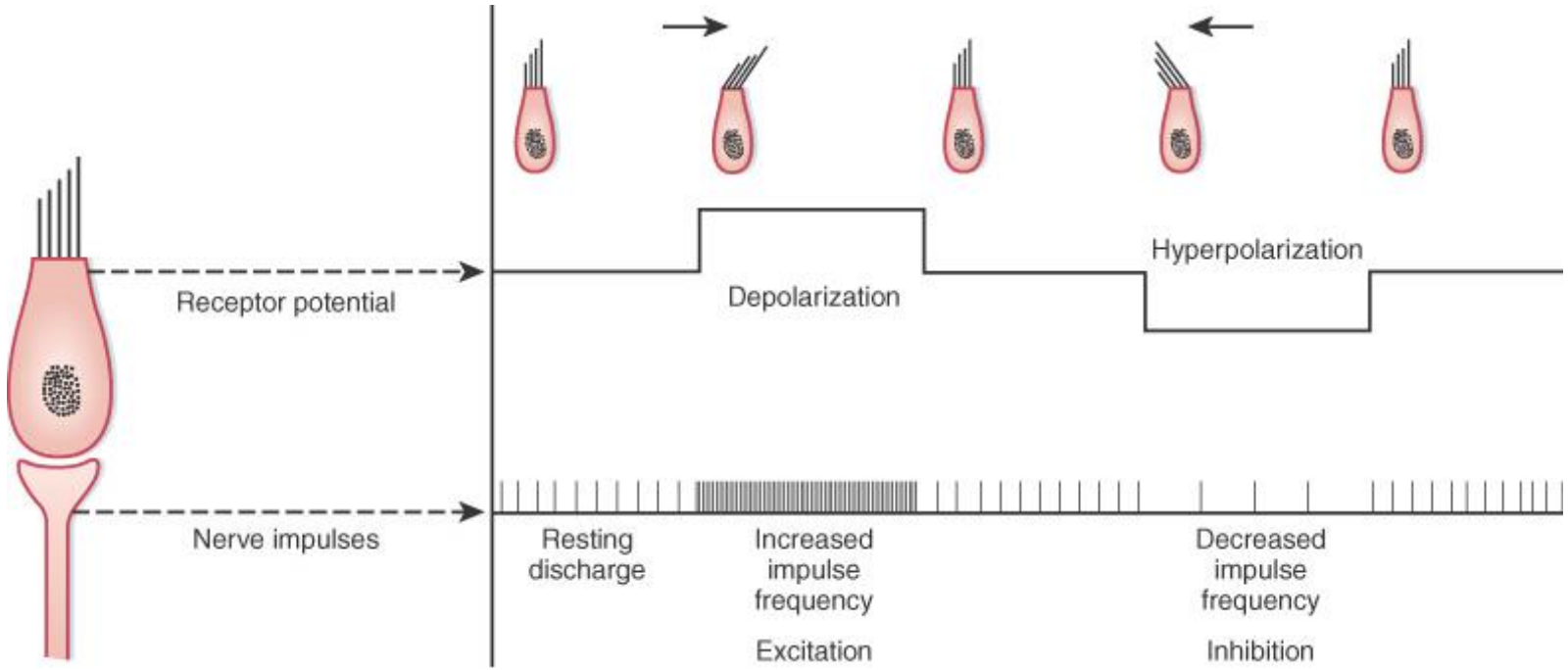


http://www.slideshare.net/CsillaEgri/presentations

MUNI MED

Mechanism of reception

- Flexion towards stereocilia
  - Mechanically activated K^+ channels are opened –depolarization
- Flexion away from stereocilia
  - The channels are clsed - hyperpolariztion

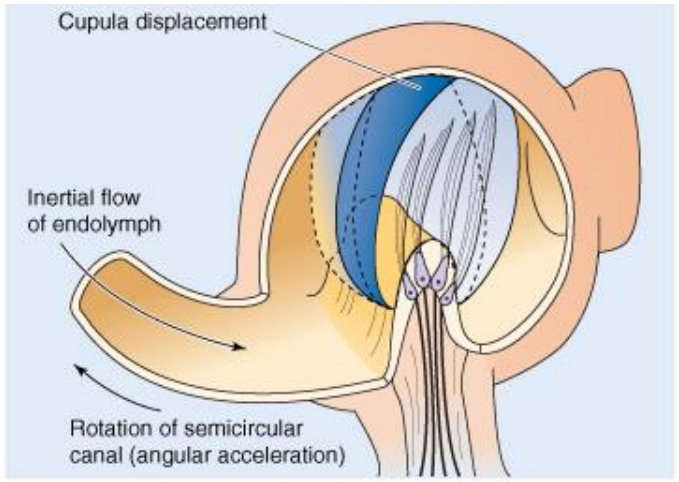


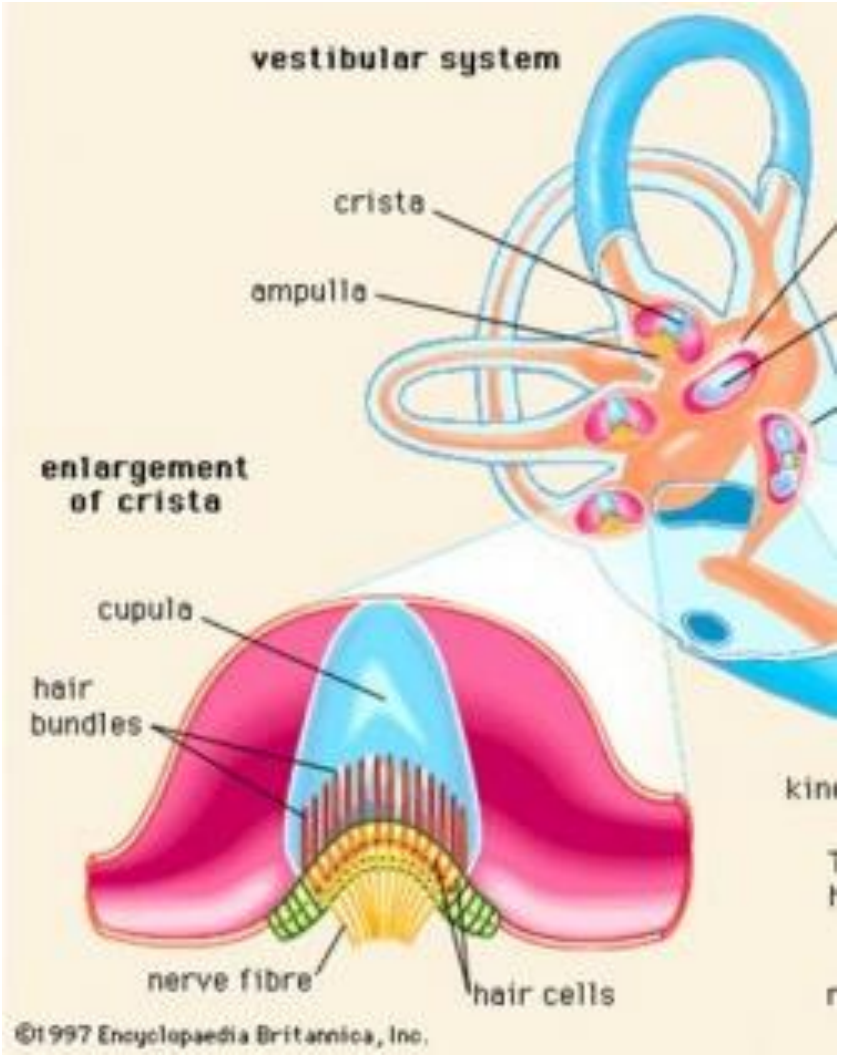
http://www.slideshare.net/CsillaEgri/presentations

MUNI MED

Information about angular acceleration

- Ampulla
- Semicircular canals
  - Upper
  - Horizontal
  - Posterior





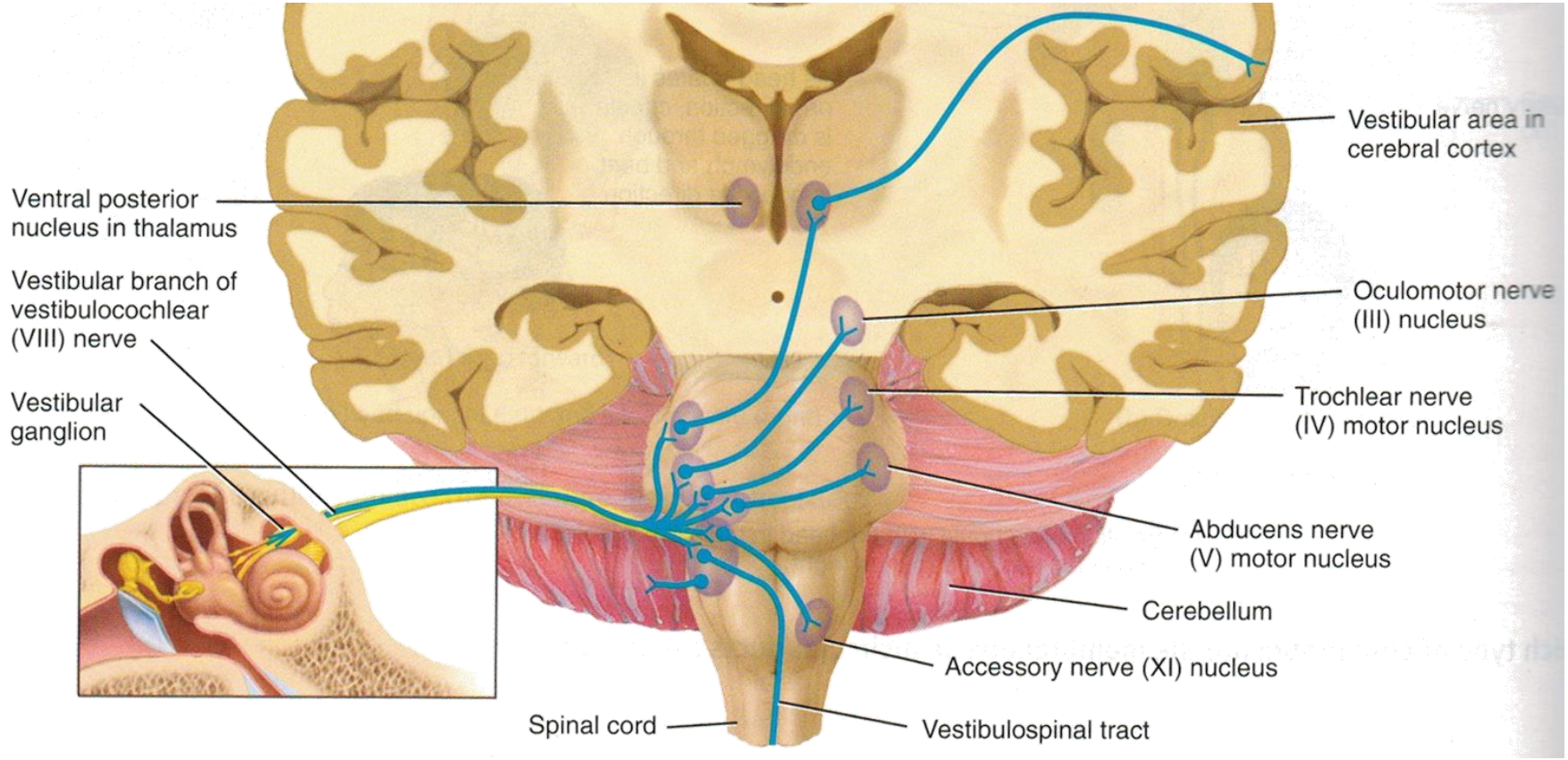
http://www.slideshare.net/CsillaEgri/presentations

MUNI MED

Vestibular nuclei

- ✓ Integration of vestibular, visual and somatosensoric information

- ✓ Projections
- Cerebellum
- Oculomotoric nuclei
- Nucleus of n. Accessorius – the muscles of the neck
- Spinal nuclei
- Thalamus - cortex



http://www.slideshare.net/CsillaEgri/presentations

MUNI MED

MUNI
MED

76. The basic physiology of auditory and vestibular system – brief characterization of the modality, basic information about signal detection and processing

- The auditory and vestibular systems are interconnected by similar mechanisms of reception (“hair cells” activated by mechanical stimuli)
- Auditory system
  - Brief characteristic of sound
  - Overview of ear anatomy and physiology
  - Middle ear more in details
  - Inner ear in details (anatomy, hair cells categorization and function…)
  - Main structures involved in signal processing and source localization
- Vestibular system
  - Overview of anatomy with respect to fucnction (detection of position, linear and angular acceleration)
  - Main projections from vestibular nuclei
- Nystagmus (presentation Vision II)

MUNI
MED