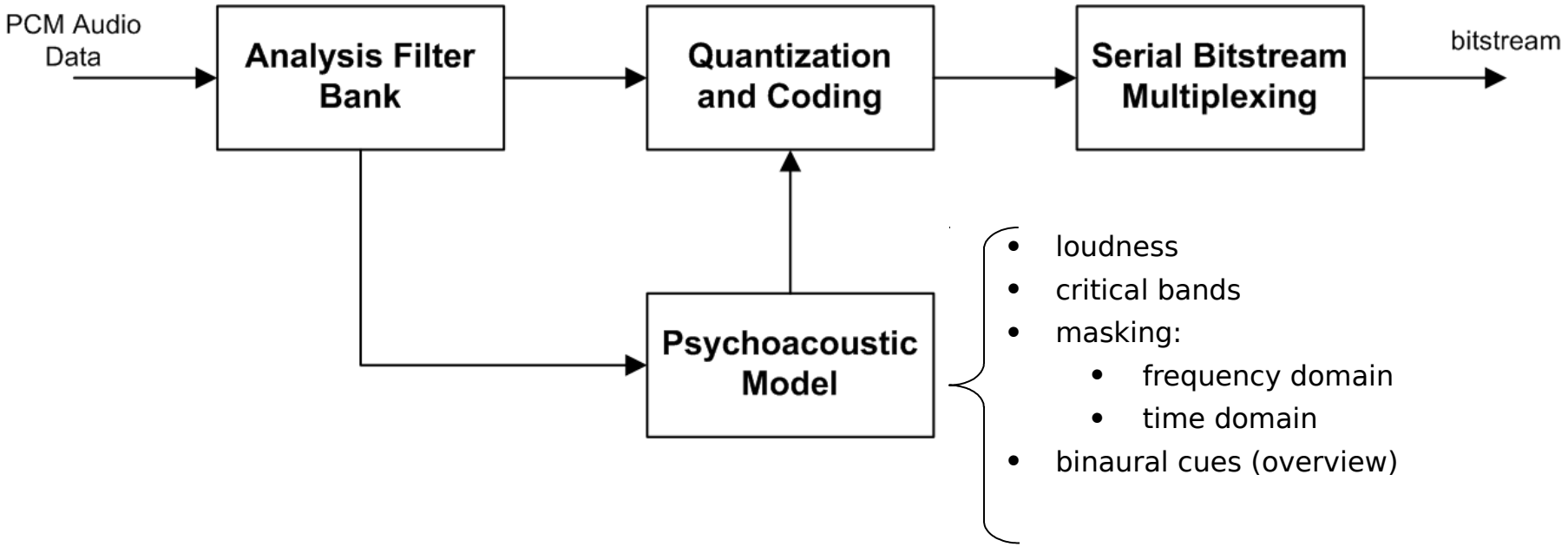
Physiological Effects
WS 2016/17

related lectures:
Applied and Virtual Acoustics (Winter Term)
Advanced Psychoacoustics (Summer Term)

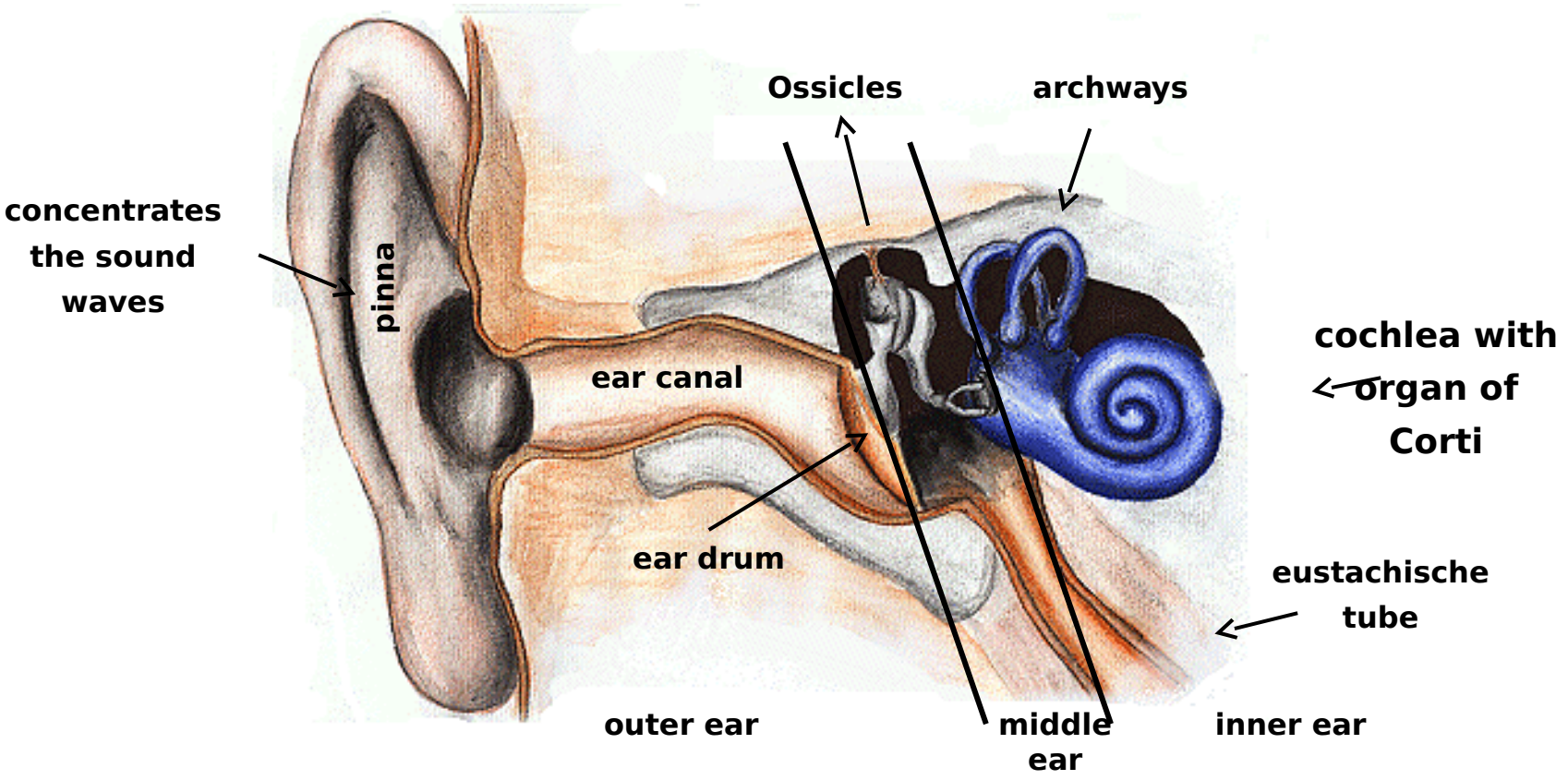
Block Diagram of a Perceptual Audio Encoder



Source: Brandenburg, “Vorlesung: Dig. Audiosignalverarbeitung”

Structure of the Human Ear

Structure of the Human Ear (1)

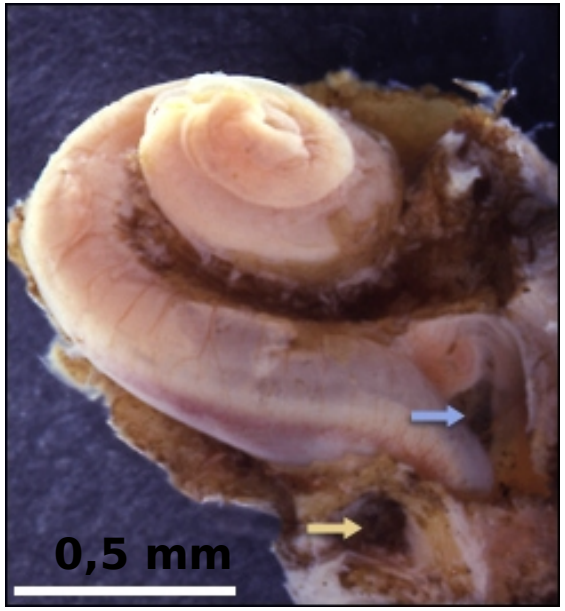


Quelle: Ars Auditus; http://www.dasp.uni-wuppertal.de/index.php?id=57, 2010

Structure of the Human Ear (2)

- **eardrum** – transforms sound wave into vibrations
- **ossicular bones** - transfer the mechanical vibrations to the cochlea
- **cochlear structure** - induces traveling waves along the length of the basilar membrane
- **neural receptors** - connected along the length of the basilar membrane
    - convert these traveling into chemical and electrical signals

Structure of the Human Ear - Cochlea

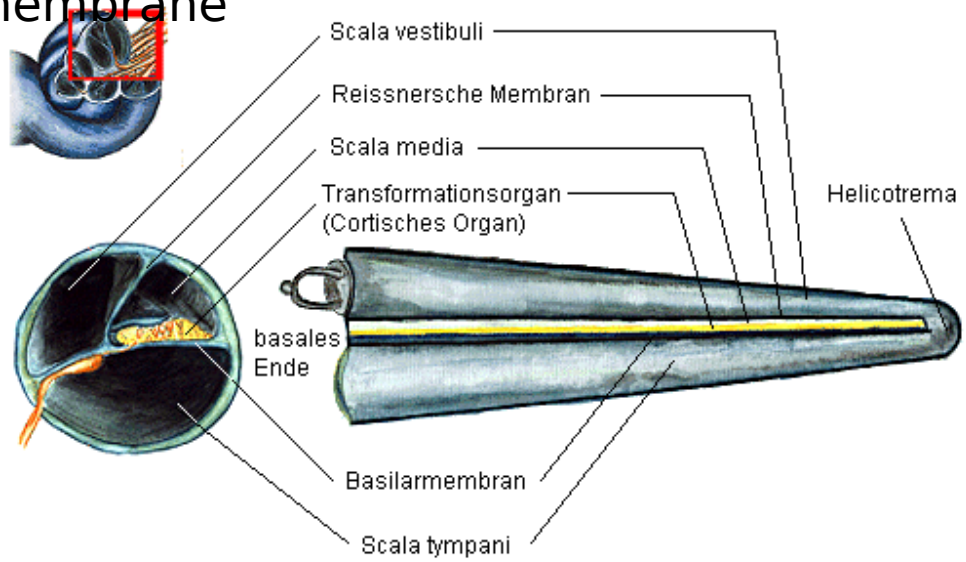


Quelle: Cochlee, http://www.cochlee.org, 2010

left picture :

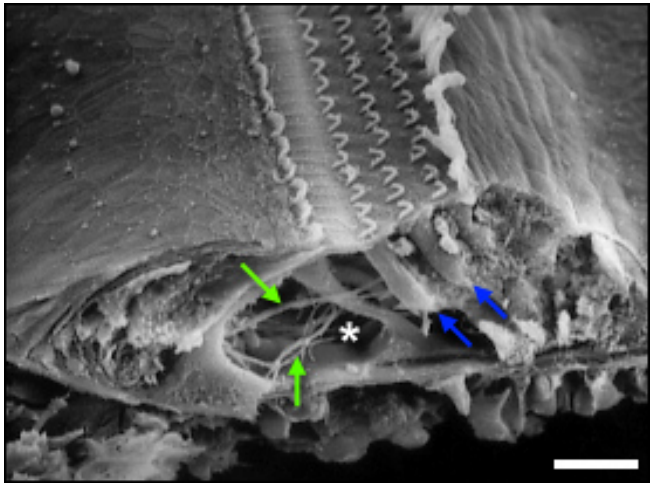
- cochlea of a 5 month old fetus,
  - spiral-shaped, fluid-filled structure
  - contains the coiled basilar membrane

- blue arrow ✉ oval window
- yellow arrow✉ round window



Quelle: Ars Auditus; http://www.dasp.uni-wuppertal.de/index.php?id=57, 2010

Structure of the Human Ear – Organ of Corti



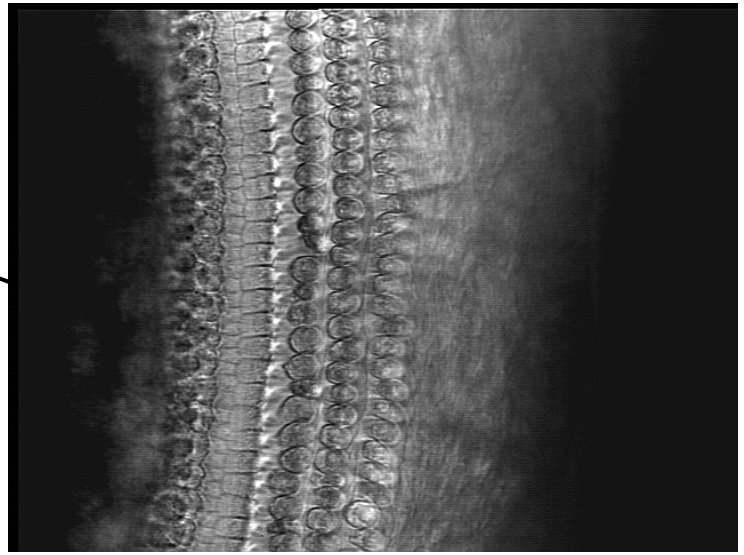
Quelle: Cochlee, http://www.cochlee.org, 2010

- organ of corti of a guinea pig
- white bar = 20 µm

outer hair cells (OHC)

inner hair cells (IHC)

pumping OHC

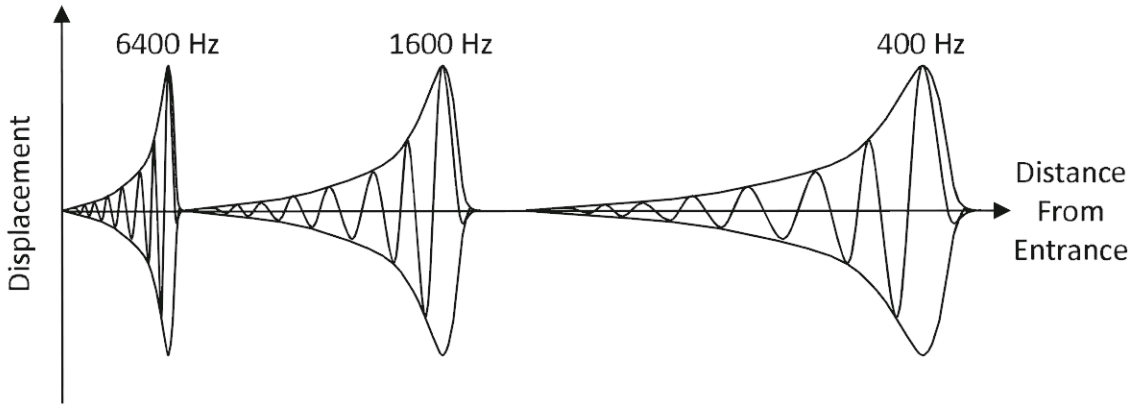


Quelle: David C. Mountain, Boston University, 146th ASA Meeting

- ~ 3500 IHC and ~12000 OHC at humans
- hair cells convert fluid motion into el. impulses in auditory nerve

Preprocessing of Sound in the Peripheral System

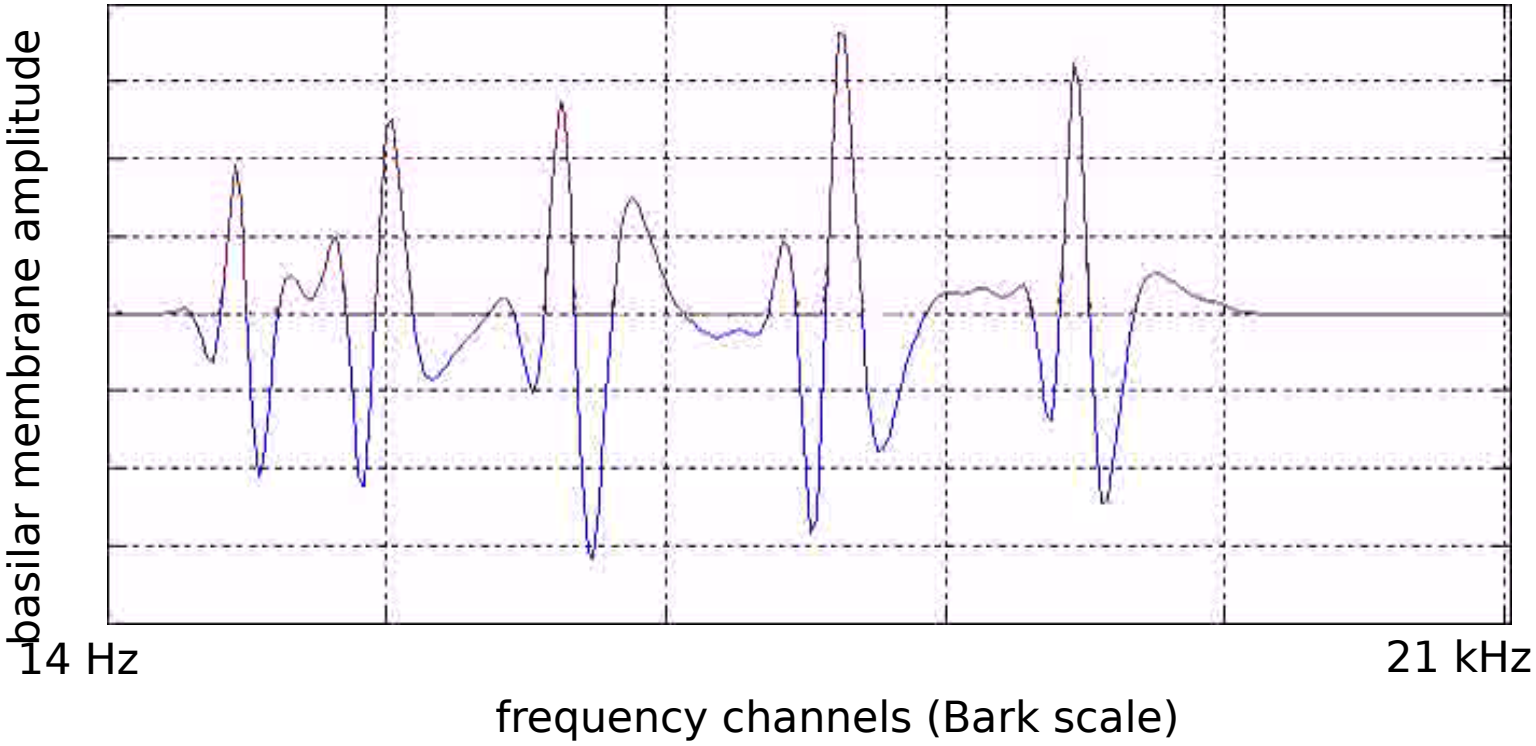
- frequency selectivity of the basilar membrane
- traveling wave envelopes occur in response to an acoustic tone complex containing e.g. sinusoids of 400 Hz, 1600 Hz and 6400 Hz
- peak responses for each sinusoid are localized along the membrane surface, with each peak occurring at a particular distance from the oval window (cochlear “input”)



Source: Yuli You “Audio Coding Theory and Applications ”

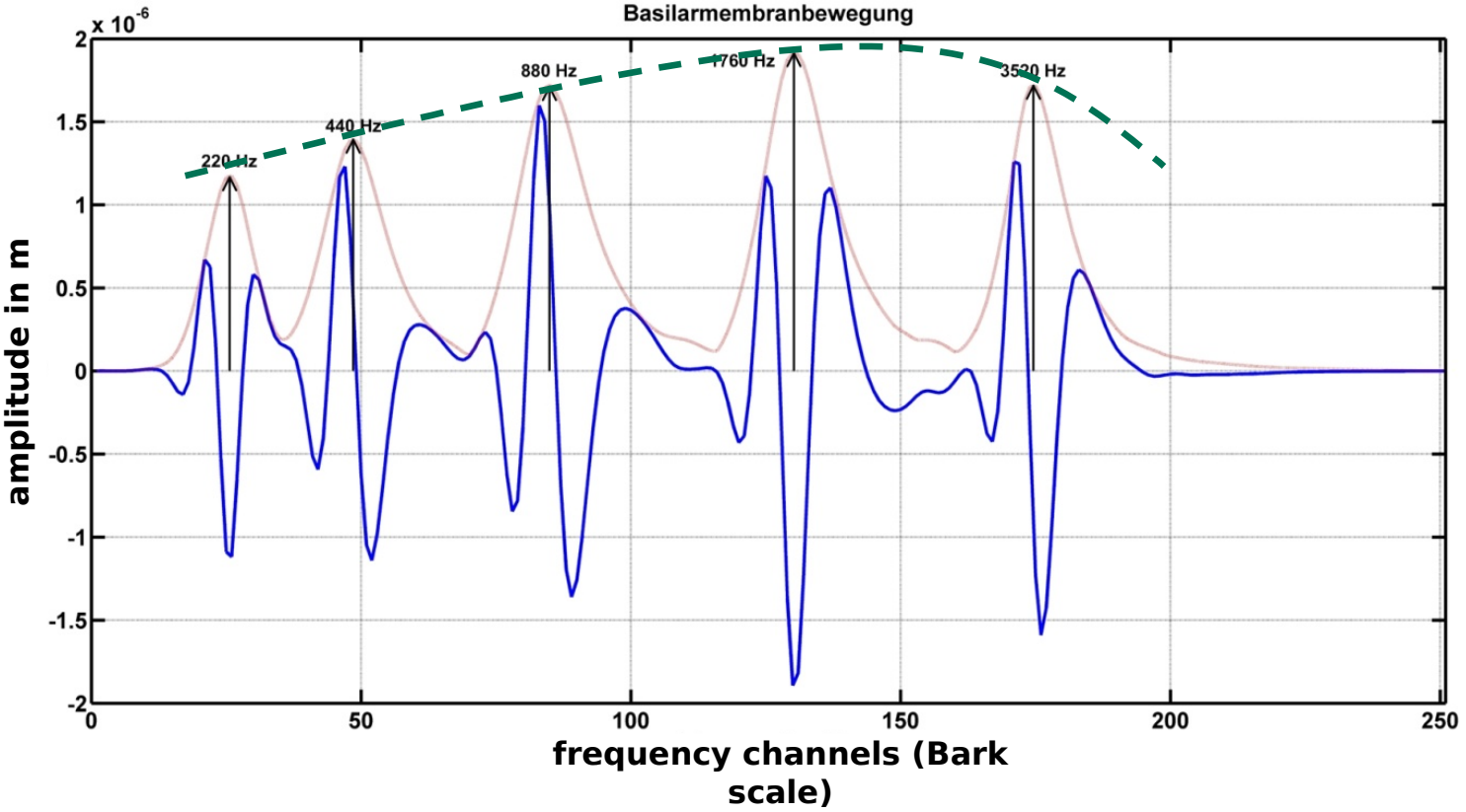
Preprocessing of Sound in the Peripheral System

- frequency selectivity of the basilar membrane (simulation)



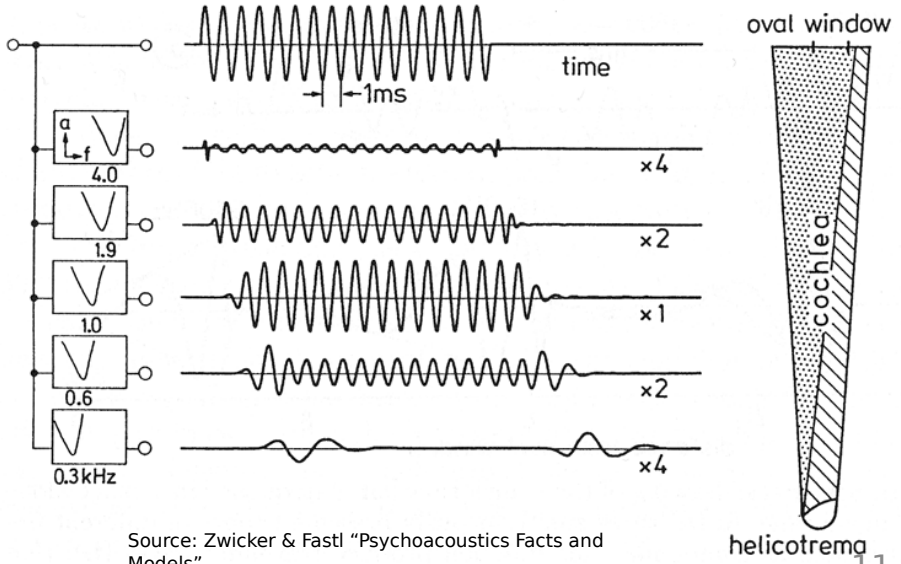
Preprocessing of Sound in the Peripheral System

- frequency selectivity of the basilar membrane (simulation)



Information Processing in the Auditory System

- basilar membrane as a filter bank
- bank of highly overlapping bandpass filters
- the magnitude responses are asymmetric and nonlinear (level dependent)
- non-uniform bandwidth, and the bandwidths increase with increasing frequency



Source: Zwicker & Fastl “Psychoacoustics Facts and Models”