

5/3/04

auditory system:

- very fast processing (visual system slower)
 - ↳ 2nd messengers etc.

- very sensitive: process 2 components of sound

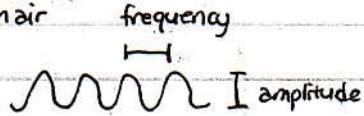
1. amplitude of sound wave (decibels)

- human ear detects 0 → 120 dB, can detect 0.01 nm shift in air

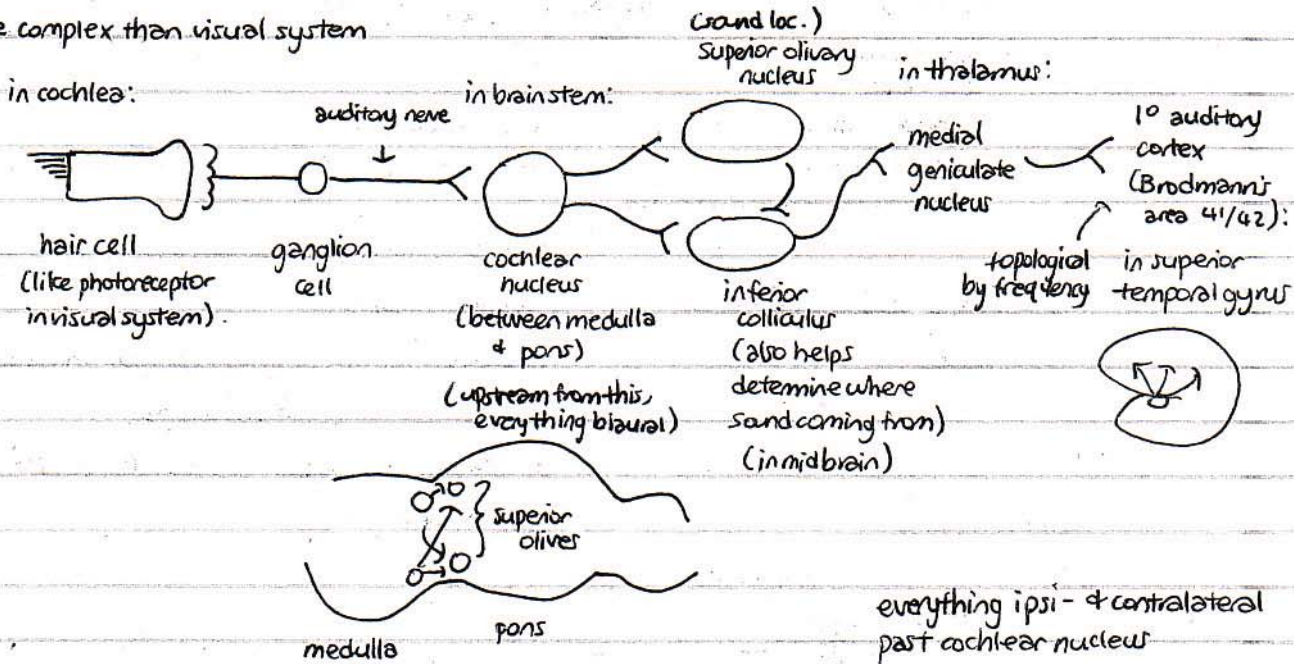
2. frequency of sound (Hz)

- 20 - 20,000 Hz: speech ~ 1000 - 3000 Hz

- 50 μsec detection (faster than synaptic transmission?) ← 1 ms

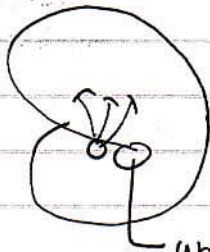


- more complex than visual system



Contralateral projections (each to other auditory olivary nucleus), allows to compare inputs from each ear

everything ipsi- & contralateral past cochlear nucleus
 (to get hearing loss in one ear, must affect path before cochlear nucleus)
 past this, must have bilateral lesions for hearing loss



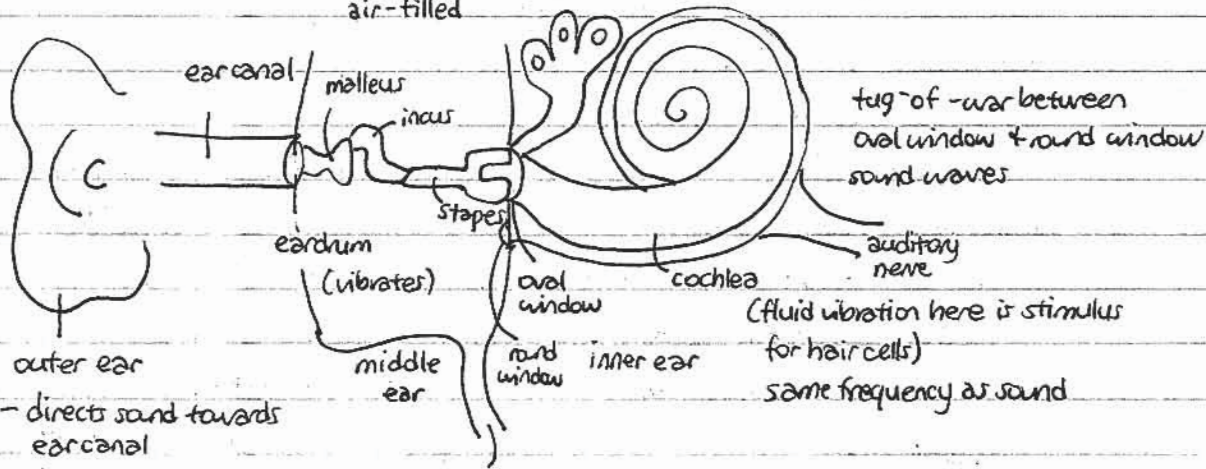
association area
 Wernicke's area: important for language, unilateral lesion (esp. on left) can have devastating effects

- hair cells have graded potentials (like PRs & bipolar cells)

- ganglion cells fire APs

(2 muscles that can reduce sound?)
air-filled

semicircular canals (balance)



- directs sound towards ear canal
(damage still lets you localize sound b/c one ear can do this somewhat)

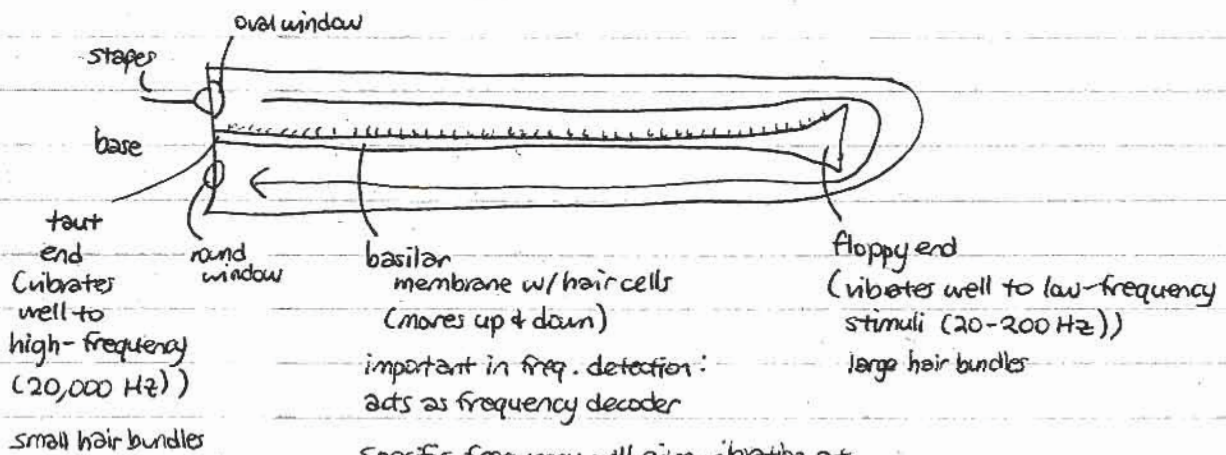
eardrum is 35x bigger than oval window

if get ear infections, can get middle ear scar tissue (common in children)

otosclerosis in old people, bone spurs in connective tissues (can correct w/ prosthetic stapes)

or damage to cochlea, certain frequencies you hear over & over

unfold cochlea:

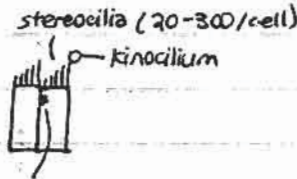
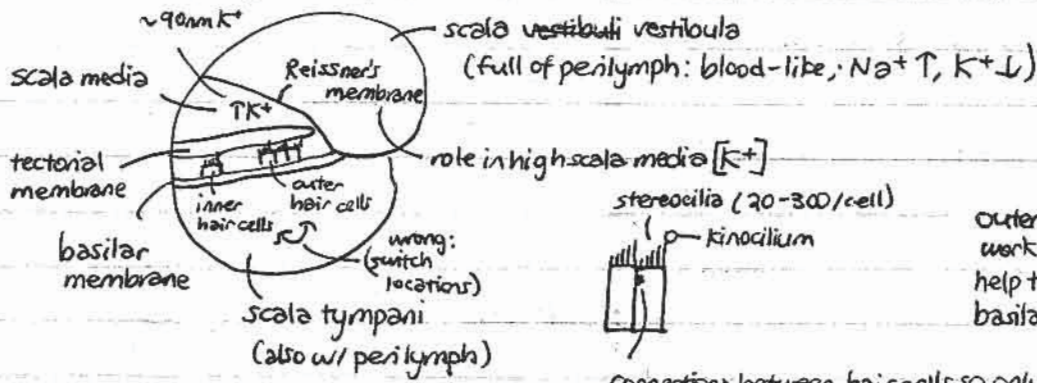


important in freq. detection: acts as frequency decoder

Specific frequency will give vibration at specific area

- hair cells have place code

cochlear cross-section:

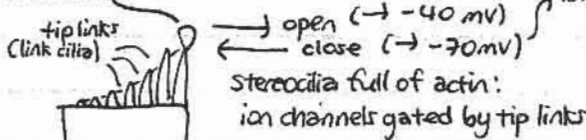


outer hair cells work in vibrating, help to vibrate basilar membrane

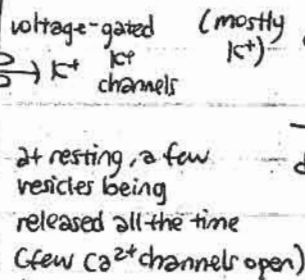
connections between hair cells so only cilia bathed in high K^+ (rest of hair cell in normal fluid) (adherens junctions)

- as basilar membrane goes up, // // //

kinocilium goes down, // // //



$V_m \sim -60\text{ mV}$
(~15% of channels open all the time: always little bit of I_K depolarizing)



tip link connects to accessory protein that connects to channel

ganglion cell

primary auditory nerve (can record from this)

(activity) no sign change:

beta fire at slow constant rate; more w/ sound, less when sound off

unusual b/c charge carried by only one ion (K^+)

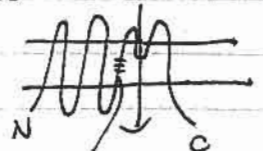
- this helps make it fast:

- direct gating of ion channel (our time scale)

- K^+ can come in & leave

ion channel that mediates mechanotransduction yet to be cloned in humans

- trp channel (K^+ channel)

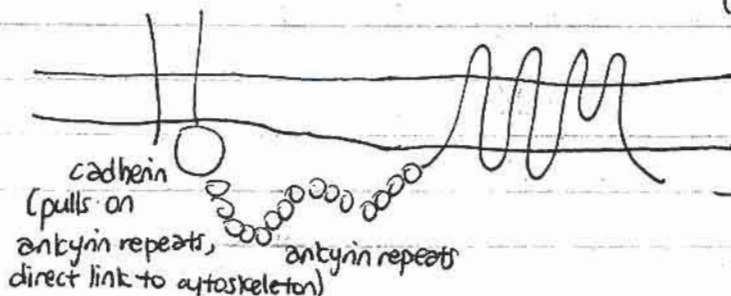


trp channels - 6 TM

- no 5 γ

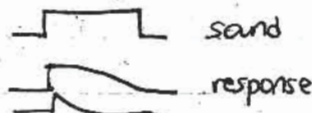
- very unusual N^+ termini (long, w/ ankyrin repeats)

(motif that binds cytoskeleton (eg actin)

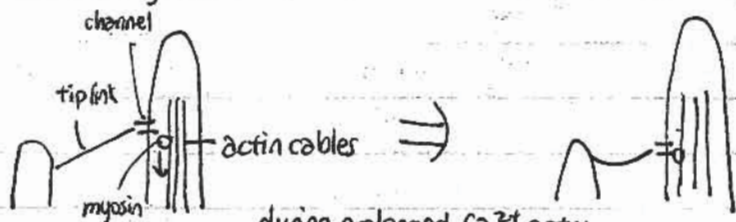


- when hair bundle shifted, little bit of Ca^{2+} goes in channel (along w/ K^+)

- adaptation to constant sound



- change in way channel is gated



during prolonged Ca^{2+} entry,
binds myosin, drags down actin
cable, channels start to close:

now tip link doesn't activate channel anymore



air waves



~~stimulus~~ stimulus locking:

hair cell V_m oscillates w/
movement of stereocilia
(\rightarrow 3 KHz)

in upper range, doesn't keep up but
talks to many ganglion cells



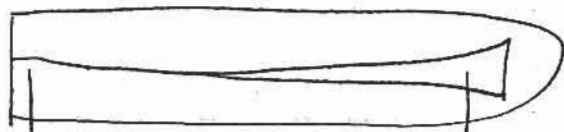
each hair cell talks to many (10-20) ganglion cells

- need dense body (particular to hair cells): like conveyor belt
to release NT very rapidly

frequency
of firing matches
stimulus oscillation

place code: depending on where hair cells are, encode particular frequencies

stereocilia length
also help tune to
specific frequencies

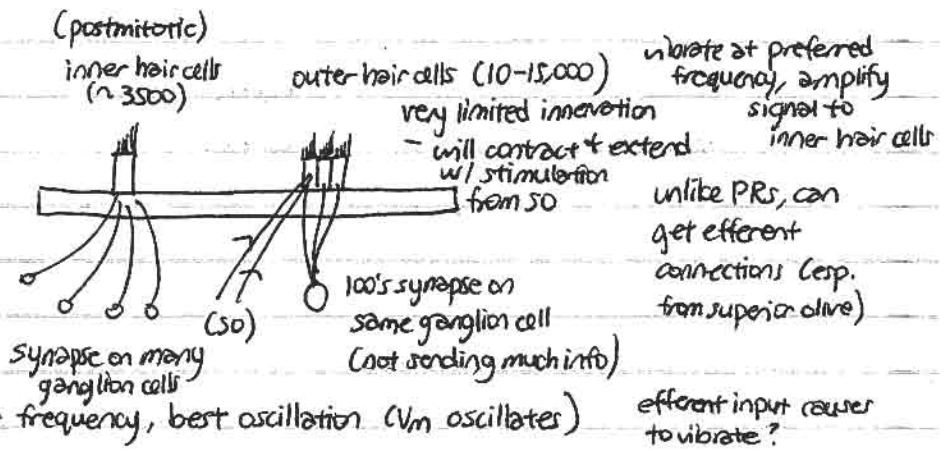


high (shorter
stereocilia)

low (longer stereocilia)

specific frequency response:

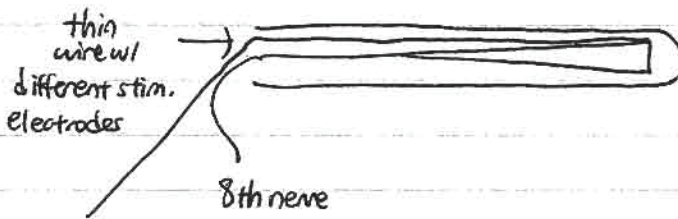
1. basilar membrane
2. stereocilia length
3. slo K^+ channels
4. outer hair cells



- hair cells can lock into particular frequency, best oscillation (V_m oscillator)
- stereocilia resonate
- feedback between Ca^{2+} & efflux of K^+ (slo channels, voltage-gated)

↳ many splice variants (placed along membrane)
 ia - also used in frequency tuning

- aminoglycoside antibiotics (eg kanamycin, streptomycin) block mechanosensitive channels, can kill hair cells over time
- loud noise can shear stereocilia: worst if same frequencies over + over
 - correct w/ hearing aids at base of ear drum (tune to defective frequencies)
 - can also use cochlear implants: if ganglion cells still alive

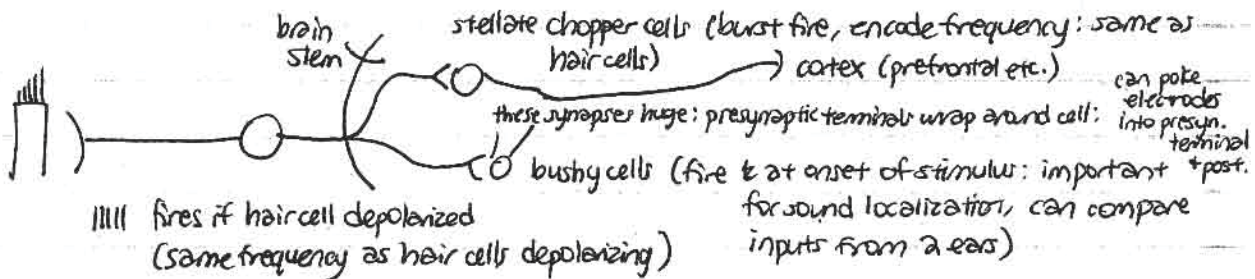


packet, motor, amplifier

(doesn't work if have 8th nerve damage)

(frequency decoder)

- ↳ takes place of basilar membrane frequency decoder, excite correct electrodes, stimulate correct axons



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