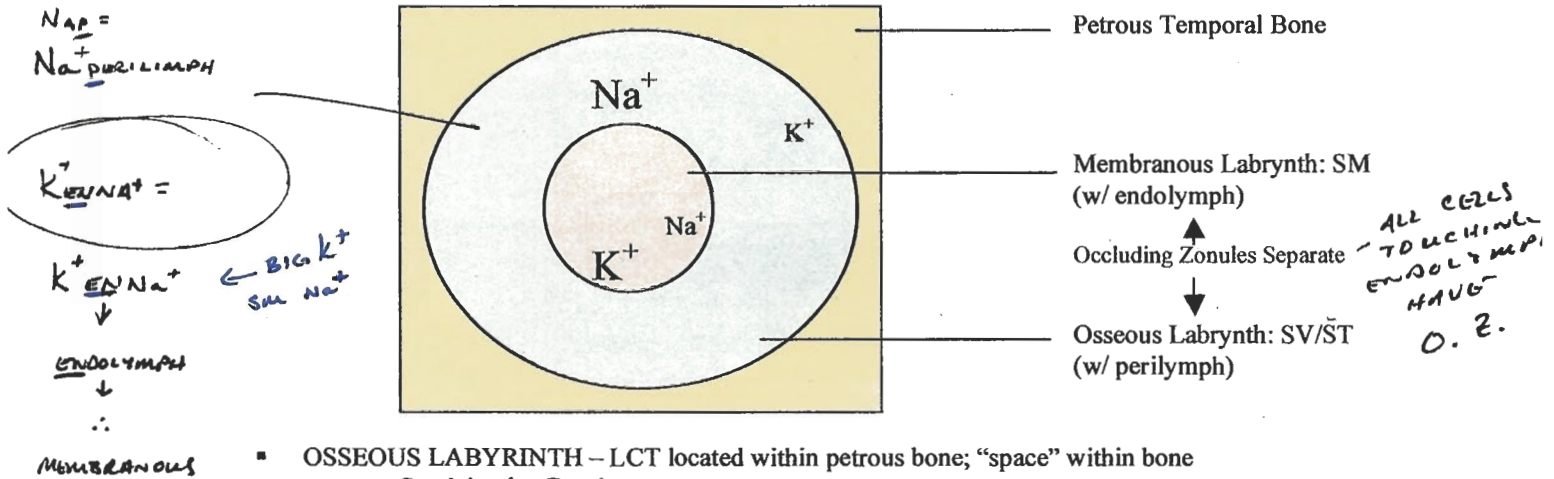


THE EAR

- OVERVIEW (lecture notes p. 283)



- OSSEOUS LABYRINTH – LCT located within petrous bone; “space” within bone
 - Semicircular Canals
 - Three bony tubes orthogonal (rt. / 's) to ea. other
 - Superior, posterior, horizontal
 - Ending in the vestibule (see next)
 - Ampulla – swelling at one end (vestibular end) of semicircular canals
 - Vestibule - space connecting semicircular canals (posteriorly) & cochlear (anteriorly)
 - Osseous labyrinth part is the bony material surrounding the vestibular space & vestibular aqueduct (smaller bony channel given off by vestibule)
 - Oval window
 - Part of wall of vestibule
 - Stapes (middle ear) inserts onto oval window
 - Cochlea
 - A spiral-shaped tube indented in x-section (humans = $2 \frac{1}{2}$ - $2 \frac{3}{4}$ spirals)
 - Modiolus (cone-shaped)
 - Bony central axis
 - Gives polarity
 - Inner: toward modiolus
 - Outer: away from modiolus
 - Contains fibers of 8th CN & peripheral ganglion → innervates:
 - Auditory system
 - Spiral Ganglion (composed of bipolar cells)
 - Osseous spiral lamina – given off by modiolus
 - Spiraling shelf
 - Indents inner edge of the cochlea
 - NOTE:
 - Modiolus & Osseous Spiral Lamina is like a “pointed screw with spiraling treads”; with the screw upside-down the *point* would be the apex/helicotrema of the cochlea
 - The core of the screw would be the modiolus and the treads would be the spiral lamina
 - Scala (described below) with apex/helicotrema pointing superior:
 - Scala Vestibula (part of the osseous labrynth) would be superior to the tread border/spiral lamina
 - Scala Tympani (part of the osseous labrynth) would be inferior to the tread border/spiral lamina
 - Scala Media (part of membranous labrynth) – the inner (twrd modiolus) border attaches at the “tread”/spiral lamina edge

- *Spiral Ligament* – DCT layer of outside wall
- Tubular compartments (the three in bold):
 - Osseous Labrynth component:
 - *Scala Vestibuli (SV)* – connects with oval window
 - *Scala Tympani (ST)* – connects with round window
 - *Helicotrema* (cochlear apex) – connects SV w/ ST
 - *Perilymph*
 - Believed secreted by bv's in osseous labyrinth CT
 - Like extracellular fluid (high Na⁺; low K⁺)
 - Membranous Labrynth component:
 - *Scala Media* – flanked by SV & ST (flank = side)
- MEMBRANOUS LABYRINTH (membranous “inner” portion)
 - Introduction:
 - Continuous series of epithelially-lined (simple squamous) membrane channels, derived from otocyst containing *endolymph* (like intracellular fluid: high in K⁺; low in Na⁺)
 - Occluding Zonules:
 - Keep perilymph (osseous) & endolymph (membranous) from mixing
 - Histology:
 - Mostly simple squamous
 - Sensory regions – quite complex
 - Membranous Labyrinth Components:
 - Semicircular ducts
 - Ampulla
 - Swelling at one end (vestibular end) of semicircular duct
 - *Crista Ampullaris*
 - Sensory structure housed by ampulla
 - Detects rotational movements of the head
 - Begin & end in continuity with a larger sac, the *utricle* (next)
 - Utricle:
 - *Macula* – Detects linear acceleration along with the Saccule macula
 - Connecting duct (small)
 - Connects the *utricle* to the *sacculle* (below)
 - Gives off blind ending tube, *endolymphatic duct & sac* (next)
 - Fxn unknown
 - Crossland said, “just know it exists”
 - Endolymphatic duct & sac
 - A blind-ending tube given off by the *Utricle*
 - Travels within the vestibular aqueduct (See Vestibule of Osseous Labrynth)
 - Sacculle –
 - *Macula* – Detects linear acceleration along with the Utricle macula
 - Connected by another small duct to the *Cochlear Duct*
 - Cochlear Duct (Scala Media)
 - “Flanked” by Scala Vestibuli (oss^{ous}) & Scala Tympany (oss^{ous})
 - ~~W/in cochlea (surrounded by Scala Vestibuli & Scala Tympani)~~
 - Spiraling & somewhat triangular shaped
 - Several important features:
 - Roof of Duct = Vestibular (Reissner's) membrane
 - 2 simple squamous epithelial sheets
 - The layer opposed to Scala Media contains occluding zonules
 - separated by a basal lamina
 - Floor of Duct = Basilar Membrane
 - Derived from osseous labrynth tissue
 - Organ of Corti

OK

VESTIBUL

- Sensory Surface: columnar epithelium w/ 2 types of cells
 - *Supporting Cells* – tall columnar w/ secretory granules
 - *Sensory Hair Cells* – Cupula
 - Gelatinous membrane that stereocilia & kinocilia are embedded; acts like a sail (endolymph = wind)
 - Process:
 - Appropriate head mvmt (rotational)
 - Endolymph moves w/in Semicircular duct
 - Endolymph pushes against/deviates cupula
 - Deviated cupula causes stereocilia deflection
 - Stereocilia deflection/deviation determines polarity of receptor potential of hair cells as described above (see “Fxn’l Polarity”)
 - Away from kinocilium/BB = hyperpolarization
 - Twrd kinocilium/BB = polarization
 - Stereocilia K^+ channels open mechanically via connection to adj. stereocilia
 - Upon depolarization, more neurotransmitter released to CN VIII afferent (sensory) processes → ↑ in signal to vestibular or auditory centers of the brain
- Sensory Maculae (of the utricle & saccule)
 - “flattened” or concave (easy I.D. histologically)
 - Detects linear acceleration
 - Sensory Surface: columnar epithelium w/ 2 types of cells
 - *Supporting Cells* – tall columnar w/ secretory granules
 - *Sensory Hair Cells* – Otilithic
 - Gelatinous membrane that stereocilia & kinocilia are embedded
 - In its surface, contains otoliths (otoconia),
 - Crystalline inclusions
 - Increase the mass of the membrane surface to augment the effect of accelerating forces on the membrane &, in turn, on stereocilia
 - Process:
 - Appropriate head mvmt (linear acceleration)
 - Endolymph moves w/in utricle/saccule
 - Endolymph pushes against & deviates otolithic
 - Deviated otolithic causes stereocilia deflection
 - Stereocilia deflection/deviation determines polarity of receptor potential of hair cells as described above (see “Fxn’l Polarity”)
 - Away from kinocilium/BB = hyperpolarization
 - Twrd kinocilium/BB = polarization

- Zonula Occludins
 - *Tectorial Membrane* (rigid)
 - Hinged at spiral limbus
 - Contains keratin-like protein
 - Most (if not all) stereocilia hair cells embedded
 - H/w base of cells do NOT rest on the basilar membrane
 - Inner hair cell stereocilia relationship uncertain
 - *Basilar Membrane* (supple) - part of osseous labyrinth
 - Dense mat of collagenous fibers that is supple rather than rigid
 - Organ of Corti rests upon it
- Process
 - Sound (compression waves in perilymph)
 - Shifting of two rigid plates (Reticular Lamina & Tectorial Membrane)
 - Deviates stereocilia
 - Produces receptor potentials in sensory/afferent cells
 - Neurotransmitters released upon afferents from spiral ganglion cells (some traverse the inner tunnel)
- Fxn of Cochlea (NOT tested on; to be covered in neuroscience; included for general understanding)
 - Sound → outer ear → ossicles (specifically stapes) → movement of stapes against oval window → compressional waves travel along scala vestibule, helicotrema, & scala tympani → round window
 - Mvmt of compressional waves sets up oscillations of basilar membrane; peak of vibration depends upon frequency of stimulation
 - Basilar membrane mvmt → Organ of Corti to rock up & down
 - Where peak of vibration occurs, the max shearing force is applied to the stereocilia of hair cells: interpreted by brain as
 - “Pitch” – a fxn of where the peak is located b/w the base & apex of the cochlear duct
 - “Loudness” – the amplitude (waves/unit time) of the receptor potentials generated by the hair cells
- Clinical Correlations:
 - *Vertigo (dizziness)* – disturbances of vestibular fxn may have a number of causes such as infections of the vestibule or lesions of the CNS or PNS
 - *Ménière's Disease*
 - swelling of the membranous labyrinth leads to
 - Dizziness (vertigo)
 - Tinnitus (ringing in the ears)
 - Low frequency hearing loss
 - *Motion sickness* (a more commonly experienced problem) is thought to be produced by over stimulation of the utricle/sacculle
 - Hearing Loss:
 - *Conductive Losses*
 - Reflect a break in the conduction pathway from the atmosphere to the inner ear
 - disruption of the tympanic membrane
 - *Ankylosis* – Fusion of the ossicles
 - *Otosclerosis* – increased bone growth and fusion of the middle ear ossicles

- Beethoven is said to have suffered from otoclerosis and was deaf while composing some of his greatest works
- This problem is currently treated surgically
- *Sensorineural Loss*
 - May reflect loss of hair cells or CN VIII nerve fibers
 - Lip reading & sign language usage are behavioral approaches to living with this disability
 - Cochlear implants are a surgical approach
 - *Presbycusis* (type of sensorineural loss)
 - One of the most common inner ear problems
 - Poor high frequency perception due to age-related loss of hair cells at the basal turn of the cochlea