Histology of Ear

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References:

Ear

1. External Ear
2. Middle Ear
3. Inner Ear
External Ear

- Pinna (Auricle)
  - Irregularly shaped plate o/t elastic cartilage covered by thin skin

- Meatus acusticus externa
  - The canal that extends f/t pinna into the temporal bone to the external surface o/t tympanic membrane
  - Superficial portion is composed of elastic cartilage, which is continuous with the cartilage o/t pinna. Temporal bone replaces the cartilage as support in the inner 2/3 o/t canal
  - Is covered with skin containing hair follicles, sebaceous glands, ceruminous glands (modified sweat glands)
Pinna

Ca

Skin
Lumen of canal

Meatus Acusticus Externus

Hyaline cartilage
Connective tissue
Trace of parotid gland
Lymph node
Ceruminous glands

- Modification of apocrine sweat gland
- Tubular glands;
- Produce cerumen (earwax)
- Myoepithelial cells surrounded the secretory portion of ceruminous glands
Middle Ear

- Tympanic membrane
- Tympanic cavity
- Auditory ossicles
  - malleus (hammer)
  - incus (anvil)
  - stapes (stirrup)
- Auditory (Eustachian) tube
- Muscle
  - Tensor tympani muscle
  - Stapedius muscle
Tympanic membrane

- External surface is covered by epidermis;
- Collagen and elastic fibers, fibroblasts interposed btw 2 epithelial layers
- Internal surface is covered by simple squamous to cuboidal epithelium
Tympanic cavity

- Is an air filled space located i/t petrous portion o/t temporal bone
  - Posterior: mastoid air cell
  - Anterior: auditory (eustachian) tube
  - Medial wall: oval window and round window
  - Lateral wall: tympanic membrane
  - Bony ossicles spans the distance btw tympanic membrane and the membrane o/t oval window.

- Is lined mostly by simple squamous epithelium, and pseudostratified ciliated columnar ep (near auditory tube)
  - Lamina propria
    - Bony wall: Adheres to bony wall and has no glands
    - Overlying cartilage portions: has many mucous glands whose ducts open into tympanic cavity

- Muscles
  - M tensor tympani: movement o/t tympanic membrane
  - M stapedius: movement o/t bony ossicles
Auditory Ossicles

- Malleus
  - Is attached to tympanic membrane
- Incus
  - Interposed btw malleus and stapes
- Stapes
  - Is attached to the oval window

- Are articulated in series by synovial joints lined with simple squamous ep.
Inner Ear

- Bony labirynth
  - Semicircular canals
  - Vestibule
  - Cochlea
- Membranous labyrinth
  - Semicircular ducts
  - Saccule and Utricle
  - Cochlear duct and Organ of Corti
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Bony labyrinth

- Is lined w/ endosteum and is separated f/t membranous labyrinth by perilymphatic space that is filled w/ perilymph.
- Semicircular canals are oriented at 90° to one another
  - One end of each canal is an enlarged end called ampulla
  - Semicircular duct (membranous labyrinth)
- Vestibule is the central region o/t bony labyrinth
  - Oval window (fenestra vestibuli)
  - Round window (fenestra cochlea)
  - Utricle and saccule (membranous labyrinth)
- Cochle arises as a hollow bony spiral that turns upon itself
  - Modiolus: central bony column
  - Osseous spiral lamina
Membranous labyrinth

- Is composed of an epithelium from embryonic ectoderm derived f/t embryonic ectoderm, which invades the developing temporal bone and gives rise to saccule and utricle, semicircular duct, and cochlea.

- Circulating through the entire membranous labyrinth is endolymph.

- Thin strands of connective tissue from endosteum pass through the perilymph to be inserted into membranous labyrinth. The connective tissue strands carry blood vessels.
Saccule and utricle

- Ducts o/t saccule and utricle
  - Ductus utriculosaccularis connects saccule and utricle
  - Endolymphatic duct → endolymphatic sac
  - Ductus reuniens joins the saccule with cochlear duct

- The walls are composed of
  - A thin outer vascular layer of connective tissue
  - Simple squamous to low cuboidal epithelium
    - Non receptor epithelium
      - Light cells
      - Dark cells
    - Receptor epithelium (neuroepithelium) → maculae
Maculae

- Are located so that they are perpendicular to each other
  - Macula o/t saccule is located in the wall → detecting linear vertical acceleration
  - Macula o/t utricle is located in the floor → detecting linear horizontal acceleration
- Are thickened areas of epithelium, 2 – 3mm in diameter.
- Are composed of
  - 2 types of neuroepithelial cells (Type I and Type II hair cells)
  - supporting cells
- Are covered by and embedded in a thick, gelatinous, glycoprotein mass, the otolithic membrane. The surface of this membrane contains otolith (otoconia), small calcium carbonate.
Type I hair cells

- Has a single kinocilium and stereocilia arranged in rows according to length
  - Each stereocilium is anchored in terminal web
  - Bending can occur only in the neck region of stereocilia
- Are plump cells with a rounded base that narrows toward the neck
- Cytoplasm:
  - Occasional RER
  - A supranuclear golgi complex
  - Numerous small vesicles
Type II hair cells

- Has a single kinocilium and stereocilia arranged in rows according to length
  - Each stereocilium is anchored in terminal web
  - Bending can occur only in the neck region of stereocilia

- Is more columnar than type I hair cells

- Cytoplasm
  - A larger golgi complex and more vesicles
Supporting cells

- Are interposed btw hair cells
- Structure
  - Have a few micovilli
  - Junctional complexes bind these cells to each other and hair cells
  - Exhibit well-developed golgi complex and secretory granules
- Functions:
  - Maintain the hair cells
  - Contribute to the production of endolymph
Innervation

- from vestibular portion o/t vestibulocochlear nerve
- Base of type I hair cells are entirely surrounded afferent nerve fiber
- Type II hair cells exhibit many afferent fibers synapsing on the basal area of the cell.
- Synaptic ribbons
  - Type II synapses w/ efferent nerves for increasing efficiency of synaptic release
Semicircular ducts

- Continuation o/t membranous labyrinth from utricle
- Each of 3 ducts is dilated at its lateral end (near the utricle) → ampullae
- Cristae ampularis:
  - specialized receptor areas
  - Is composed of a ridge whose free surface is covered sensory epithelium
    - Type I and II hair cells
    - Supporting cells
  - Cupula: similar to otolithic membrane but it’s cone-shaped and does not contain otoliths
Cochlear duct and organ of corti

- Cochlear duct is a diverticulum of the saccule.
  - Wedge-shaped receptor organ housed in the bony cochlea
  - Surrounded on 2 sides by perilymph but separated from it by 2 membranes
  - The roof is vestibular (Reissner’s membrane) whereas the floor is the basilar membrane

- The perilymph-filled compartment lying above the vestibular membrane is scala vestibuli whereas the perilymph-filled compartment lying below the basilar membrane is scala tympani. These 2 compartments communicate at the helicotrema, near the apex o/t cochlea.
Vestibular and Basilar membrane

● Vestibular membrane
  ● Is composed of 2 layers of squamous epithelium separated each other by a basal lamina
  ● Inner layer: from scala media
  ● Outer layer: from scala vestibuli
  ● Tight junction seal both layers of cells

● Basilar membrane
  ● Extends from the spiral lamina at modiolus to the lateral wall
  ● Is composed of 2 zones:
    ● Zona arcuata
      ▪ Thinner, medial, supports the organ of corti
    ● Zona pectinata
      ▪ Fibrous meshwork containing few fibroblast
Vestibular Membrane  

Basilar Membrane
Stria Vascularis

- Is a pseudostratified epithelium located in the lateral wall of the cochlear duct, extends between vestibular membrane and spiral prominence.
- Contains an intraepithelial plexus of capillaries which are surrounded by:
  - Basal processes of marginal cells
  - Ascending processes of basal and intermediate cells
- Is composed of 3 cell types:
  - Marginal cells
    - Dark staining → dense cytoplasm containing mitochondria and small vesicles
    - Abundant microvilli on their free surfaces
  - Basal cells
    - Less dense cytoplasm
    - Its cytoplasmic process interdigitate with other cells
  - Intermediate cells
    - Less dense cytoplasm
Capillary
- MC = marginal cells
- IC = Intermediate cells
- BC = basal cells
- ZO = zonula occludens
- ZA = zonula adherens
- D = desmosome
- CAP = capillary
Spiral Prominence

- Located on the inferior wall of cochlear duct
- Is a small protuberance that just out from periosteum of cochlea
- The basal cells and vascular layer covers the prominence.
- Inferiorly, these cells are reflected into spiral sulcus, where they become cuboidal and continue onto basilar lamina as cells of Claudius, which lies overlie the smaller cells of Böttcher
**Limbus**

- Located at narrowest portion o/t cochlear duct, where the vestibular and basilar membranes meet
- Is composed of periosteum
- Part of limbus projects over the internal spiral sulcus (tunnel)
  - Vestibular lip: the upper portion
  - Tympanic lip: the lower portion
- Accomodates branches o/t accoustic nerve
- Interdental cells secrete the tectorial membrane
Reissner's membrane (RM), spiral ligament (SL), stria vascularis (SV), spiral prominence (SP), external sulcus (ES), basilar membrane (BM), pars arcuata (PA), pars pectinata (PP), Boettcher's cells (B), Claudius' cells (C), organ of Corti (OC), tectorial membrane (TM), inner sulcus cells (IS), spiral limbus (L), habenula perforata (circled), and osseous spiral lamina (OSL).
Organ of Corti

- Specialized receptor organ for hearing
- Lies on basilar membrane
- Is composed of
  - neuroepithelial hair cells
  - supporting cells
    - Pillar cells
    - Phalangeal cells
    - Border cells
    - Cells of Hensen
  - Tectorial membrane
  - Inner tunnel
Supporting Cells

- **Inner and outer pillar cells**
  - Tall cells with wide bases and apical ends that are attached to basilar membrane
  - The central portions are deflected to form the walls of inner tunnel; apical portion contact each other.

- **Phalangeal cells**
  - **Outer phalangeal cells**
    - Tall columnar cells that are attached to basilar membrane
    - Apical portions are cup-shaped to support the basilar portions of outer hair cells along with efferent and afferent nerve fibers
    - Do not reach the free surface of organ of corti
    - Space of Nuel: a fluid-filled gap around unsupported regions of outer hair cells
      - Communicates with inner tunnel
  - **Inner phalangeal cells**
    - Located deep to the inner pillar cells
    - Completely surround the inner hair cells
Supporting Cells

- **Border cells**
  - Delineate the inner border of organ of corti
  - Slender cells that support inner aspects of organ of corti

- **Cells of Hensen**
  - Define the outer border
  - Located between outer phalangeal cells and cells of Claudius
Neuroepithelial (Hair) cells o/t Organ of Corti

- Inner hair cells
  - Single row of cells supported by inner phalangeal cells
  - Are short and exhibit a centrally nucleus, numerous mitochondria located below terminal web, RER, SER, and small vesicles.
  - Apical surface contains 50 – 60 stereocilia arranged in “V” shape
    - stereocilia: contains microfilamen, cross-linked w/ fimbrin
  - Basal aspects contains microtubules and synapses w/ afferent fibers o/t cochlear portion o/t vestibulocochlear nerve
Neuroepithelial (Hair) cells o/t Organ of Corti

- Outer hair cells
  - Are supported by outer phalangeal cells
  - Are arranged in rows of 3 (or 4)
  - Are elongated cylindrical cells whose
    - Apical portion:
      - 100 stereocilia in “W” shape
    - Lateral portion
      - Cortical lattice: filaments that support cell
    - Basal portion:
      - Nuclei and mitochondria
      - afferent and efferent fibers synapses
The outer wall of the cochlear duct is made up of a thickening of the periesteum (called the spiral ligament). A pseudostratified epithelium lines a connective tissue rich in capillaries (the stria vascularis).
The crest of the spiral ligament forms a prominence known as the spiral prominence.

The osseous spiral lamina is a bony shelf projecting from the modiolus. It forms canals for the cochlear nerve fibers.
Tectorial Membrane

- Contains $\alpha$- and $\beta$-tectorin proteins
- Extends outward over the sensory epithelium from the spiral lamina
- Is in close contact with taller stereocilia of hair cell
- When the basilar membrane and organ of corti are displaced, stereocilia hit the tectorial membrane and depolarization of hair cells occurs
Thank You