

Ear

Overview

- In the adult, the ear is a single anatomic unit for hearing and equilibrium.
 - In the embryo, it develops from three distinct parts:
 1. External ear → sound-collecting organ.
 2. Middle ear → sound conductor from external to internal ear.
 3. Internal ear → converts sound waves into nerve impulses and detects equilibrium changes.
-

INTERNAL EAR

Early Development

- First appearance: ~22nd day of development.
 - Site: Surface ectoderm thickens on each side of the rhombencephalon → forms otic placodes.
 - Otic placodes → invaginate → form otic (auditory) vesicles / otocysts.
 - Each otic vesicle divides into:
 - Ventral component → saccule + cochlear duct.
 - Dorsal component → utricle, semicircular canals, endolymphatic duct.
 - These epithelial structures together form the membranous labyrinth.
-

Saccule, Cochlea, and Organ of Corti

Formation of the Cochlear Duct

- 6th week: Sacculle forms a tubular outpocketing → cochlear duct.
- The cochlear duct grows in a spiral fashion through surrounding mesenchyme.
- By 8th week: completes 2.5 turns.
- Connection with sacculle becomes a narrow canal → ductus reuniens.

Formation of Scalae and Membranes

- Surrounding mesenchyme → differentiates into cartilage.
- 10th week: cartilage undergoes vacuolization → forms two perilymphatic spaces:

1. Scala vestibuli

2. Scala tympani

- Separation of spaces:

- Scala vestibuli ↔ cochlear duct → separated by vestibular membrane.
- Scala tympani ↔ cochlear duct → separated by basilar membrane.

- Cochlear duct attachments:

- Lateral wall → attached to surrounding cartilage via spiral ligament.
- Median angle → attached to modiolus (axis of future bony cochlea).


Differentiation of Cochlear Epithelium

- Initially: epithelium of cochlear duct is uniform.
- Later forms two ridges:

- Inner ridge → future spiral limbus.
- Outer ridge → gives rise to sensory hair cells:
 - One row of inner hair cells.
 - 3-4 rows of outer hair cells.

Organ of Corti

- Hair cells are covered by tectorial membrane (fibrous gelatinous structure).
- Tectorial membrane attaches to spiral limbus, rests on tips of hair cells.
- Together with sensory cells → forms the Organ of Corti.
- Function: Transduces mechanical sound vibrations into nerve impulses.
- Impulse pathway: Organ of Corti → Spiral ganglion → Auditory fibers of CN VIII → CNS.

 Exam Pointers

- Week of development:
 - 22 days → otic placodes.
 - 6th week → cochlear duct outgrowth.
 - 8th week → 2.5 turns of cochlea complete.
 - 10th week → scala vestibuli & tympani form.
 - Structures derived from ventral vs dorsal components of otocyst.
 - Organ of Corti = essential hearing structure (hair cells + tectorial membrane).
 - Nerve supply: Cochlear division of CN VIII.
-

UTRICLE AND SEMICIRCULAR CANALS

- 6th week: Semicircular canals form as flattened outpocketings of the utricular part of the otic vesicle.
- Process of canal formation:
 - Central portions of these outpocketings' walls appose and disappear → formation of 3 semicircular canals.
 - One end of each canal dilates → crus ampullare (with ampulla).
 - Other end does not dilate → crus nonampullare.
 - Two crus nonampullare fuse → only 5 crura open into the utricle (3 with ampullae, 2 without).

Sensory Structures

- Crista ampullaris → sensory crest in ampullae, detects angular acceleration.
- Maculae acusticae → sensory areas in walls of utricle and saccule, detect linear acceleration and gravity.

- Impulses from cristae and maculae → carried via vestibular fibers of CN VIII to brain.
-

STATOACOUSTIC GANGLION

- During formation of the otic vesicle, some cells detach and form the statoacoustic ganglion.
 - Other ganglion cells → derived from neural crest.
 - Ganglion splits into:
 - Cochlear portion → supplies sensory cells of the organ of Corti.
 - Vestibular portion → supplies sensory cells of saccule, utricle, semicircular canals.
-

MIDDLE EAR

Tympanic Cavity and Auditory Tube

- Origin: Endoderm of first pharyngeal pouch.
- Development:
 - Pouch expands laterally, contacts floor of first pharyngeal cleft.
 - Distal portion (tubotympanic recess) → primitive tympanic cavity.
 - Proximal narrow portion → auditory (Eustachian) tube, maintaining communication with nasopharynx.

Ossicles

- Origin:
 - Malleus + Incus → from cartilage of 1st pharyngeal arch.
 - Stapes → from cartilage of 2nd pharyngeal arch.

- Appearance: Form during first half of fetal life, embedded in mesenchyme.
- 8th month: Mesenchyme surrounding ossicles dissolves → ossicles become free.
- Endodermal epithelium of tympanic cavity grows to cover ossicles, suspending them in a mesentery-like fashion → later forms their supporting ligaments.

Muscles of Ossicles

- Tensor tympani (attached to malleus):
 - Derived from 1st arch.
 - Nerve supply → Mandibular branch of CN V (trigeminal).
- Stapedius (attached to stapes):
 - Derived from 2nd arch.
 - Nerve supply → CN VII (facial nerve).

Later Development

- Late fetal life: Tympanic cavity expands dorsally → forms tympanic antrum.
- After birth: Epithelium of tympanic cavity invades mastoid bone → formation of air sacs (mastoid air cells) = pneumatization.
- Most air cells connect with antrum and tympanic cavity.

Clinical Correlation

- Otitis media (middle ear infection) may spread into:
 - Tympanic antrum.
 - Mastoid air cells → mastoiditis (serious complication).

 Points for Exams

- Pharyngeal arch origin of ossicles + muscles + nerve supply.
 - First pharyngeal pouch → tympanic cavity + Eustachian tube.
 - Sensory structures:
 - Crista ampullaris (angular acceleration).
 - Maculae acusticae (linear acceleration).
 - Neural crest + otic vesicle cells → statoacoustic ganglion.
 - Clinical: Spread of otitis media → mastoid air cells.
-

EXTERNAL AUDITORY MEATUS

- Origin: From dorsal portion of 1st pharyngeal cleft.

- 3rd month:
 - Epithelium at bottom proliferates → forms meatal plug (solid epithelial plate).

- 7th month:
 - Meatal plug dissolves.
 - Floor of meatus → contributes to definitive tympanic membrane.

- Anomaly: If plug persists until birth → congenital deafness.

Eardrum (Tympanic Membrane)

- Composition (3 layers):
 1. Ectodermal epithelium → from auditory meatus.
 2. Endodermal epithelium → from tympanic cavity.

3. Intermediate connective tissue → forms fibrous stratum.

- Attachment: Major part firmly attached to handle of malleus.
- Function: Separates external auditory meatus from tympanic cavity.

Auricle

- Origin: Six auricular hillocks (mesenchymal proliferations).
 - 3 from 1st pharyngeal arch.
 - 3 from 2nd pharyngeal arch.
- These swellings fuse around the 1st pharyngeal cleft → form definitive auricle.
- Position change: Initially low in the neck region, ascend with mandible growth → reach level of the eyes.

- Note: Fusion process is complex → auricular abnormalities are common.

Clinical Correlates

Hearing Loss

- Causes:
 - Abnormal development of membranous/bony labyrinth.
 - Malformations of ossicles or eardrum.
 - Complete absence of tympanic cavity + external meatus (rare, severe).
- Factors:
 - Genetic causes (many syndromes).
 - Environmental/teratogenic causes:
 - Rubella infection.
 - Cytomegalovirus infection.
 - Isotretinoin (Accutane) → causes multiple ear defects.

External Ear Abnormalities

- Common and variable (minor → severe).
- Significant because:
 1. Cause psychological & emotional impact.
 2. Often associated with other malformations → important diagnostic clue.
 3. Seen in most chromosomal syndromes (frequent sign).
- Examples:
 - Preauricular pits → shallow depressions anterior to ear (abnormal hillock development).
 - Preauricular appendages (skin tags) → may arise from accessory hillocks.
 - Both may be isolated or linked with other anomalies.

✓ Exam Checklist

- External auditory meatus = 1st pharyngeal cleft.
 - Meatal plug (3rd month → dissolves in 7th month). Persistence = congenital deafness.
 - Tympanic membrane = ectoderm + endoderm + connective tissue.
 - Auricle = 6 hillocks (1st + 2nd arches). Initially low in neck → ascends.
 - Clinical: congenital hearing loss (genetic, viral, teratogenic), external ear anomalies (pits, appendages, auricular defects in syndromes).
-

-> The End <-