

# Embryonic Development Of The Ear

The ear consists of three sections:

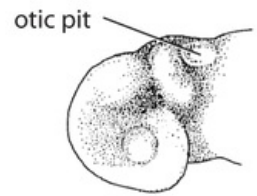
1. **internal**,
2. **middle**,
3. **external**.

## Inner Ear

Auditory placodes are formed **on day 22th** 'from the **ectoderm** on both sides of the *rhombencephalus*. They gradually sink in and form auditory sacs (**otocysts**). **The ventral part' of the** *cam* provides the basis for the formation of the *sacculus* and the *ductus cochlearis*. **Dorsal** is for the *utricle* and the *ductuli semicirculares* and the *ductus endolymphaticus*. Together, therefore, it provides the basis for the membranous labyrinth. From the mesenchyme around the *ductus cochlearis* cartilage arises, which later becomes vacuolated - the *scala tympani* and the *scala vestibuli* are formed. Gradually, other structures of the inner ear are formed.

During the 6th week 3 semicircular ducts (*ductus semicirculares*) are formed as flattened protrusions of the utricle. The widened part of the ducts is called the *ampulla*. The two ampoules then merge into one. In the ampoules there is the *crista ampularis* = component of the kinetic part of the balance organ.

The static part develops in the saccule and utricle - *maculae staticae*. The impulses are conducted by the vestibulocochlearis nerve, which forms the ganglion *vestibulocochleare*.



Otic placode

## Otocyst

Around **22nd day of embryonic development**, an **otic placode** in the form of condensed ectoderm is present on each side of the future rhombencephalon (in the region of the 3rd brain pouch). In **4th week**, the otic placode, after being induced from the mesoderm and rhombencephalon by the **growth factor FGF8**, begins to snap inward as an otic pouch, which is called **an otocyst** after decompression. The otocyst is formed by the ectoderm epithelium, which after invagination gets closer to the rhombencephalon and the statoacoustic ganglion begins to form in the mesenchyme.

Around **5th week**, the otocyst divides into 2 parts:

- a) **Ventral area'** (induced from the ventral part of the rhombencephalon by SHH) which will give rise to the future *sacculus* and the *ductus cochlearis* (cochlear part).
- b) The **Dorsal area'** (induced from the dorsal part of the rhombencephala via the WNT) which gives rise to the future *utricle*, *ductus endolymphaticus* and the *ductus semicirculares* (vestibular part).

## Ductus cochlearis

- In 6th week a canal grows from the lower part of the saccule - the ductus cochlearis, which grows to a length of 2.5 turns and remains connected to the saccule through a narrow '**ductus reuniens**'.
- Ductus cochlearis is encased in mesenchyme, which turns into cartilage, which is the basis for the future bony labyrinth.
- In **10th week**, vacuolization occurs in this cartilaginous base and 2 perilymphatic spaces are formed:

1. **scala vestibuli** - a space separated by the vestibular membrane,
2. **scala tympani** - space separated by the basilar membrane

The ductus cochlearis is laterally connected to the cartilage by means of a *ligamentum spirale*, it is medially supported by a cartilage projection = **modiolus**'.

The cells in the ductus cochlearis are initially the same size, but gradually differentiate into cylindrical cells that form 2 mounds:

- **Internal** - future limbus spiralis.
- **External** - hair cells arranged in parts:

1. outer (1 row of cells),
2. inner (3-4 rows of cells)

## Hair cells

- Hair cells are actually hearing sensory cells, their projections touch the tectorial membrane, which has the character of a jelly-like substance and is attached to the limbus spiralis. The stereocilia of the hair cells

protrude above the level of the tunnel of Corti and penetrate into the membrana tectoria.

- Sensory cells Organ of Corti are secondary sensory cells that convert mechanical stimuli (which originate from sound waves) into nerve impulses. These are further transmitted by dendrites of ggl cells. spirals, which are at the base of the sensory cells and go to the modiolus to the fundus meatus acustici interni to the ggl. spiral. Axons of cells from ggl. spirals emerge from the fundus meatus acustici interni as 'n. cochlearis'.

### ***Ductus semicirculares***

- In the autricular part, in **6 week** 3 flattened projections appear. The central parts of the walls of these protrusions are attached to each other, merge and eventually disappear apoptotically, creating 3 semicircular canals - ductus semicirculares (anterior, posterior, lateral).
- The semicircular canals have a dilated part - the **ampulla** and a non-dilated part. The unexpanded parts of the anterior and posterior semicircular canals merge together, and thus the canals open into the utriculus with 5 (not 6) openings (3 contain an ampulla, 2 are unexpanded).
- There are other sensory structures in the ampullae - **cristae ampullares**. They are raised ridge-like edges that protrude from the wall of the ampulla. They contain sensory and supporting cells.

### ***Utriculus and sacculus***

- Utriculus and sacculus are sacs in the wall of which there are receptors of gravity - maculae staticae. They are also secondary sensory cells that receive stimuli and change them into nerve impulses, which they transmit through the endings of the sensitive fibers of the vestibular nerve.
- Stereocilia protrude from the sensory cells, of which there is always one typically longer cilia.
- The apical surface of the cells is covered with a high gelatinous layer of glycoproteins in which the cilia are embedded. On the surface of this layer are calcium carbonate crystals called '**otoliths**', which exert their weight in the direction of gravity on the gelatin layer and thus on the stereocilia.
- The deformation of the cilia is transferred to a nerve impulse and further carried up to the CNS.
- Ductus utriculosaccularis is a thin duct connecting the utriculus and the sacculus.

### ***Ductus endolymphaticus***

- Ductus endolymphaticus originates from the bend of ductus utriculosaccularis and heads to the back surface of the pyramid, where it opens into the dura mater with its blind extension - saccus endolymphaticus (lymph is absorbed there).

## **Middle Ear**

The middle ear consists of the **middle ear cavity** (cavum tympani) and the **auditory ossicles** (ossicula auditoriva). The middle ear cavity is formed from the endoderm of the first gill slit. Laterally, it gives rise to the 'recessus tubotympanicus'. The medial part gives rise to the 'auditory tube' (Eustachian tube). Malleus and incus arise from the first gill arch, stapes from the second. The primitive middle ear cavity is lined by endoderm epithelium. The *Musculus tensor tympani* is innervated from the n. mandibularis, *musculus stapedius* from n. facialis.

### ***Cavum tympani***

- The middle ear cavity develops from the pharyngeal gut, specifically from its 1st branchial notch on the lateral side.
- It is lined with endoderm.
- Increases its size up to 2x during development.
- The medial continuation of the cavum tympani is the auditory tube = Eustachian tube, which connects the middle ear cavity with the nasopharynx.
- Laterally, the cavum tympani comes into contact with the 1st gill cavity and at their interface forms the future ear drum = membrana tympanica (between the cavity and the cleft there is still a layer of surrounding mesenchyme). So the drum has 3 layers.

(\*In fish, this membrane is called the membrana obturans and does not contain mesenchyme - the protrusion and depression are closely attached to each other.)

### ***Ossicula auditory***

- Inside the cavum tympani, cartilaginous models of ossicula auditoriva = ossicles of the middle ear are formed.

**Malleus** = anvil (remains of the cartilage of the 1st pharyngeal arch - *Meckel's cartilage*). **Incus** = malleus (cartilage remnant of the 1st pharyngeal arch). **Stapes** = stirrup (cartilage remnant of the 2nd arch - *Reichert's cartilage*).

- Ossicula auditoriva are surrounded by mesenchyme until the 8th month of development, which gradually decreases, and the endoderm epithelium lining the primitive middle ear cavity thus reaches these ossicles from the walls.
- Endoderm transitions to bones in the form of algae, in which ligaments later differentiate.
- Ossicula auditoriva are the first ossifying bones in the human body (4th month of development).

- During the fetal period, the middle ear cavity also expands backwards and resorption of the tissue occurs, in which the *antrum mastoideum* is formed. Postnatally, the epithelium from the middle ear cavity penetrates into the processus mastoideus, where epithelium-lined cellulae mastoideae are formed. Antrum mastoideum is connected with cellulae mastoideae.
- In case of otitis media, the inflammation can spread up to the procc. mastoid.

## External ear

The external ear consists of the *auricula*, the '**meatus acusticus externus**' and the the *tympanic membrane* (*membrana tympani*), which forms the border with the middle ear. The meatus acusticus externus develops from the ectoderm of the first gill cavity. In the 3rd month, the cells proliferate and form a solid epithelial plug. In the 7th month it is luminized. The tympanic membrane consists of 3 parts: the ectoderm, the middle fibrous layer and the endoderm on the inner side. The pinna develops from 6 mesenchymal ear bumps.

### *Auricula*

- The pinna is made up of 6 mesenchymal bumps (ectomesenchyme covered with ectoderm) surrounding 1st ***gill depression*** at the dorsal end of the 1st and 2nd gill arches.
- 3 bumps in the front and 3 in the back merge to form the pinna
- Originally, the pinna and external auditory canal were located in the neck area, but due to the development of the mandible, they move to the head area up to the level of the eyes.

### *Meatus acusticus externus*

- The external ear canal develops from **1st Branchial cavity**.
- At the beginning of **3. months**, ***an epithelial plug*** appears at its base, created by the proliferation of ectoderm cells.
- In **7. month**, this plug luminizes (if it does not occur, one of the types of deafness occurs).
- Thus, a definitive drum is formed at the base, to which the manubrium mallei is attached.

### *Tympanic membrane*

The drum has 3 parts:

- **external** - ectoderm (from the 1st gill cavity),
- **middle** - stratum fibrosum (from mesenchyme),
- **internal** - entoderm (from the 1st gill slit).
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## Links

### Related Articles

- Auditory pathway
- Organ of Corti
- Pharyngeal arches
- Hearing
- Developmental disorders of the ear

### Literature

- ČIHÁK, Radomír – GRIM, Miloš. *Anatomie 3*. 2., upr. a dopl edition. Grada, 2004. 673 pp. ISBN 80-247-1132-X.
- SADLER, Thomas, W. *Langmanova lékařská embryologie*. 1. české edition. Grada, 2011. 414 pp. ISBN 978-80-247-2640-3.