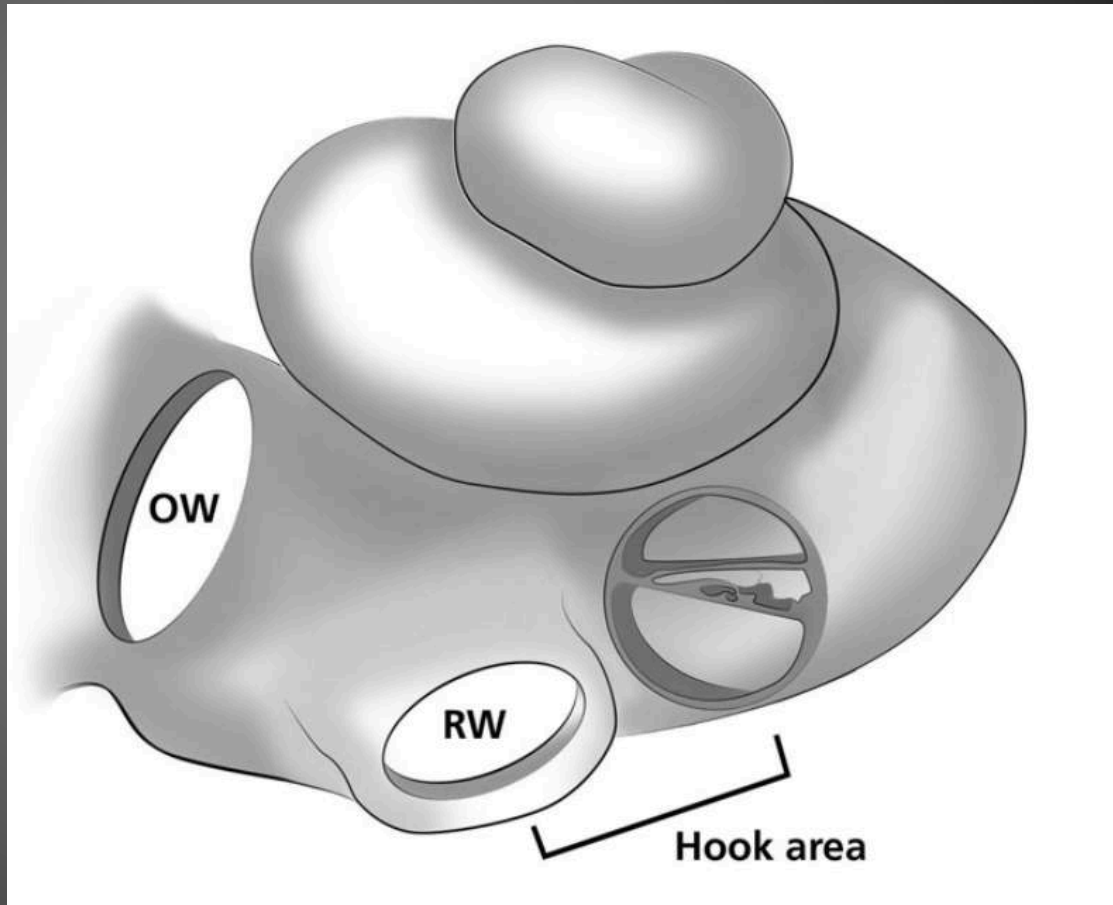
Cochlear window

Giovanni Ralli

Dipartimento di Organi di Senso , Università di Roma

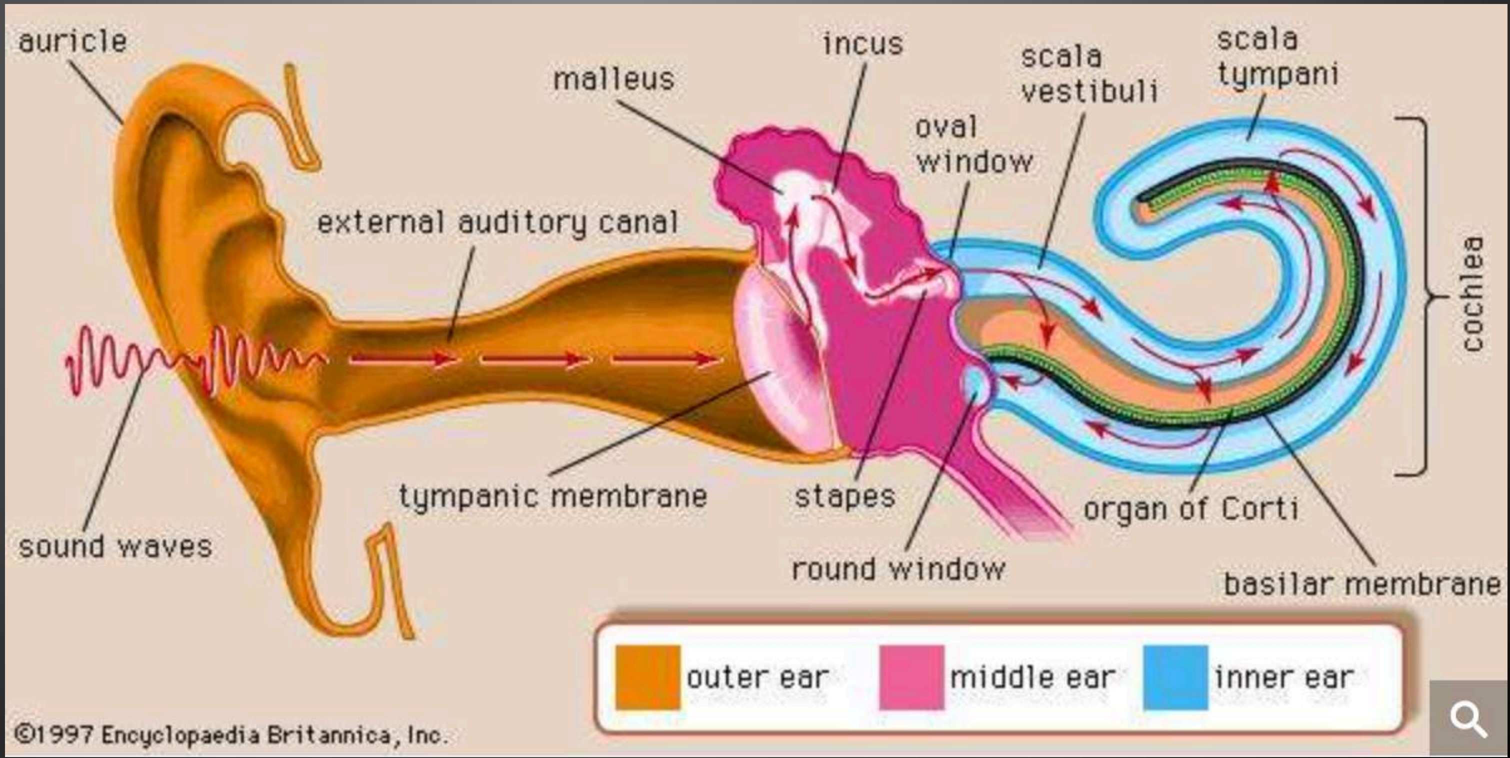
"La Sapienza"

The round window is 1 of the 2 natural openings from the middle ear into the inner ear.



The round window works as a valve, balancing the pressure in the inner ear, which is changed by movements of the stapes inside the oval window.

For this, the round window membrane vibrates with opposite phase to vibrations of the stapes footplate, letting the sound energy dissipate again.



Hence, the round window is considered to be a precondition for audition, as it allows the incompressible fluid in the cochlea to move, which in turn stimulates the inner ear hair cells by consecutive movement of the basilar membrane.

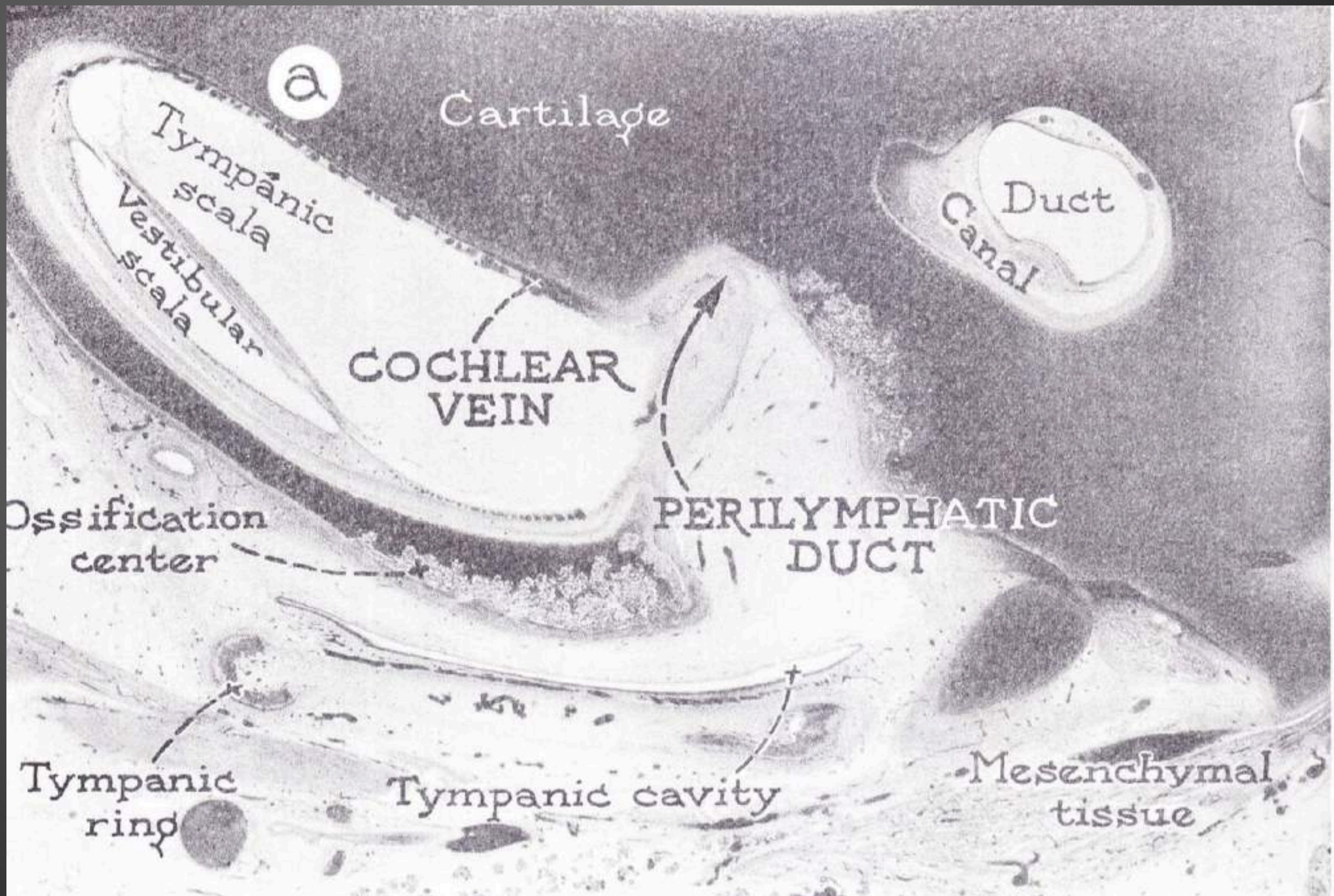
Test dell'inserto

The round window membrane (secondary tympanic membrane) is housed in a small niche (fossula fenestrae rotunda) located postero-inferior to the promontory in the middle ear.

Ossification of the round window niche starts in the 16th foetal week and is complete at time of birth.

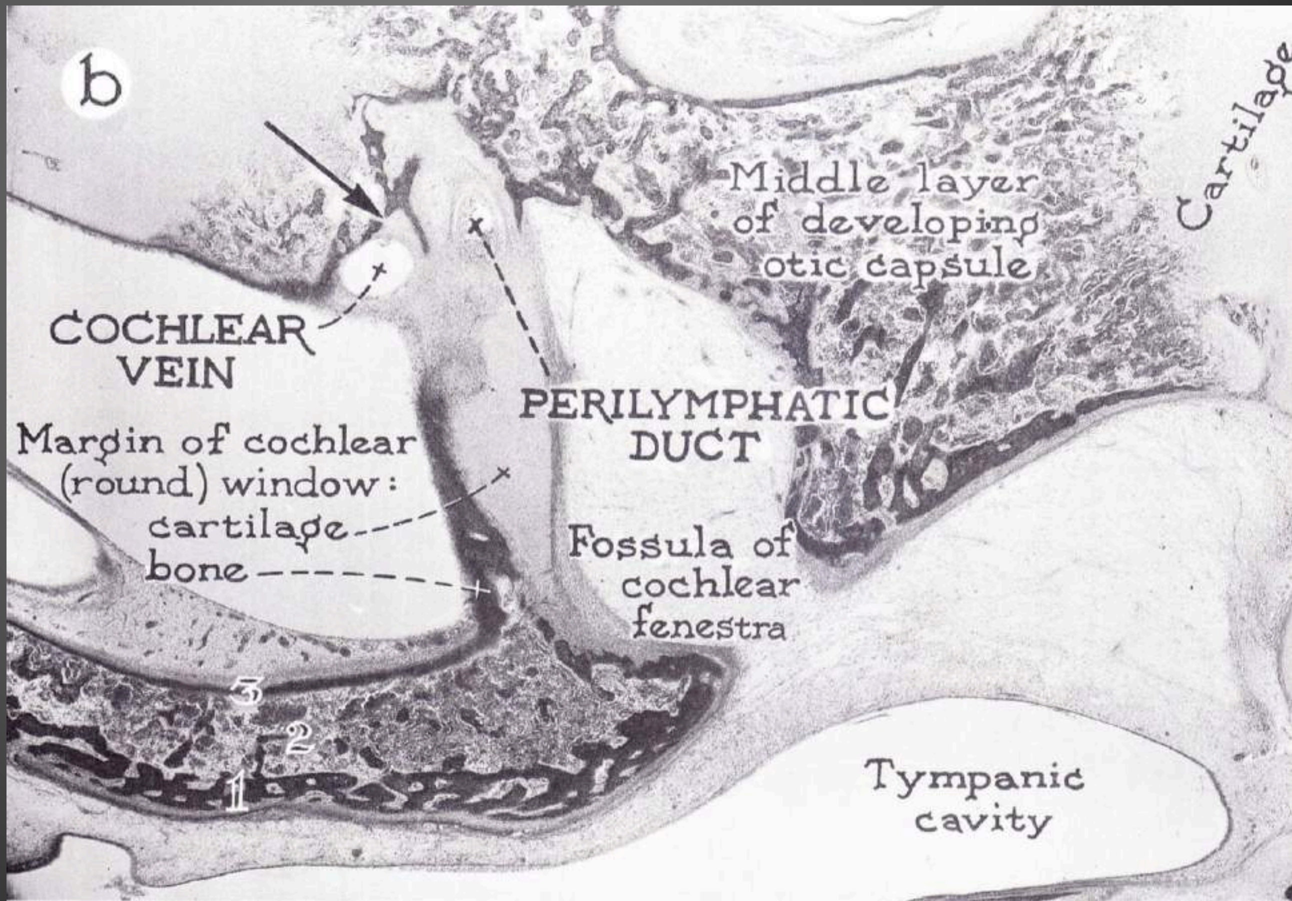
In the fetus at 4-mounth stage, the rim of the cochlear window is still formed in cartilage .

The fondamental relations are established :
the tympanic scala and the fossula of the cochlear finestra .



One mounth later, ossification of the capsule is in progress.

At the level of fenestra both cartilage and bone are present.



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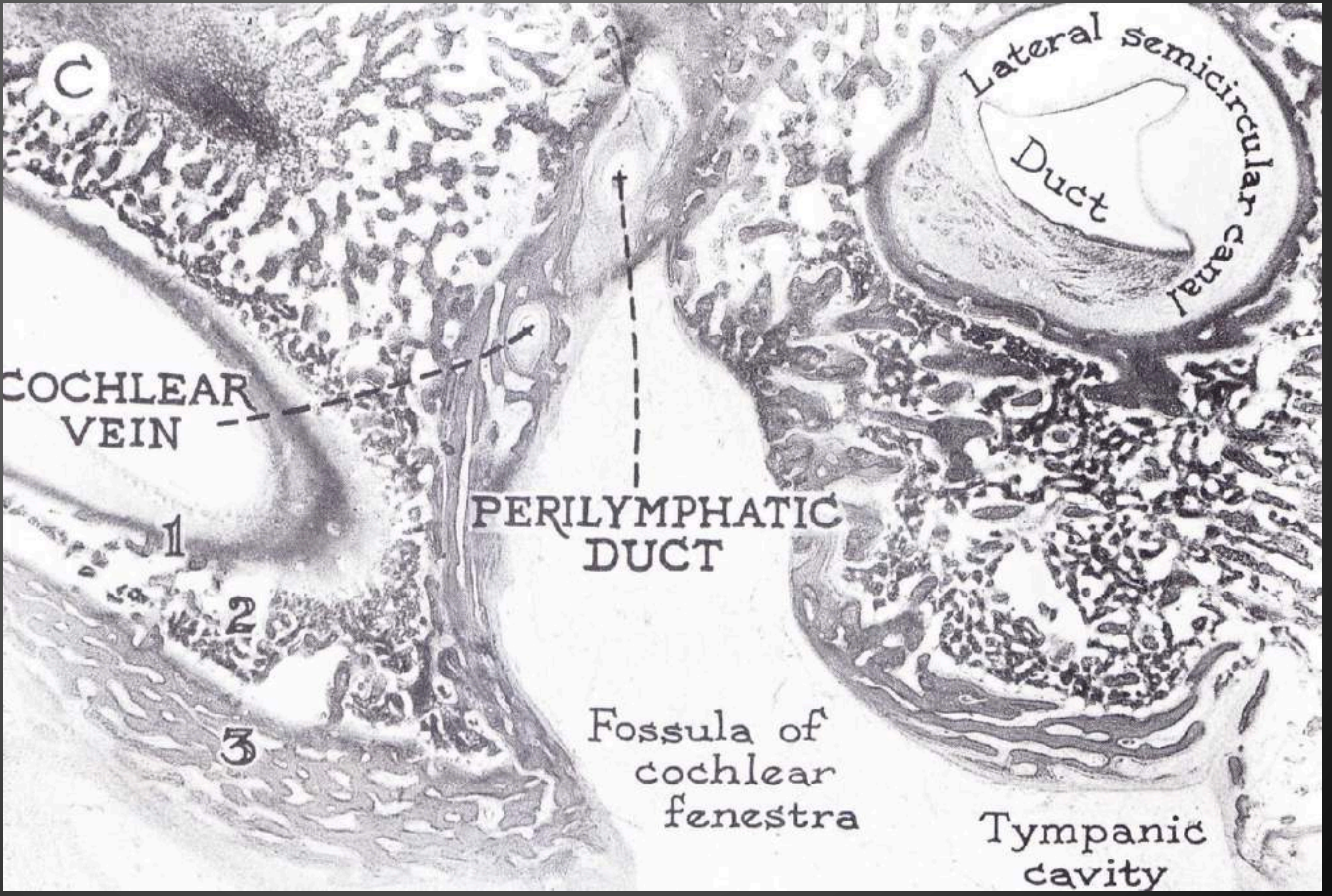
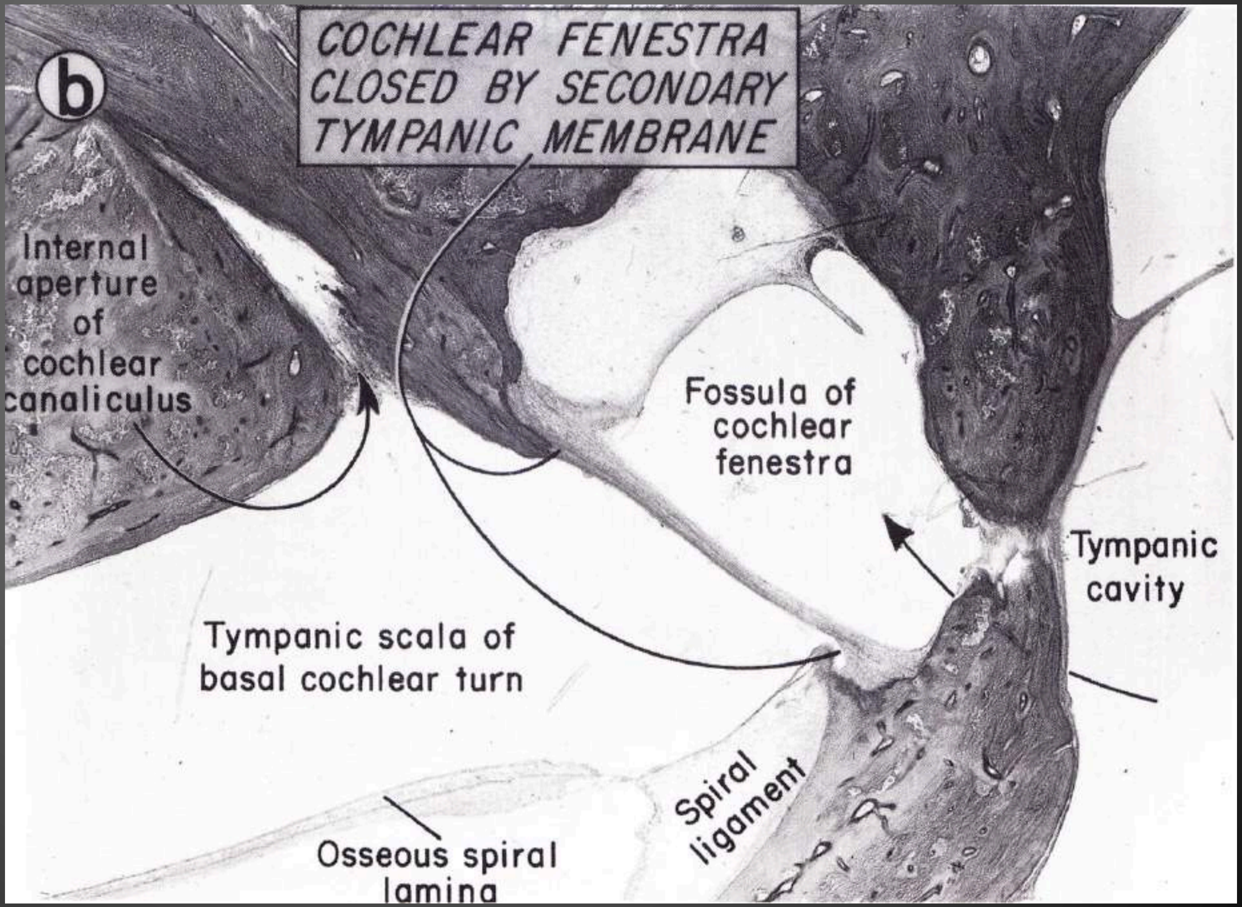
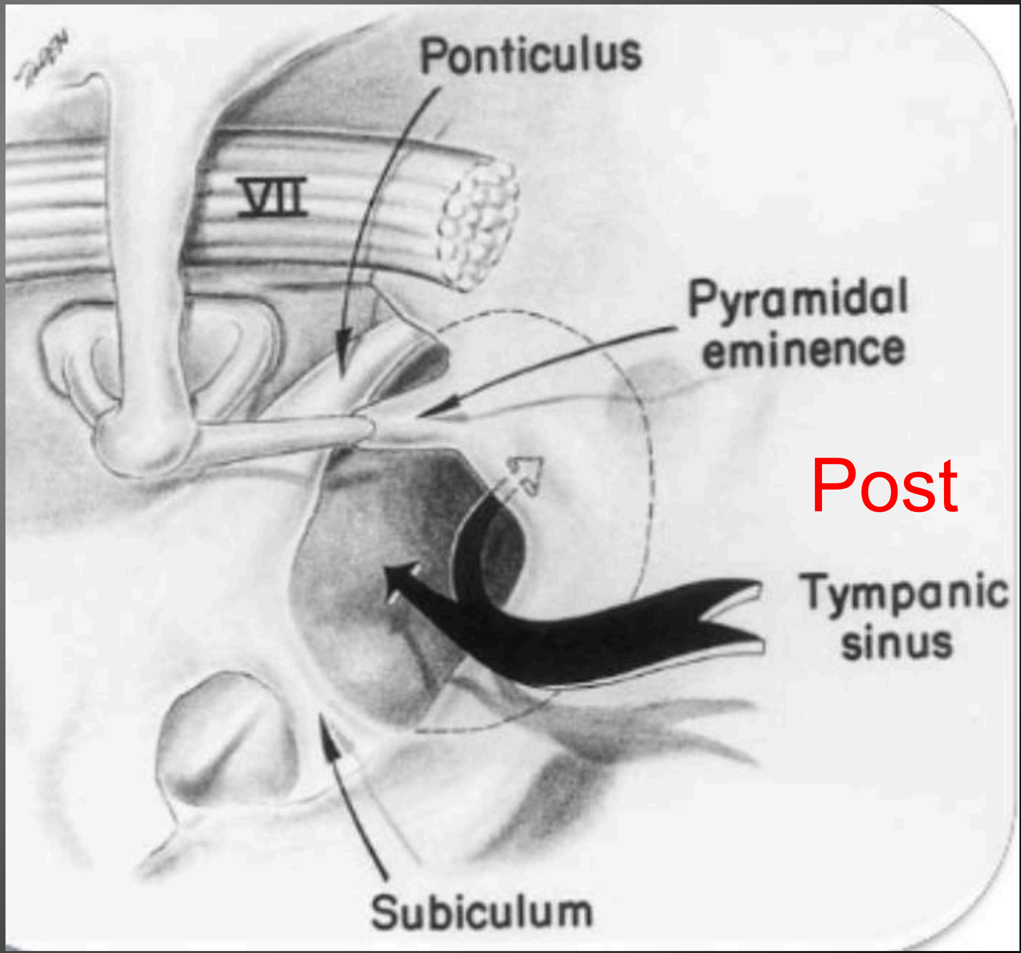


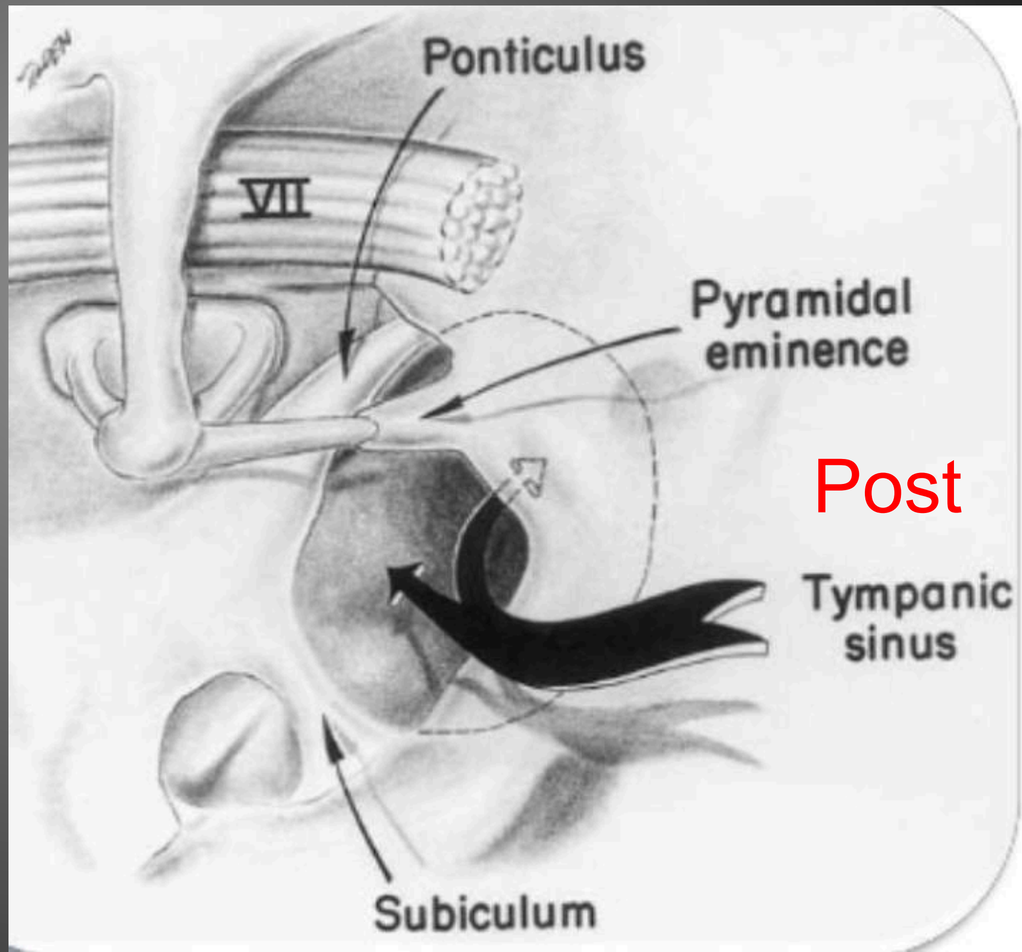
The anterior and superior walls of the niche form by intramembranous ossification, whereas the posterior and inferior walls are predominantly formed by endochondral ossification.



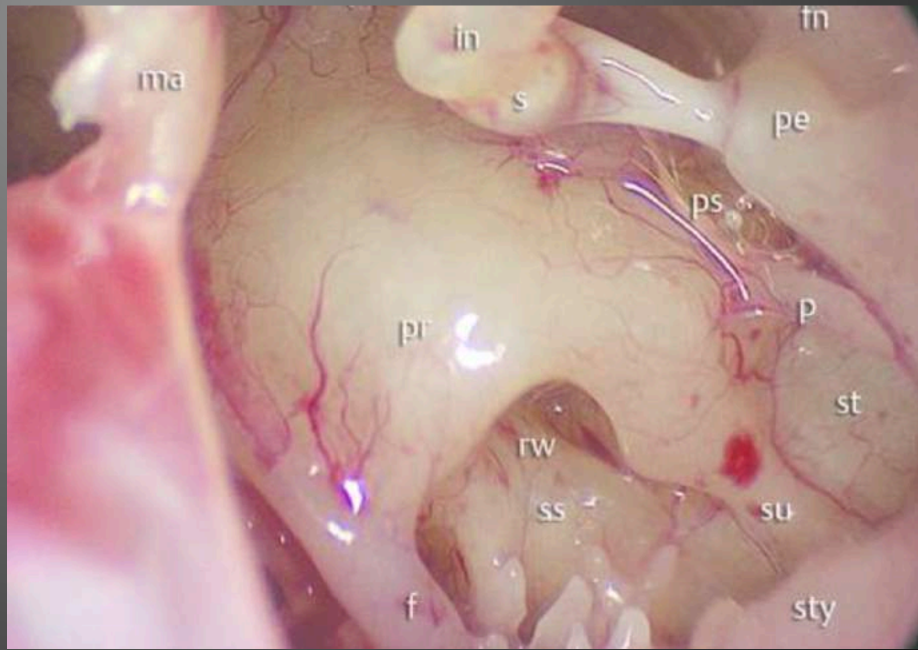
The depressions in that area of the postero-medial tympanic wall are formed by two bony ridges, the subiculum (separating the round window niche from the tympanic sinus) and the ponticulus (separating the tympanic sinus from the oval window niche).



The anterior wall often sees a small projection of the inferior bony margin, which some authors refer to as the crista fenestrae or the crista semilunaris.

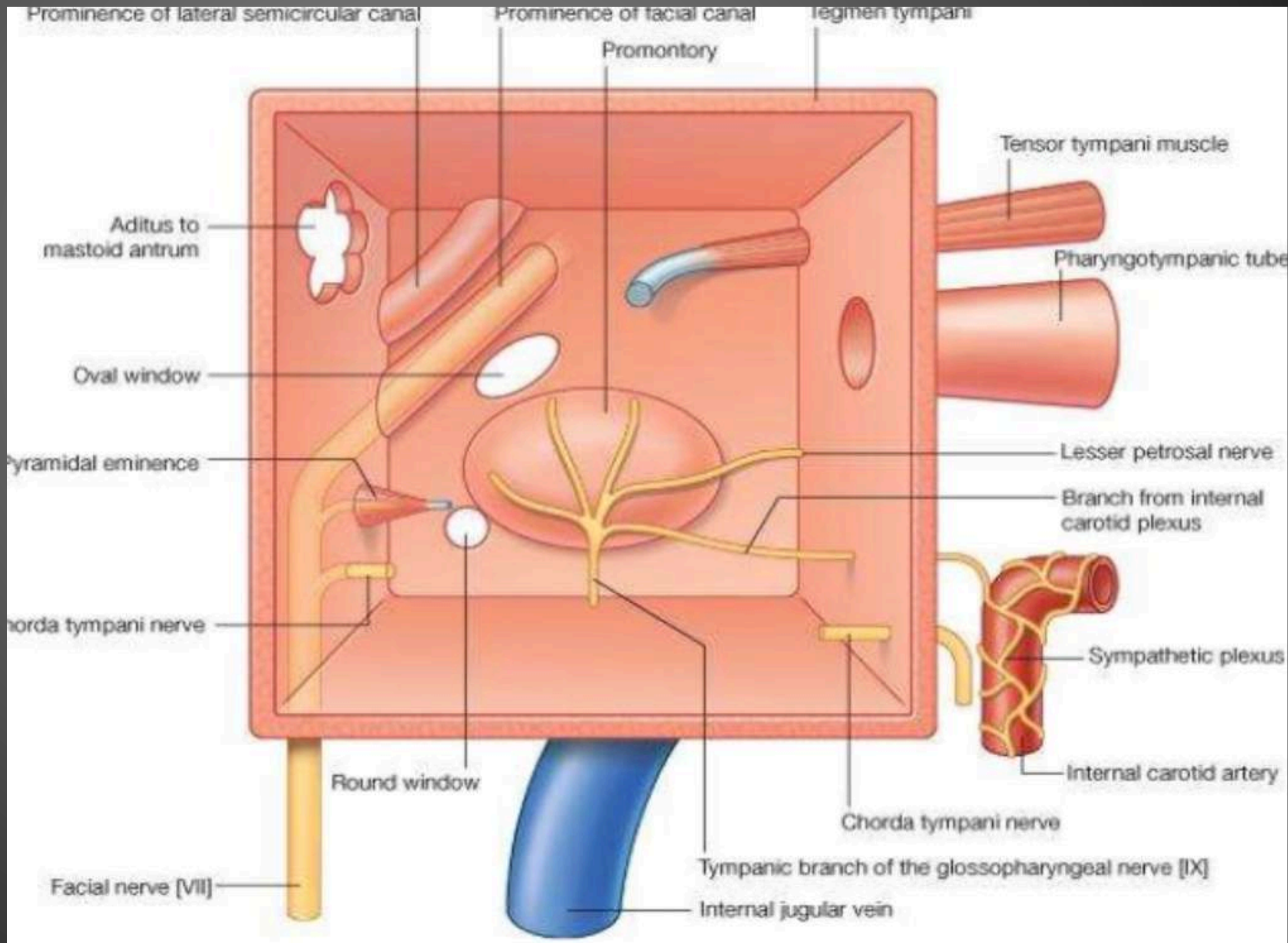


Anterior to the anterior wall of the niche is a supporting pillar of bone formed around the inferior tympani artery, It is a small branch which passes through a minute foramen in the petrous portion of the temporal bone which is called tympanic canaliculus, in company with the tympanic branch of the glossopharyngeal nerve (Jacobson's nerve), to supply the medial wall of the tympanic cavity and anastomose with the other tympanic arteries



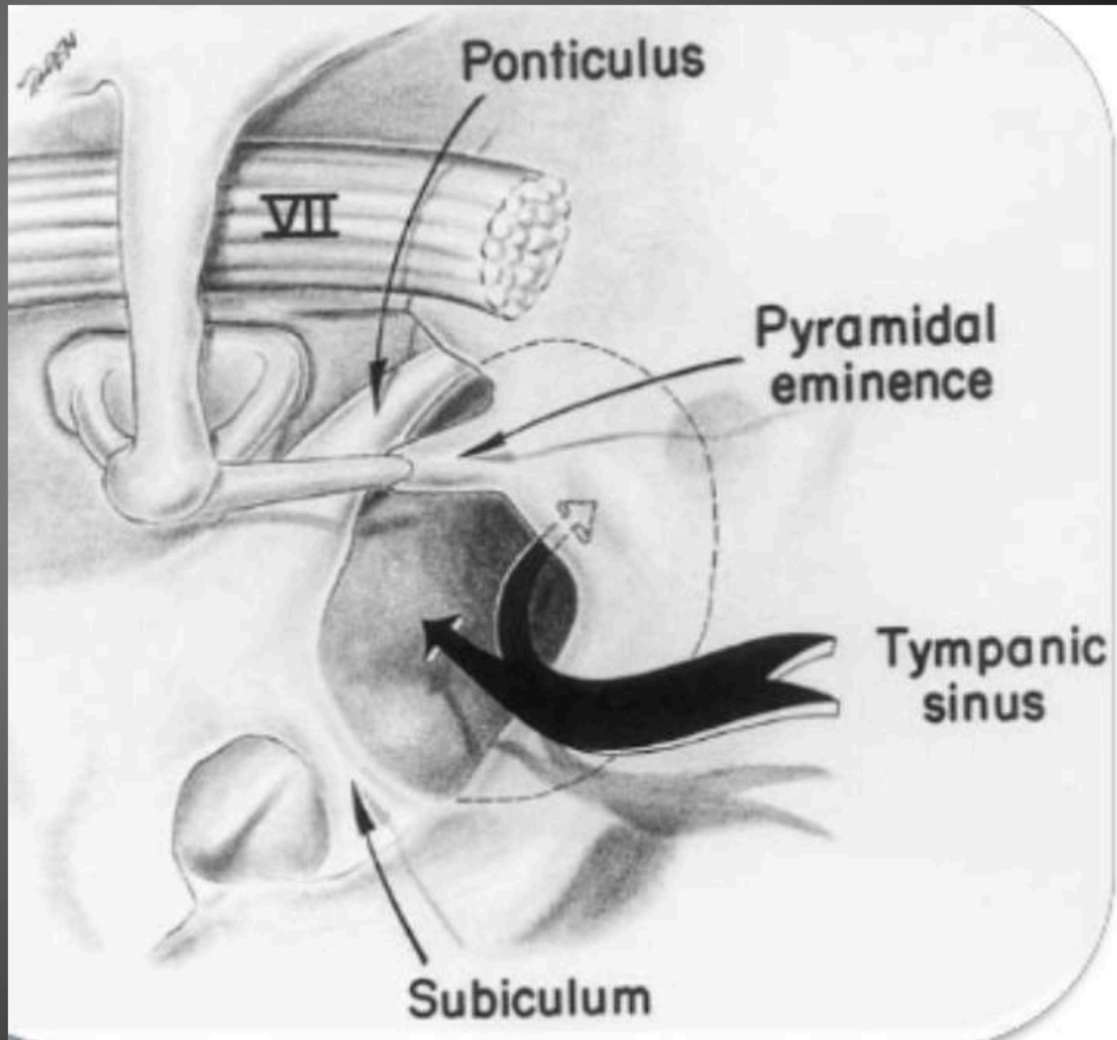
Jacobson's nerve contains both sensory and secretory fibers. Sensory fibers supply the middle ear.

Parasympathetic secretory fibers continue as the Lesser Petrosal nerve and provide secretomotor innervation to the parotid gland.



Jacobson's nerve may be involved by paraganglioma, in this location referred to as glomus jugulare or glomus tympanicum tumours.

The posterior wall of the niche fuses with the subiculum. It turns inward through the niche entrance but may reach the depth of the niche perpendicularly, or it may bend outward to the floor of the sinus tympani.



The round window membrane partially hides behind an overhanging oblique ridge from the promontory, which regularly limits visibility of the round window membrane during surgery.

The overhang is narrowest at its free edge and widens medially, measuring about 2.1 mm (range 1.9-2.4 mm).

Inferior to the round window is the fustis (depth) and a vault called area concamerata, lying between hypotympanum and sinus tympani .

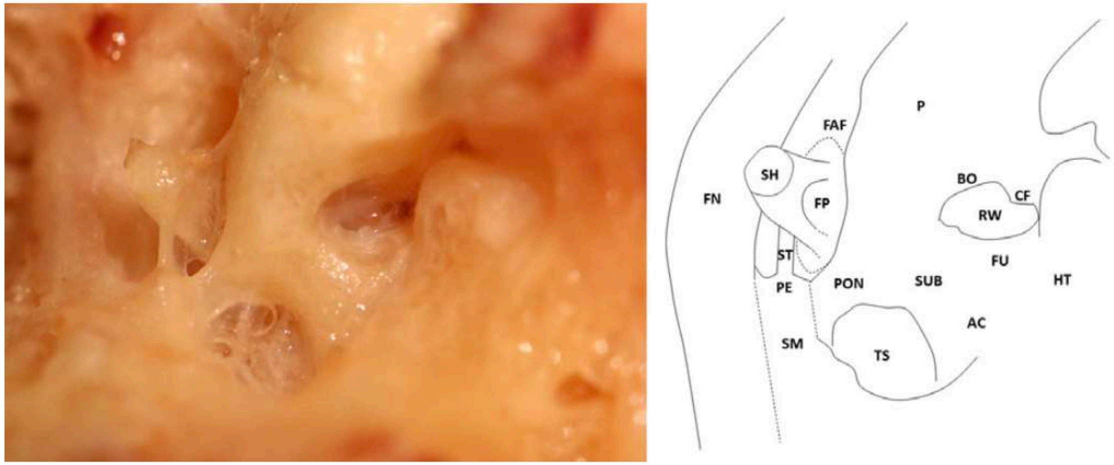


FIGURE 1 Middle ear anatomy with the tympanic membrane, malleus and incus removed (left = temporal bone, right = schematic drawing) showing facial nerve (FN), stapes head (SH), footplate (FP), fissula ante fenestram (FAF), stapedial tendon (ST), pyramidal eminence (PE), stapedial muscle (SM), promontory (P), ponticulus (PON), subiculum (SUB), tympanic sinus (TS), round window (RW), superior bony overhang (BO), crista fenestrae (CF), fustis (FU), area concamerata (AC) and hypotympanum (HT)

The uneven growth of different walls of the round window niche alters the shape of the entrance, a fact which led to the description of eight different types of round window niches.

In certain cases, especially with congenital anomalies, full atresia of the RW may occur.

Another factor obscuring the view onto the membrane is a false round window membrane created by mucoperiosteal folds which in temporal bones can be detected in about 55%.

The mean depth of the round window niche is 1.34 mm, with a range of 0.69-2.28 mm.

Note that the level of the niche entrance and the level of the round window membrane are not parallel, and hence, a canal-membrane-angle would normally be greater than the canal-niche-angle.

The round window membrane is recessed within the round window niche.
It is fixed to the otic bone via a fibrous ring.

Both the niche and the membrane vary greatly in shape, which has been described as round, oval, conical, triangular, quadrangular.

It seems that the development of the round window in terms of shape and size is completed prenatal.

The round window membrane consists of three layers: the outer epithelium, middle layer of connective tissue and inner epithelium.

The outer epithelium consists of a single layer of cells that is continuous with that of the promontory. The epithelial cells contain numerous cylindrical-shaped mitochondria, a well-developed rough endoplasmic reticulum and a Golgi complex.
The middle layer contains collagen fibres, fibroblasts and elastic fibres as well as blood and lymph vessels. There are both radial and longitudinal bundles of collagen fibres, with some fibres irregularly arranged. This core of connective tissue provides the main structural support for the round window membrane .
The inner epithelial cells are squamous, with long lateral extensions.

There are large extracellular spaces which can contain amorphous substances.

On occasion, there are “gaps” noted between epithelial cells resulting in the connective tissue matrix being in direct contact with the perilymphatic space.

Ultrastructural characteristics change with ageing:

in infants, the outer epithelium is thicker, and at times there are more than one layer.

In the elderly, the connective tissue has a looser arrangement. There is an increase in ground substance, elastic fibres become thicker, and thin elastic fibres are absent.

The thickness of the membrane varies between 50 and 100 micron (average 70 lm) with the centre being the thinnest part.

Middle ear diseases such as otitis media might induce changes of round window membrane in thickness and permeability and induce possible sensorineural hearing loss.

There is substantial variability in size of the round window membrane itself.

Its horizontal and vertical axis differ in lengths, and hence, the membrane has more an elliptical shape.

The Scala Tympani attaches to the round window membrane from the medial side.

The membrane has a slight convexity towards the Scala Tympani .

The round window is a structure of tremendous variability in size and shape.

Its important role as a portal for Cochlear implants electrode insertion is well supported by the fact that the round window is the safest landmark for to identify the Scala Tympani .

To improve the efficacy and reduce the adverse effects of systemic drug delivery, more localized drug delivery systems were developed to target inner ear disease.

Schuknecht et al was the first to introduce intratympanic injection as a means of delivering streptomycin into the inner ear for the successful treatment of Meniere's disease patients (1957).

Intratympanic injection injection of a drug into the middle ear space allows for drug diffusion across the round window membrane into the inner ear.

In bypassing the labyrinthine artery and blood-inner ear barrier, intratympanic injection provides a more direct and efficient approach as compared to systemic drug administration.

In fact, drug concentrations measured in the inner ear fluids, perilymph and endolymph, are significantly higher with intratympanic injection than with oral or parenteral administration.

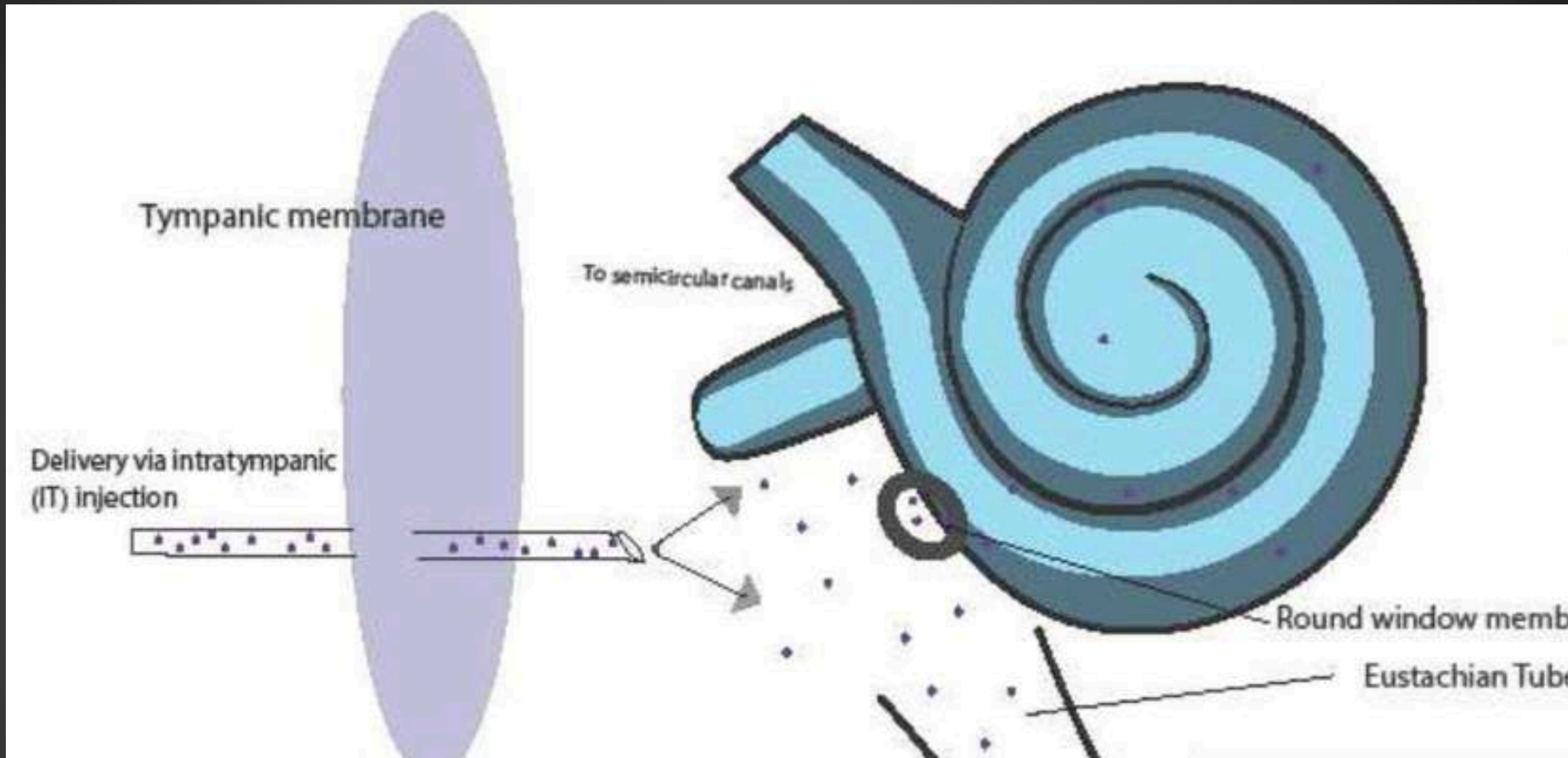
Not only can intratympanic injection more efficiently deliver drugs into the inner ear, it can also avoid many of the side effects associated with systemic therapy.

Due to these advantages and the relative ease of performing the procedure in the office, intratympanic injection of corticosteroids and aminoglycosides is now commonly used for treatment of SHL and Meniere’s disease

Because intratympanic injectionrelies on diffusion for the drug to reach the inner ear from the middle ear, its success is directly related to the amount of drug that comes into contact with the RWM.

Any drug that is not in contact with the round window membrane is eliminated via the Eustachian tube.

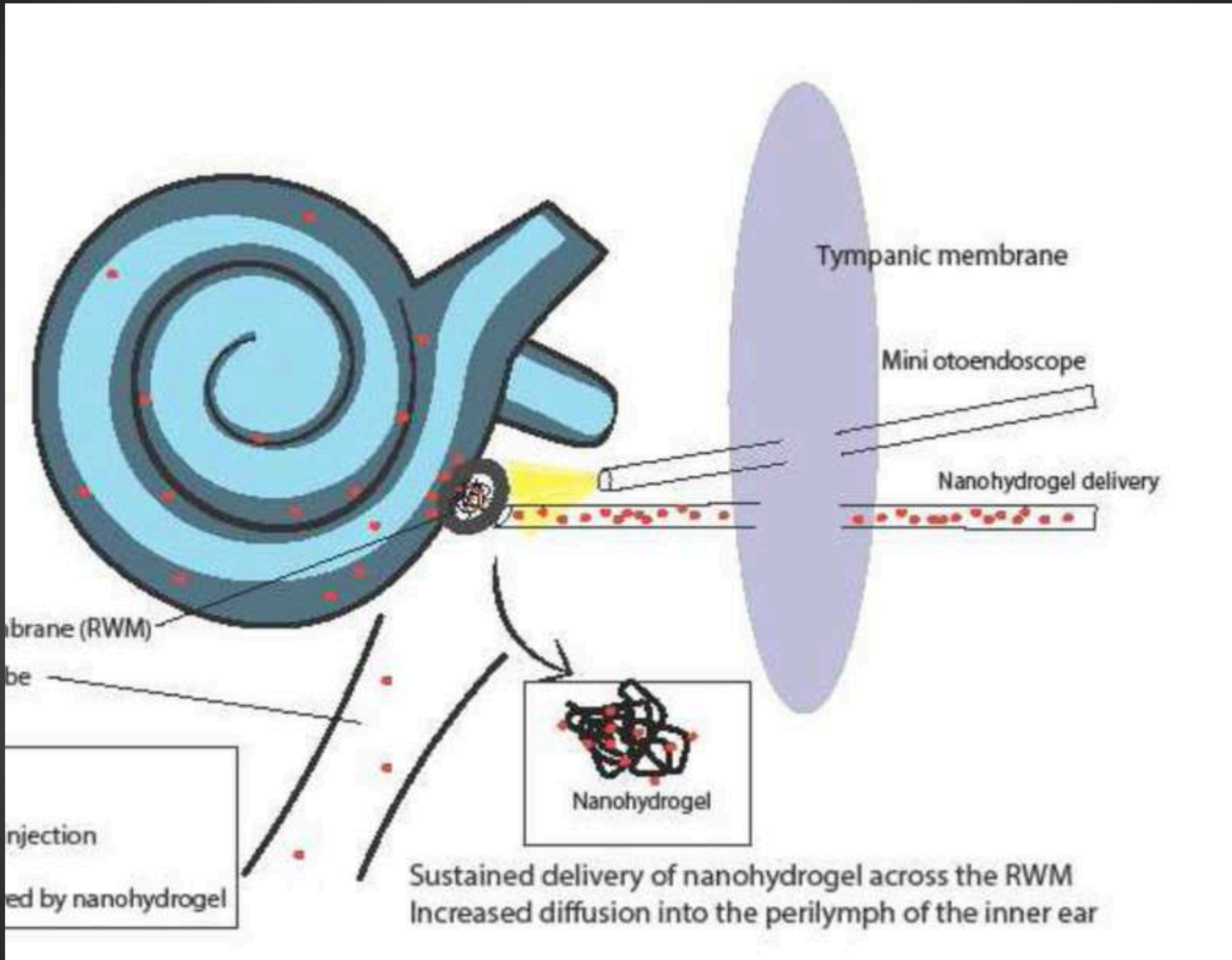
Differences in round window membrane permeability can thus lead to variable rates of drug retention and elimination.


Tympanic membrane
To semicircular canals
Delivery via intratympanic
(IT) injection
Round window memb
Eustachian Tub

In recent years, nanotechnology has become one of the primary strategies to address the epithelium barrier.

Poly (lactic-co-glycolic acid) nanoparticles for delivering drugs to the inner ear are becoming increasingly popular due to their biocompatibility, biodegradability, and ability to sustain therapeutic drug concentration for an extended period.

Compared to free drugs, encapsulating them into Poly (lactic-co-glycolic acid) can facilitate entry into the perilymph, thus promoting drug local bioavailability.


Tympanic membrane
Mini otoendoscope
Nanohydrogel delivery
brane (RWM)
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ed by nanohydrogel
Sustained delivery of nanohydrogel across the RWM
Increased diffusion into the perilymph of the inner ear

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