

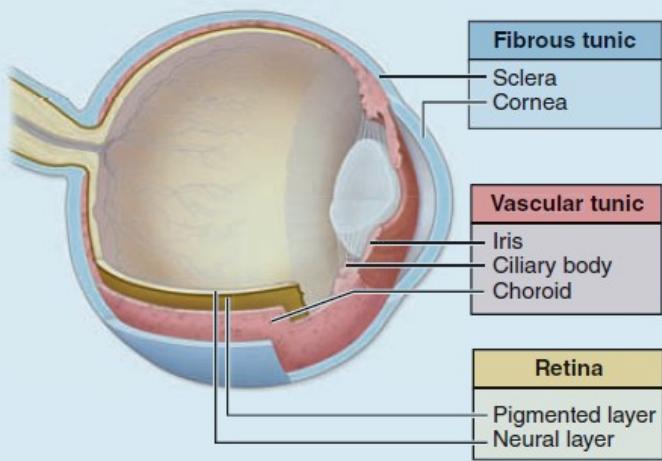
Eye & Ear

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# BI 455 CHAPTER 23

<http://ed.ted.com/lessons/the-evolution-of-the-human-eye-joshua-harvey>

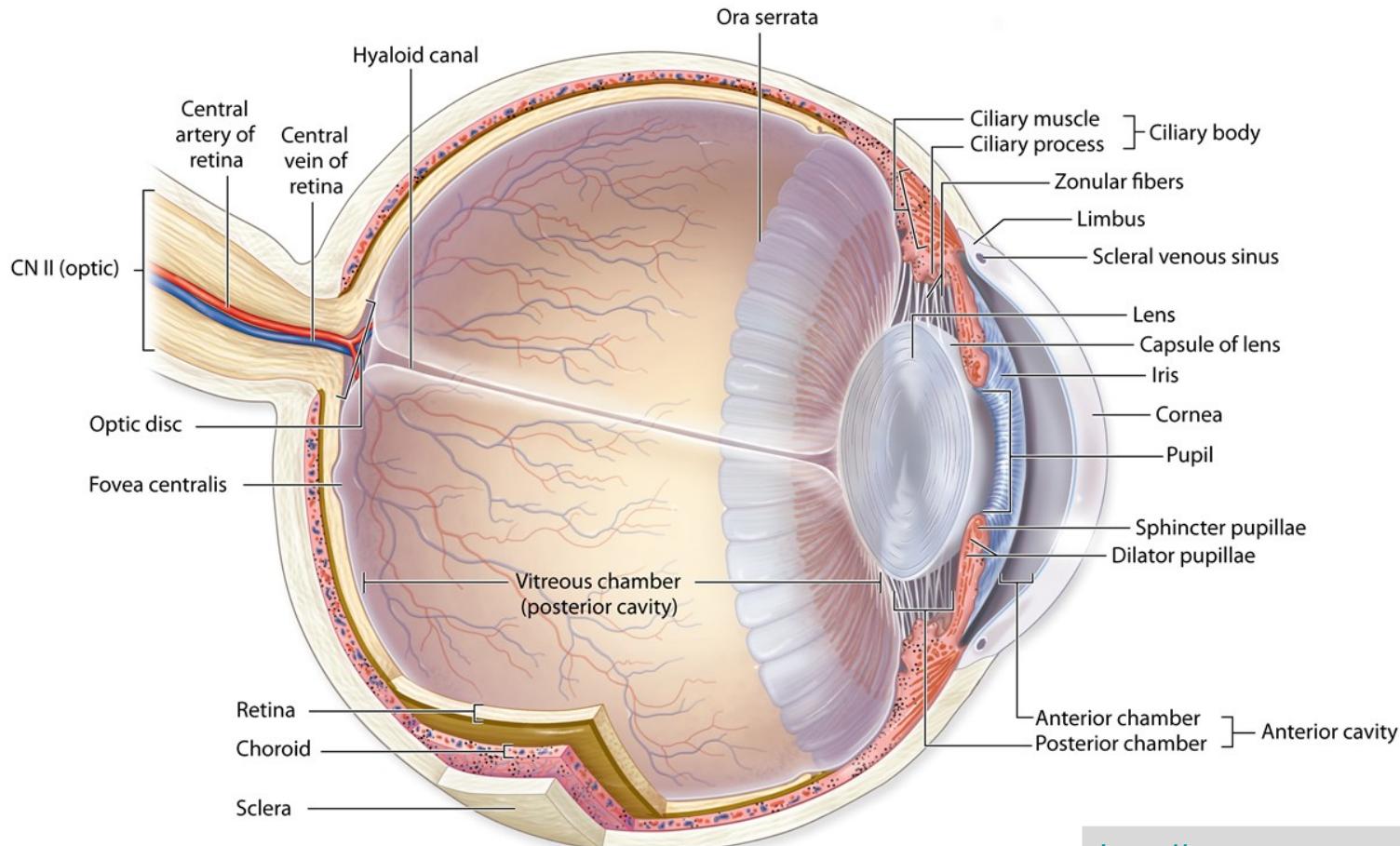
Structures	Components	Function
<b>Fibrous Tunic (External Layer)</b>		
Sclera	Dense irregular connective tissue	Supports eye shape Protects delicate internal structures Extrinsic eye muscle attachment site
Cornea	Two layers of epithelium with organized connective tissue in between	Protects anterior surface of the eye Refracts (bends) incoming light
<b>Vascular Tunic (Middle Layer)</b>		
Choroid	Areolar connective tissue; highly vascularized	Supplies nourishment to retina Pigment absorbs extraneous light
Ciliary body	Ciliary smooth muscle and ciliary processes; covered with a secretory epithelium	Holds suspensory ligaments that attach to the lens and change lens shape for far and near vision Epithelium secretes aqueous humor
Iris	Two layers of smooth muscle (sphincter pupillae and dilator pupillae) and connective tissue, with a central pupil	Controls pupil diameter and thus the amount of light entering the eye
<b>Retina (Internal Layer)</b>		
Pigmented layer	Pigmented epithelial cells	Absorbs extraneous light Provides vitamin A for photoreceptor cells
Neural layer	Photoreceptors, bipolar neurons, ganglion cells, and supporting Müller cells	Detects incoming light rays; light rays are converted to nerve signals and transmitted to the brain



# Internal anatomy of the eye

Three major layers or tunics of the wall

Refractive elements: cornea, lens, and vitreous



# The lens: transparent, elastic tissue that focuses light on the retina.



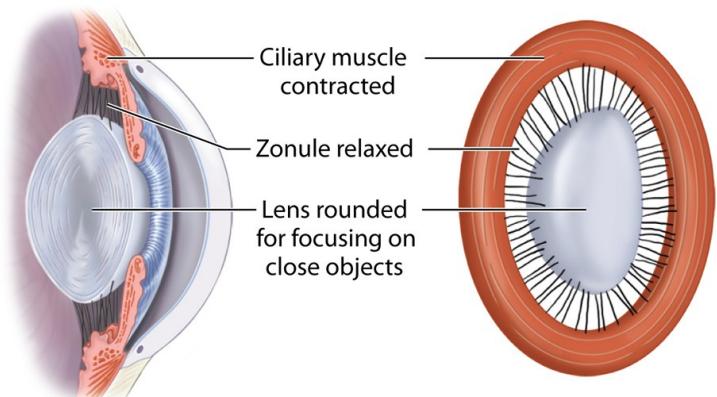
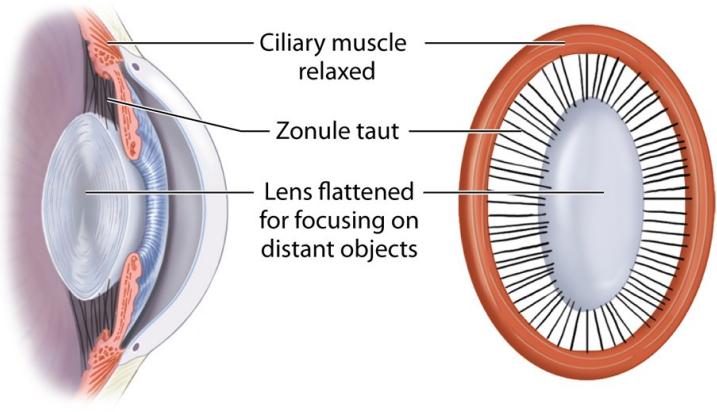
Lens capsule (LC): thick, external lamina

Columnar lens epithelium (LE): Epithelial cells proliferate and give rise to lens fibers.

Differentiating lens fibers (DLF): have nuclei, making crystallin proteins

Mature lens fibers (MLF): No nuclei, densely packed, transparent

# Accommodation: changes in shape of lens keep images focused on the retina



- (a) Distant vision: Ciliary muscle relaxes, lens flattens
- (b) Near vision: Ciliary muscle contracts, lens rounds

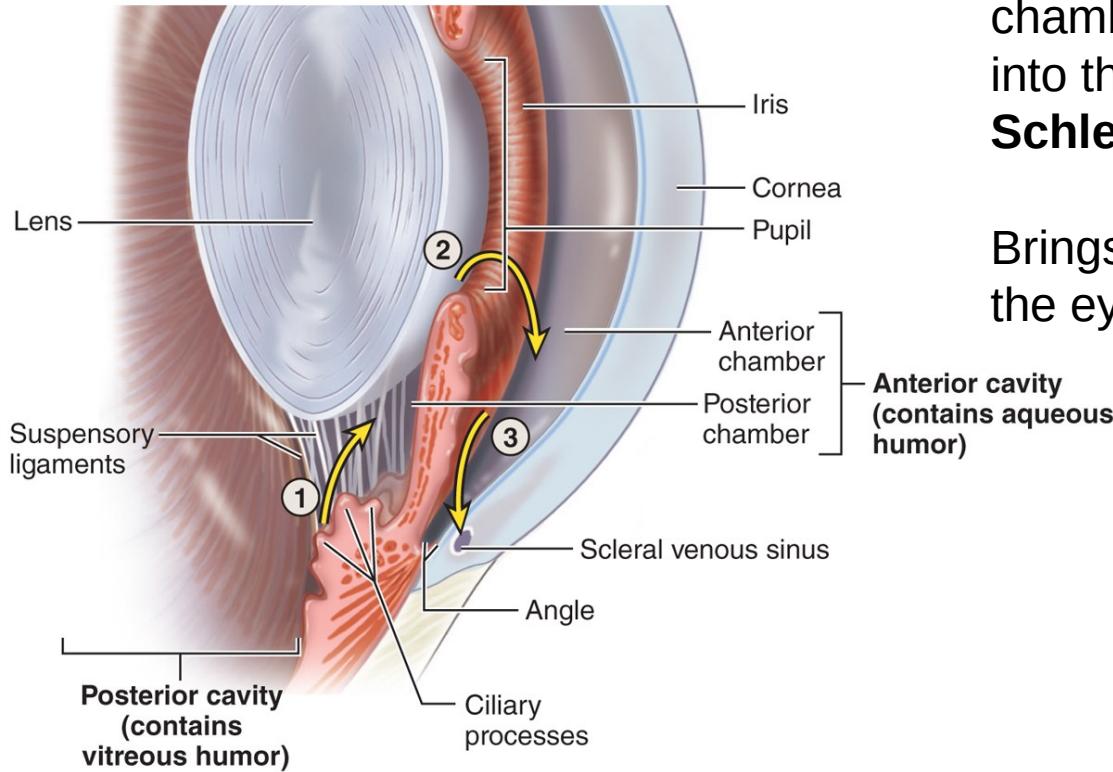
## MEDICAL APPLICATION

**Presbyopia** (far sightedness): Denaturation of crystallins commonly begins to occur in lens fibers, making them less transparent.

**Cataract:** areas of lens become opaque. the condition is termed a

Causes: excessive UV exposure, trauma, diabetes mellitus, and hypertension.

# Production and removal of aqueous humor



- ① Aqueous humor is secreted by the ciliary processes into the posterior chamber.
- ② Aqueous humor moves from the posterior chamber, through the pupil, to the anterior chamber.
- ③ Excess aqueous humor is resorbed via the scleral venous sinus.

Aqueous humor secreted from **ciliary processes** into posterior chamber of the anterior cavity, flows into the anterior chamber through the **pupil**, and drains into the **scleral venous sinus (canal of Schlemm)**.

Brings nutrients to the **anterior cavity** of the eye.

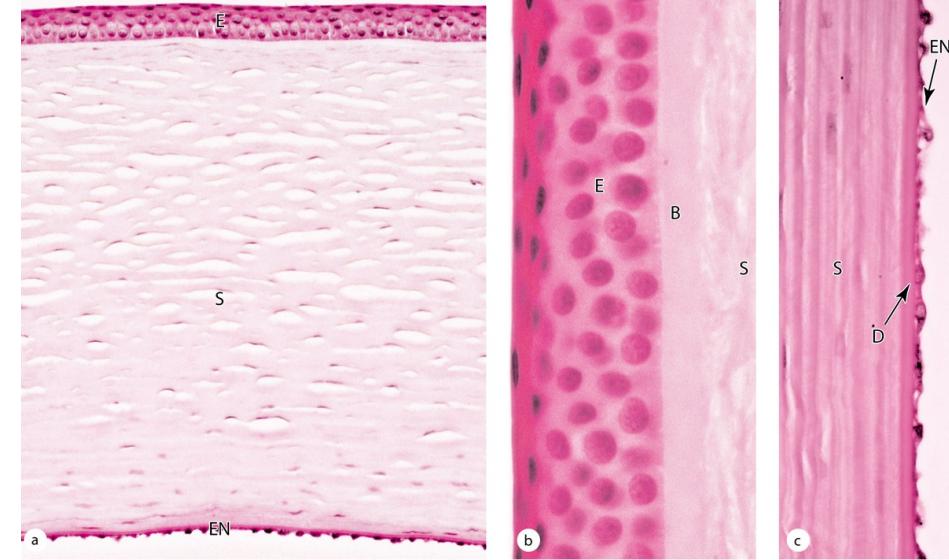
## MEDICAL APPLICATION:

**Glaucoma:** If aqueous humor drainage is impeded, intraocular pressure pushes vitreous body against the retina

# Cornea

External stratified squamous epithelium (E): nonkeratinized, sensory-free nerve endings that trigger the blinking reflex.

Stroma (S): Collagen fibers with flattened **keratocytes**. Avascular, nutrients diffuse aqueous humor behind the cornea



**Medical Application:** The shape of the cornea can be changed via laser - assisted in situ keratomileusis (**LASIK**) surgery. The corneal epithelium is displaced as a flap and the stroma reshaped by an excimer laser which vaporizes collagen and keratocytes in a highly controlled manner with no damage to adjacent cells or ECM. LASIK surgery is used to correct myopia (near-sightedness), hyperopia (far-sightedness), or astigmatism (irregular curvature of the cornea).

**Corneal grafts** (transplants) between unrelated individuals can usually be accomplished successfully without immune rejection due in part to this tissue's lack of both a vascular supply and lymphatic drainage.

<https://www.youtube.com/watch?v=TL4m7cPYyUY>

# Corneoscleral junction (limbus) and ciliary body



Corneoscleral junction (CSJ): corneal stroma merges with the opaque, vascular sclera (S).

Conjunctiva (C) cover the anterior sclera and lining the eyelids.

Scleral venous sinus (SVS), or canal of Schlemm: receives aqueous humor from an adjacent trabecular meshwork at the surface of the anterior chamber (AC).

Iris (I): anterior extension of ciliary body and  
Ciliary body:

Ciliary muscle (CM): smooth muscle

Ciliary processes (CP): epithelium, produces aqueous humor that flows through pupil into the anterior chamber

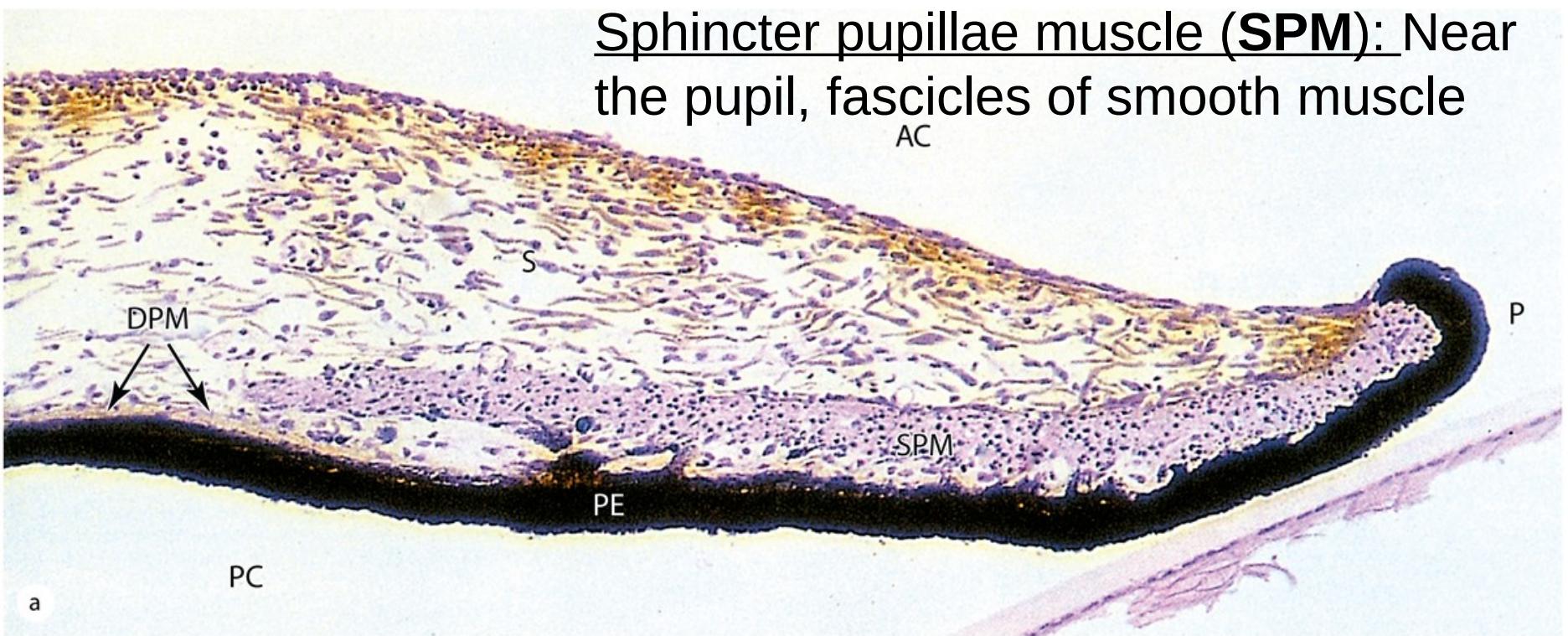
Ciliary zonule (CZ): fibrillin-rich fibers that attach to the capsule of the lens (L)

Posterior chamber (PC)

Vitreous chamber (VC)

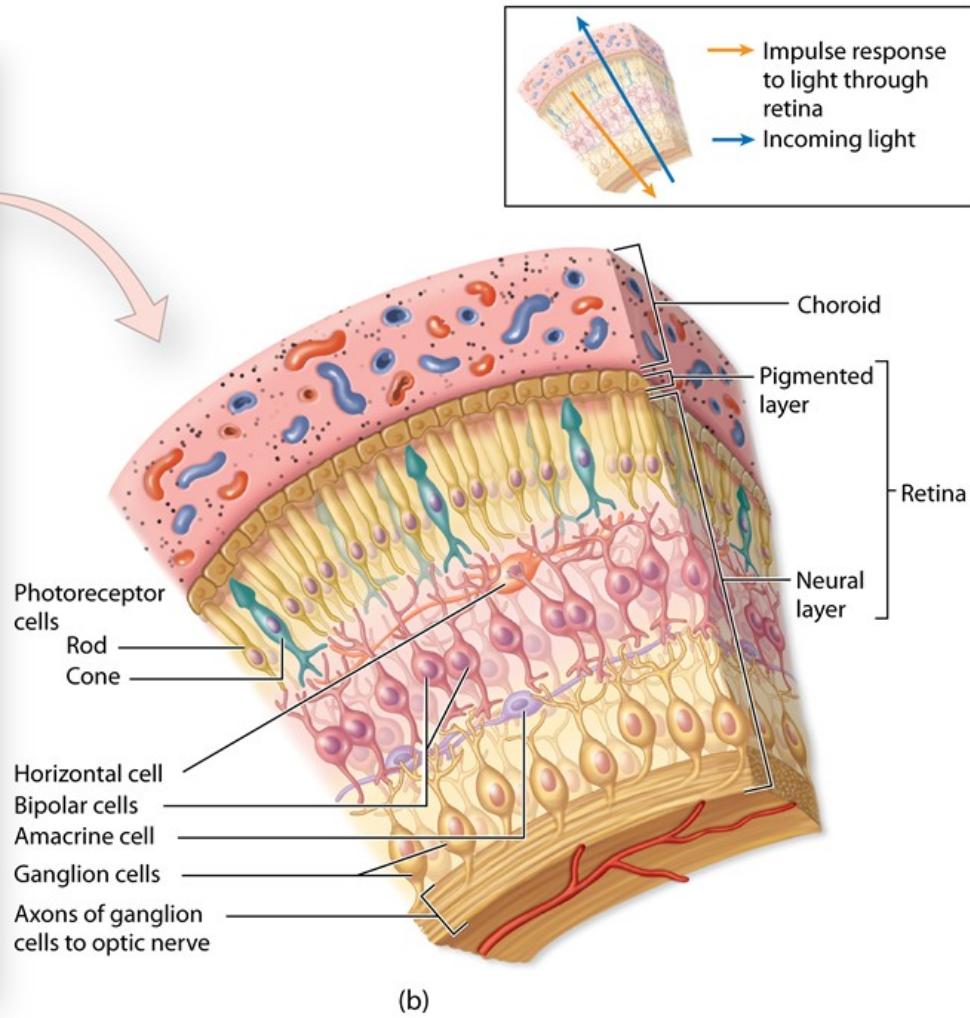
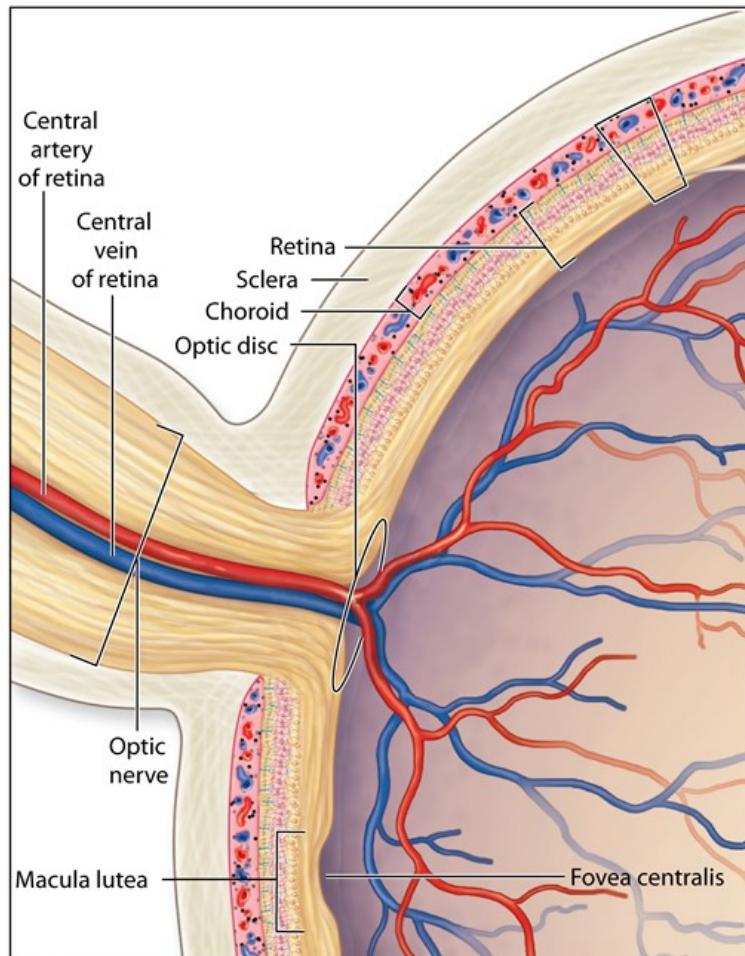
**The iris regulates the amount of light to which the retina is exposed**

Pupil (P): Space between iris  
Anterior chamber (AC): On anterior surface of iris,  
External pigmented epithelium (PE): Rich in melanin granules to protect the eye's interior from an excess of light. Dilator pupillae muscle (DPM): Extends along most of the iris.  
Sphincter pupillae muscle (SPM): Near the pupil, fascicles of smooth muscle



# The retina is the thick layer of the eye inside the choroid.

Nutrients and  $O_2$  for the outer retinal layers diffuse from capillaries in the choroid.



(a)

(b)

# Retina: pigmented epithelium and photosensitive neural layer

Outer plexiform layer (OPL):

Axons of rods and cones

Outer nuclear layer (ONL):

Nuclei of rods and cones

Inner segments (IS):

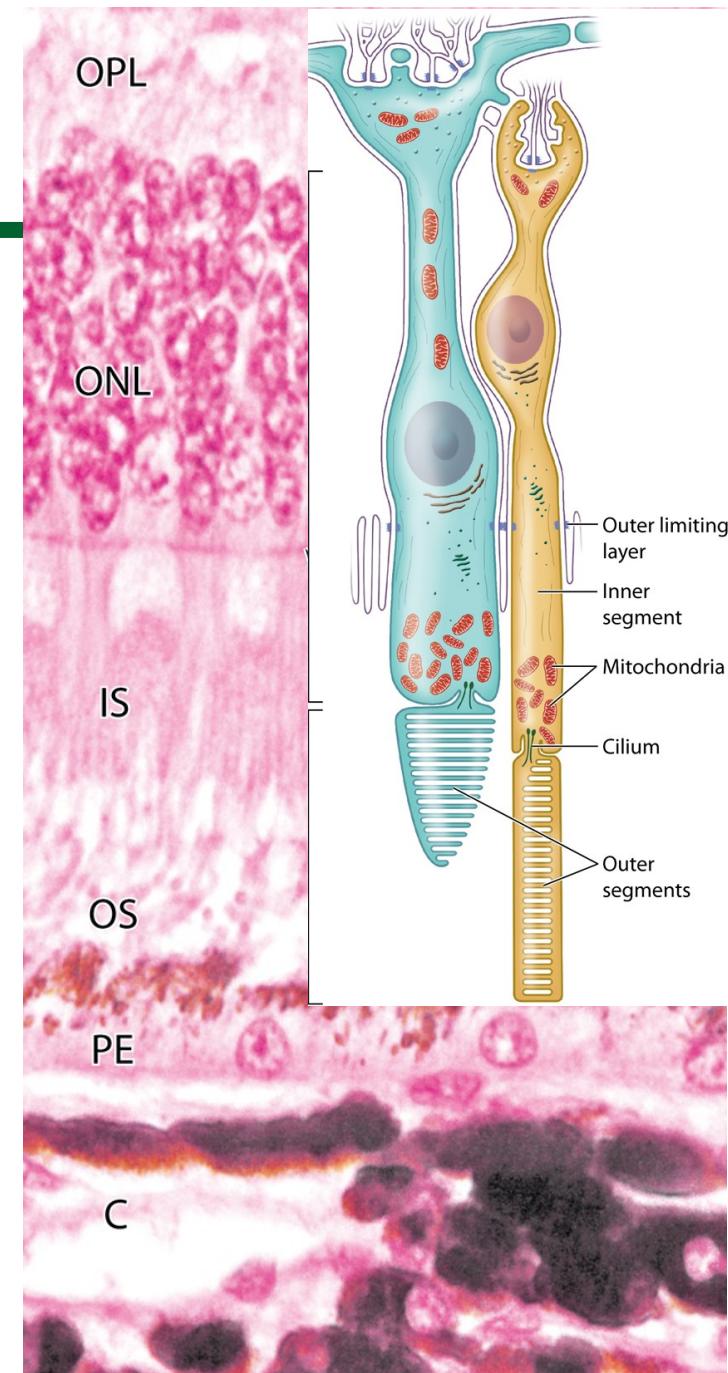
mitochondria-rich

Outer segments (OS):

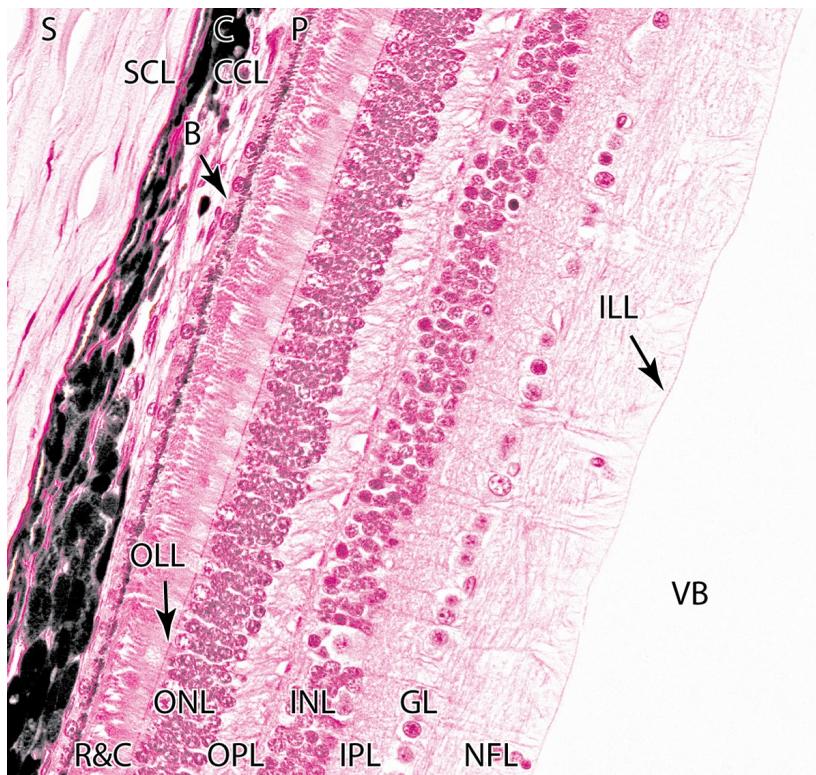
Photosensitive stacks of folded membranes with visual pigments

Pigmented epithelium (PE):

simple cuboidal cells inside choroid (C).



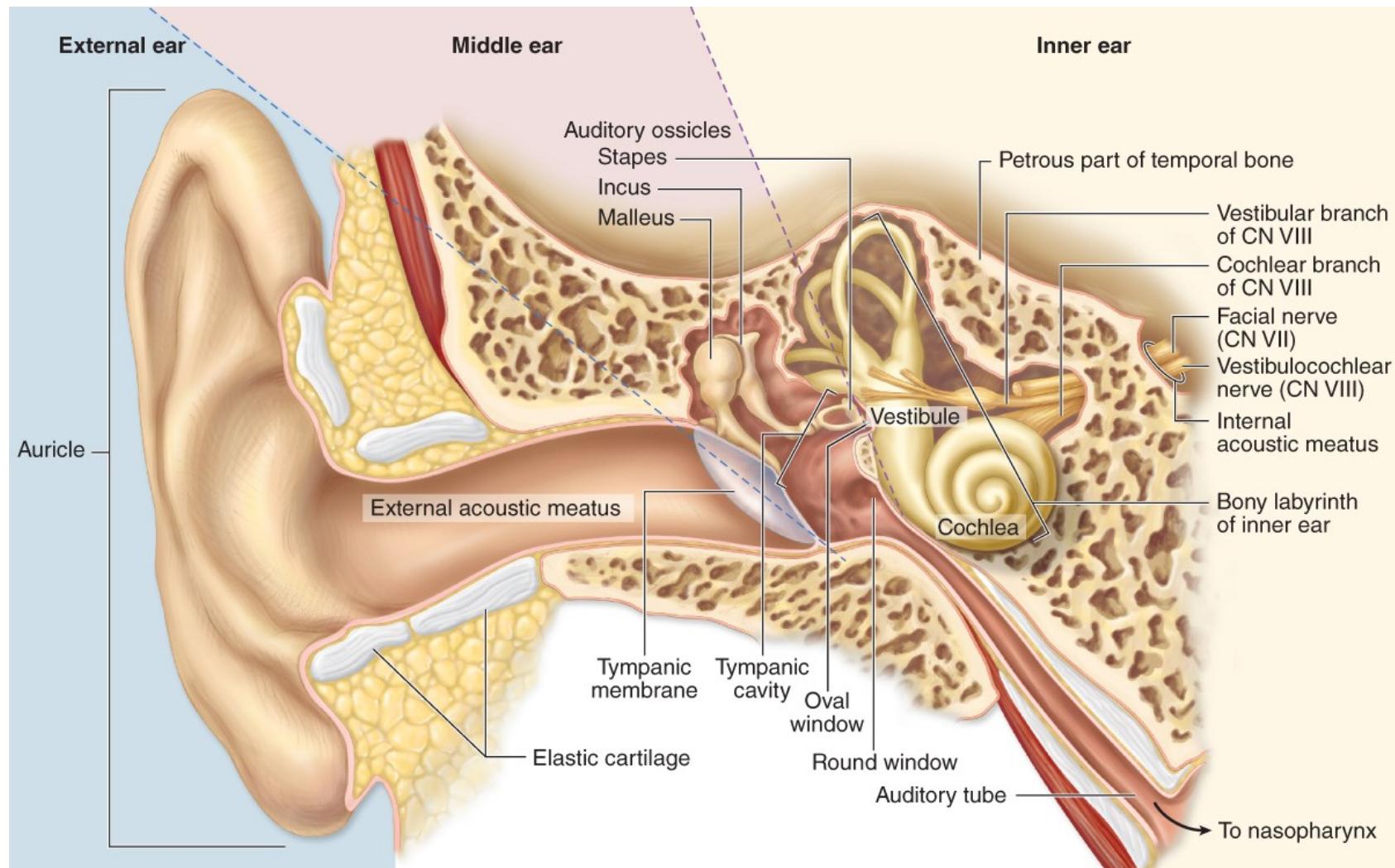
# Lateral wall of the eye: sclera, choroid, and retina



## MEDICAL APPLICATION:

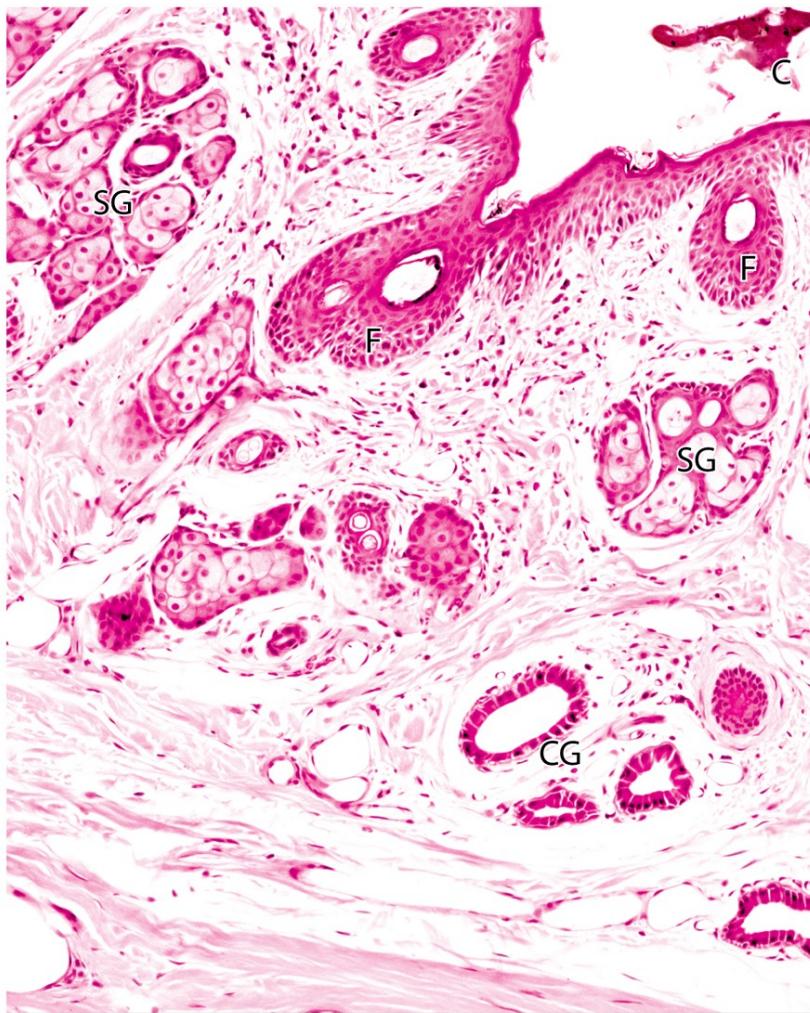
**Retinal detachment:** The pigmented epithelium and the photoreceptor layer of the retina, can be separated by head trauma. Loss of metabolic support causes this area of retina to die. Prompt repositioning of the retina and reattaching it with laser surgery is an effective treatment.

# Major divisions of the ear: external, middle, and internal



Ear Anatomy | Inside the ear | 3D Human Ear animation video | Biology | Elearnin: <https://www.youtube.com/watch?v=p3Oy4lodZU4>

**The external acoustic meatus leads from the opening in the auricle to the tympanic membrane (or eardrum).**



Outer third of the acoustic meatus is lined with skin.

Small hair follicles (F)

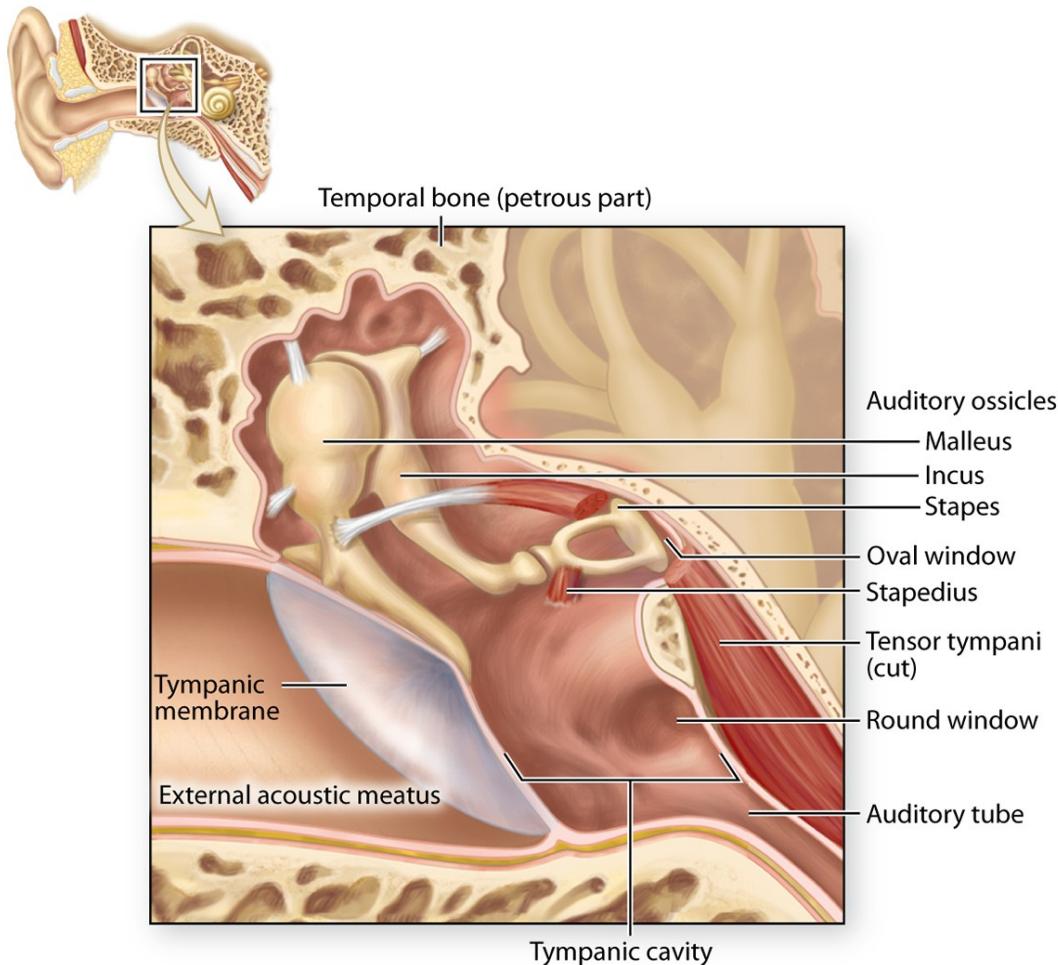
Sebaceous glands (SG)

Ceruminous glands (CG): and modified apocrine sweat glands

Secretions from these two glands form a yellowish, waxy product called cerumen (C)

# Middle Ear

Three **auditory ossicles** are enclosed by the **temporal bone** and the **tympanic membrane**



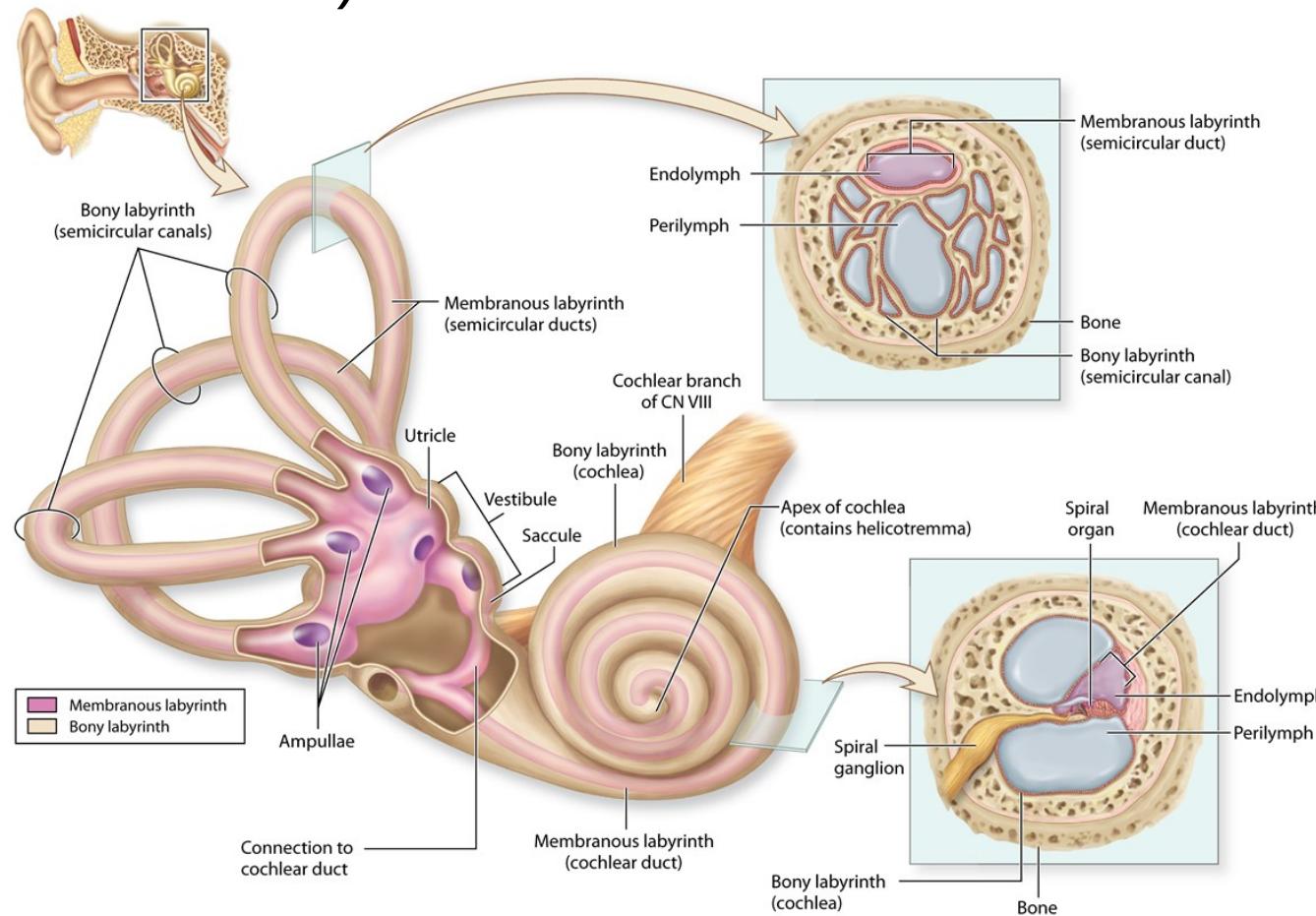
## MEDICAL APPLICATION

Inflammation (**otitis media**) of middle ear via viral or bacterial infections from the upper respiratory tract via the auditory tubes.

Otitis media is common in children, as short auditory tubes facilitate infection of the tympanic cavity.

# The internal ear consists of a cavity in the temporal bone, the bony labyrinth, which houses a fluid-filled membranous labyrinth.

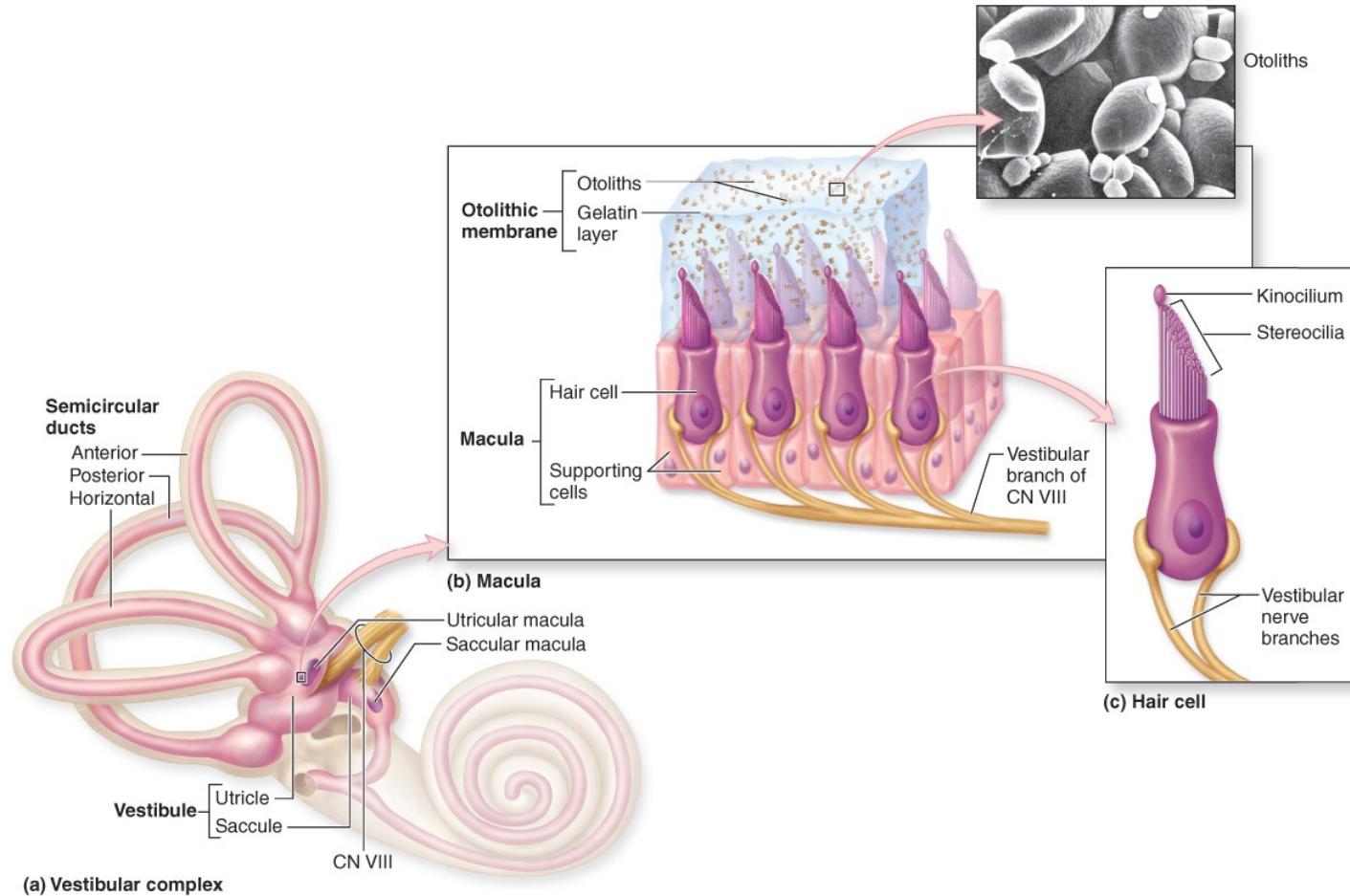
The membranous labyrinth includes the vestibular organs for the sense of equilibrium and balance (the **saccule**, **utricle**, and **semicircular ducts**) and the **cochlea** for the sense of hearing.



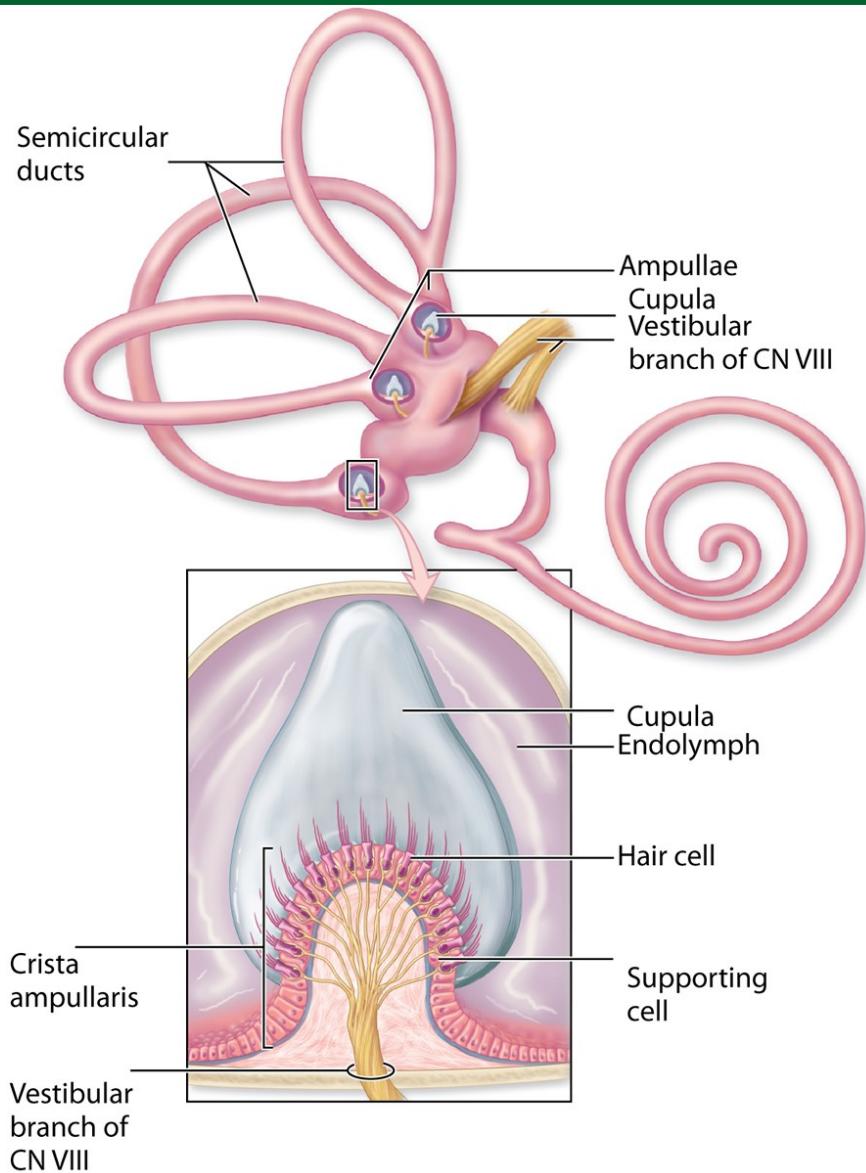
# Vestibular maculae are specialized for detecting gravity and endolymph movements.

**Hair cells:** covered by a gelatinous otolithic layer, basal ends of the cells have synaptic connections with the nerve fibers.

**Kinocilia and stereocilia:** moved by gravity or movement of the head.



# Ampullae and cristae of the semicircular ducts



Ampulla: end of semicircular ducts  
Crista ampullaris: Contain hair cells with hair bundles projecting into layer of proteoglycan called the cupula.

Cupula is moved by endolymph movement within the semicircular duct.

**MEDICAL APPLICATION: Vertigo**  
caused by internal ear inflammation or neurologic conditions.

Brief periods of vertigo produced by sudden changes in position of head, such as standing up quickly or sitting up after lying in bed, may result when otoliths detach from the otolithic membrane.

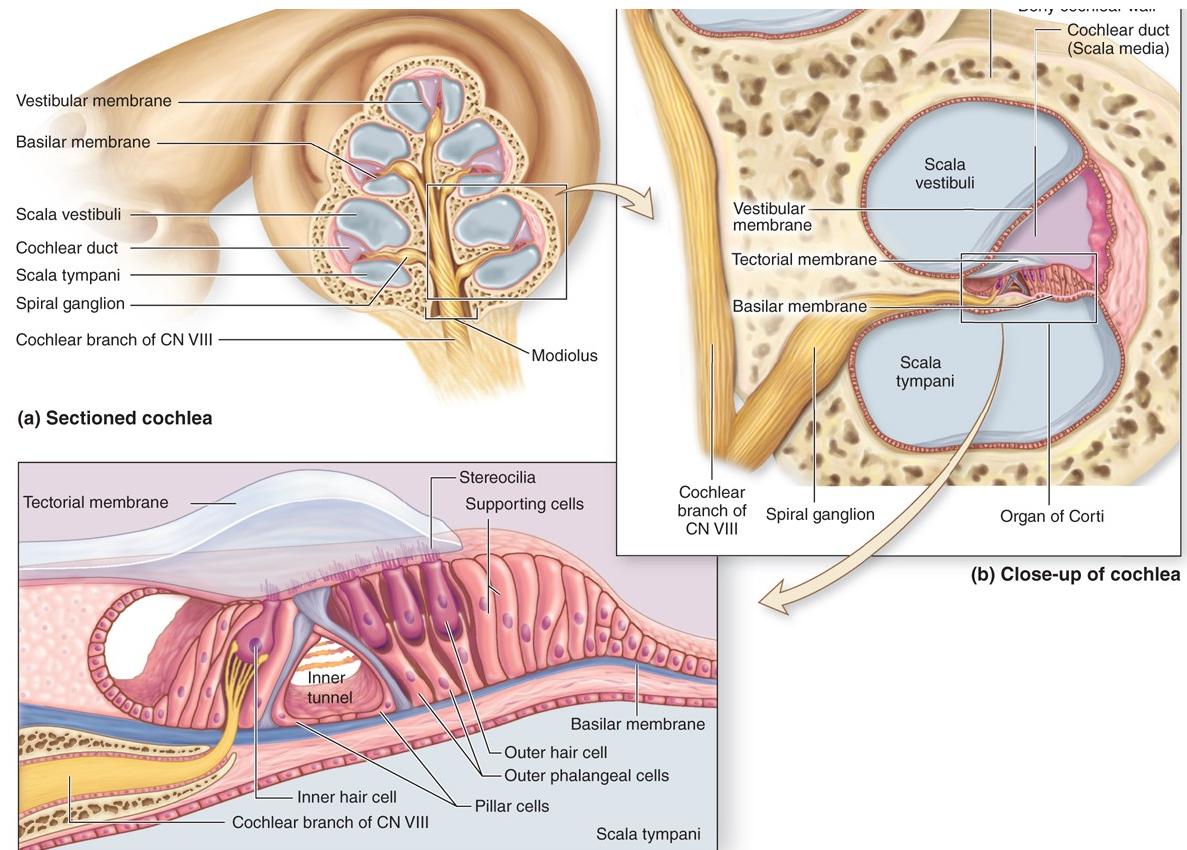
# Cochlea and spiral organ (of Corti)

Cochlea: snail-like spiral bony and membranous labyrinths.

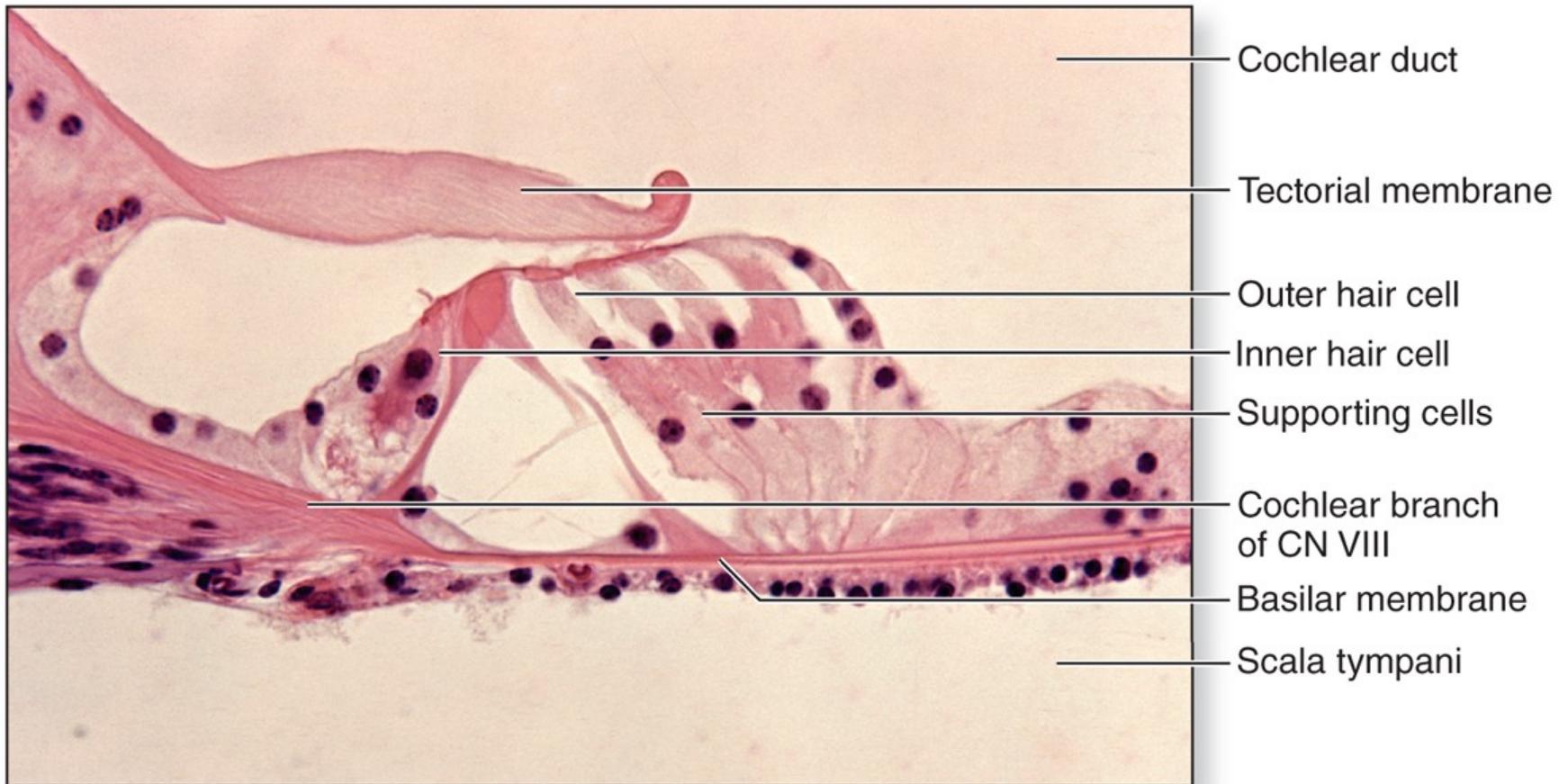
Cochlear duct (scala media): Endolymph filled

Organ of Corti: on the basilar membrane,

Perilymph-filled spaces: scala vestibuli and scala tympani.



[http://highered.mheducation.com/sites/0072495855/student\\_view0/chapter19/animation\\_effect\\_of\\_sound\\_waves\\_on\\_cochlear\\_structures\\_quiz\\_1\\_.html](http://highered.mheducation.com/sites/0072495855/student_view0/chapter19/animation_effect_of_sound_waves_on_cochlear_structures_quiz_1_.html)



(d) Organ of Corti



## Cochlear duct and spiral ganglion:

Cochlear duct (CD): filled with endolymph produced in the epithelial cells of stria vascularis (STV),

Bone (B)

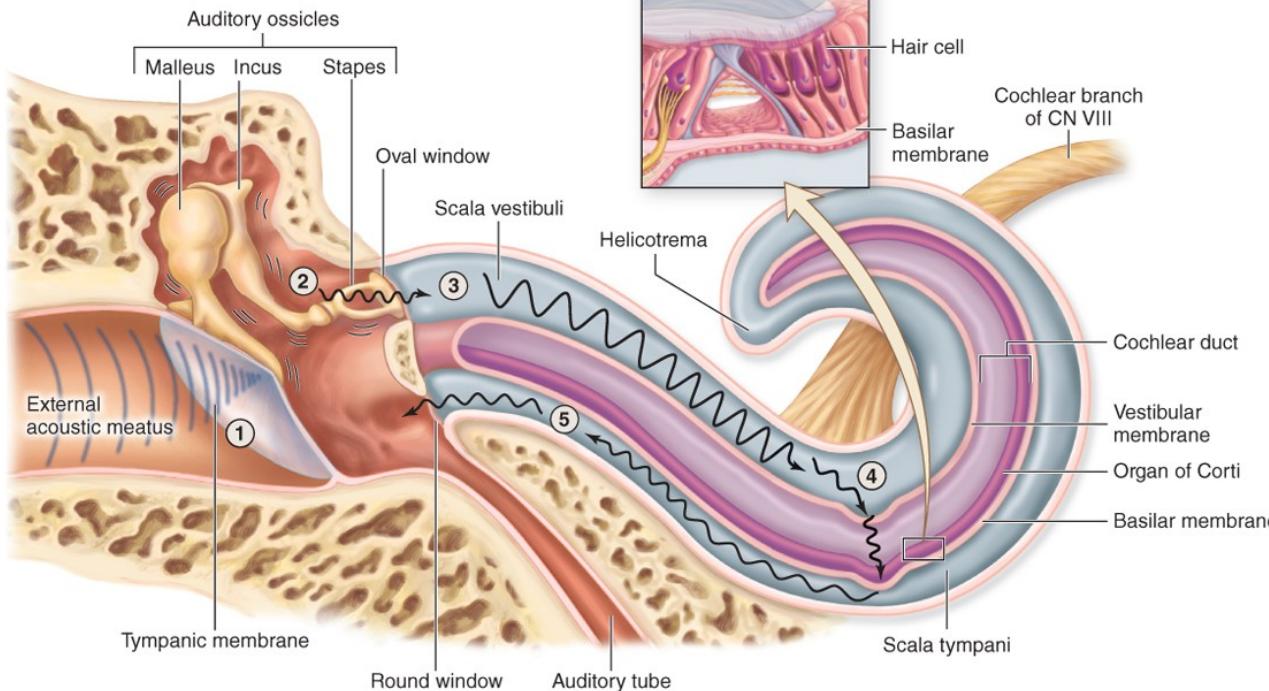
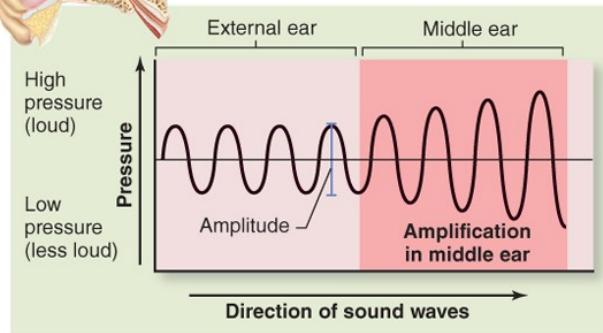
Scala vestibuli (SV) and scala tympani (ST): filled with perilymph

Vestibular membrane (VM): separates perilymph in the scala vestibuli from endolymph in the cochlear duct.

Spiral ganglion (SG): Contains cell bodies of bipolar neurons which send axons to the cochlear nuclei of the brain.



# Path of sound waves through the ear



① Sound waves enter ear and cause the tympanic membrane to vibrate.

② Tympanic membrane vibration moves auditory ossicles; sound waves are amplified.

③ The stapes at the oval window generates pressure waves in the perilymph within the scala vestibuli.

④ Pressure waves cause the vestibular membrane to move, resulting in pressure wave formation in the endolymph within the cochlear duct and displacement of a specific region of the basilar membrane. Hair cells in the organ of Corti are distorted, initiating a nerve signal in the cochlear branch of CN VIII.

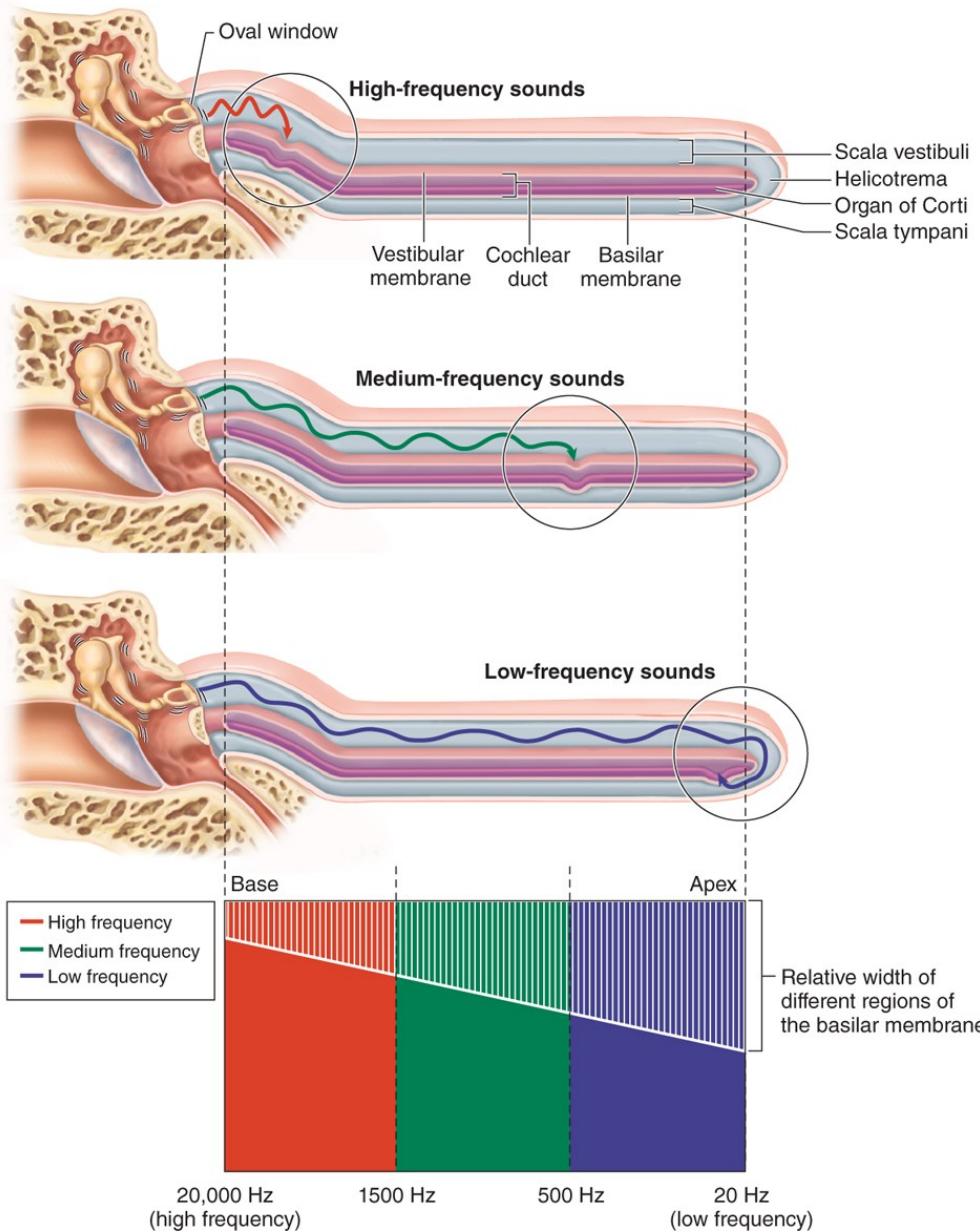
⑤ Remaining pressure waves are transferred to the scala tympani and exit the inner ear via the round window.

## MEDICAL APPLICATION

**Conductive hearing loss:** conduction of vibrations by the chain of ossicles from the tympanic membrane to the oval window reduced

**Sensorineural deafness:** defects in any structure or cell from the cochlea to the auditory centers of the brain

# Interpretation of sound waves in the cochlea



High-frequency sound waves (red arrow) generate pressure waves that displace the basilar membrane near the base of the cochlea, close to the oval window.

Medium-frequency sound waves (green arrow) and low-frequency sound waves (blue arrow) displace the membrane closer to the apex

## MEDICAL APPLICATION

Cochlear implant: A microphone transmits signals to a receiver that stimulates nerve branches appropriate for those frequencies.

<https://www.youtube.com/watch?v=zeq4qTnYOpw>