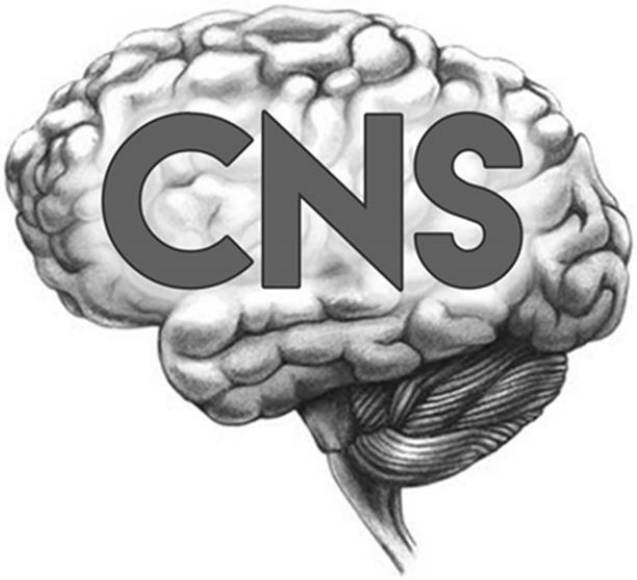

PHYSIOLOGY

✓Sheet ○Slide ○Handout

Number

17

Subject

vision & hearing

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Date: 00/00/2016

Price:

- **Main topics; review of the vision &introduction to hearing.**

❖ Review ; Central Neurophysiology Of Vision

❀ The Visual Pathway

- Last time we talked about the visual processing and the visual pathway; which starts from the photoreceptors in the retina (rods and cons), to the bipolar cells, then to the ganglion cells; passing some inhibitory neurons (for lateral inhibition).

- Axons of the ganglion cells will form the optic nerve; the nasal fibers will cross in the optic chiasm while the temporal fibers won't cross. This crossing allows **the right visual cortex** to receive from **the left visual field** and **the left visual cortex** to receive from **the right visual field**. This principle apply to all other sensations **(Rem. right hemisphere is responsible for the control of the left side of the body and vice versa).**

- After crossing, the fibers will form the optic tract; which will project to the suprachiasmatic nucleus, to the pretectal nucleus (important in light reflex) and the superior colliculus, then the fibers will synapse in the lateral geniculate nucleus (ventral & dorsal) in the thalamus, finally to the primary visual cortex by way of the optic radiation.

❀ Visual Abnormalities(see fig-1)

- Defect in the **optic nerve** results in **blindness** of the ipsilateral eye.
- Defect in the **optic chiasm** results in **heteronymous bitemporal hemianopia**.
- Defect in the **optic tract** results in **contralateral homonymous hemianopia** (one field of the vision is lost).
- Defect in the **temporal/parietal parts of optic radiation** results in **contralateral superior/inferior homonymous quadrantanopia**. (The optic radiations are huge it's rare to be fully defected).
- Because the macula / the fovea centralis is **represented in large area on the cortex**; it's very hard to destroy the macular representation, that's why even if we have quadrantanopia

From Wikipedia:
Visual input from the macula occupies a substantial portion of the brain's visual capacity. As a result, some forms of visual field loss that occur **without involving the macula** are termed **macular sparing**.

the macula will be spared (**macular sparing**).

- **Pituitary tumor** is common in kids, when a kid come with pituitary tumor he will complain from abnormity in the visual system hence **the optic chiasm is above the pituitary gland**, (he complained from **bitemporal hemianopia→tunnel vision**).

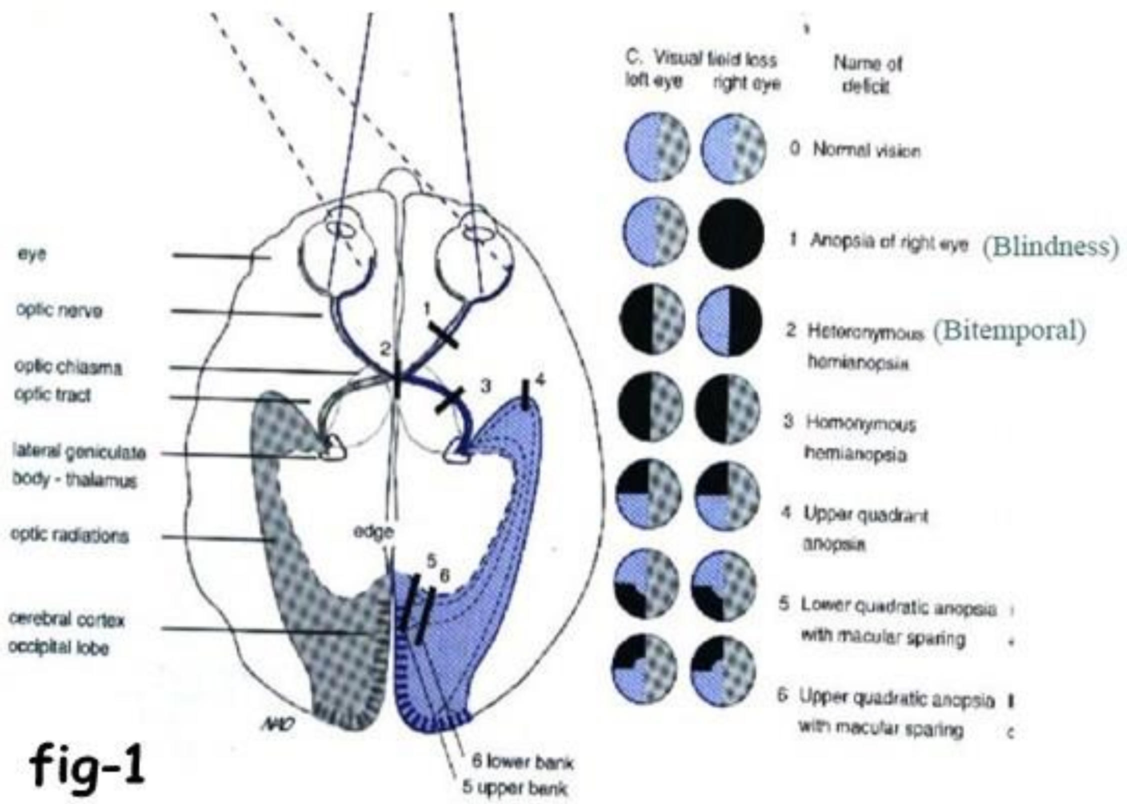


fig-1

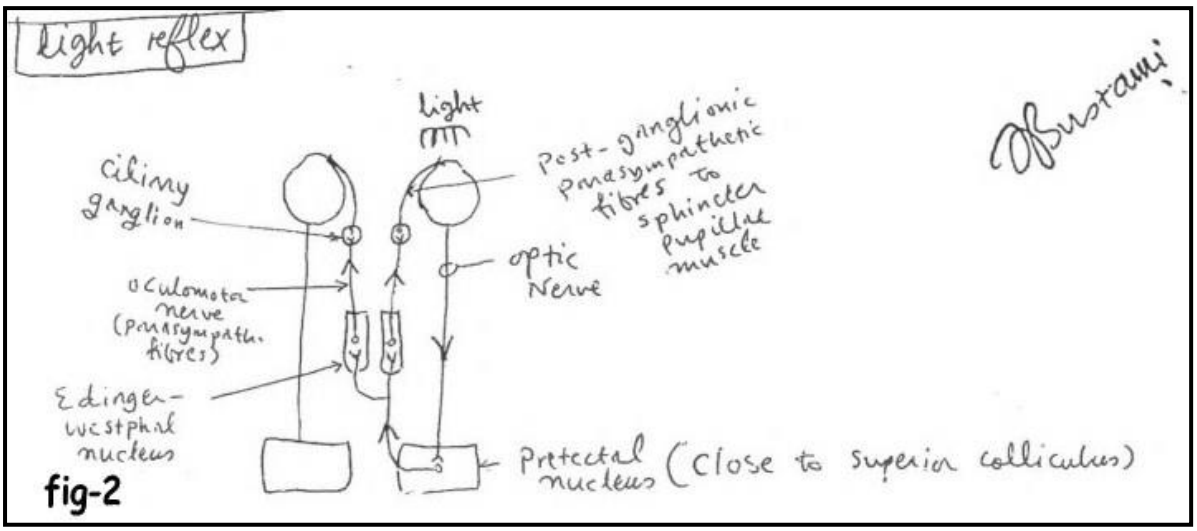
❀ **Light Reflex**(see fig-2)

- There are 2 types of light reflexes; **direct** & **indirect** (consensual).

- The **direct** reflex: when you flash a light on your right eye the right pupil will constrict, why? The light will stimulate the optic nerve, and then signals will be transmitted from the **optic nerve** to the **pretectal nucleus** then to **Edinger Westphal nucleus** then coming back to the **3rd cranial nerve** (to the parasympathetic) to constrict the pupil.

- The **indirect** reflex: there is crossing from the right pretectal nucleus to the left one and then to the left **Edinger Westphal nucleus** to the **3rd cranial**

nerve constricting the left pupil. So, **constriction of the pupil on the left side due to stimulation of the right side is called <u>indirect/consensual light reflex</u>**.



- So if you know this neural circuit, you examine the light reflex to know if there is damage to the **optic nerve** (2nd cranial nerve) or the **oculomotor nerve** (3rd cranial nerve) by testing the 2 eyes.

- Example: if you flash a light in the right eye and the **right pupil constrict** (direct reflex) but the **left doesn't constrict**, where is the problem? You have to **test the left eye**→ if you flash a light on the left eye and the right pupil constrict but the **left doesn't constrict**; the problem is in the **3rd cranial nerve on the left side.**

❀ **Function Of Lateral Geniculate**

- **Ventral** lateral geniculate controls behavioral function – it's part of the emotional/ limbic system.
- **Dorsal** lateral geniculate has representation of both retina and is involved in "Gate" function.
- There is **specific** organization of the retina and fibers go to specific parts of the **dorsal lateral Geniculate**, which is **topographically organized** (the representation is proportional to the number of receptors).

❀ **The Visual Cortex** (fig-3)

- The visual cortex is located in the occipital lobe and it's designed into columns, each column is specific for certain color, direction, and specific for certain area in the retina.
- Notice the primary visual cortex and the secondary/association visual cortex. The **association area** is important to explain what is seen**(it analyzes visual information, area for 3 dimensional position, & area for color analysis).** When there is destruction in the association area with no destruction in the primary area, the patient will have "Agnosia" including word blindness; he doesn't understand what he sees.
- Each cortex (on each side) receives from the 2 eyes, these cortices are stimulated in different areas and signals will overlap so you can see one object.
- There is no difference between the visual cortex and other cortices, it has six layers, and afferents come to (ascend to) layer 4 & efferent come from (descend from) layer 5 & 6.
- **Processing** in the visual cortex is not that simple, there are 3 kinds of cells; **simple** cells, **complex** cells and **hyper-complex** cells, each cell is specific for certain thing;
    - ✓ **Simple** cells just know if there is a light (**spots** of light).
    - ✓ The **complex** cells recognize the light arranged in **lines**.
    - ✓ The **hyper complex** cells respond to **3-dimensional stimulation**.

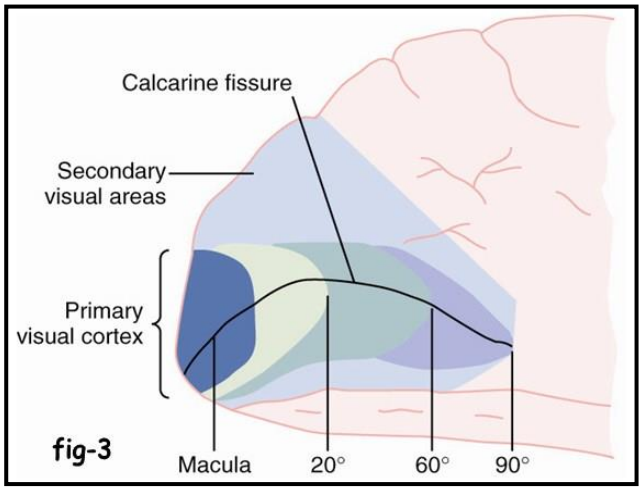


fig-3

❖ Auditory sensation (Hearing)

- Hearing is a type of special sensations; the receptors are located in specialized area in the inner ear (organ of Corti).

❀ Objectives

- Define **decibel** (intensity) and **Hz** (frequency)

These are the units of hearing defects.

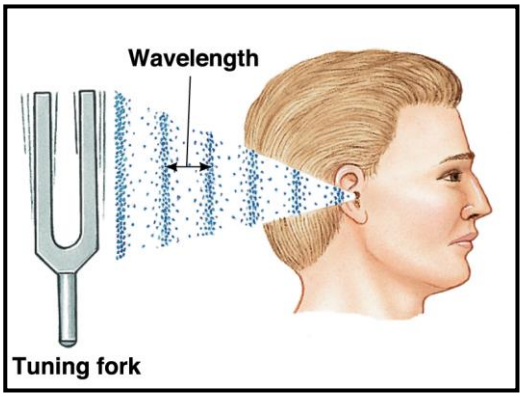
***Deci = 1/10** ***Decibel = 0.1 bel**

- Describe the ossicular system and explain its function
- Follow up sound transmission up to the cochlea
- Outline the structure of cochlea, and the organ of Corti.

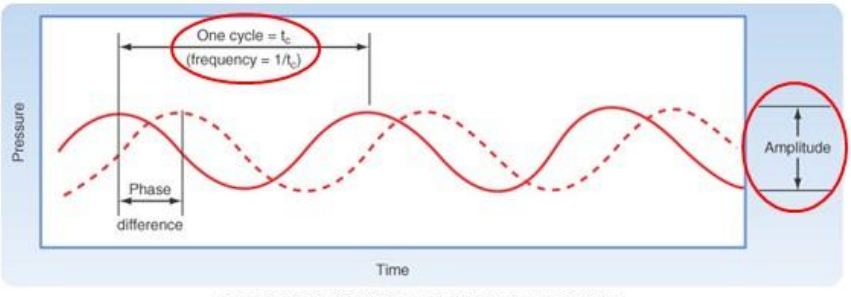
Hearing receptors are located in organ of Corti and they are mechanical receptors, because the sound is going to induce movement in them. The receptors here are hair cells. (Note: Receptors of the vestibular system (balance), receptors of hearing and receptors of taste → all are hair cells)

- Describe the mechanism of sound transduction
- Describe auditory abnormalities (types of deafness)

❀ Wave Length



- When you **describe a sound**, you can say it's <u>loud or not loud</u> **(**also called **intensity**; the unit used is **Decibel)**, you can also describe it by its <u>frequency</u> **(pitch**; the unit used is **Hz=cycle per second)**.
- The **audible frequency** is between **20-20,000 Hz.**
- You can have the same frequency but with **different loudness→different amplitude**. (each tuning force have certain frequency)
- **So , (frequency = pitch) &(loudness = intensity = amplitude)**



- Speed of sound is **much smaller** than the light speed; speed of sound is 335 m/sec in Air.
- Again, **frequency** is measured by **Hz** and the **amplitude** by **Decibel**.
- Look at fig-4 and determine the frequency, the amplitude, and wave length.

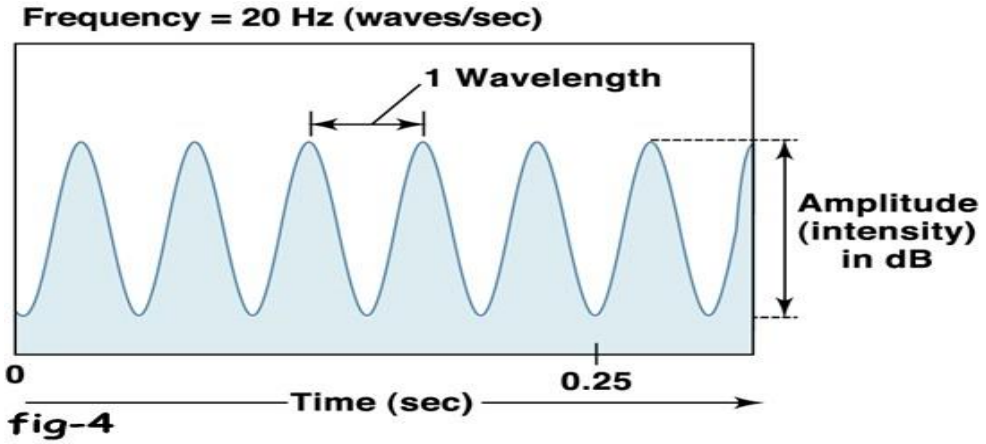


fig-4

❀ **Decibel: a measure of sound intensity**

- We can hear from **0-120 Decibel**
- **Decibel** (dB) = 10 log $\mathbf{I/I_R}$
  - ✓ **I** = intensity of sound, $\mathbf{I_R}$= reference intensity
- $\mathbf{I_R}$ is the threshold- the minimal intensity that can stimulate the ear.
- It's not easy to deal with intensity it's easier to deal with **pressure** level, just multiple by **2,** (the wave exert pressure while moving).
- **SPL (dB)** = **2**0 log P/P_R
  - ✓ **SPL**= sound pressure level, **P**= sound pressure in N/m^2, $\mathbf{P_R}$= reference pressure
  - ✓ $\mathbf{P_R}$ either 0.0002 dynes/cm^2, the **absolute threshold for human hearing** and equal 20 micropascal, or 1 dyne/ cm^2

❀ Why we use log scale?**(the important explanations will be mentioned next lecture, you can skip this)**

The threshold of hearing is $\mathbf{10^{-12}\ Wm^{-2}}$, we take our reference intensity **IR** as $\mathbf{10^{-12}\ Wm^{-2}}$.

Decibel level = 10 $\log_{10}$ $1/10^{-12}$

=10 $\log_{10}$ 10^{12}

= 120 $\log_{10}$ 10.

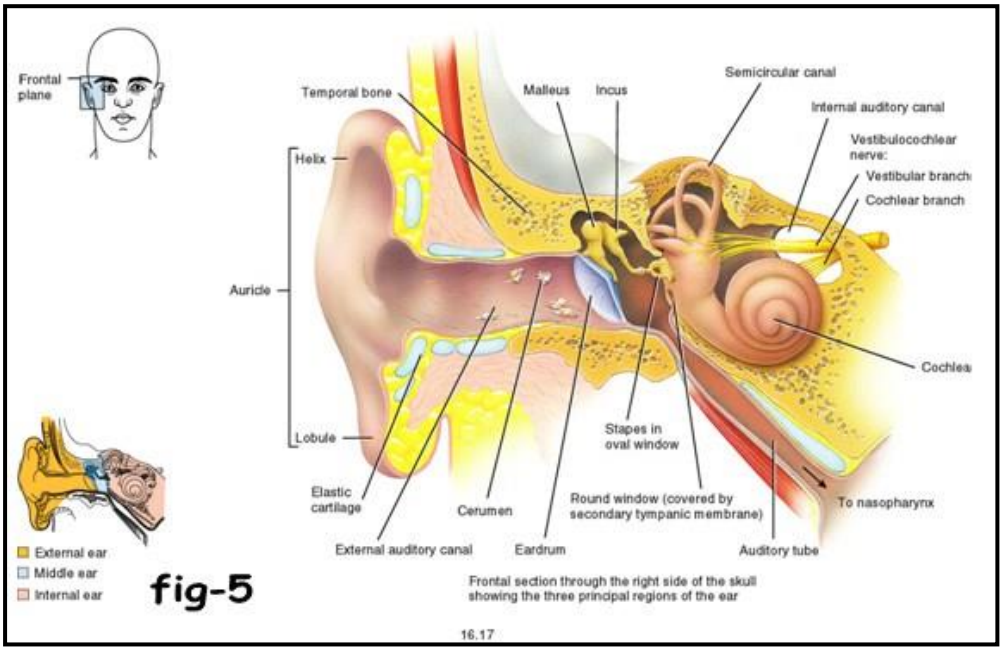
=120 dB

which is **Threshold of Pain**.

A decibel level of **zero dB** represents the lowest level of sound and a level of **120 dB** represents the level of pain for humans. Sound of higher level than **120 dB** can harm our ears and can even cause rupturing of ear drums.

❀ **The Ear, structure and function** (fig-5)

- Notice ear pinna (the auricle),external auditory canal, tympanic membrane (ear drum), and in top of it **the malleus, incus and stapes**, (these 3 form what we call **the lever system**), the stapes end at the oval window.



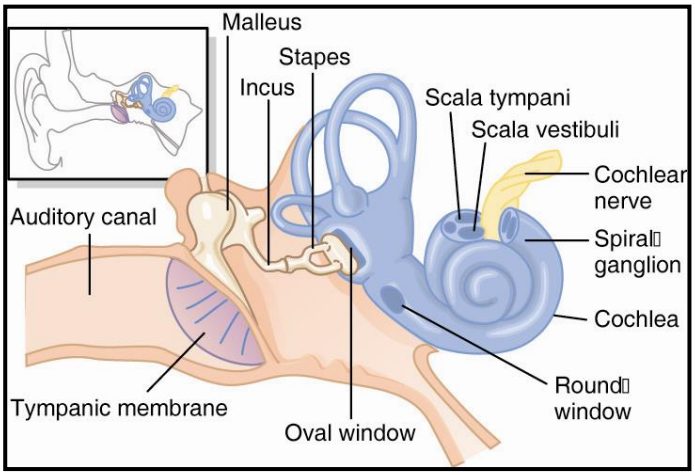
-What is the importance of the **external ear?**

→Sounds conduction, and **wax formation.**

- When the sound comes it will cause vibration of the **tympanic membrane** according to the frequency of the sound, (the tympanic membrane will vibrate at the same frequency of the sound wave) and this is going to be transmitted through the malleus, incus and stapes (the lever system) and the stapes will move in or out.

- What is the importance of **middle ear? (Which include the malleus, incus and stapes if you consider the tympanic membrane as part of the external ear).**

→Sounds conduction, <u>amplification</u> and <u>attenuation</u>



- Amplification (Impedance Matching)

- It's **easier** for the sound waves to move through the **air** because there is **no resistance**: inside the cochlea there is **fluid**, when the stapes move inside and outside it has to have **higher pressure to move the fluid**, this is what we call resistance/ impedance →**matching this resistance/ impedance** (between the air and the fluids) is the function of the **middle ear**.

- **How come?**
  - ✓ There is difference between the surface area of the **tympanic membrane** and the surface area of **the stapes→17** time difference. Which mean that we collect the sound from a large area (the tympanic membrane) and concentrate it on a small area (the stapes); this **will increase the pressure of the sound wave**.
  - ✓ **The lever system** also increase the pressure by **1.3** times
  - ✓ So, the **total** increase in the pressure = 17*1.3 =**22** times
    - ➔ So there is increase in the pressure between the air and the fluid of around **22 times**; and this is going to be able to move the fluid.
    - ➔ You are matching the **resistance** of moving the sound wave in the air and moving it in the fluid.

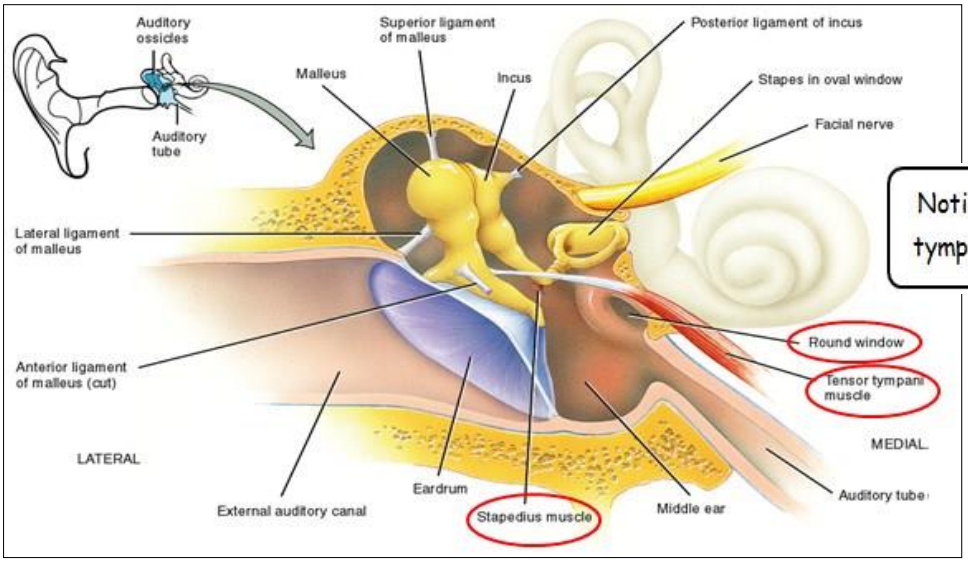
- Attenuation reflex

- The middle ear contains **the smallest muscles in our bodies**, **stapedius** (supplied by facial never) and **tensor tympani** (supplied by the trigeminal).

- These muscle respond to high intensity sound (very loud sound), this sound may cause damage to the cochlea; so to protect it → these 2 muscles contract making the ossicular system very rigid, (it's hard to vibrate) so it's very hard to transmit the sounds to the cochlea (protective reflex).

- This reflex also functions to **mask low frequency sounds**; you don't need to hear your sounds to know that you're talking.
→From the slides: Serves to <u>protect cochlea</u> and <u>damps (mask) low frequency sounds</u> in loud environment .i.e., your own voice.

Other **protective** reflexes:
light reflex and **withdrawal** reflex



Notice the stapedius muscle, tensor tympani muscle and the round window

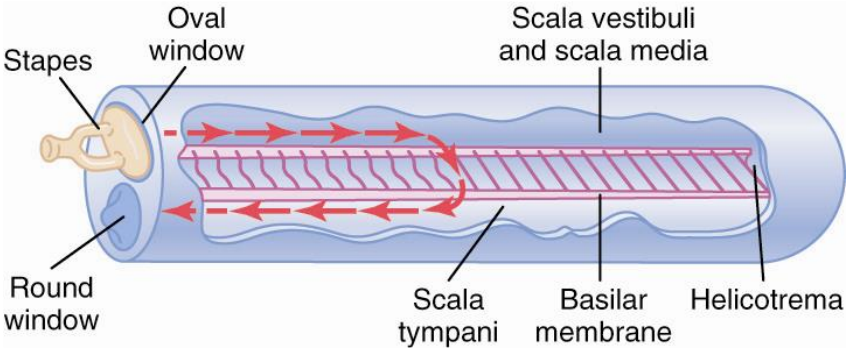
- The middle ear is connected to the nasopharynx by the **Eustachian tube** which functions to **equalize and dissipate the pressure**.

❀ **The Cochlea**

- It's a snail like structure, if you spread it you can see 3 scalas / layers separated by membranes :

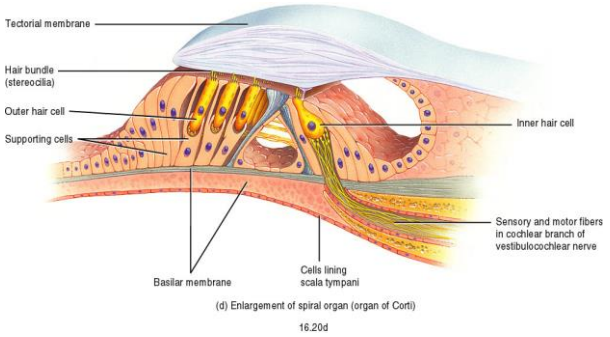
*Scala vestibuli; the upper one *Scala media*Scala tympani; proximal to tympanic bone

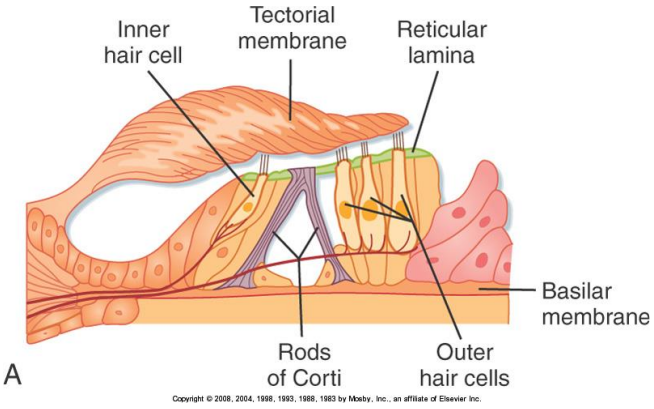
Remember; **otolithic membrane** is above the macula, and the **cupula** is above the crista ampullaris



- **Vestibular membrane (also called Reissner membrane** – in reference to the person who describes it**).** It separate Scala vestibuli from Scala media, it's a **very thin membrane**→ any movement of the scala vestibuli will be transmitted right away to the scala media.
- **Basilar membrane** separate the scala media from scala tympani, on top of it we have the receptors of hearing, (which form the organ of corti). This membrane is triangular in shape; its apex is wider than its base. At the apex we find the **helicotrema** and at the base there is the round window.

- **Organ of Corti:** It is where the **receptors** of hearing are located. It consists of **hair cells.** On the basilar membrane there is **one** row of **inner hair cells** (there number is around 3,500), and beside them there is **3** rows of **outer hair cells**. These cells have stereocilia and kinocilia, **on top of these hairs** there is a **tectorial membrane**.





- The hair cells are supplied by the **cochlear branch** of the vestibulocochlear nerve (8th cranial nerve), also supplied by **efferent corticofugal fibers** for lateral inhibition, sharpening the signal and increasing the sensitivity.

- The fluid inside Scala **vestibuli** and Scala **tympani** is the same (because they are connected at what's called the helicotrema) → **perilymph**; it resemble the extracellular fluid

- Scala **media** contain a fluid called **endolymph,** it resemble intracellular fluid; it's very low in sodium & rich in potassium (K+ equivalent = no. of moles→1 mole of K+ = 1 equivalent).

- **Mechanism of sound conduction: The tympanic membrane** will vibrate, the vibration will be transmitted to the ossicular system, to **the stapes** that will move inside and outside; when it moves inside (pushing the oval window into the **scala vestibuli**) the perilymph will vibrate, these vibration will be transmitted through the **vestibular membrane** to the **basilar membrane** that will vibrate at the same frequency of the sound waves.

Best regards❁