CENTRAL NERVOUS SYSTEM

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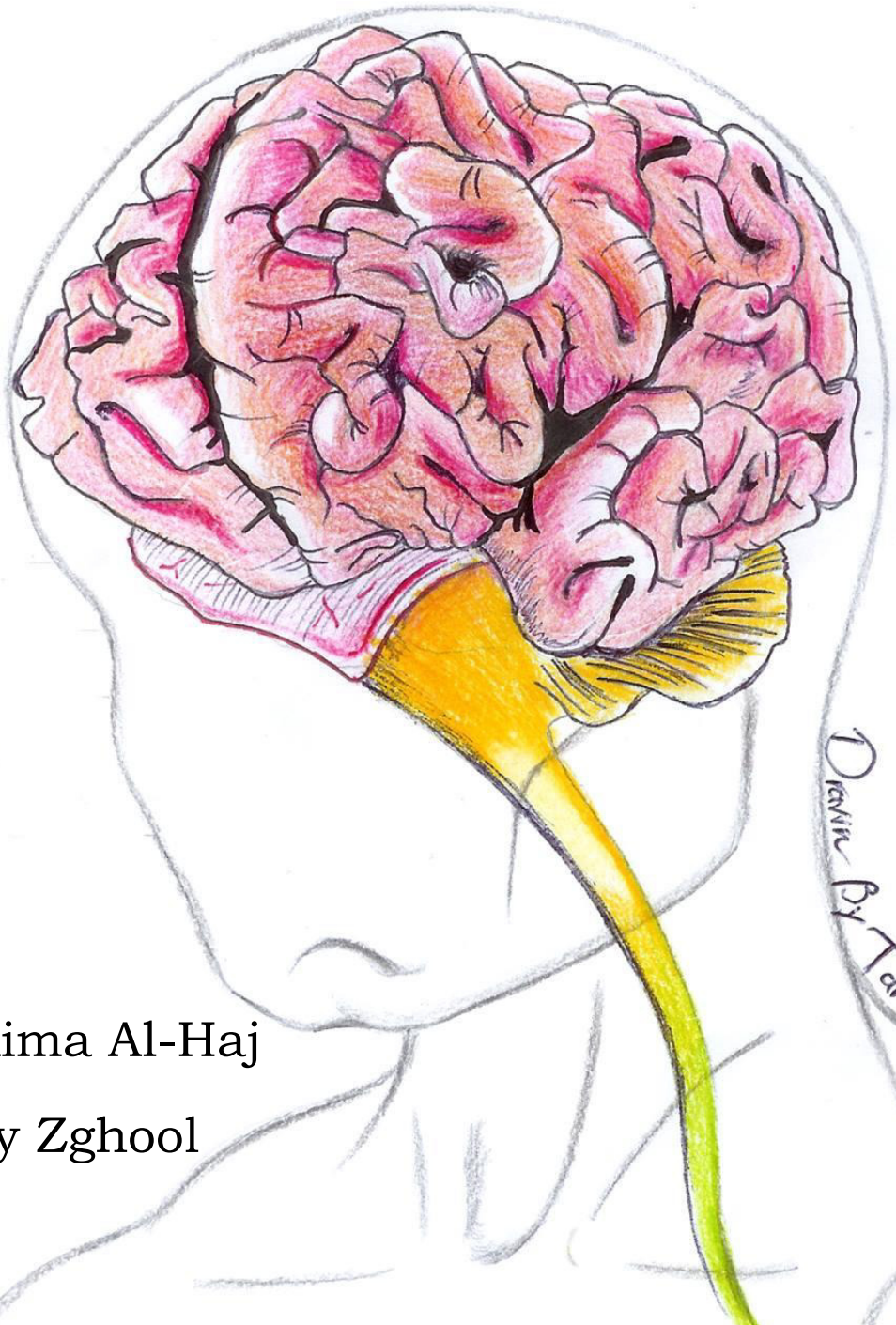

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Lec #: 17

Vision +Auditory pathway

- This sheet is written according to sec 2 record .
- This sheet includes two subjects : first, the Dr. completes the vision pathway and starts talking about auditor pathway .
- Please check the slides for any more information .

Vision pathway :

In the last lecture ,we talked about vision pathway , the vision information goes to the cortex. The pathway includes : optic nerve → optic chiasma→ thalamus → optic radiation → primary visual cortex (area 17) .

Actually, like any other sensation the vision has information that is sent to the cortex to be processed , analyzed and perceive meaning to the sensation. But also we have some parts that enter the preferred cells or go to the subcortical areas or to other pathways.

Actually , some of the optic information are sent to the cortex and the other information have another three targets that are sent to : the first one is **hypothalamus** , in retina there is direct information that is sent to hypothalamus which gives indication about our day/night cycle , light/dark cycle and this target will go and give information about the range of light which is present and makes circadian rhythm of the body , also regulates year rhythm of the body and the most important one of them regulates waking up/ sleep cycle .

Ganglions in retina have different types of ganglionic cells , we talked about X,Y and W cells , these pathways (the three other pathways that we are talking about) have different retinal ganglionic cells ,their name is **Melanopsin ganglionic cells** .From their name they have a dye like skin, they are not activated from

photoreceptors .They are directly activated by light and do action potential ,they work as ganglionic and receptors at the same time .

Lesion in anything after sending information to the hypothalamus does not damage day/night cycle like macular degeneration .whereas If there is a lesion before going to hypothalamus ,the patient suffers from disturbance in sleep .

The second target is **pretectum** and its function is related to the control of looping and lens constriction ,interferes with reflexes of pupil constriction and lens to determine the amount of light which will enter the retina and lens constriction or lens curvature .

- Dr. answered a question: all these pathways are direct from retina before actually it goes to the thalamus .

The last target is **superior colliculus** in tectum ,here it interferes with relation of movement especially movements and orientation of the head .

This tract is responsible for body reflexes in response to auditory stimulus and its part of the extra pyramidal tract which is called Tectospinal tract.

Tectospinal tract (extra pyramidal tract) takes information from **superior colliculus** and **inferior colliculus** ,which are collectively called **tectum** and goes down to control muscles of neck ,trunk and eyes and also do orientation or movement to neck and body due to any vision or auditory corroboratory stimuli .Superior colliculi will give information from vision ,where as inferior colliculus takes information from auditory complex. so its function is oriented movement of head and eye in response to visual stimuli .

The last information about this tract that will work in a two different manner : the first one will work by reflexes and make processing but also this tract takes mainly from Y and W ganglionic cells that do quick response and quick information about movement. I need the cortex to understand this movement although it goes as reflexes but I need to process movement information , so this tract also is sent to the cortex , the pathway is optic nerve , optic tract , superior colliculus then to the cortex .

It has to pass through thalamus to be able to go to cortex , we do not talk now about lateral geniculate body ; because it is a different tract, the nucleus which is responsible about this tract in thalamus is called **pulvinar nuclei** from that it goes to the cortex related to movement and orientation : (like in the visual pathway→one which is inferior medial whereas dorsal pathway go to superior part of parietal lobe which has more interferance with movement) beccause of that it will go from superior colliculus to **pulvinar nuclei** and do not go to primary or secondary visual cortex and will go to associated cortical area which interfere with movement and large part of it interfere with dorsal part of tract and cortex and a part of them is posterior superior parietal lobe .

Lesion to this pathway or the cortex or mainly to this pathway has a role in **blind sight** that means the blind can see , a patient comes with a damaged primary visual cortex or the tract is damaged completely , put him in front of you asks him if he can see your hand movement .

Some people can train, he/she can tell you that the room is far away from him/her or if there is something on the right ,1.5m away from him/ her.

- Dr. answered a question : when there is movement in front of the patient. so the first tract is damaged but the second is intact . because of that the patient is still able to see the movement in front of him .
- Dr answered another questions : does the posterior superior parietal give the second pathway ? part of them but actually it goes to more than one area .

Auditory pathway :

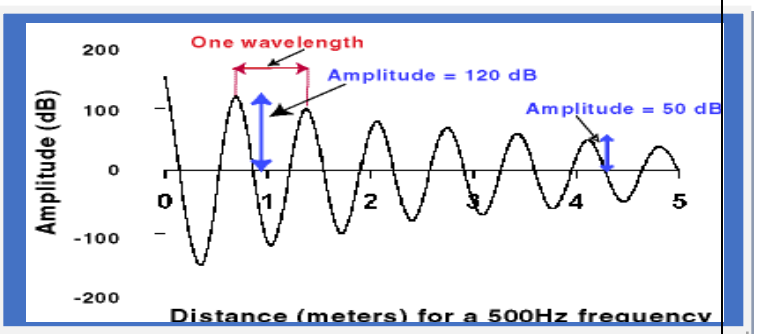
Now we will talk about auditory pathway. and nature of sound. one of them is **amplitude** which represent the strength of wave ((علو أو شدة الصوت) and it represent the intensity ,so when I say "good morning" in calmly voice it has intense and amplitude .

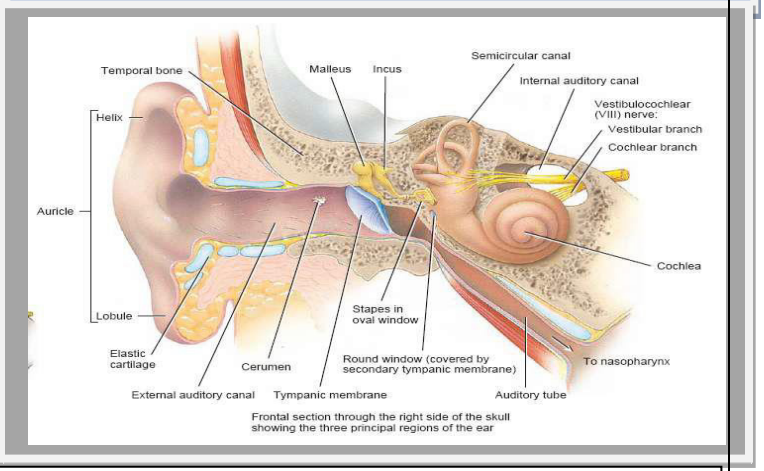
If I raise my voice in saying; " good morning" I will increase the intensity and amplitude of the wave .

The other thing which distinguish sound waves is **frequency** which represent pitch (حدة الصوت) the quiet voice usually has a low frequency whereas the acute voice has high frequency.

Each letter is one or combination between multiple frequencies , to differentiate between "P" and "V" there is different frequencies . let us suppose that 'P' is low frequency 15 K hertz while 'V' is 17 Kilo Hertz and this to differentiate between two letters and sounds .

Humans can hear from 20-20000 hertz





Quick review to anatomy of the ear ; there are external , middle and inner ears . External ear include auricle its main function to gather the sound. loss of auricle does not cause deafness, the gathering of sound decrease but this leads to lose the ability to distinguish of sounds in vertical dimension.

The folds of the auricle allow the sound to inverse in a special way , so allow to inner ear and brain stem to determine sound in a vertical dimension , so loss of auricle mainly leads to lose the ability to distinguish of sounds in vertical dimension .

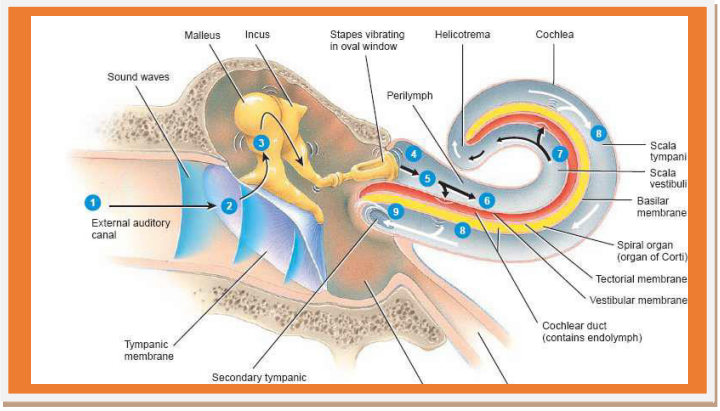
External auditory channel has ceruminous gland its function is production of cerumen or ear wax for protection ,clearance and antibiotic and at the end we have a tympanic membrane its function is to vibrate as a result of vibration of sound waves.

In middle ear there are three free bones :**malleus** , **incus** and **stapes** their function is to transmit the sounds of the tympanic membrane to inner ear (cochlea) .

Function of the middle ear is amplification of the sound signals ,why ? First thing, the presence of three tinny bones work as lever , so if the vibration of the first bone is small .with presence of lever the vibration sill be larger and stronger.which is amplification of the signal .

There is Amplification of the signal because in the cochlea the vibration is not in the air it will be in fluid , so it must be amplified to get rid from differences of viscosity or differences of density .

Between the air and the fluid in the cochlea .



The second thing in the cochlea that helps to do amplification is the difference of between the space of tympanic membrane and the space of the end of stapes ;because tympanic membrane has a very large space in comparison with the end of stapes , so the space difference allow the signal to concentrate at one point → more amplification in the middle ear.

In the middle ear there are 2 muscles : **tensor tympani** and **stapedius**. Tensor tympani attaches to malleus and tympanic membraneWhile stapedius attaches to stapes.

The function of these muscles are damping of the sound vibration and reduce the intensity .

When you go to party where there is a high sound. The parts that reduce the pitch of the sound so the voice does not annoy you is by contraction of these muscles and these are innervated by mandibular facial which supply tensor tympani.

Why we decrease the vibration ? mainly for protection; to conserve the tympanic membrane from rupture and to decrease vibration in cochlea and conserve from damage .

Also in the middle ear there is auditory tube or Eustachian tube. their main function is equilibrium of the pressure against tympanic membrane.

When you go to Al-Ghour ,there will be a higher pressure → compress the tympanic membrane → becomes tight and the vibration is difficult; because of that you have to open your mouth or to take a gum to allow the air enter through auditory tube to the middle ear and equalize the pressure .

Now we go to inner ear which includes cochlea and labyrinth .

The choclea is snail shaped hard shell , inside there is a fluid which has 2 openings, the first is oval window from then ,there will be stapes pressuring on it and in the other end or in the other side we have round window and it is an exit to vibration .

So the vibration enters from oval window and exits from round window , so it is as a cochlea has a cavity inside it , has two doors :oval entry and round exit .

In nature, if the entrance is from one side and the exit from other end usually the vibration takes the easiest way , so all the cochlea will be functionless .

To ensure that the vibration pass through all the cochlea there is a section and barrier at the long of the cochlea and inside it there is a cavity this is the auditory duct .

The section of the auditory duct mainly not a one layer or one wall separation . It is actually 2 separations between of them there is a space because of that it is called duct not auditory wall.

Inside the space there is a fluid , the whole cochlea has a fluid resembles CSF which is the **perilymph** that is high in Na+ low in K+ whereas inside the auditory duct or cochlear duct , there is a different fluid resembles the fluid which is in vestibule →high in K+ it is called **endolymph** .

The upper wall of the cochlear duct is hard whereas the lower wall is elastic , so it (the lower elastic wall) can vibrate and its name is **basilar membrane**.

What happen in us is, vibrations comes from outside it will vibrate the tympanic membrane this will transmit through the bones of hearing , stapes starts pressuring against the oval window then there is a vibration in the fluid this vibration will transmit lead to vibration of basilar membrane .

Now when we look to basilar membrane there is what we called **organ of corti** which is the mechanism or combination that makes sensation which will transform the vibration to normal signal , it is composed of : basilar membrane and on the basilar membrane there is hair cells.

Hair cells which we see also in vestibular and above them there is tectorial membrane .

Vibration of the fluid which is in cochlea will lead to vibration on basilar membrane that will ascend and descend , so if the hair cells ascend and descend with the basilar membrane and on it there is a very thick very heavy membrane which is tectorial membrane , vibration of them can not push it much so each time the basilar membrane go up bending hair cells or Cilia and return and this will lead to opening of K+ ion channel ,in which K+ ion enters, this cause depolarization and neurotransmitter release as what happens in vestibule .

We know the mechanism of detection at the end as we said hair cells will throw neurotransmitters in synapse or dendrites of first order neuron which is found on spinal ganglia inside the cochlea and which takes the information from cochlea and send them to brain stem to cochlear nuclei.

Still to know how we can detect the 2 characteristics of sound which are the intensity and frequency .

Now the intensity, more intensity of vibration means more vibration of the cochlea to the tympanic membrane this means more vibration of fluid more vibration of basilar membrane so it goes more upward and downward → so bending of hair cells will be larger opening of more channels →more NT release and in this case we return to the same principle of any sensation .

Increase the intensity more NT release then more frequency of AP to the cell which is first order neuron .

When there is one type of hair cells , how does the hair cells distinguish different frequencies and we can distinguish from 20-20000 hertz which allow us to distinguish the letters from 'p' to 'v' which is differ and make us to distinguish different frequencies or which we call it **tonotopic organization**.

Tone have different locations, and different types of cells, but the same basilar membrane and cochlea .

The basilar membrane inside the cochlea has 2 features the first one anatomically is narrow at the base at round and oval windows and very flat wide in the apex and attach at the base and almost free at the apex this permit the higher frequency to make vibration at the base where as low frequency makes vibration at the apex and which allows to this characteristic to increase and increase the presence of cochlea itself and the rotation of the cochlea so the high frequency mainly do resonance only with the base , moves the basilar membrane only at the base .

When I hear 'v' letter only the cells not whole basilar membrane will vibrate , only cells that are near the base suppose their frequency as we said 16 kilo hertz , only cells in 16 kilo hertz will move and will send information and AP to brain .

There is 16 kilo hertz information that reaches the brain which is heard in association with the letter 'v' so I know I have 'v' not 'p' , when I say 'p' this is low frequency will do resonance and move the basilar membrane only almost at the apex in this only 12 kilo hertz will transform which represent 'p' and this will receives and always remember that the sound and words have different frequencies and when I hear thisletterwith other letterthis means I hear this letter not this letter or this word not other word . anatomical variation between child and adult and between humans and other animals is the size of cochlea , the length of basilar membrane and the shape of cochlear rotation this determine that we hear 20-20 kilo hertz .

Now the information is sent , we know how we determine the vibration , the intensity and different frequencies and this information will transmit to brain and must pass on brain stem to the thalamus and from the thalamus to the cortex .

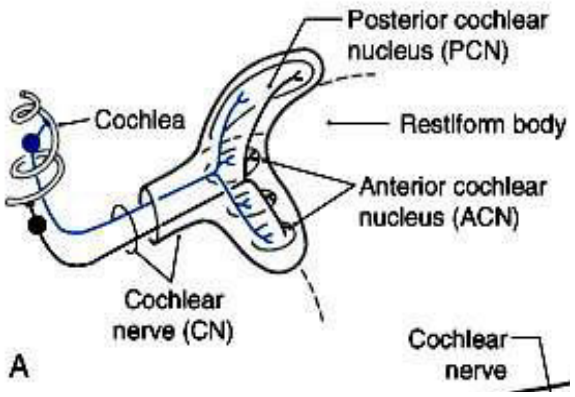
We said that the first order neuron are present in the spinal ganglia will send the information to brain stem through vestibular cochlear nerve , enters the brain stem in the cochlear nucleus .

We have 2 different cochlear nucleus in each side , one is anterior cochlear nucleus and the other is posterior cochlear nucleus . The same principle in transmitting information of PCML and ALS sensation and vision is present in auditory system.

Each neuron responds to one frequency when it reaches cochlear nucleus different response or different frequencies will be represented as separate lines through all auditory pathway so when they come at cochlear nucleus we call the most medial one which is high frequency whereas the lateral is low frequency because of that ,pressuring it from outside to inside leading the

patient to lose low frequency before high frequency and this as we said will continue tonotopic organization according to the line theory which we talked about which is each frequency does not mix with beside frequency all the way whatever the synapse .

There are anterior and posterior nuclei and this is the location of these nuclei and each one of them will send the information to the brain in a different pathway so there will be two auditory pathways:one from the anterior nucleus and the other from posterior nucleus and each one of them has all frequencies .



Posterior cochlear nucleus transmits frequencies to cortex so they give us identification and processing of sound before it reaches the cortex it have to go to thalamus then to the primary auditory cortex and as any different sound or any different sensation hearing from right ear goes to left cortex .so from posterior nucleus → crossing and pass to Inferior colliculus.

Inferior colliculus makes movement and reflexes , here makes synapses then to the thalamus especially to the medial geniculate nucleus then to the primary auditory cortex which is in the roof and banks of temporal loop , this mainly will give best information about frequencies and intensities which is most important from word to word identification and letter to letter .

Now the second which sends sound information but on the way it determines location , direction of the sound in horizontal plain , in addition to its localization and we know that the sound comes from right and left according to two things in hearing right ear is **quicker** than left ear although the difference is millisecond and on right ear is **higher** than left ear in this case you know that the sound comes from right side not from left side .

Differences in time and intensity determine the sound comes from right with 45° or 90° angle , to still able to do orientation it must has a location on CNS to compare the time between two ears , differences of intensity and this happen in what is called **superior olivary complex** .

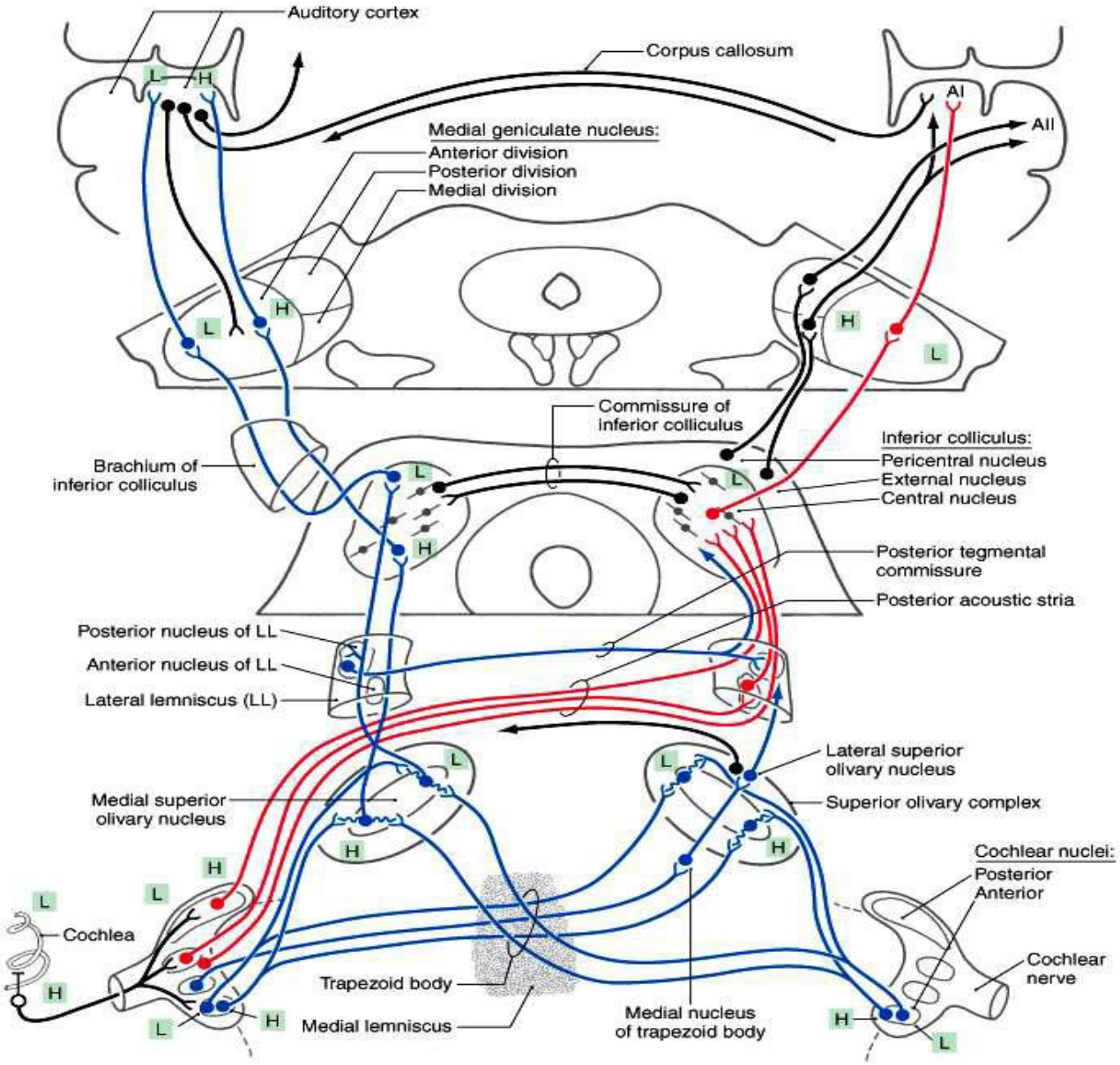
Superior olivary compares sounds between two ears in relation to time and intensity and to do this it compares the frequencies' time and intensity .

If there is one says 'p' and hear 'v' letter so we will compare all frequencies to know it is 'v' on right and 'P' on left. To compare the two it needs information from two ears because of that the superior olive and anterior cochlear nucleus will send information ipsilateral and contralateral and the crossing which is happen will be in **trapezoid body** whereas the first crossing in posterior auditory side. This crossing which is good for identification of words and sounds quality .Damage to it will decrease the sense of orientation and direction of sound .

We said that superior olive will receive information about intensity and time frequency or what we said time difference which is processed from medial side of superior olive whereas the intensity will be processed in the lateral part or outer part which is lateral superior olive nucleus from that still each frequency alone compared which was quicker and higher from that the information goes to and pass through the pathway on superior colliculus to thalamus to the cortex .

Notice that there is the first pathway which was from posterior colliculus and we call it mononaural from one ear, whereas the other pathway (**binaural**;because from two ears) , one mainly important for localization whereas other is mainly for differentiation of sounds because of that the information that is sent to right differ from left in localization and identification .Because the second pathway has intensity difference and each frequency still alone no mixing . lesion to the first cause small compromisation in the ability to localize sound .so if the (red in slide) is damaged, lateral (blue) will compensate little , whereas if the lateral (blue in the slide) is damaged ,the red is hard to compensate the difference except if

the person is very trained, So there will be no reflexes to sound but there will be complete identification .



Because every complex after cochlear nerve or nucleus is presentin two ,one to each side. If there is a Lesion to any auditory or the cochlear nucleus or before , we cannot hear by this ear whereas any lesion unilateral the patient will still hear by two ears because of the presence of pathway of the superior olive , pons .

Now I have different frequencies and each frequency still as a line until it reaches the cortex , notice in the cortex that reaches from

ipsilateral ear and from contralateral ear and it reachs along anterior tract and posterior tract of cochlea and this still unmixed , whole frequency go to specific region . primary auditory cortex and each one will be from ipsilateral and contralateral ears separately or anterior and posterior tracts separated and from that the cortex will process the information to convert these frequencies to words and from words to meaning go to language .

Descending control as in olfactory , control from the cortex to the olfaction because it let us to forget sensation or ignore sensation because it has a long time appearance we have control feedback same as from higher order to olive to cochlear nucleus and to cochlea to determine which sound I want to amplify or concentrate on it or hear clearly .

You are in a party , once you enter the sound is high you are annoyed and cannot hear anything after a while the voice become calm ,your friend comes to talk with you , you ask him to repeat because you cannot hear him , when he repeats you hear him although he did not increase the intensity of his voice higher than the music .

Females understand this more than males , the girl is sitting in the entrance of faculty she hears her name or an important information , suddenly she hears the talking of girl far in about 5 m from her although her sound is not higher than the loudness around .What happens ?

There is selection amplification feedback from **cortex**to the cochlea , there is stapes and tensor tympanic membrane to do damping for all vibration but now I hear someone said this frequency and I want to increase it and hear it so I must be able to do amplification to this frequency alone without changing the other frequencies , leave all of them low and increase only part of the frequency , this is called **selective amplification** this must be a reflex but from the cortex ;because the cortex that can determine the talking of my friend beside me is the frequencies which is from

12-17 , so I need to do amplification for this frequencies not all and it must go to cochlea because of that from primary cortex to inferior olive to inferior colliculus to superior olive from that to cochlea and do amplification on the level of cochlear nucleus , makes the sensitivity of the neurons that are responsible for frequencies from 12-17 higher and better .

Also will return as motor control on same hair cell, we have two different types of hair cells : inner hair cells (one hair cell)and outer hair cells(and these are three in number) and nerve for each .

Inner and outer , inner cells are in one line and nerve for each hair cell send sometimes to 2 and 3 nerves ,it is highly representative in the vestibular cochlear nerve .whereas outer hair cells are compact in small area (مدحوشين) each 3 or 4 lines are found together and each nerve takes from five to sex hair cells because of that the role of differentiation of frequency is minimum and may determine the intensity.

What happen that descending feedback when I want to do amplification of this signal I cannot change the vibration because I decrease all of them before reaching cochlea this is a motor control on the outer hair cell can lead to contract shorter and make their hair cells shorter so this means tympanic membrane in this case become nearer to the inner hair cell so any vibration will make more bending more AP differ from other this means if I want to make amplification to certain signal I will send control to outer hair cells → become shorter to that region of basal membrane .

The membrane will become nearer so only that region is amplified and this state let me hear a sound from all this loudness although it is lower and farer from other by selection amplification .

- Intensity was represented by amount of hair vibration and basal membrane was go up and down and bending ,when we go to party or loudness around tensor tympani is stretched and stapedius is stretched , the amount of whole vibration is decreased so we do not feel the voice much high and the basilar membrane vibrate less .

now when I want to amplify certain part of frequency, outer hair cells become shorter due to feedback that comes from the cortex , so tectorial membrane in this region becomes nearer from other regions, so this vibration will lead inner hair cell to bend more from the hair cells beside them .

auditory reflexes →when I knock the table you are boggling as a result of inferior colliculus send descending as tectorial spinal tract to head and neck and also sometimes to trunk and body to control movement .

Introduction to the coming lab :

There are two types of deafness : conductance deafness if there is any inability to conduct wave from outside to cochlea and inner hair cell in this case we call it **conductance deafness**.Another deafness w**sensory neuronal deafness**,which is any deficiency in transmitting or detecting sensation from inner hair cells to cortex .

These 2 deafness which we are going to talk about in the lab and their detection in Rinne and Weber tests .

I DO MY BEST TO WRITE THIS SHEET PLEASE FORGIVE ME FOR ANY MISTAKES .

DONE BY : SHAIMA AL-HAJ