EFFECTS OF NOISE ON AUDITORY SYSTEM

Reg No.8403

GOPAL N.K.

AN INDEPENDENT PROJECT WORK SUBMITTED IN PART
FULFILMENT FOR THE FIRST YEAR M.Sc,
(SPEECH AND HEARING) TO THE
UNIVERSITY OF MYSORE

ALL INDIA INSTITUTE OF SPEECH & HEARING
MYSORE-570006

1985

TO MY BELOVED MOTHER
****

CERTIFICATE

This is to certify that the Independent Project entitled "EFFECTS OF NOISE ON AUDITORY SYSTEM" has been prepared under my supervision and guidance.

GUIDE

DECLARATION

This Independent Project entitled "EFFECTS OF NOISE ON AUDITORY SYSTEM" is the result of my own study undertaken under the guidance of Dr.(Miss) Shailaja Nikam, Professor and Head, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore.

Dated : May 1985. Register No.
8403

CERTIFICATE

This is to certify that the Independent Project entitled "EFFECTS OF NOISE ON AUDITORY SYSTEM" is the bonafide work in part fulfilment for First Year M.Sc, (Speech and Hearing) of the student with Register No. 8403.

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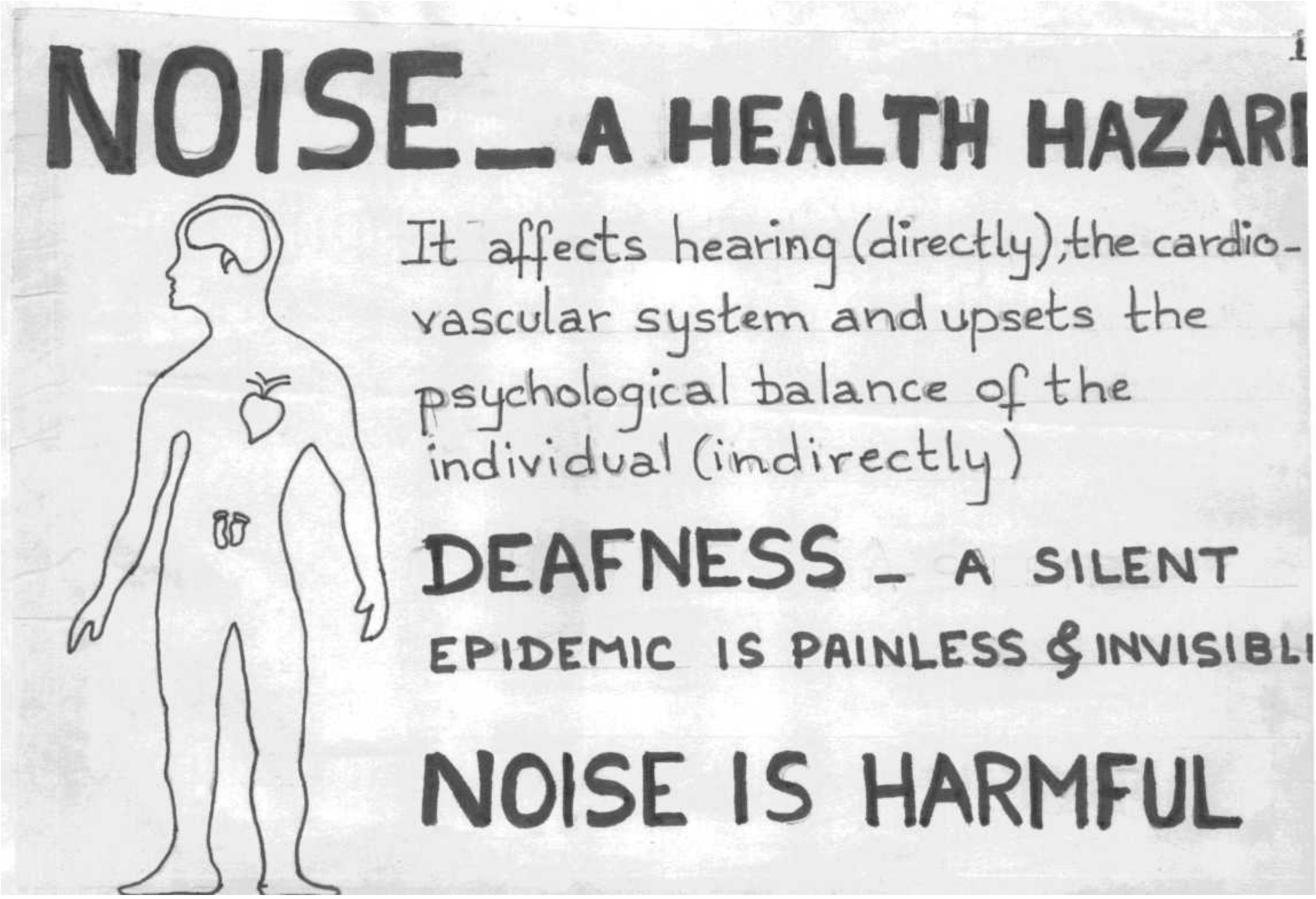
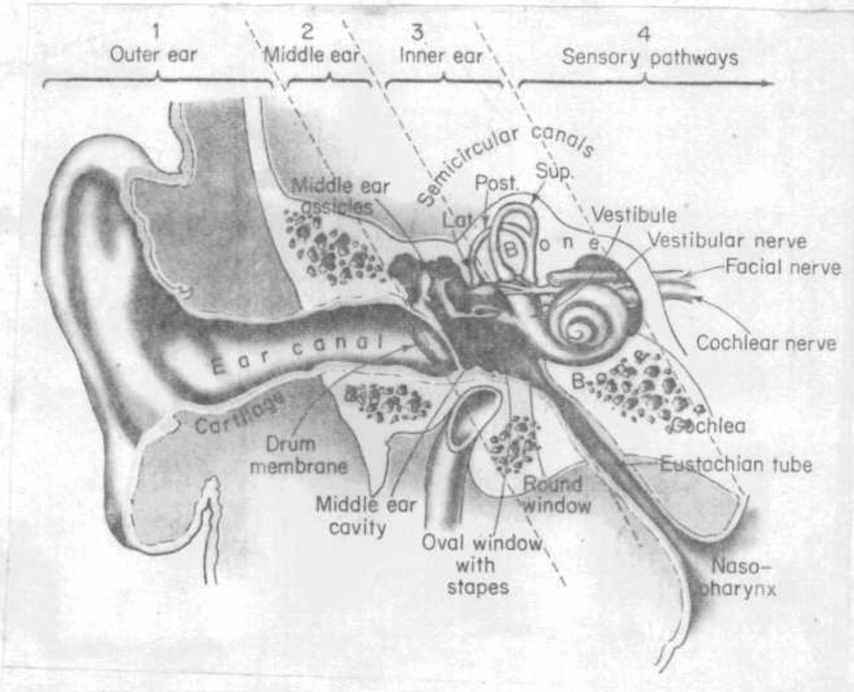


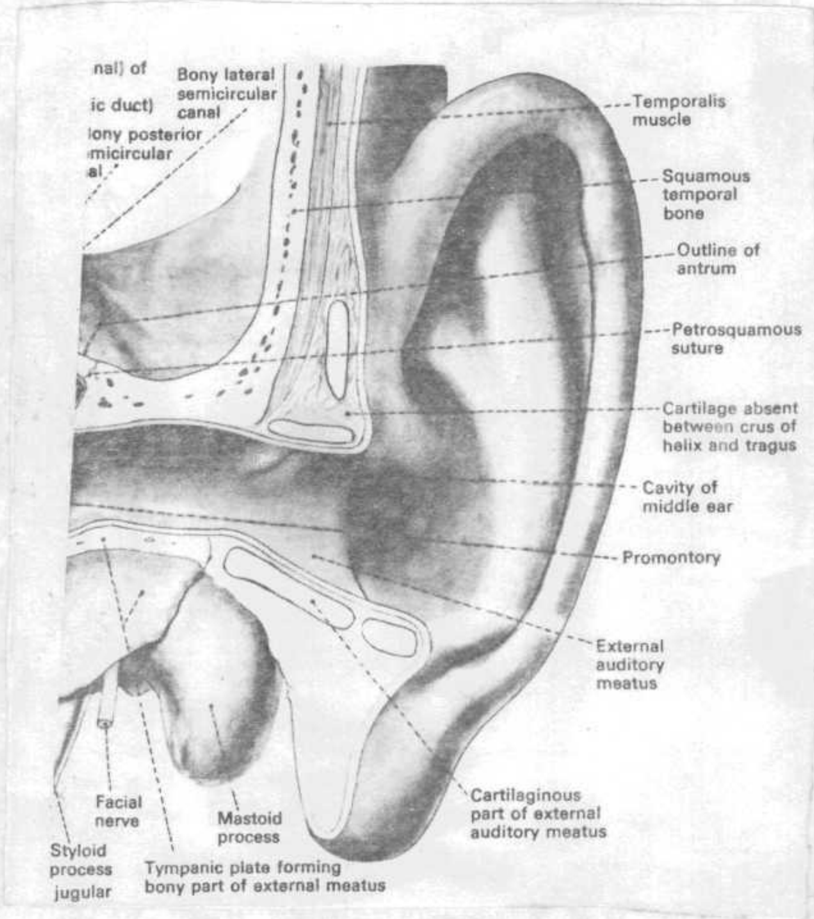
INTRODUCTION:

Noise pollution is common in modern age. It affects the organism both physiologically and psychologically. Noise causes irreversible damage to the hearing mechanism. Early detection is therefore necessary.



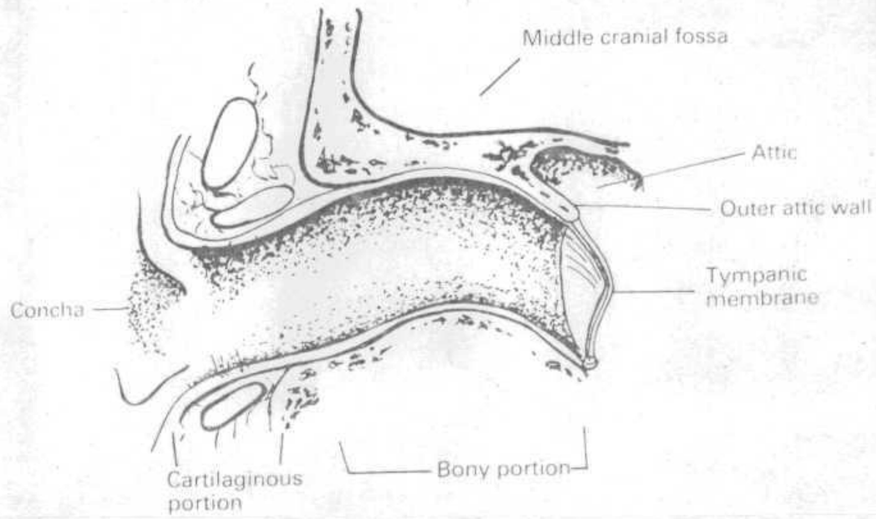
ANATOMY AND PHYSIOLOGY:

The human ear consists of the external ear, the middle ear and the inner ear.



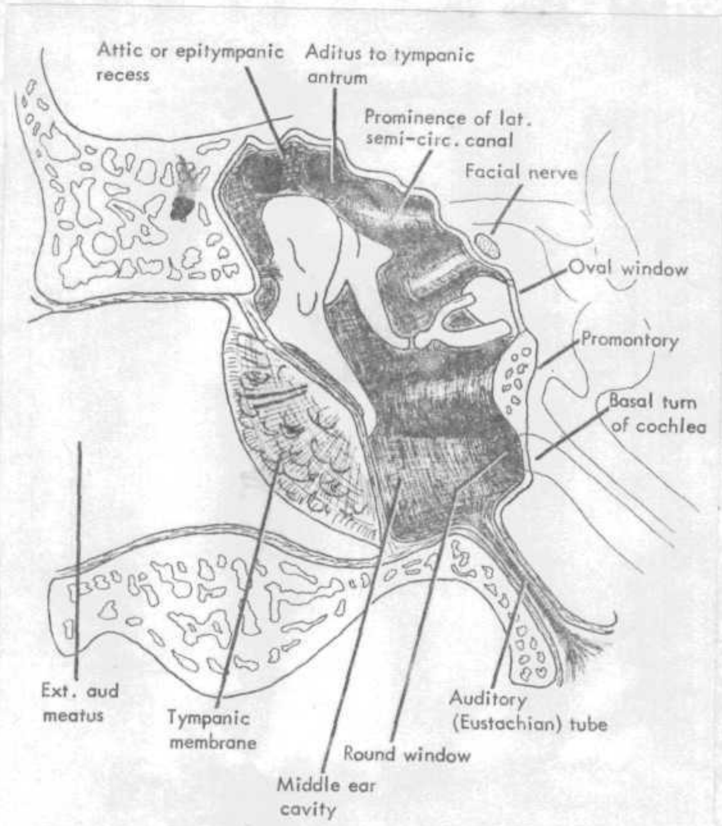
AURICLE:

The external ear consists of the auricle, the EAM and outer layer of tympanic membrane. The auricle consists skeleton of elastic cartilage covered with skin. The auricle is designed to collect sound waves and transmit them along the EAM to tympanic membrane. It helps in localization of sound source.



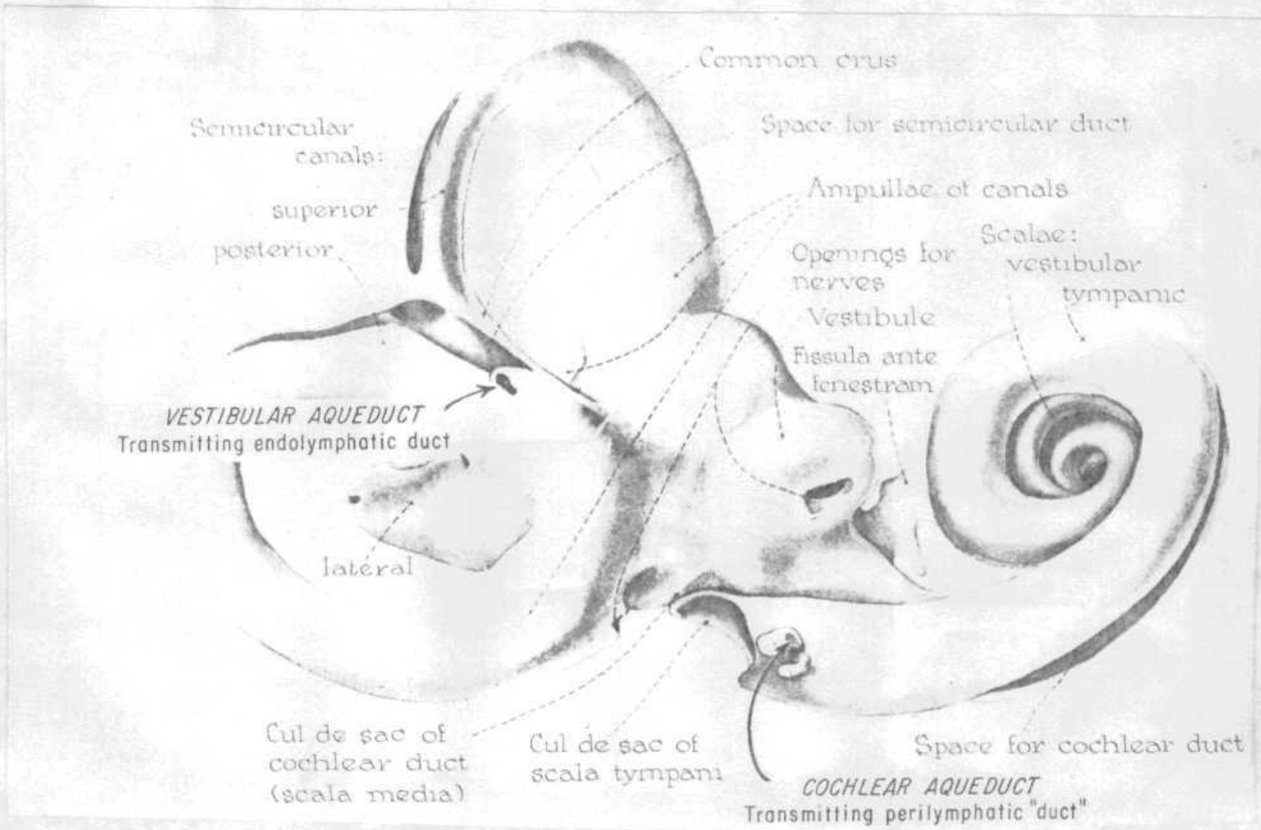
EXTERNAL AUDITORY MEATUS:

The external auditory meatus protects the tympanic membrane and maintains a constant level of temperature and humidity. It acts as resonator amplifying sound by 5-10 dB around 2 KHz. Wax formation in the cartilagenous part traps foreign body. The external auditory meatus cleans itself owing to migration of lining epithilium.



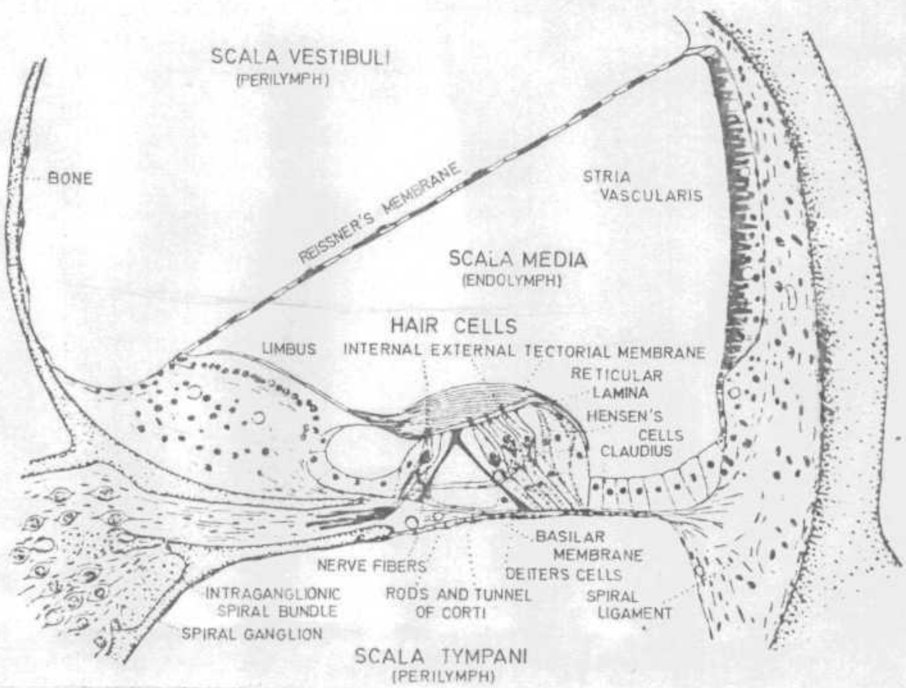
MIDDLE EAR:

The middle ear is a narrow cavity filled with air. It measures 2 to 6 mm in depth and 15 mm in length. The ossicles namely the malleus, the incus and the stapes which transmit vibrations from tympanic membrane to the oval window. Of its 6 walls only the lateral wall consisting of tympanic membrane is not bony. The middle ear is connected with the nasopharynx by means of Eustachian tube. The middle ear acts as an impedance matching device between the air media and the cochlea fluid.



INNER EAR:

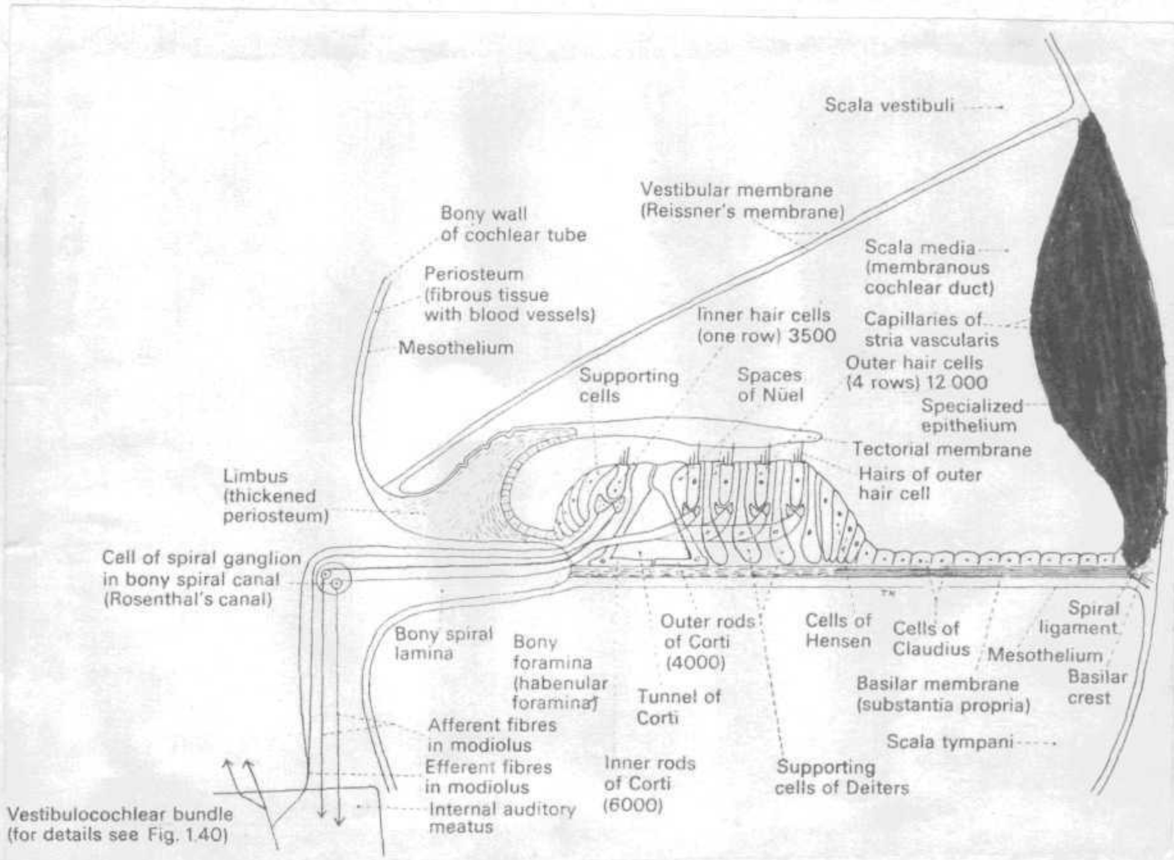
The inner ear consists of bony and membranous cochlea. The body part is cone shaped and measures about 5 mm from base to apex. It consists of a bony tube coiled 2 3/4 inches around a bony pillar, the modiolus. The basal coil of the tube is widest with an elevation called promontary. The tube is incompletely divided into two chambers by the lamina, a bony septum attached the modiolus. The two chambers, the scala vestibuli and scala tympani,contain a fluid the perilymph which is high in sodium and low in pottasium gradient. The two chambers communicate with each other at a point the apex called helicotrema.



MEMBRANOUS COCHLEA:

Membranous part of the cochlea, the cochlear duct is a narrow channel which ends blindly at the apex. At its base the cochlear communicates with saccule by canalis reuniens.

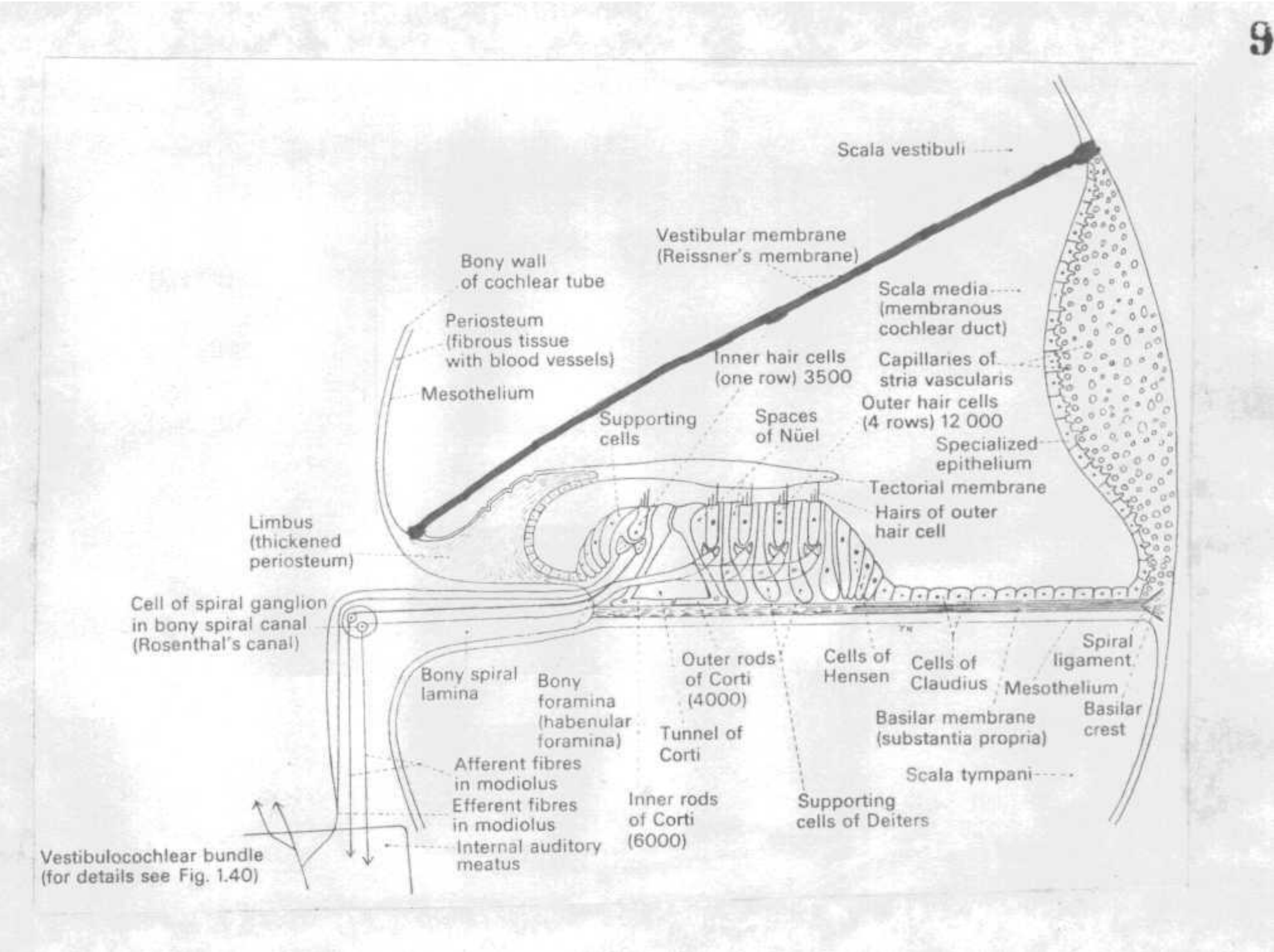
The cavity of the cochlea is called the scala media. The scala media is triangular in shape. It contains a fluid, the endolymph, high in pottasium content and low in sodium. Like the brain, it is ectodermal in origin. Its outerwall is formed by striavascularis and the roof by the Reissner's Membrane.



STRIA VASCULARIS:

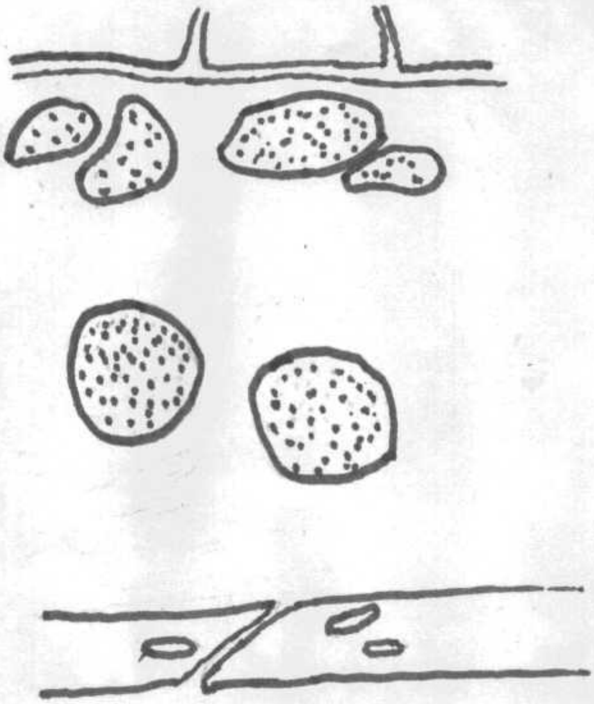
The stria vascularis forms the lateral wall of the cochlear duct. It is held in place by the spiral ligment and in some degree by its connection to radiating arterioles and draining venules. Which are continuous with the capillary net work of stria vascularis.

It has 3 types of cells (1) Marginal cells (2) Intermediate cells (3) Basal cells. Stria vascularis has highest. ATPase activity in the cochlea. Marginal type cells play a major role in concentration of pottasium in endolymph.



REISSNER'S MEMBRANE:

The Reissner's membrane is a thin, flat, cellular membrane, which extends from medial edge of the spirallimbus to the upper edge of the stria vascularis. It is composed of two sheets of cells the cells that face the endolymph are epithial in origin and are low cuboidal almost squamous in form. The second layer is mesenchymal, which faces perilymph. These cells are very flat and loosely joined. Reissner's membrane has low ATPase activity, which shows that it does not participate remarkably in ion transport activity.

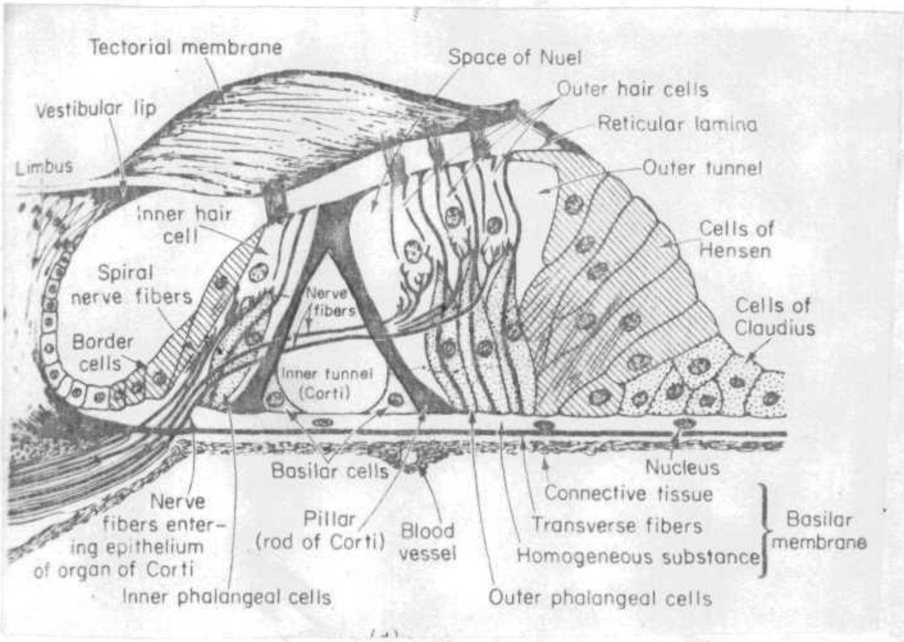


BASILAR MEMBRANE:

The basilar membrane extends from bony spiral lamina to the thickening periostem called basilar erest. The basilar membrane consists of substantia propia which is made up of numerous fibres called auditory strings, 24,000 in number.

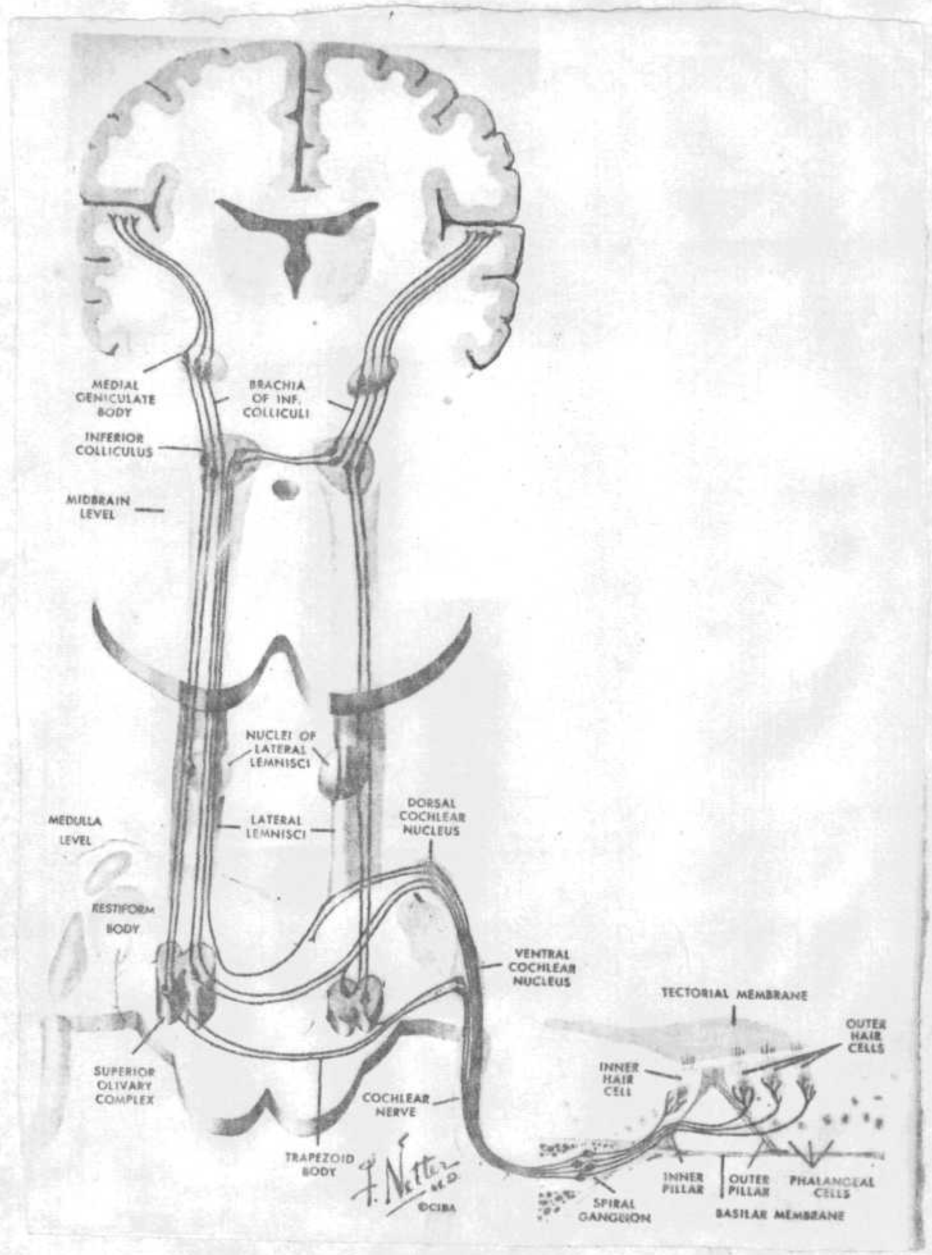
The average length of basilar membrane in man is 30 mm. It is. 4 times wider at the apex than at the base. It is attached both medially and laterally and resists extreme stress.

The upper surface of the basilar membrane is covered with the layer of epithilium derived from the wall of cochlear duct. The inner zone of this epithilium is specialized to form the organ of corti.



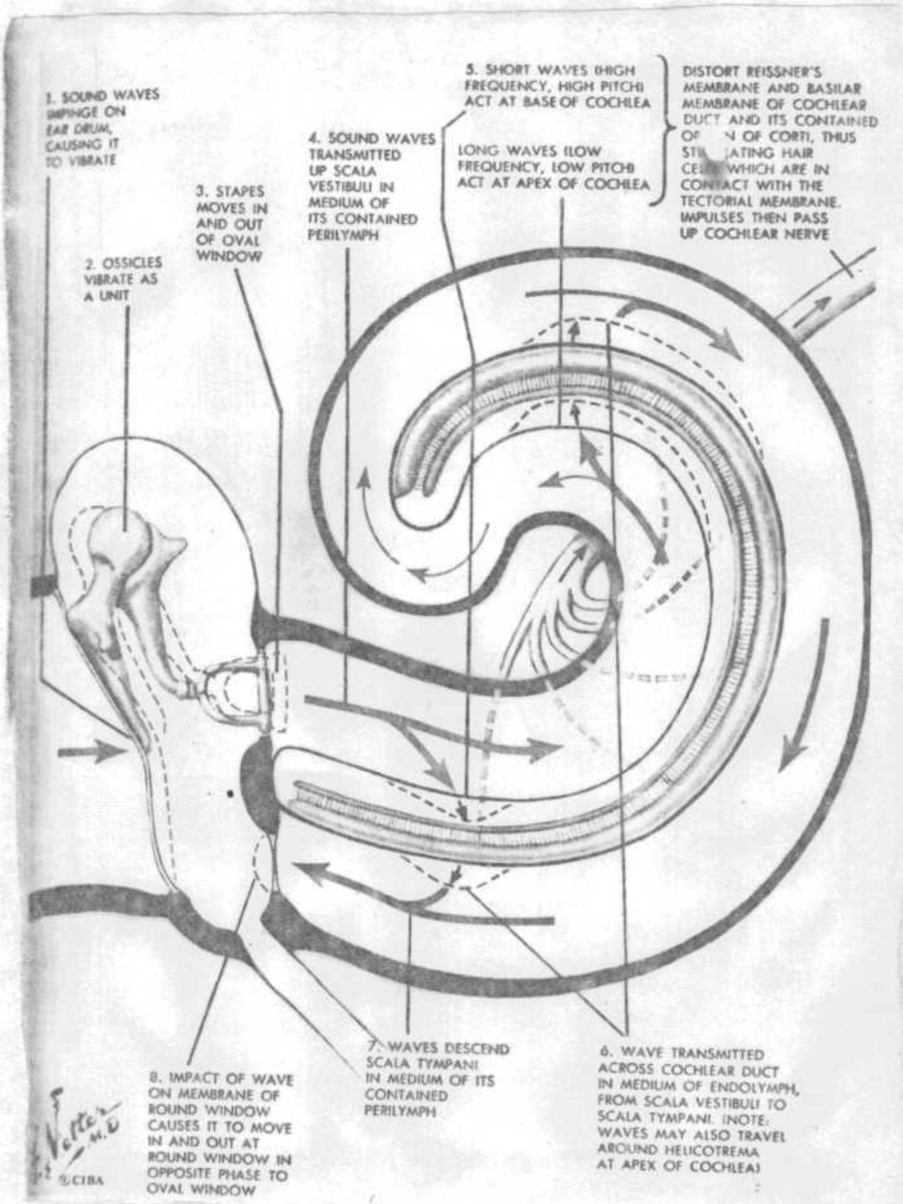
ORGAN OF CORTI:

The organ of Corti contains two types of hair cells. They are the outer hair cells and the inner hair cells. The arch of corti separates a single row of from 3000 to 3500 inner hair cells and 3 or sometimes 4 rows of 9000 to 12000 outer hair cells. Inner hair cells and outer hair cells run in parallel rows.along the basilar membrane from base to the apex. Many hairs or cilia project from each of the hair cells through the reticular membrane and then make contact with tectorial membrane, which extends over-them. Each inner hair cell sprouts from 30 to 60 cilia and each outer hair cell sprouts from 75 to 100 cilia. On each outer hair cell, the cilia are arranged in a W shaped pattern. In addition to hair cells, the organ of corti contains supporting cells and Dieters cells. Between outer hair cells and spiral ligament are other supporting cells, cells of Hensen and cells of Boettcher and cells of Claudius.



AUDITORY PATHWAY:

The nerve fibres leading from the hair cells collect at spiral ganglian and then emerge from temporal bone through internal auditory meatus, in company with the fibers of vestibular branch of VIII nerve and the VII facial nerve. The neurons from cochlear portion of VIII nerve proceed to the ventral and dorsal cochlear nuclei on ipsilateral side of the upper medulla and pons of the brain stem. Next the neurons proceed to the superior olivary complex of the pons. Some additional decussation occurs at this level. The neurons then proceed to lateral leminscus and then to inferior colliculus. From here the neurons proceed to the thalamic nuclei called medial geniculate body. From these points, the auditory radiations spread to cortex specifically to Heschl's gyrus in temporal lobe.

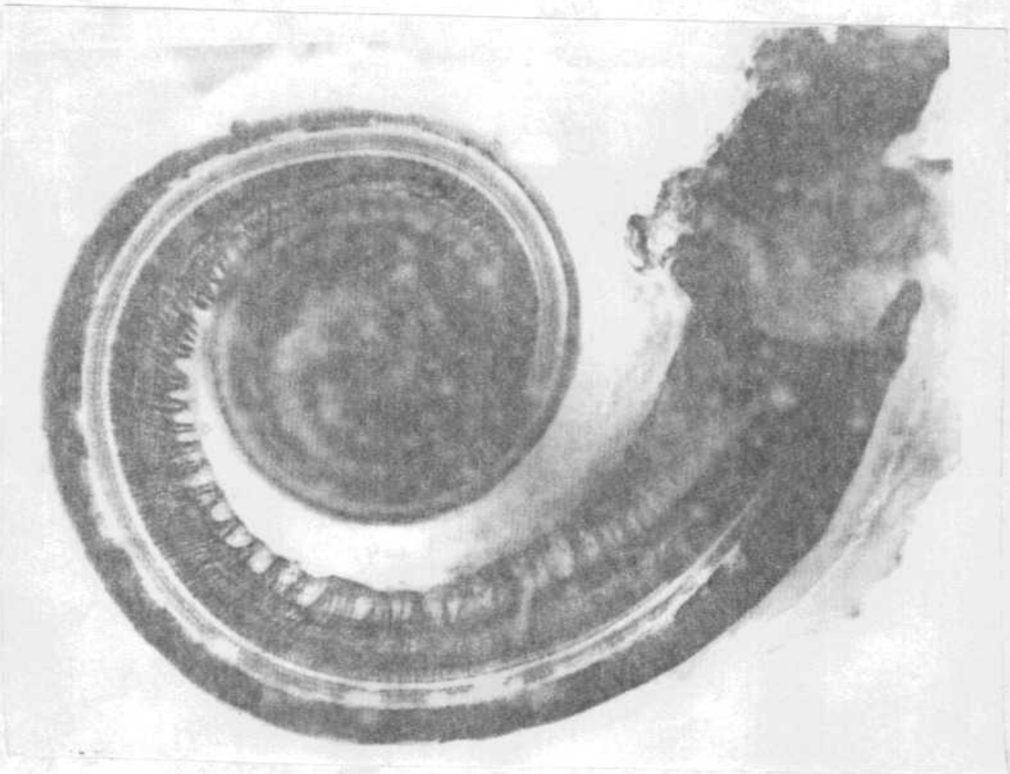


MOVEMENT OF BASILAR MEMBRANE:

Vibrations of foot plate of stapes produce a flow of perilymph up the scale vestibuli, through the helicotrema and down the scala tympani, to the round window. This simple hydraulic effect displaces the organ of corti and its supporting basilar membrane to and fro motion between scale vestibuli and scala tympani. It has been shown by Von Bekesy, that when actual vibrations of basilar membrane are observed, a travelling wave is seen to start from the base of cochlea and progress toward its apex with increasing amplitude until it reaches an area of maximum displacement, the position which is determined by the frequency of stimulus. For high frequencies the maximum displacement of basilar membrane is confined to the basal turn of cochlea, low frequency cause a longer travelling wave, with its maximum amplitude near the apex.

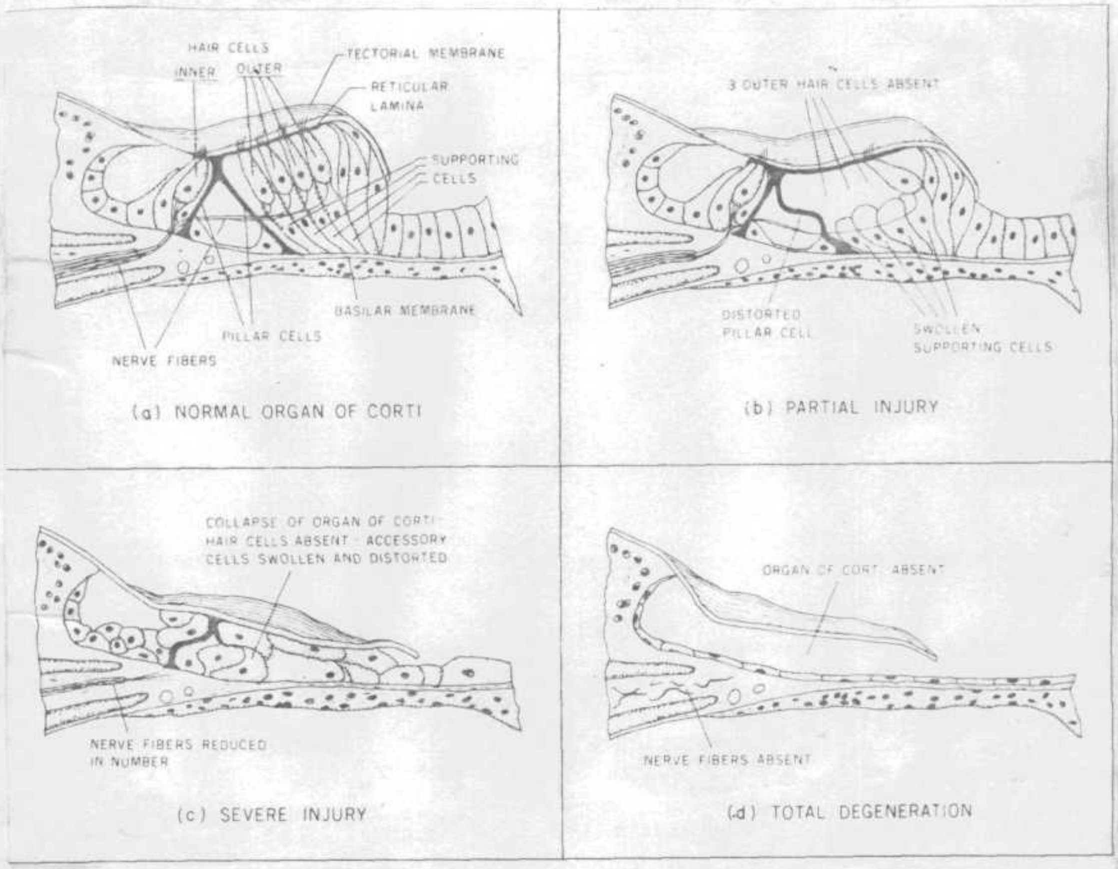
STRUCTURAL CHANGES IN CONDUCTIVE MECHANISM:

According to Eames et al (1975) tympanic membrane is the only structural damage occuring to conductive mechanism. They reported that the tympanic membrane ruptures at greater than 180 dB SPL. Impulsive noise before the ossicular chain is significantly involved Explosion causes blast wave as well as sound wave. Blast wave produces a wave of compression which travels down the ear canal. The effect is to cause an extreme vibration of tympanic membrane and ossicles. Tympanic membrane may rupture by this extreme movements or the ossicles may be damaged and joints dislocated. If tympanic membrane is not damaged then full force of explosion may be transmitted to the inner ear causing severe damage. Singh and Ahluwalia (1968) observed central perforation, reddened and edematous membrane with bleeding in the external auditory meatus, after exposure to noise.



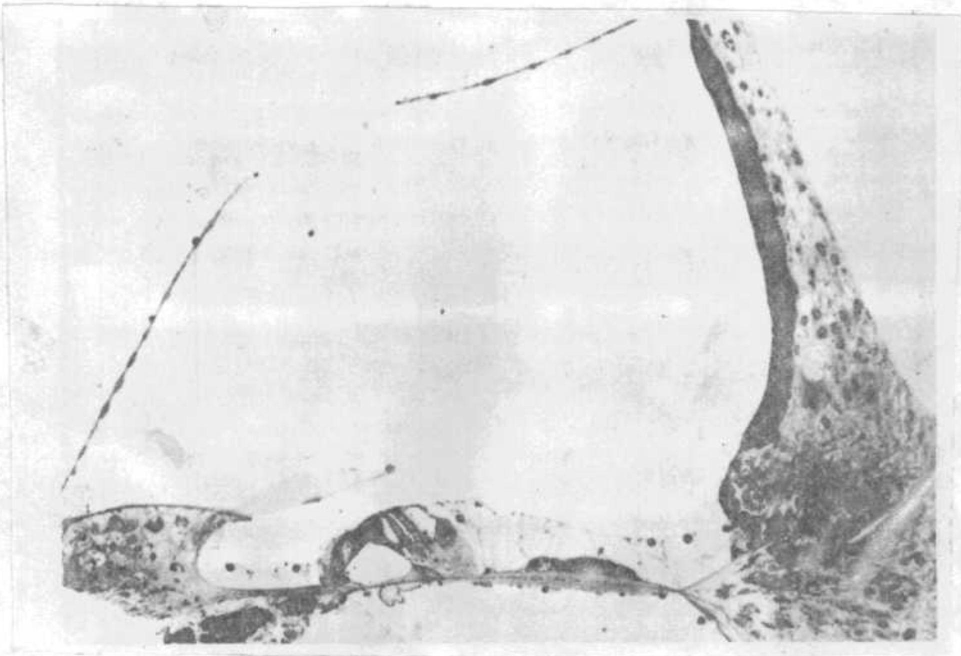
STRUCTURAL CHANGES IN COCHLEA:

Cochlea is more vulnerable to noise exposure. Hawkins and larsGoran, Johnsson (1976) found that the sensoryneural degeneration due to noise focused on first quadrant of basal turn for intermittent noise. Continuous noise damages two quadrant ie., region between 9 and 13 mm, characterized by dip at 4000 Hz. Minute black droplets were found in cochlea in scale vestibuli and scala tympani indicating presence of lipid, osmiophi substances by Lipscomb, Axellsson, Vertes (1976). In blast injuries, although pressure components do the most damage, possible the secondary, negative component of wave, by its suction effect may damage the cochlea.



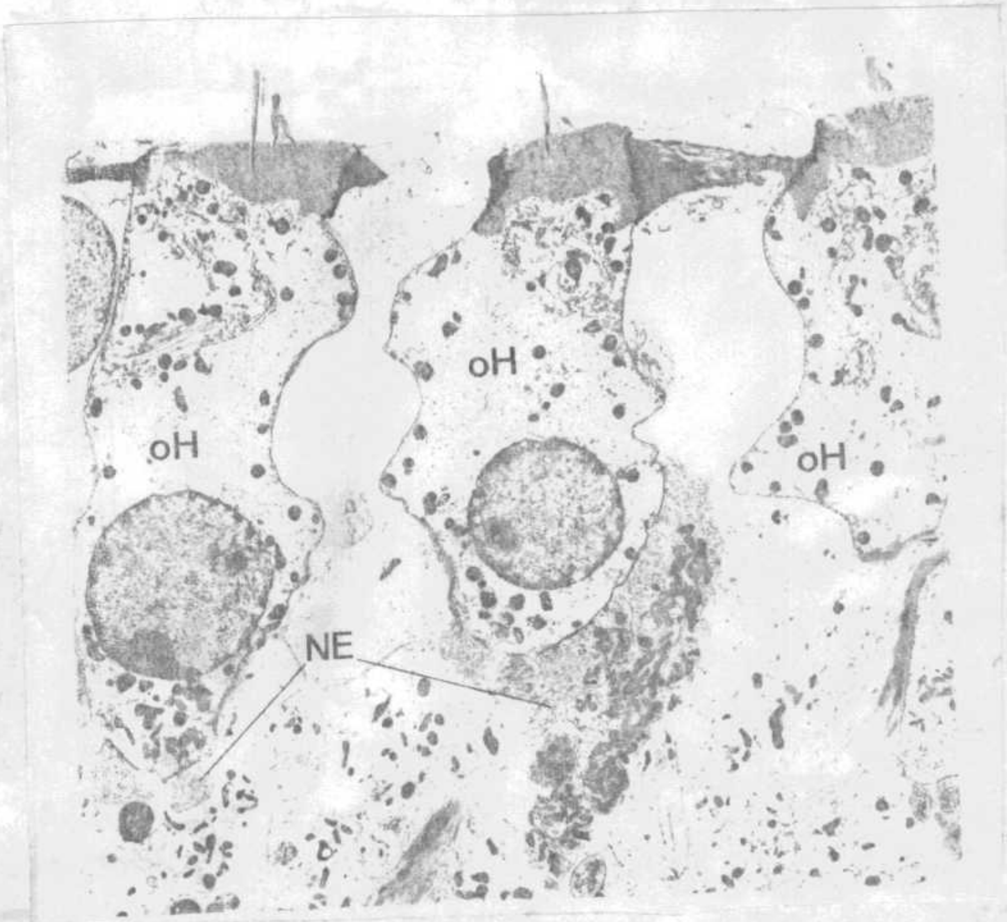
STRUCTURAL CHANGES IN ORGAN OF CORTI:

The organ of corti most vulnerable to high intensity bambardment. Damage of organ of corti depends on frequency of the stimuli, with high frequency sounds damaging the base and low frequency sounds damaging the apex. However, Bohne (1976) found that damage can be more wide spread than one would expect, based on travelling wave theory. For stimuli in excess of 120 dB SPL, even short duration sounds are incriminating.



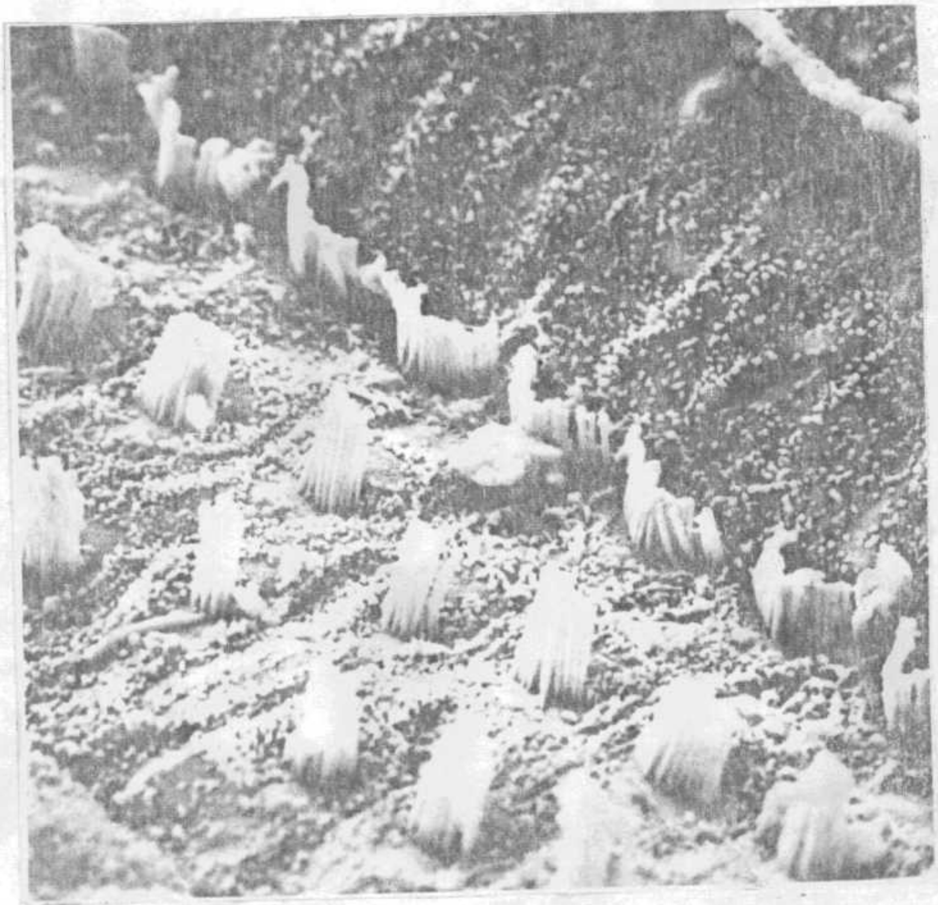
DAMAGE OF REISSNER'S MEMBRANE:

Rupture of the Reissner's membrane seen due to exposure to noise. The Reissner's membrane shows signs of repairing itself along the edges of tear. Newly formed scar closes the gap between scale vestibuli and scala media. The Reissner's membrane is thick and vascular as toward apex. Scar thins out until it becomes as thin as normal. Lipscomb et al found that the Reissner's membrane may distended or bulging into the scala vestibuli, throughout the cochlea or it may collapse in some parts of cochlea.



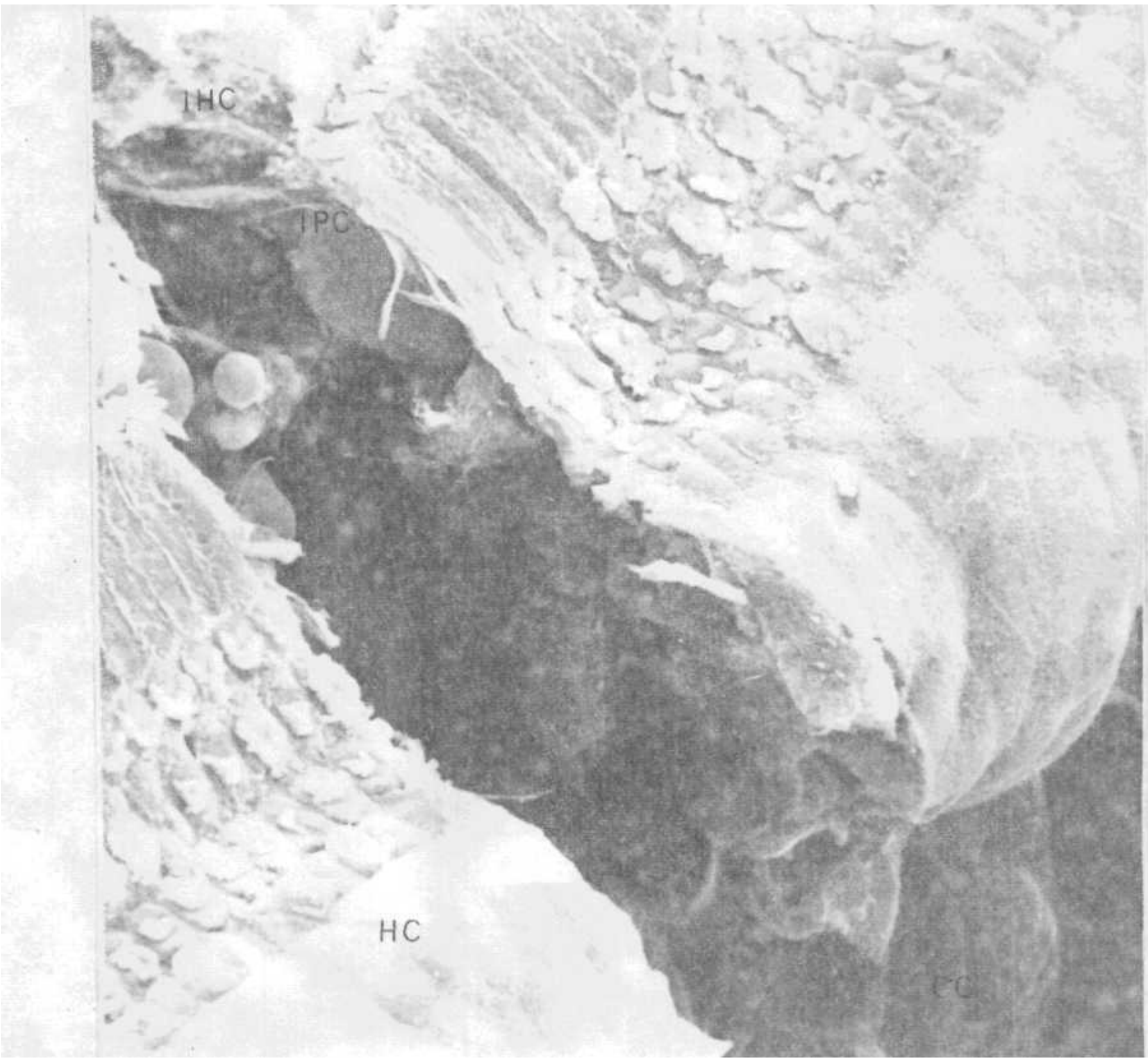
HAIR CELL DAMAGE:

Damaging of hair cell due to noise exposure may range from normal hair cell to complete disappearance. In general hair cell damage is greater in the apical region than in the basal region. The outer hair cells are more vulnerable than the inner hair cells. Lipscomb et al (1976) reported that, more frequently damage is seen in the 3rd row of the outer hair cells, decreasing toward inner hair cells. Earliest signs of damage are: swelling and pyknosis of hair cells. With increasing exposure to noise proliferation, vasiculation of endoplasmic reticulum of hair cells are observed. As stimulation increases outer hair cells have a distorted appearence and began obvious process of degeneration. Kraak found that, increase of impulsive exposure at high intensities viz. firing with small arms direct destruction of hair cells may occur. Healthy cells in between two dying cells is possible. This random effect of cell destruction inthe inner ear rather than a widespread destruction of single area of cochlea often occurs.



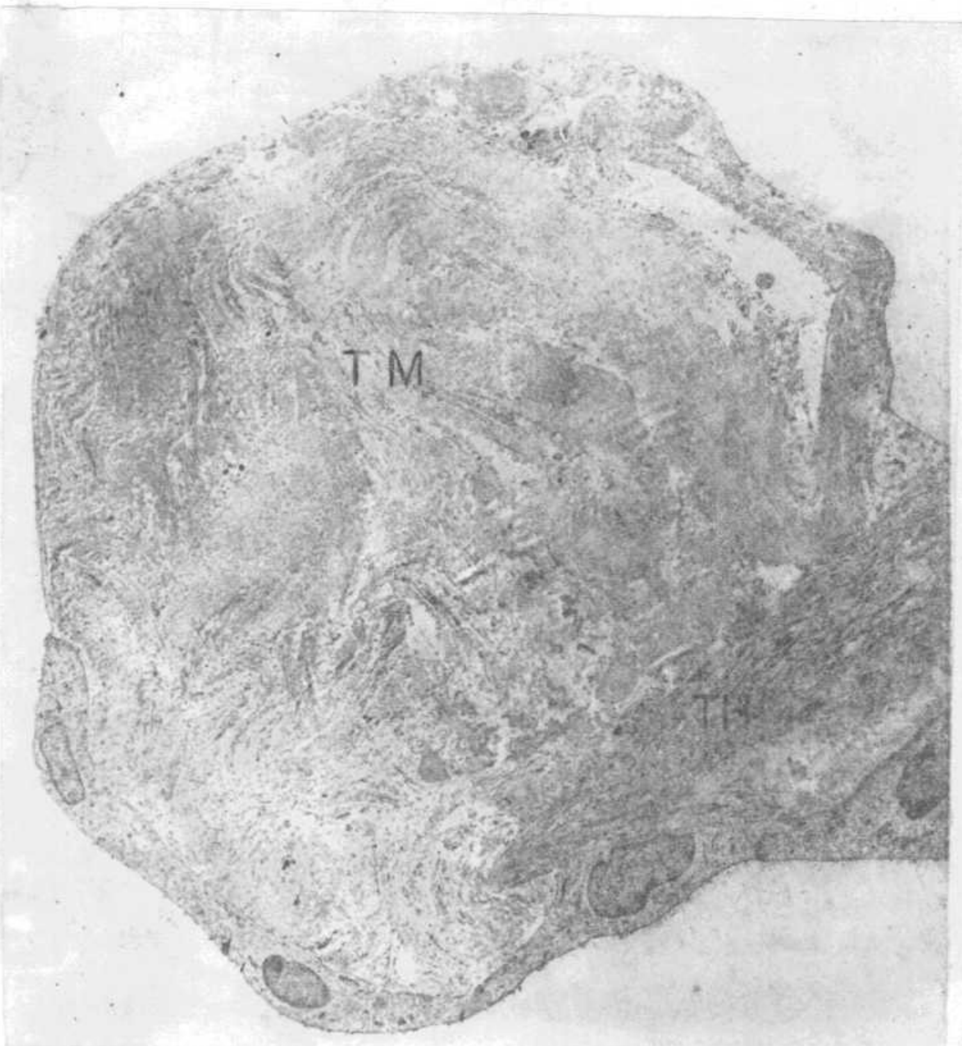
DAMAGE OF STEREO CILIA:

Stereo cilia of hair cells tend to fuse suggesting that the electrostatic properties of membrane permeability is changed. Loosening of stereo cilia membrane and disintegration of root lets stereo cilia enlarged.



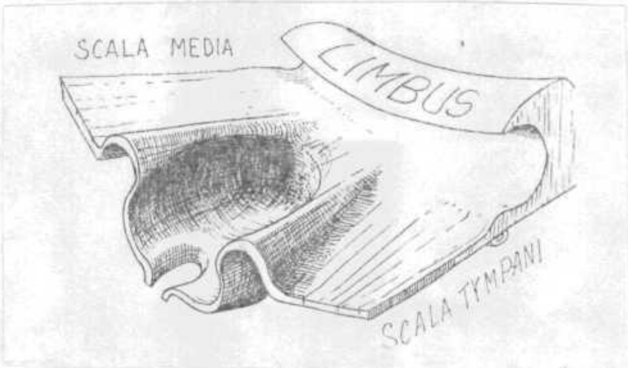
DAMAGE OF SUPPORTING CELLS:

Engstrom et al (1966) reported that due to exposure to noise, vasiculation may appear in supporting cells of hair cells including cells of Henson. Dieter and Claudius hair cells are replaced by collapsed phalangeal process of Dieter cells noted as damaged on the cochleogram.



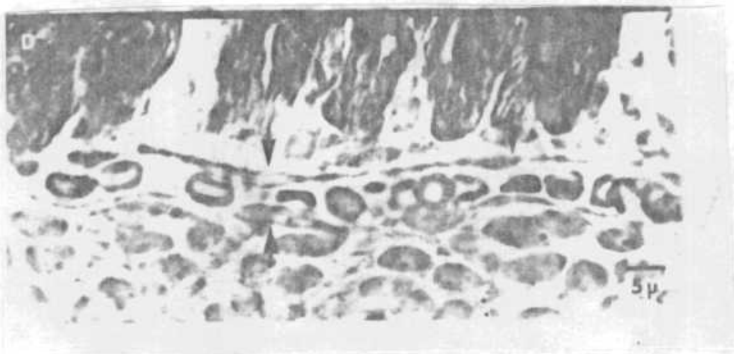
STRUCTURAL DAMAGE OF TECTORIAL MEMBRANE:

Tectorial membrane is lifted up from organ of corti in its damaged area. Ward-Duall in 1971 observed occasional rolled up tactorial membrane surrounded by thin layer of cells.



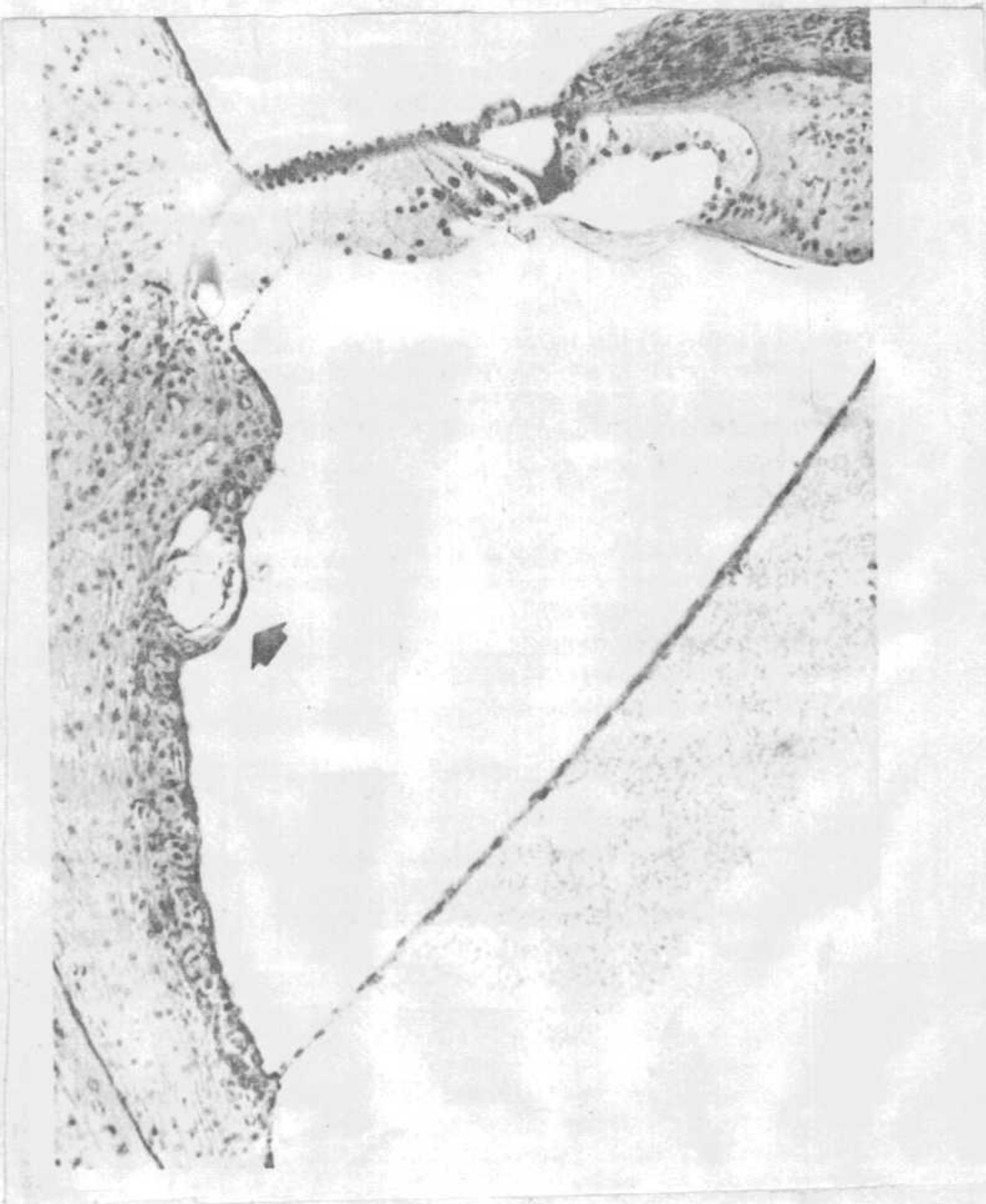
DAMAGE OF BASILAR MEMBRANE:

In exposure to intense noise, the organ of corti may be dislodged completely basilar membrane in some places. But the basilar membrane itself is not broken. Cuboidal layer on basilar membrane and swelling of endothelial cells have been observed exposure to noise.



VASOCONSTRICTION DUE TO NOISE:

Joseph E Hawkins found that marked constriction of lumen often blocking the passage of red blood cells. Constriction is due to swelling of endothelial cells.



STRIAVASCULARIS DAMAGE DUE TO NOISE:

Histo pathological findings in wall, often surface cells appeared un even, swollen or shruken with intercellular gaps particularly frequent apically decreasing toward the base of cochlea.

Lipscomb, Alexsson, Vertes in 1976 observed common vacuoles in stria vascularis, condition present in all turns in localized, but most common in 3rd turn and in apical parts. The epithilium of stria vascularis is separated from spiral ligament.

*Picture inserted upside down

Barbara A Bohna in 1976 found, following dynamic changes after noise exposure

Less than hour after termination	90 minutes after exposure
Exposure to 108 dB SPL Octave Band Noise centered at 4 KHz produces maximal damage in the lower first turn approximately 4mm from basal end. Fewer than l0outer hair cells are missing. Although most of outer hair cell present, their cell bodies were swollen. In addition, the cells contained accumulations of dense-staining material within their cytoplasm, which turn out to be coil of cisternae of smooth endo plasmic reticulum. Stereocilia pattern undisturbed. The rest of cells and the nerve fibers within organ of corti, including fibers in inner spiral bundle had normal appearence.	Outer hair cells shows more signs of damage. Stereocilia formed a dot pattern rather than a smooth line. Fusion of several stereocilia formed gaint stereocilium. Outer hair cells bodies were more swollen, plasma membrane of these cells appeared think. Nerve fibers in the inner spiral bundle and within the tunnel space still have normal appearance.

After 2 hours	Beyond 2 hours
No hair cell bodies were seen in a 1 mm long segment of organ of corti in the first lower turn. Apices of 3 rows of outer hair cells were still present. Small holes were left in reticular lamina, since phalangeal process had not yet enlarged to form phalangeal scars. First signs of damage appeared in radial tunnel fibers. Clumping of axoplasm giving appearance of beads on string, tunnel factors were swollen slightly.	Supporting cells and inner hair cells began to show signs of injury. These cells continued to undergo nectrotic changes so that by 14th day after exposure, an average of 1 mm of organ of cortiral missing.

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