QUESTIONS AND ANSWERS

TO THE

EAR AND ITS FUNCTIONS

REG NO: 8409
SUMA R.

An independent project submitted in part fulfilment for the
Degree of Master of Science (Speech and Hearing)
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C E R T I F I C A T E

This is to certify that the Independent Project entitled "Questions and Answers to the ear and its functions" is a bonafide work done in part fulfillment for the Degree of Master Science (Speech and Hearing) of the student with Register No.

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C E R T I F I C A T E

This is to certify that this independent project has been prepared under my supervision and guidance.

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DECLARATION

This independent project is the result of my own study undertaken under the guidance of Dr S Nikam, Professor and Head of Department of Audiology, All India Institute of Speech and Hearing, and has not been submitted earlier at any other University for any other Diploma or Degree.

Mysore: Reg.No. 8409

Date:

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CONTENTS

CHAPTER - I

INTRODUCTION:

"We sleep, but the loom of life never stops
and the pattern which was weaving
when the sun went down
is weaving when it comes up tomorrow"

- Henry Ward Beecher

Our ears never rest. They are constantly in touch with the external environment, acting as a warning sense. It alerts one to approaching danger or allows time to react to the warning shouts of others.

Auditory system is phylogenetically of higher order. Structures which are phylogenetically of higher order are more complex, because they have to find their way through the already well established patterns within the brain. It differs considerably from other sensory systems. It makes synapses within the brain stem before establishing connections with the cortex. Whereas other senslry systems establish connections with the cortex, bypassing the brain stem. (Fisch et al, 1970)

For most people ears are oddly wrinkled things attached to the head, but not all animals have these. Birds, for instance, do not. What is it that animals have in common that translate sounds into nervous impulses? It is the inner ear that is protected by some of the dense and hard bones in the body. (Van Bergeijk, Pierce, David, 1968). In primitive ears, inner ear structure was all that was necessary to provide response to fluid borne sound signals (Lipscomb, 1982). Leaving the sea for terrestrial

life introduced fresh problems. The inner ear filled with fluid needed help to deal with a very different acoustic environment. Nature provided animals with various auxilliary organs to take care of this difficulty. To match the impedance between fluid and air middle and outer structures developed. Depending on what species of animal we look at, one, two or three very small and light bones are found in the middle ear i.e. on the inside of the cardrum, Amphibians (eg. frog) possess a simple middleear with a single rod like bone, which looks like columns is appropriately called columella. But all mammals have 3 bones in the middle ear. They are called hammer, anvil and stirrup. Aves have a single bone in the middle ear and a long external canal. Pinnae or ear flap is chiefly an attribute of mammals. In most animals pinna is movable and enhances high frequency hearing range.

Knowledge of the function of hearing comes, not only through the study of phylogenetic development, but also through theories or models, electrophysiologic tests and extirpation studies. In science, the theories account for the behavior of complicated mechanisms. The electrophysiologic tests include tracing the flow paths through neural networks and examining the neural signals to find what transfirmations have been accomplished by these networks. Extirpation studies are done to establish the function of various anatomical structures by selectively destroying them. With this in mind the last three chapters about "hearing theories" "procedures and potentials" and "social and damage" have been included to broaden our knowledge about the functions of hearing. The last chapter i.e. "sound and damage" has been confined to the physiological effects of noise on ear structures.

Brief structure of the anatomy is presented, with a view to help reader gain better understanding of the subject. As the basics have been treated, the book can be used as a supplemental text for a group of students undergoing introductory courses in Audiology and hearing science

Facts collected have been treated objectively in the question form, as it is known to measure special abilities of human mind like comprehension of materials, reasoning abilities, skills etc. Questions treated, here, which reduce subjectivity and ambiguity, can be used as guide to those approaching for interviews and for conducting interviews. It can be used as a reference for setting questions.

In training courses, even with prescribed syllabus training programmes differ in terms of the emphasis placed on different areas. The questions included in this project is an attempt at attaining the necessary uniformty

This project can be used for short term and refresher courses. The objective tests can be administered before the training programme, to assess the students' level of performance. It helps us in taking into consideration the compromises that can be made when they show different levels of competencies. The tests can be administered periodically to note the progress made by the student as well as to note the effectiveness of the on-going training programme. At the end of the training programme, the test can be administered again to assess the level of competency achieved. These tests can be used to discriminate students' ability in their respective area.

Most of the questions here constitute a means of assessing the extent, to which one has actually learned the material, i.e. It can be used as a self, study guide. It also serves as a means of arousing the students further interest and thinking. In Bekesy's words "Stimulating questions are the most valuable kind. They induce you to do something, when you do things, you may turn up strategic questions. They lead to knowledge".

The project undertaken is an initial step in treating the subject matter in the objective form. It is to be emphasized that questions are not in the order of difficulty. This will be done in subsequent years, when continuous feed back becomes available.

"Let us pretend there is a way of getting through into it, somehow, Kitty. Let us pretend the glass has got all soft like gauze, so that we can get through. Why, it is turning into a sort of mist now, I declare ! it will be easy enough to get through_____"

Alice through the looking glass

CHAPTER II

GENERAL

A. Give the Synonyms for the following:

1. External ear
2. Pinna
3. External Auditory Meatus
4. Tympanic - Membrane
5. Malleus
6. Incus
7. Stapes
8. Oval window
9. Round window
10. Middle Ear
11. Eustachian - Tube
12. Pars flaccida
13. Scala - Media
14. Auditory nerve
15. Trapezoid body
16. Stria of held
17. Stria of Monakow
18. Primary Auditory cortex
19. Marginal cells of stria vascularis
20. Intermediate cells of stria vascularis
21. Deiter's cells
22. Reissner's membrane
23. Endolymph
24. Efferent fibres

B. Audio Structure Advantages
What is the advantage of

1. The shapre of the auricle
2. Cerumen and Hair collicles in the EAM
3. Curved External Auditory Canal
4. Helin doubled over in a loose roll
5. TM placed at an angle
6. Cone shape of TM
7. Slack edge of TM
8. ME cavity open at the anterior wall
9. Collapsed Eustachian Tube
10. Malleus head
11. Axis of rotation of ossicles close to the centre of gravity
12. Encloing muscles within a bony canal and their tendons outside the bony canal
13. Location of oval window and Round window at different plan
14. Coiled Cochlea
15. Unmyelinated portions of the afferent fibres in the organ of eorti.
16. Short fibres of ME Muscles arranged parallel to each other

C. Fill in the blanks with the words given in the brackets.

(Anterior, Posterior, Medial, Laterla, Superior, Inferior, upwards, Backwards, Downwards, Inwards, Outward).

1. In children, the auricle has to be pulled_____&_____ to straighten the canal
2. In adults, the auricle has to be pulled& _____ to straighten the canal
3. Tensor Tympani muscle contraction increases the ME pressure slightly by_____displacement of the Tympanic Membrane (TM)
4. Malleus is drawn_____&_____by the contraction of the Tensor Tympani
5. Malleus pulls the TM_____in the shape of a cone
6. The footplate is rigidly fixed _____ than _____
7. The_____portion of the stapes footplate pushes into and out of the cochlea on sound stimulation
8. The compressional wave results in_____movement of the stapes.
9. The rarefaction wave produces_____movement of the stapes.
10. _____movement of the stapes produces fluid displacement
11. The over pressure, created in the inner ear, is relieved by an_____movement of the Round window.
12. The_____ligament attaches to the epitympanic recess roof, and to the head of the malleus
13. Laterall wall of the Middle ear cavity and the neck of the malleus is supplied by_____ligament
14. The attachment of looser ligamental fibres at the _____ than at the_____margins enables the stapes to rotate on its axis.
15. Neck of the Malleus is supplied by_____ligament.
16. The_____ligament attaches to the incus
17. The tendxon of the stapedius muscle enters the tympanic cavity from the_____wall
18. _____movement of the temporal bone results in _____ movement of the stapes due to inertial lag of the ossicular chain.

D. Formulae

Match the following:

1. Resonance of the canal
2. Areal Ratio
3. Level Ratio
4. Stiffness reactance
5. Mass reactance
6. Impedance

a) $M\ 2\pi f$

b) $P = ST$

c) $\sqrt{R^2+(s/2\pi f - M2\pi f)}$

d) $P_2/P_1 = A_1/A_2$

e) $N/4\Gamma$

f) $L_1/L_2 = F_2/F_1$

g) $S/2\pi f$

E. What happens if.

1. If fluids were present in the external auditory Meatus
2. If Tympanic Membrances effective area were twice its original size
3. If ME mechanisms was over complaint
4. If ME mechanism were noncomplaint
5. If only one ossicle were present in the ME
6. If there was only one window
7. If sound waves different in phase, strike both windows which are at the same plane
8. If both windows are free and attacked by sound waves,' identical in pressure eg.phase.
9. If perilymph was in place of endolymph
10. If stapes mass were the same as the other 2 ossicular bones
11. If the drumhead were attached to the head of the stapes.

F. Choose between the two.

1. The external and Middle ear structures favours (low/high frequency)
2. The transformer action begins (before the ear canal is reached/on reaching the ear canal)
3. Which inserts into the ossicles? (Muscles/Tecons)
4. In which quadrant is the cone of light present? (Anterior-Inferior/Posterior-Inferior)
5. The Middle ear structures are visible through an intact drum (Yes/No)
6. The lower end of the lenticular process is supplied by _____blood supply (Rich/Boor)
7. Which fibres are more in number? (Afferent/efferent)
8. The tunnel crossing fibres are (Afferent/efferent)
9. The basilar fibres innervating the outer hair cells (cross the tunnel of carti/pass below the tunnel of corti)
10. The inner hair cells can perform the function of spatial integration? (Yes/No)
11. The only wall of the Middle ear which is not bony (Antterior/lateral)
12. The rods of corti which are more in number (Inner/outer)
13. Which cell types are more in number?(Sensory/supporting)

G. Say True/False ((Five reason)

1. The transmission of vibratory energy is poor from one medium to another.
2. Slight + ve pressure is present in the ME under normal conditions.
3. ME muscles attenuate high intensity sounds.
4. Eustachian tube opening at high pressures involves muscular action
5. Localization is affected in the no pinna condition with free head movement.

H. Fill/the blanks in column (B) with a pathological /in condition corresponding to the structure given in volumn (A)

'A' Normal	'B' Pathological condition
1. Tympanic Membrane	a. Tympanic _____
2. Ossicular chain	b. Ossicular_____
3. Mastoid cells	c. Mastoid _____
4. Eustachian Tube	d. Eustachian _____
5. Endolymphatic duct	e. Endolymphatic_____
6. Facial nerve	f. Facial__ _____
7. Acoustic nerve	g. Acoustic_____
8. Auditory area 20	h. Auditory_____

ANSWERS

A.
1. Outer Ear
2. Auricle
3. External Auditory Cabal
4. Eardrum
5. Hammer
6. Anvil
7. Stirrup
8. Fenestra Vestibuli
9. Fenestra Rotunda
10. Tympannm or Tympanic cavity
11. Auditory- tube
12. Shrapnell's membrane
13. Ductus cochlearis
14. Stato acoustic or vestibulo cochlear nerve
15. Trapezoid body ventral Acoustic Stria
16. Intermediate Acoustic Stria
17. Dorsal acoustic stria
18. Area AI or Auditory Konicortex
19. Dark cells
20. Light cells
21. Phalangeal cells
22. Vestibular membrane
23. Liquor oticus
24. Olivocochlear Bundle

B. 1. Ridges Snd Indentations in the amicle produce delayed paths and spectral differences in the stimulus, thereby increasing the sensitivity of hearing.

2. Cerumen protects ear canal from drying out and together with hair follicles trap dust and insects, thereby protecting the ear from foreign bodies (Zemlin 1968)

3. The curved external canal
   a) Provides delay for the sound impinging on the TM
   b) Protects the TM by cutting down the velocity of sound
   c) Prevents any change in humidity and temperature from affecting the TM (Yost & Neilson, 1977)

4. The helix, doubled over in a loose roll, it, along with the extended portion of the amicle, serves as a cushioning for each side of the head in the event of trauma.

(Lipscomb 1982)

5. The TM placed at an angle provides larger surface to the air particles than if it were at the axis of canal

(Shaw 1974)

6. The conical form of the Tympanic membrane assures close coupling between membrane and manubrium. The Tympanic membrane and manubrium. The tympanic membrane, because of its configuration, acts as a piston, transmitting its pressure changes to the ossicles.

Judson & Weaver (1965)

7. The advantage of Tympanic Membrane having a slack edge is, it permits the membrane to move without distorting the central part.

(Judson & Weaver, 1965)

8. An opening in the anterior wall, aids in the movement of the tympanic membrane by balancing the pressure within the ME cavity with that of the atmospheric pressure

(Yost & Neilson, 1977)

9. The collapsed condition of the Eustachian tube prevents infection entering the Middle ear from the upper respiratory tract and also prevents ones own speech entering the middle ear and hence the inner ear.

(Davis & Silverman, 1970)

10. The advantage of having Malleus head is, it reduces the rotation of ossicles during bone conduction hearing.
11. When the axis of rotation of the ossicles is close to the centre of gravity, the inertia of the system is small. This reduces excess strain on the ossicles and prevents production of noise when the ossicles vibrate.

(Davis & Silverman 1970)

12. Enclosing the muscles within the bony canal produces only a pull and not to be set into vibrations themselves (Yost & Neilson 1977) According to (Beksy, 1936) the presence of tendons outside the bony canal reduces the muscular vibrations of sound transmission and the effective mass of the ossicular chain, (Zemlin 1968).
13. Situation of ovalwindow and the Round Window at different planes prevents striking of sound wave on both windows at the same instant, thereby preventing the cancellation effects in the Inner ear fluids.
14. The nerves and blood vessels are known to receive better protection from the bony modiolus when the cochlea is coiled than when it is straight.

(Judson & Weaver, 1965)

15. The unmyelinated portions ofthe acoustic nerve fibres in the organ of corti enable coding of the acoustic information and stimulus integration within the cochlea

(Spoendlin (1973)

16. Short fibres arranged parallel to each other gives greater tension and provides scope for only a slight displacement.

C. 1. Downwards & backwards
2. Upwards and backwards
3. Medial
4. Medially and anteriorly
5. Inward
6. Posteriorly, anteriorly
7. Anterior
8. Medial
9. Lateral
10. Inward
11. Outward
12. Superior
13. Lateral
14. Posterior, anterior
15. Anterior
16. Posterior
17. Posterior
18. Lateral, Inward

D. 1. e
2. d
3. f
4. g
5. a
6. c

E.l. Hearing would have been affected, if fluids were present within the ear canal.

2. A tympanic membrane twice its size yields 3 dB improvement. But a tympanic membrane that large would be difficult to damp and as a result there would be continuous ringing sound in the ear, even upon cession of the sound. This would cause the rapidly occurring sounds to run together and become less comprehensible

(Lipscomb, 1982)

3. The inadequte coupling of structures to the mechanism is present in over complaint condition. This condition produces increased energy absorption and decreased sound transmission.

(Lipscomb, 1982)

4. A noncomplaint mechanism produces reflections of sound energy striking the drum. This results in less energy reaching the cochlea, which in turn produces decreased sensitivity of hearing.

(Lipscomb, 1982)

5. A single ossicle connecting the drum membrane and oval window has 3 degrees of freedom. Due to this, we would be hearing subharmonies. This is overcome by the presence of 3 ossicles.

6. If there was only one window, fluid mobility would have been affected with a loss of about 50-60 dB or more.

7. Difference in phase produces increase in the effectiveness of sound transmission from Middle Ear space to inner ear, irrespective of the positions of the windows

Lawrence (1960)

8. Cancellation of tone do not occur in the inner ear if sound waves, identical in pressure and phase strike both windows which are free. As a result there will be no movement of fluids in the inner ear.

9. Perilymph is toxic in endolymph space. The haircells would become opaque and organ of certi nonfunctional

(Bern 1974)

10. The transmission of high frequency sounds would have been affected, if mass of stapes were the same as the other two ossicular bones.

(Lipscomb, 1982)

11. Bypassing the malleus and Incus, the portion of the transmission ratio due to the areal ratio of the membrane and oval window remains effective. It is unimportant if the malleus and incus are damaged, provided good mechanical linkage between the oval window and drumhead is established

(Grover, 1979)

F. 1. High
2. Before the ear canal is rea
3. Tendons
4. Anterior - Inferior
5. Yes
6. Poor
7. Afferent
8. Efferent
9. Pass below the tunnel of corti
10. No
11. Lateral
12. Outer
13. Supporting cells.

G. 1. True: Transmission is affected, as most of the energy is reflected at the interface, due to difference in impedance of the 2 media
2. True: Slight +ve pressure is present, as small air volume are forced into the ME during closing of the Eustachian t
3. True: 'transmission of the high intensity sounds are stopped by the contraction of the ME muscles.
4. False: Muscle action does not come into play since the Eustachian tube opens by itself due to overpressure.
5. False: As the head movements contribute to the localization of sound, not having the pinna does not affect the localization of sound.

H. a. Perforation
b. discontinuity
c. itis
d. catarrah
e. hydrops
f. palsy
g. neuroma
h. agnosia

A colored man brought a suit against another man for

Defaming him. In the Court the Judge askied him what the other man hag done.

" He called me a rhinoceros" answered the man.

" How long back?" asked the judge.

"Two years ago".

"Why then are you complaining now"?

"Because I saw the animal only this morning".

A name has a great power if we know what it means.

CHAPTER III

NAMES AND NUMBERS

A Names and Dates.

What contributions were made by the following persons.

1. Weiner & Ross (1946)
2. Bekesy (1953)
3. Helmhollz
4. Smith et al (1952)
5. Heroog & Krainz (1926)
6. Bekesy (1932) & Baranyl (1938)
7. Davis (1956)
8. Teas et al (1962)
9. Turato (1962)
10. Held (1926)
11. Retzius (1984)
12. Lorento de No (1933)
13. Perlman & Case (1939)
14. Jepson (1955)

B. Name the following which occurs in two's.

1. Portions of EAM
2. Parts of TM
3. TM fibres
4. ME muscles
5. ME Windows
6. Eustachiantube Muscles
7. Branches of VIII nerve
8. Parts of Basilar Membrane
9. Cell layers of Reissner's membrane
10. Cells lying outside the outer phatangeal cells
11. Rods of corti
12. Cells lying on either side of tunnel of corti
13. Cochlear nuclei
14. Cells of Stria Vascularis
15. Combined effect generates positive potential in endolymph
16. Cochlear channel is divided incompletely by asseous spiral lamina
17. Completes the incompletely divided Cochlear Channel
18. Inner Ear fluids
19. Communicates through helicotrema
20. Fibrillar filaments of pillar and Deiter's cells

C. Name the following which occur in three's.

1. ME ossicles
2. ME principles to match the impedance of TM to that of Inner ear
3. ME structures which change its mode of vibration at high sound levels
4. Components forming total Impedance
5. Layers of TM
6. Ridges on the Medial wall of the ME
7. Nuclear divisions of the Cochlear nuclei
8. Projections of striae from the Cochlear nuclei
9. Cochlear ducts
10. Nuclei of the inferior colliculus
11. ME divisions
12. Gyri of the temporal lobe

D. Loss Vs Gain.

1. In what frequency range does the external ear gain pressure?
2. What is the gain in dB produced in the above frequency of range?
3. What is the hearing loss in dB produced by the removal of an auricle?
4. What is the hearing gain in dB in front of the Tympanic Membrane at 2.5 KHZ?
5. What would be the hearing loss in dB caused by cerumen plugs?
6. What would be the dB loss incurred if sound were striking the Inner ear directly?
7. What is the pressure gain at the stapes due to the difference in areal ratios of the Tympanic Membrane and the stapes foot plate?
8. By how many times does the force increase at the stapes due to the lever action?
9. What is the dB attenuation i.e. produced for loud sounds due to Middle Ear Muscle contraction?
10. How many dB's of reduction does the Middle Ear Muscle contraction produce at high frequency?
11. What is the loss produced by a large Tympanic Membrane perforation with ossicular discontinuity?
12. Conventionally at what frequency is the dip seen in
    a) Noise induced Hearing Loss
    b) Carhart notch
    c) Drug induced hearing loss

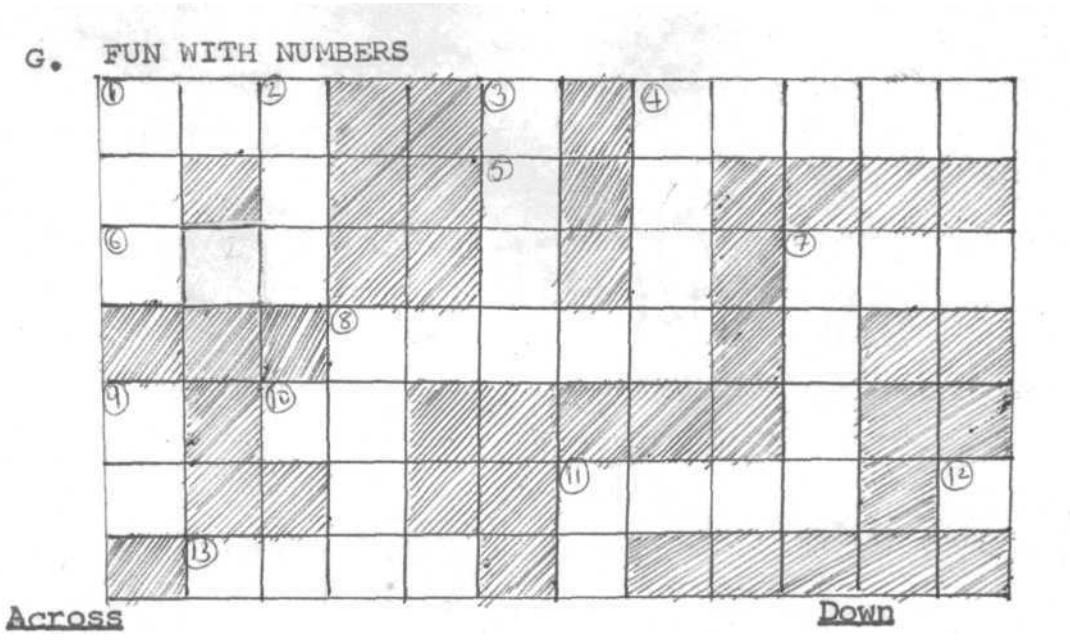
E. PROBLEMS

1. Calculate the resonant frequency of the EAM whose length is 1 cm.
2. Calculate the length of canal, which has a resonant frequency of 2000 Hz?
3. Calculate the force produced at the stapes given,
   Area of the TM - 60 mm^2
   Area of the stapes footplate - 2.0 mm^2
4. Calculate the force produced by the lever action, if the effective length of the Malleus is 2.5 times that of the incus.

F. Milli volts.

1. Scala media has_____
2. Organ of Corti has _____
3. _____is seen in Scala vestibuli and Scala tympani

G. FUN WITH NUMBERS



Across

1. Basal end of the Basilar Membrane (in mm)
4. No.of outer hair cells present within the auditory system
5. What is the no.of hair cells present/mm on the basilar membrane?
6. How many different intensity level can bhe ear detect?
7. What is the rough equivalence of one critical band (in mels)
8. No. of cell bodies of nerve fibres in the auditory system
10. Effective area of the Tympanic membrane
11. No. of inner hair cells
13. Resonant frequency of concha (Hz)

Down

(1) One JND in pitch corresponds to a constant difference in position of maximum amplitud< (mm)

(2) No. of efferent fibres coming from SOC

(3) No. of pitch changes ear can detect

(4) Break up of TM vibratory pattern (in Hz)

(7) Above what frequency do the nerve fibers don't fire as unit

(8) Resonant frequency of ear canal (Hz)

(9) Size of the outer hair cell (microns)

(11) Length of basilar membrane (mm)

(12) Size of the inner hair cell (microns)

ANSWERS

A. 1. Gave the first description of the transfer function of the outer ear.
2. Provided evidence for the transfer function of the inner ear
3. Proposed the mechanism of curved membrance
4. First to report the high K^+ and low Na^+ concentration in endolymph and viceversa in Perilymph
5. Explained the compressional mode of BC
6. Explained the Inertial mode of BC
7. Gave varied resistance model
8. Pointed to the emergence of the activity from the internal meatus as the event i.e. signified by the AP
9. First to describe the structure of Basilar Membrane
10. Described the pillar cells of corti
11. First one to count the number of pillar cells and the number of hair cells in human cochlear
12. Reported the pons as the reflex centre for the stapedial reflex
13. First one to record latency of action potentials in Tympanic muscles
14. Reported the role of age in stapedial reflex testing.

B. 1. Bony and cartilaginous
2. Pars tensa and parsflaccida
3. Circular and Radial
4. Tensor Tympani and Stapedius
5. Oval and Round windows
6. Tensor Velipalatini & Levator Veli palatini
7. Vestibular and Cochlear
8. Parstecta & pars pectinata
9. Epithelial and endothelial
10. Hensen and Claudius
11. Inner and outer rods of corti
12. Inner and outer
13. Dorsal and Ventral
14. Marginal and Intermediate
15. Electrogenic pump and potassium diffusion potential
16. Scala vestibuli and Scala Tympani
17. Basilar membrane and Spiral ligament
18. Emdolymph and perilymph
19. Scala vestibuli & Scala Tympani
20. Tube like & micro filaments.

C. 1. Malleus, Incus, and Stapes

2. (a) Difference in areal ratio of the Tympanic Membrane and the stapes foot plate

(b) Lever action of the ME

(c) Buckling action of the TM (Pickles, 1982)

3. Tympanic Membrane, Incudo Malleal joint, Stapes

4. Acoustic Mass, Acoustic; Resistance, Acoustic compliance. (Lipscomb, 1982)

5+ The outer spithelial layer, Middle fibrous layer, Inner Mucosal layer.

6. (a) The cochlear promontory

(b) Swelling due to the horizontal Semicircular canal

(c) Swelling due to the facial nerve canal

7. Antero ventral cochlear nucleus, Postero ventral cochlear nucleus, Dorsal cochlear nucleus

8. Trapezord body, Stria of Monakow,and Stria of Held

9. Scala vestibuli, Scala media and Scala Tympani

10. Central nucleus, peripheral nucleus and external nucleus

11. Epitympanum, Mesotympanum and Hypotympanum

12. Superior temporal gyrus, middle temporal gyrus and inferior temporal gyrus.

D. 1. 1.5 - 7 KHZ

2. 10 - 15 dB

3. 5 dB

4. 20 dB

5. 40 dB

6. 35 dB

7. 27e

8. 1.32

9. 10 - 30 dB

10. None

11. 30 - 40 dB

12.a. 4 KHz

b. 2 KHZ

c. 4 KHZ

E. Formula for calculating _ $\frac{\text{Velocity}}{4 \times \text{length of canal}}$

1. the resonance of EAM

Velocity of air = 34000 cm/sec^2

Length of canal = 1 cm

$= \frac{34000}{4x1}$

= 8500 Hz

= Resonant frequency of EAM whose canal length is 1 cm is 8500 Hz

2. Formula for calculating the _ $\frac{\text{Velocity}}{4 \times F}$

length of CAM

Velocity of air : 34000 cm/sec^2

F = resonant of EAM = 2000 Hz

$= \frac{34000}{4 \times 2000}$

$= \frac{34}{}$

Length of canal = 4.25 cm

3. Force = P_1 A_1 = P_2 A_2

A_1 = Area of the TM = 60 mm^2

A_2 = Area of the stapes foot plate = 2.0 mm

P_1 = Pressure on the TM

P_2 = Pressure on the stapes footplate

$P_2 / P_1 = A_1/A_2 = 60/2 = 30$

Sd increase at the stapes is 30 times greater

4. Lever action of the first order formula = L_1 F_2

L_2 F_1

L_1 = Malleus length F_1 & F_2 = are the force at L_1 & L_2

L_2 = Incus length

Length of Malleus is 2.5 times greater than that of In

$$\frac{F_2}{F_1} = 2.5 \text{ times}$$

$F_2 = F_1$ (2.5)

= Hence, the lever action multiples the force by 2.5 time

= The velocity is decreased by 2.5 times

Impedance ratio is = 2.5 x 2.5 = 7.25 times increased by

F. 1. 80 mv
2. - 70 mv
3. OMV

G.

Accross:		Down:	
1.	0.05	1.	.02
4.	12,000	2.	500
5.	400	3.	1400
6.	280	4.	1000
7.	100	7.	1000
8.	30,000	8.	3500 .
10.	55	0.	10
11.	3000	11.	35
13.	5000	12.	8

Energy supplied by the blood vessels
brings about protective action of the ear muscles.

CHAPTER IV

MUSCLES AND VESSELS

A. Muscles.
Fill in the balnks

1. The smallest Middle Ear Muscle is the_____.
2. The largest muscle in themiddle ear is the _____.
3. The tensor tympani is innervated by branch of the_____.
4. The stapedius muscle receives its innervation from the _____
5. Middle ear muscle which responds to acoustic stimuli is the_____.
6. The tensor tympani originates from the_____part of the eustachian tube
7. Stimulation of the Middle ear muscle results in _____ acoustic reflex
8. Middle ear muscle which responds to nonacoustic stimuli is the_____.
9. _____muscle helps in eustachian tube dilation.
10. There is simultaneous contraction of the_____and _____muscles of the eustachian tube during the acts of swallowing and yawning.
11. The stapedius tendown attaches to the_____of the stapes
12. The tensor tympani has both_____&_____innervation.
13. The stapedial reflex pathway involves_____,_____
14. The tendon of the tensor tympani attaches to the_____.

B. Questions and answers.

1. What is the contractions of ME muscles called?
2. What is the effect of destruction of cochlea on both sides on ME reflexes?
3. Which muscle contracts on mere expectation of sound
   (a) What is it called?
4. What is the effect of voluntary contractions of periorbital muscles on ME muscles?
5. Which muscle in the ME gets fatigued easily?
6. What is the effect of ME muscle contraction on ossicles?
7. Which muscle in the ME has long latency?

C. Say true or false. Correct the false statements.

1. The ME muscle contractions decreases with increasing intensity of stimulus.
2. Contralaterally elicited reflexes show a greater impedance change than ipsilaterally recorded reflexes.
3. Stapedius reflex threshold decreases while the threshold of hearing increases with age.
4. High and low frequencies have lower thresholds for stapedius reflex while mid frequencies have higher thresholds
5. Reflex thresholds are affected by ME pressure
6. Latency becomes longer with increasing intensity of stimulus.
7. Continued stimulation brings about an increase in contraction of the-ME muscles.
8. Staedius muscle contraction begins shortly after the onset of acoustic stimulation.
9. Stapedius muscle continues to be in the contracted position until the sound ceases.
10. Middle ear muscles attenuate short duration sounds.

D. Blood - Vessels.

(Choose the appropriate answer.

1. The lateral surface of Auricle is supplied by
   a. Pharyngeal ascending artery
   b. Posterior auricular artery
   c. Deep auricular artery
   d. Superficial temporal artery
2. _____ artery supplies the cranial surface of the auricle.
   a. Superficial temporal Artery
   b. Posterior auricular artery
   c. Deep auricular artery
   d. Pharyngeal ascending artery
3. The inner part of the meatus is supplied by
   a. Superficial temporal artery
   b. Posterior auricular artery
   c. Deep auricular artery
   d. Pharyngeal ascending artery
4. The eustachian tube receives the blood supply from
   a. ascending pharyngeal artery
   b. Middle meningeal artery
   c. Artery of pterygoid canal
   d. All of the above
5. The inner layer of the TM is supplied by
   a. Posterior auricular artery
   b. Internal maxillary artery
   c. Middle meningeal artery
   d. From a & b
6. Plexus around the incudo stapedial artery is from
   a. Posterior auricular artery
   b. Deep auricular artery
   c. Middle meningeal artery
   d. Superficial temporal aretery

7. The head of Malleus and Incus is supplied by
   a. Vertebral artery
   b. Spiral artery
   c. Basal artery
   d. Branch of Middle meningeal artery
8. The handle of Malleus and the plexus round the anterior crus of the stapes is from
   a. Branch of inferior cerebellar artery
   b. Tympanic branch of maxillary artery
   c. Pharyngeal ascending artery
   d. Branch of basal artery
9. Stapedius muscle is supplied by
   a. Vertebral artery
   b. Spiral modiolar artery
   c. Stapedial artery
   d. Basal artery
10. The labyrinthine artery enters the Inner ear through the
   a. Semi circular canals
   b. Internal Auditory meatus
   c. Utricle and Seccule
   d. Modiolus
11. The artery supplying the cochlea is
   a. Spiral modiolar artery
   b. External carotid artery
   c. Internal carotid artery
   d. Cerebral artery
12. The vestibulo cochlear artery supplies
   a. Saccule and basal coil of cochlea
   b. Utricle and apical coil of cochlea
   c. Semi-circular canals and cochlea
   d. All of the above

ANSWERS

A. 1. Stapedius
2. Tensor Tympani
3. V nerve
4. VII nerve
5. Stapedius
6. Cartilaginous
7. Bilateral
8. Tensor Tympani
9. Tensor veli palatini
10. Tensor veli palatini & levator veli palatini
11. Neck
12. Sensory and motor
13. Acoustic nerve, AVCN, MSO & VII nerve
14. Handle of Malleus

B. 1. Acoustic reflex
2. The reflex contractions of both muscles are abolished on destruction of the two cochleas
3. Stapedius muscle
a. It is called 'anticipatory acoustic reflex'.
4. The voluntary contractions of periorbital muscles brings about simultaneous contractions of both muscles on both sides.
5. Tensor tympani
6. ME muscle reflexes bring about stiffness of ossicular chain. They also change the degree of coupling between ossicles.
7. Tensor tympani

C. 1. False : The ME muscle contractions increases with increasing intensity of stimulus.
2. False : Homolaterally elicited reflexes show a greater impedance change than contralaterally recorded reflexes.
3. True
4. False: High and low frequencies have high thresholds for stapedius reflexs while mid frequencies have lower thresholds.
5. True
6. False: The latency becomes shorter with increasing intensity of stimulus
7. False: continued stimulation bring about a decrease in contraction and a return to resting stage.
8. True
9. False: Stapedius muscle continues to be in the contracted position until the sound is transmitted.
10. False: short duration sounds are not attenuated by the middle ear muscles.

D. 1. d
2. b
3. c
4. d
5. d
6. c
7. d
8. b
9. c
10. b
11. a
12. a

Travelling up and down
conveying the message to be known

CHAPTER V

MEMBRANES AND FLUIDS

A. Membranes.

Fill in the blanks.

1. The tympanic membrane is held tightly and under tnesion by _____
2. Round window is covered by _____
3. Reissner's membrane forms the roof of_____and floor of
4._____keeps the hairs in alignment
5. Basilar membrane (BM) extends from the_____to the
6. BM forms the roof of the_____and floor of the _____
7. The broader part of the BM is close to the_____and narrow end near the _____
8. The wider part of the BM is the_____end and the narrower part is the_____end.
9. The broader part of the BM is_____stiff, whereas the narrower end is_____stiff.
10. BM separates the_____from the_____of scalatympani
11. Basilar Membrane is the seat of _____
12. Superior to the Reticular Membrane is the _____
13. Outer Hair Cells are embedded within the _____
14. Ressner's membrane has the capacity of _____
15. The tectorial membrane is_____at one end on the modiolar side and_____at the other end.

B. Travelling wave

$R_EA_RR_AN_GE$ the following:

1. Between response the the a 2 wave pressure is differential scalaeto traveling
2. Impedance Impedance to the the excoursion is from higher traveling of lower wave of the area.
3. Grows progresses apex toward the amplitude the wave as it traveling of
4. the the the depends on strength amplitude of of stimulus waveform sound displacement
5. the stimulation of on displacement frequency depends maximum waveform of the
6. the sharply maximum amplitude declines beyong displacement
7. distance of wave changes with the phase.

C. Circulation and composition of fluids

1. From where does the endolymph and perilymph fluids originate
2. Explain the circulation of endolymph and perilymph fluids within the Inner ear
3. What is the composition of the endolymph and perilymph fluids?
4. (a) Which fluid in the inner ear is present in a closed system with no ducts?
   (b) How does the fluid changes occur within this system?

D. Enzymes and Ion transportations of fluids.
Fill in the blanks.

1. The ion transporting enzyme system is_____dependent.
2. Energy production in the stria vascularis has been found to be_____in nature.
3. Enzyme commonly associated with Na^+ & K^+ transport is _____.
4. Iron transportation can be inhibited by using & _____.
5._____is an energy producing enzyme.

E. Functions of fluids:

1. What functions are performed by the following?
   a. Na^+ & K^+ electrolytes in the fluids
   b. Endolymph
   c. Perilymph

F. Pathological conditions and changes in the fluids.

What conditions produce the following changes in the fluids:-

1. Decrease in volume of endolymph in cochlea and saccule
2. Volume and endolymph increases
3. Total protein context in perilymph increases temporarily and then returns to normal levels with the Na^+, K^+ and glucose remaining unchanged
4. Normal perilymph values for potassium and sodium with markedly increased protein content
5. Distention of the membranous labyrinth, more in the pars inferior than pars syperior is seen

ANSWERS

A. 1. Manubrium
2. Secondary Tympanic Membrane
3. Scala Media, Scala Vestibuli
4. Reticular Membrane
5. Spiral lamina, Spiral ligament
6. Scala Tympani, Scala Media
7. Helicotrema, stapes
8. Apical, Basal
9. Less, more
10. Supporting cells, Perilymph
11. Organ of Corti
12. Tectorial Membrane
13. Tectorial Membrane
14. Self repair
15. Attahced, free

B. 1. Traveling wave is a response to the differential pressure between the 2 scalae
2. Excursion of the traveling wave is from the area of higher impedance to lower impedance
3. Amplitude of the traveling wave grows as it progresses towards the apex
4. Amplitude of the displacement wave form depends on the strength of the sound stimulus
5. Maximum displacement of the waveform depends on the frequency of stimulation
6. Amplitude declines sharply beyond the maximum displacement
7. Phase of the wave changes with distance

Pickles (1982)

C. 1. Endolymph is secreted in the cochlea by cells of stria vascularis (Shuknecht, 1970)
Perilymph is formed as an ultra filtrate of plasma (Schneider, 1974)

2. According to guild (1927) endolymph, secreted by the stria vascularis, passes along the length of the cochlea first to the saccule and then to the endolymphatic sac where it is reabsorbed. (Bosher, 1976)

According to the radial flow theory proposed by Naftalin and Harrison (1958), Perilymph, formed as an ultrafiltrate of plasma, flows freely across the vestibular membrane, to be reabsorbed by the stria vascularis, where the exchange of sodium and potassium takes place (Bosher, 1976)

3. Endolymph has a high K^+ and low Na^+ electrolyte composition. Perilymph has a high Na and low K^+ electrolyte composition (Bosher, 1976)

4. (a) Endolymph is present with in the cochlea and Labyrinth as a continuous closed system with no ducts.

(b) Fluid changes within the endolymphatic system occur as a result of asmotic transfer across the permeable membran between the endolymph and perilymph (Deweese & Saunders, 198

D. 1. Oxygen
2. Respiratory
3. Na^+ K^+ activated ATP
4. Ouabain & Cardiac glycosides
5. Pestose -P

E. a. (1) They regulate the osmatic pressure between tissues and the various fluids.

(2) They form the basis for neural excitation.

(3) The differential permeability of cell membrane and other membrane structure for Na^+ and K^+ ions leads to the production of a potential difference between the two sides of the membrane, which is necessary: for the maintenance of essential biologic functions.

(Bern, 1973)

b+ Endolymph is concerned with the mechano electric transduction processes of the Hair cells. The endolymph composition is necessary for the integrity of the hair cells.

(Bosher, 1976)

c+ Perilymph meets the entire metabolic needs of the spiral organ of corti.

(Bosher, 1976)

F. 1. Severe agenesis or degeneration of the stria vascularis

2. Inflammatory reactions

3. Blocked cochlear aqueduct

4. Acoustic neurinomas

5. Menier's - disease and cogenital syphilis

(Shuknecht, 1970)

"Difficulties of communication decrease with Increase in number of units."

CHAPTER VI

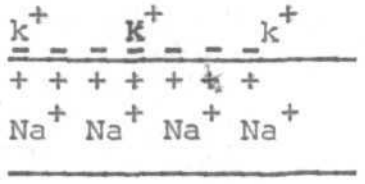
NERVES AND CELLS

A. Structure of a neuron

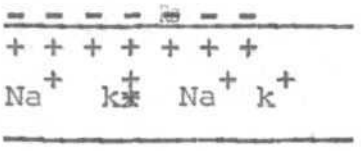
Fill in the blanks

1. The units of the nervous - system are _____
2. Nerve cells found in groups are called _____
3. The cell bodies consist of_____&_____.
4. Cell bodies are found in the__.
5. An axon is found in the__.
6. An axon is covered by_____and interrupted by _____
7. The covering of the axon helps
   (a) _____
   (b)_____
   (c)_____
8. Axons terminate in small dilatation known as _____
9. The phenomenon exhibited by an axon is _____
10. The chemical transmitted of the neuron are_____& _____

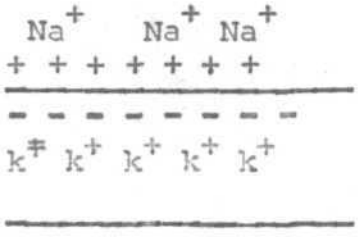
B. The following figures show electro chemical changes occurring within neuron. Arrange them according to their stages and name those stages.



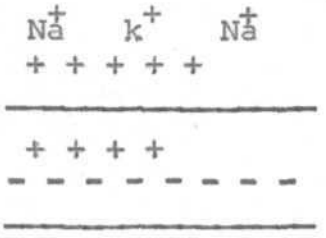
(a)



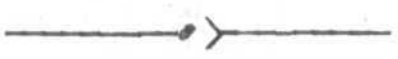
(b)



(c)



(d)



(e)

C. What do these terms mean:

1. Absolute Refractory period
2. Relative Refractory period
3. Threshold of axon
4. Excitatory potential
5. Inhibitory potential
6. Firing pattern
7. Charateristic frequency of neuron

S. True or false . Correct the false statements.

1. Sodium - potassium pump is a pump that actively pumps potassium inside and sodium outside the neuron.
2. The neuron's nucleus which has low threshold become permeable to sodium ions.
3. Action potential traveling down the axon do not reverse and travel backwards.
4. The membrane's permeability changes at the point of occurrence of action potential.
5. The axons show grades of change to the stimulis

E . Choose the answer from the words given in the bracket.
(Trigeminal nerve, Auriculo temporal nerve, great auricular nerve, Nervous spinosus, branch of tympanic plexus, Tympanic branch of N IX, Nervous spinosus, Auricular branch of NIX, Pharyngeal branch of spheno palatini ganglion, Lesser occipital nerve, facial nerve, auricular branch of NX,chorda tympani, great auricular nerve on the lateral surface, Glossopharyngeal nerve)

l. The lower 1/3 of auricle is supplied by _____
2. The upper 2/3 of auricle on the lateral surface is supplied by _____
3. The upper 1/3 of Auricle on the medial surface is supplied by _____
4. The lower 2/3 of auricle on the medial surface is supplied by _____
5. The anterior wall of the external Auditory meatus is supplied by _____
6. The posterior wall of the external Auditory Meatus is supplied by _____
7. The nerve passing the lateral wall of the ME is the
8. Tensor Tympani is innervated by the _____
9. The body part of the Eustachian tube is supplied by
10. The upper part of the cartilaginous eustachian tube which lies within the base of skull is supplied by
11. The lower part of the cartilaginous eustachian tube is supplied by _____
12. The Middle ear cavity mucosa is innervated by _____
13. The anterior half of tympanic membrane is supplied by_____
14. The posterior half of the tympanic membrane is supplied by _____
15. The inner surface of the tynpanic membrane is supplied by_____

16. The stapedius muscle is innervated by _____

F. Correct the following statements about the Auditory nerve.

1. VIII nerve is the shortest of the eranial nerve
2. VIII nerve, in addition to carrying the auditory information, carries the visual information.
3. The nervous of the cochlear nerve are peripherally directed.
4. The auditory nerve extends from the Modiolus to the Medial geniculate body.
5. Dendrites of the ganglion cells project through the Modiolus in the centre of the cochlea
6. The axonal endings reach the hair cells via the habenula perforata
7. The nerve fibres are myclinated between the hair cells ad the habenula.
8. The nerve fibres are twisted in nature as they pass through the cochlear nuclei
9. The fibres the basal end are present on the inside with apical end fibres on the surface
10. The cochlear fibres become unmyclinated after passing through the hebenula perforata
11. The auditory nerve terminates in the Medial Genuculate body.
12. The olivocochlear bundle takes its origin in the interferior colliculi.

G. Point out the differences between the inner and outerhair cells with respect to the following:-

1. Arrangement
2. Size and shape
3. Cell contents
4. Stereocilia
5. Nerve Innervation
6. Responses
7. Functions

H. Rearrange the letters of the supporting cells of Inner Ear. Numbers within the bracket indicate the number of letters in the word

(a) SSWNUULEIRC - CELLS (5 - 6)

(b) LLAAAEENNNHIPGR - CELLS (5 - 10)

(c) RALLIP - CELLS (6)

(d) UUUSSLOCTRE- CELLS (5 - 6)

(6) EEITDRS - CELLS (7)

(g) UUIACLDS - CELLS (8)

(6) EENSSNH - CELLS (7)

I. Choose the appropriate answer.

1. The cells do not touch the Basilar Membrane
   a. Pillar and Deiter cells
   b. Inner sulcus and Inner phalangeal cells
   c. Inner and outer hair cells
   d. Inner border and Inner sulcus cells.

2. The cells do not have nucrovilli at their upper surface
   a. Deiter cells
   b. Sulcus cells
   c. Pillar cells
   d. Henser cells

3. Cells which have microvilli, increase their upper surface for
   a. Improved exchange with endolymph.
   b. An attachment to tectrorial membrane
   c. Both a & b
   d. None of the above.

4. Presence of osmiophilic particles in the Inner border cells
   a. Improve nutritional value
   b. Improve the blood supply
   c. Improve attachment with tectorial membrane
   d. b & c

5. The cells are active participants in the formation of Reticular membrane.
   a. Deiter and Henseh
   b. Hensen and Clandius
   c. Deiter and Pillar cells
   d. Deiter and Clandius

6. The cells keep the hairs in allignment

a. Claudius
b. Pillar cells
d. Hensen
d. Deiter

7. The fibrillar structures are present in

a. Pillar and Deiter cells
b. Hensen and claudius cells
c. Claudius and deiter cells
d. Deiter and Hensen cells.

8. The inner phalangeal cells forms

a. Two rows
b. Three rows
c. Four rows
d. Single row

9. The Inner Sulcus cell contains

a. Few mitochondria and well developed endoplasmic reticulum
b. Few mitochondria and little developed endoplasmic reticulum
c. Many mitochondria and poorly developed endoplasmic reticulum
d. Many mitchondria and little developed endoplasmic reticulum

10. Special group of cells present in basal coil of cochlea.

a. Claudius
b. Hensen
c. Bocttcher
d. Border cells of Held

11. Cells which act as reservior in the Middle Ear Cavity

a. Boeltcher's cells
b. Mastoid air cells
c. Globular cells
d. Bushy cells.

K. Intensity coding

Correct the false statements.

1. Firing rate of the fibres decreases with increase in intensity
2. The adjacent fibres begin to fire at a higher rate with increase in intensity
3. The fibres respond corresponding to the frequency of a given stimulus.

ANSWERS

A. 1. Neurons
2. Ganglion
3. Nucleus & Cytoplasm
4. Grey matter
5. White matter
6. Myelin Sheath, nodes of Ranvier
7. a) To act as insulator
b) To protect from pressure or injury
c) To speed up the flor of nerve impulses through the axon
8. Synaptic knob
9. All or none
10. Acetyle choline and nor epinephrine

B. (c) Resting membrane potential
(e) Synapses
(b) Depolarization
(a) Action potential reaches peak
(d) Hyperpolarization

C. (a) The period during which the nerve impulses are not conducted through the axon is called the absolute refractory period

Plotnik & Mollenauer (1978)

(b) The period which requires larger electrical charges to reach the threshold of axon for conduction of nerve impulses is termed the relative refractory period

Plotnik & Mollenauer (1978)

(c) The threshold of axon is the axon's respose to a change in the membrane's permeability to sodium ions when the electro chemical charge generated by a cell body reaches a certain level

Plotnik & Mollenauer (1978)

(d) The increased neural activity in the pastsynaptic cell is referred to as the excitatory potential. Abbreviated as EPSP

(e) The decreased neural activity in the past synaptic cell is known as the inhibitory potential. Abbreviated as IPSI

(f) Firing pattern is the manner in which a fiber discharges in response to a stimulus or spontaneously in the absence of stimulation

(Gelfand, 1981)

(g) The frequency with the lowest threshold or the greatest firing rate is the best or characteristic frequency of the neuron

(Gelfand, 1981)

D. 1. False: Sodium - potawwium pump is a function of neuron where the membrane actively pumps potassium inside and sodium ions outside the membrane

2. False: The axon hillock which has low threshold become permeable to sodium ions
3. True
4. True
5. False: The dendrites and cell bodies of neuron show grades of change to the stimuli

E. 1. Great auricular nerve
2. Auriculo temporal nerve
3. Nerser occipital nerve
4. Great auricular nerve
5. Auriculo temporal nerve
6. Auricular branch of NX
7. Chorda tympani
8. Trigeminal nerve
9. Branch of tympanic plexus
10. Nervous spinosus
11. Pharyngeal branch of spheno palatlni ganglion
12. Glossopharyngeal nerve
13. Auriculo temporal nerve
14. Auricular branch of N IX
15. Tympanic branch of N IX
16. Facial nerve

F. 1. VIII nerve is the second shortest of the nerve next to the alfactory nerve.
2. VIII nerve in addition to carrying the auditory information, carries the vestibular information
3. The neurons of the cochlear nerve are centrally directed
4. The auditory nerve extends from the modiolus to the brain stem
5. Axons of the ganglion cells project through the Modiolus in the centre of the cochlea
6. The dendritic endings reach the hair cells via the habenula perforata
7. The nerve fibres are unmyelinated between the hair cells and the habenala
8. The nerve fibres are twisted in nature as they pass through the internal auditory meatus
9. The fibres of the apical end are present on the inside with apical end fibres on the surface
10. The cochlear fibres acquires its myelin sheath after passing through the habenual perforata
11. The auditory nerve terminates in the cochlear nucleus
12. The olivocochlear bundle originates in the superior olivary complex.

G-1 Arrangement

OHC	IHC
1. Arranged in 3 - 5 rows	1. Arraned in a single row
2. They are about 20,000 cells in number	2. About 3000 - 4OOO cells in number
3. Cell is obliquely placed	3. Not obliquely placed
4. Cells are arranged such that there is intercellular space	4. No intercellular space
5. Towards spiral ligament	5. Towards Modiolus
6. Supported by outer phalangeal cells	6. Supported by inner phalange cells
7. Bordered by Hensen and Claudius cells	7. Bordered by cells of Held

2. Size and Shape

1. Less bulky	1. Bulkier
2. Cylindrical	2. Flask shaped
3. 25µ meters in length	3. 35µ meters in length
4. cell surface/cuticle is flat	4. Cell surface/cuticle is oval/round

3.Cell contents

1. Nucleus in oval/round	1. Round
2. Nucleus is situated at the end of the cell	2. Situated centrally
3. Nucleus is smaller in size	3. Bigger than that of OHC
4. Lamellated body in the supra nuclear region seen	4. Not seen
5.Infranuclear portion contains large no. nutochondria and endoplasmic reticulum	5. Supranuclear portion contains large no. of nutochondria and endoplasmic reticulum
6. Has 2 to 3 layers of discontinuous membrane	6. Has only one layer of discontinuous membrane
7. Plasma membrane is smooth	7. Not so smooth as OHC
8. The central portion is free of dytoplasm but contains gycogen	S. Rich in cytoplasm

9. In all CHC's cisternae's are present which participate in the productions of CM and give protection	9. Not in all.

4. Stereocilia

1. 100 - 200 stereocilia on the cuticular plate	1. 60 stereocilia
2. V & W stereocilia	2. Stereocilia arranged parallel to each other
3. Cilia is short and thick	3. Cilia is long and thick
4. Hairs of the cells are embedded on the yndersurface of the fectorial membrane	4. Hairs of the cells are not embedded
5. Rootlets are tube like	5. Rootlets are thinner and pointed
6. Long entensions of the rootlets from the cuticular plate into the cytoplasm of the cell is seen	6. Not seen

5. Nerve innervation

CMC	IHC
1. Afferent fibres innervate in the longitudinal direction	1* Afferent fibres innervate radially
2. A single fiber innervates many hair cells (11 many)	2. Many fibers to single one hair cell (many 11)
3. Efferent fibres innervate the hair cells radially	3. Efferent fiber innervation is in the longitudinal direction
4. No axo-axonic connections of nerves	4. Axo-Axonic connections
5. The dendrites of outer spiral fibres are in the range of 0.5µ	5. The dendrites of afferent fibre to IHC are largest with an average diameter of 1µ
6. The region of neural contact is limited to the lower end (afferent)	6. The afferent fibres contact the lower end of the cell or at the sides and occasionally high up along the plasma membrane

RESPONSES

1. O.HC respond to displacement magnitude	1. 1HC respond to the velocity of BM displacement
2. OHC respond to radial sheering force	2. 1HC respond to longitudinal shearing force.

7. Function

1. Associated with spatial summation	1. Associated with f e discriminations of frequency

(Spoendlin, 1973)

H. a) Inner - Sulcus - cells
b) Inner - phalangeal - cells
c) Pillar - cells
d) Outer Sulcus cells
e) Deiter's cells
f) Claudius cells
h) Hensen's cells.

I.

1. c	7. a
2. c	8. d
3. c	9. b
4. a	10. c
5. c	11. b
6. b	

K. 1. Firing rate of the fibres increases with increase in intensity
2. The adjacent fibres begin to fire, but at a lesser rate, with increase in intensity
3. Both low and high frequency fibres respond, but at a lesser rate, with increase in intensity.

Subtler than the Subtlest,
Vaster than the Vastest,
Seated atop in all beings.

CHAPTER VII
AUDITORY PATHWAYS

A. Make the boundary and list out the names belonging to the central Auditory Pathway.

VENTRALNUCLEUSCALAMEDIANNULARLIGAME
NTRAPEZOIDNUCLEISTHMUSUPERIOROLIVARY
NUCLEUSPIRALLAMINAUDITRRYRADIATIONSCALA
VESTIBULINFERIORCOLLICULUSACCULEPITYMPANUM
EDIALGENICUIATENUCLEUSUPEIRORLIGAMENTRACT
OFHELDORSALNUCLEUSPIRALLIGAMENTHALAMUSP
IRALGANGLIONEURALCHANNELATERALLEMINISCUS
TERNALAUDITORYMEATUSTIRRUPERILSXMPHYPOTYM
PAN0MESENCEPHAL0NEURALFIBRESTAPESF00TPL
ATENDOLYMPHATICSACOCHLEARNERVEXTERNAL
SPIRALFIBRESCALATYMPANUMEDULLRFFERENT
TRACTOFMONAKOW-SHAPEDCELLARRANGEMENT
EMPORALCOBE

B Name the structure corresponding to the alphabets for the given clue.

Example

(A) Fibres carrying information from the PNS to the CMS

Ans: Afferent

(A) Nucleus which possesses properties similar to those of the auditory nerve.

(B) Fibres which convey information from the inferior colliculus to Medical geniculate Body.

(C) Fibres which help Inferior colliculus and Lateral Leminiscus to communicate with the corresponding Inferior colliculus and Lateral Leminiscus on the opposite side.

(D) Nucleus at the low level proceeds to analyze complex functions.

(E) Descending fibres.

(F) Cells present in the DCN.

(H) Termination of fibres in the gyrus at the cortex level.

(I) Level at which the 2nd crossing over of fibres occur.

(L) Level above the superior olivary complex.

(M) Nucleus of the ascending pathway just below the cortical level.

(0) Cells which occupy posterior ventral cochlear Nucleus.

(P) Nuclei which consists of cell bodies of the descending tract.

(R) The body around which the dorsal & Intermediate striae pass dorsally.

(S) Lowest level at which the binaural integration of the stimuli take place

(T) Lobe responsible for analyzing auditory information.

(U) Descending fibres which join the cochlea from the SOC of the same side.

(V) Portion of the cochlear nuclei which divides into 2 divisions.

(W) Area responsible for reception of the auditory signal.

C Pathways & Projections:

Fill in the blanks:

(1) Cochlear nuclei projections are largely

(2) The projections of the SOC & LL are largely_____.

(3) The pathway by which neurons go from the SOC to the ic is_____.

(4) The pathway by which neurons cross from one side to the other at the level of the SOC is called_____ .

(5) Fibres from the ventral division of the MGB project to the_____

(6) The auditory projections from the LL to the _____ is for the integration of information from other sensory modalities.

(7) The direct projection of DCN fibres to the _____ provides the upper brain stem with time of arrival of information.

(8) The SOC receives bilateral information about _____ _____&_____of dichotic stimuli.

(9) Bilateral Interaction at the hemispheric level is via_____.

(10) Cell bodies of the efferent fibres projecting to the IHC's and OHC's are from_____&_____.

D Tonotopic organization.

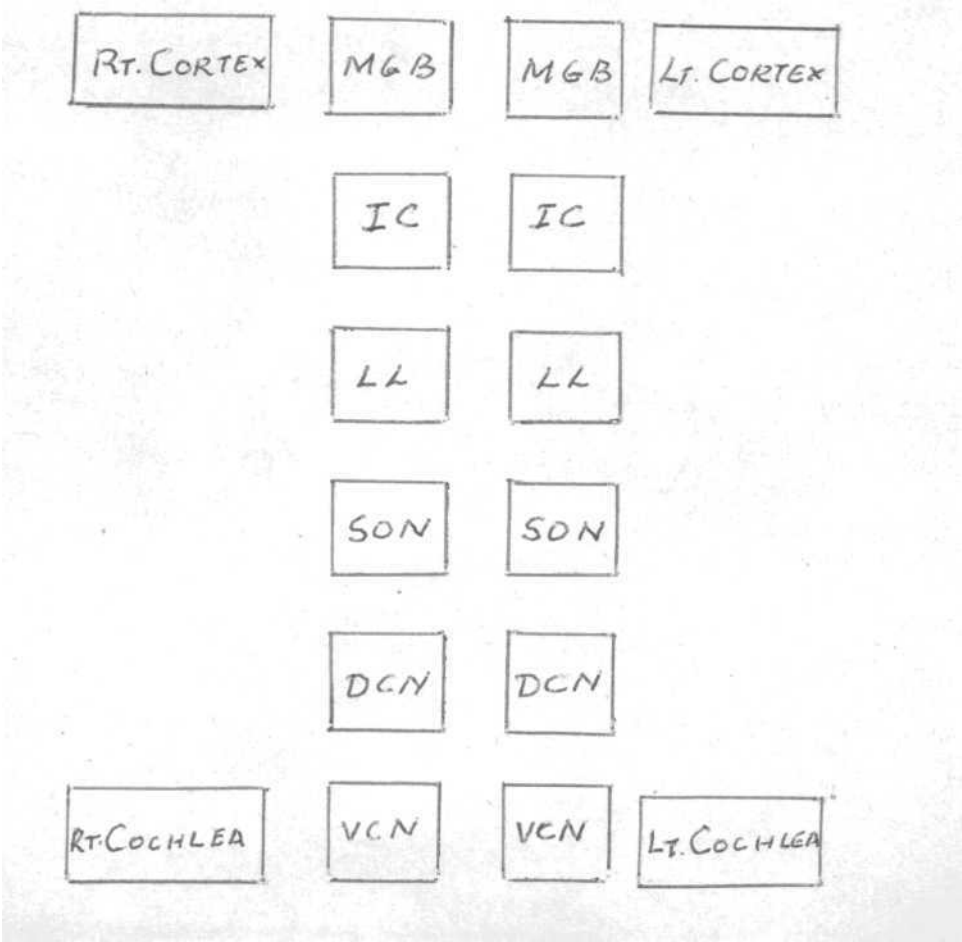
High/low

Mention whether the following are sensitive to high/low frequencies.

(1) Rostral & ventral portions of the cochlear nucleus.
(2) Caudal & dorsal portions of the cochlear nucleus.
(3) MSO Neurons.
(4) LSO Neurons.
(5) Rostral portion of the Lateral-Leminiscus.
(6) Caudal portion of the Lateral-Leminiscus.
(7) Dorsal sheets of the central-nucleus (IC)
(8) Ventral sheets of the central-nucleus (IC)
(9) Medial part of the ventral division (MGB)
(10) Lateral part of the ventral-division (MGB)

E (Shading of the Synaptic areas)

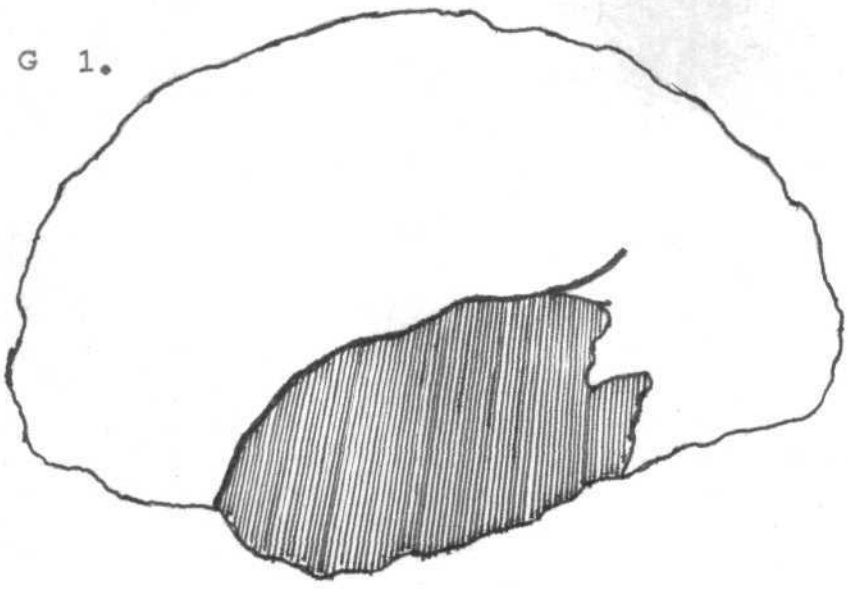
Shade the blocks where synapses occur and indicate the number of synapses that occur at each level.



F Fill in the tabular column.

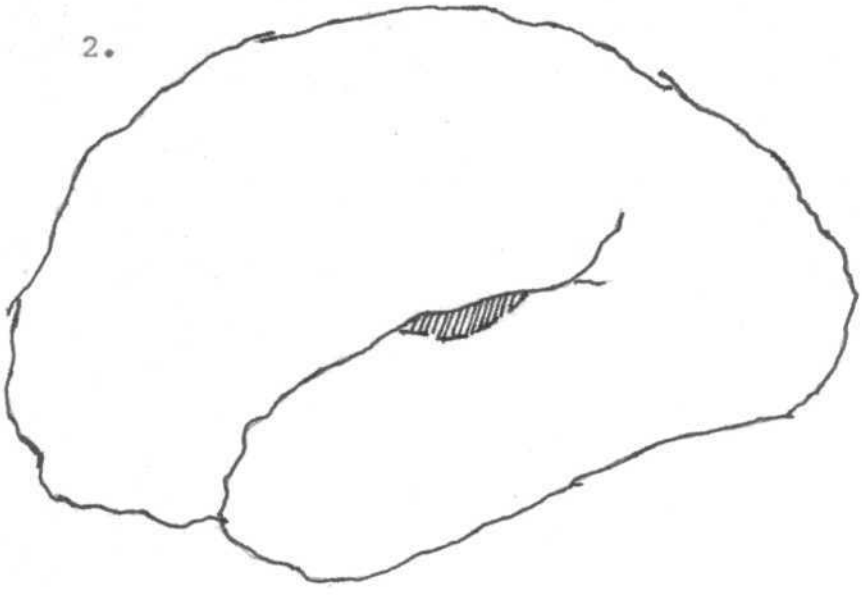
	Cell Bodies	Place of ascent
First Order Neurous		
Second Order Neurous		
Third Order Neurous		
Fourth Order Neurous		

G 1.

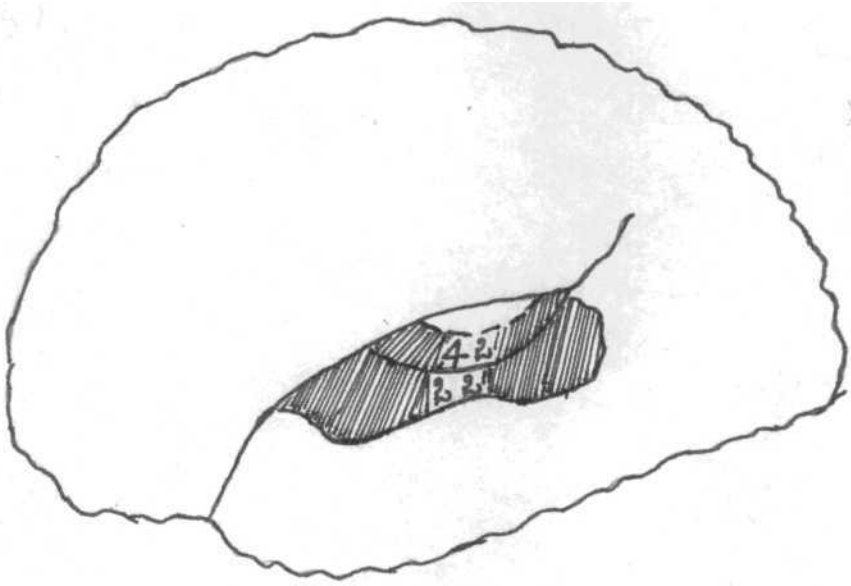


a) Name the shaded area?
b) Name the horizontal cleavage present above the shaded area?
c) Which functions are brought under the command of the shaded area?

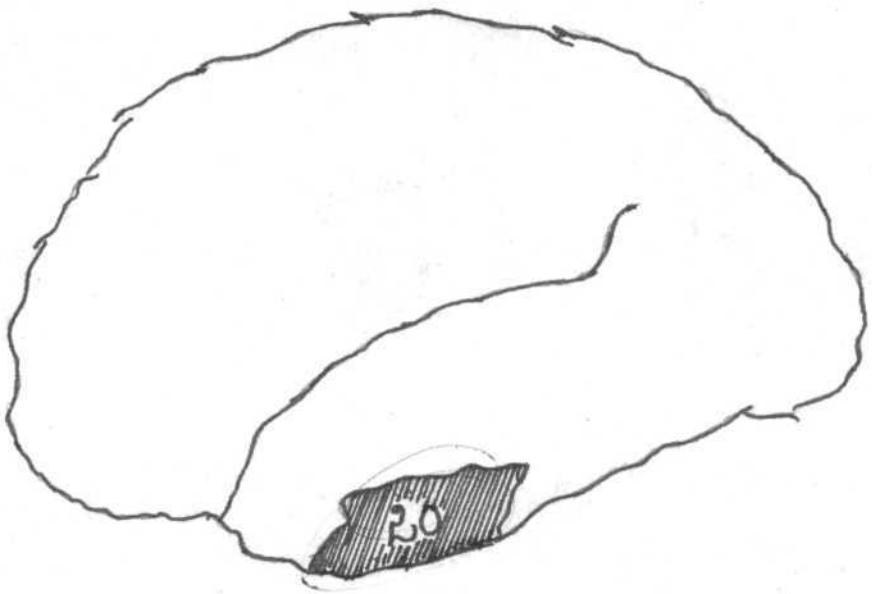
2.



The shaded area is area 41. Name it?

3. 

The shaded areas 42 and 22 together are called _____

4. 

Lesion in area 20 produces _____

ANSWERS

A.

VENTRALNUCLEU/SCALAMEDI/RNNOLARLIGAM-
.EN/TRAPEZOIDNUCLE/ISTHMU/SUPERIOROLIVACY
NUCLEU/SPIRALLAMIN/AUDITORRADIATION/SCALAVESTBUL/1
NFERIORCOLLICULU/SACCUL/EPITYMPANU/MEDIALSENI
CULATENUCLEU/SUPERIORLIGAMEN/TRACTOFHEL/DORSAL
NUCLEU/SPIRALLIGAMAN/THAIAM/SPIRALGANGLIO/NEU
RALCHANNE/LATERALLEMINISL/INTERNALAUDITORY
MEATO/STIRRU/PERILYMP/HYPOTYMPANU/MESBNCEPHA
LO/NEURALFIBRE/STAPESFOOTPLAT/ENDOLYMPHATICSA/C
OCHLEARNERV/EXTERNALSPIRALFIBRE/SCALATYM
PANU/MEDULL/AFFEREN/TRACTOFMONAKO/W-SHAPED
CEL1ARRANGEMEN/TEMPORAL-LOBE

VENTRAL-NUCLEUS

TRAPEZOID-NUCLEI

SUPERIOR.OLIVARY NUCLEUS

AUDITORY-RADIATIONS

INFERIOR-COLLICULUS

MEDIAL-GENICULATE NUCLEUS

TRACT OF HELD

DORSAL-NUCLEUS

LATERAL-LAMINISCI

TRACT OF MONKAOW
TEMPORAL-LOBE

B

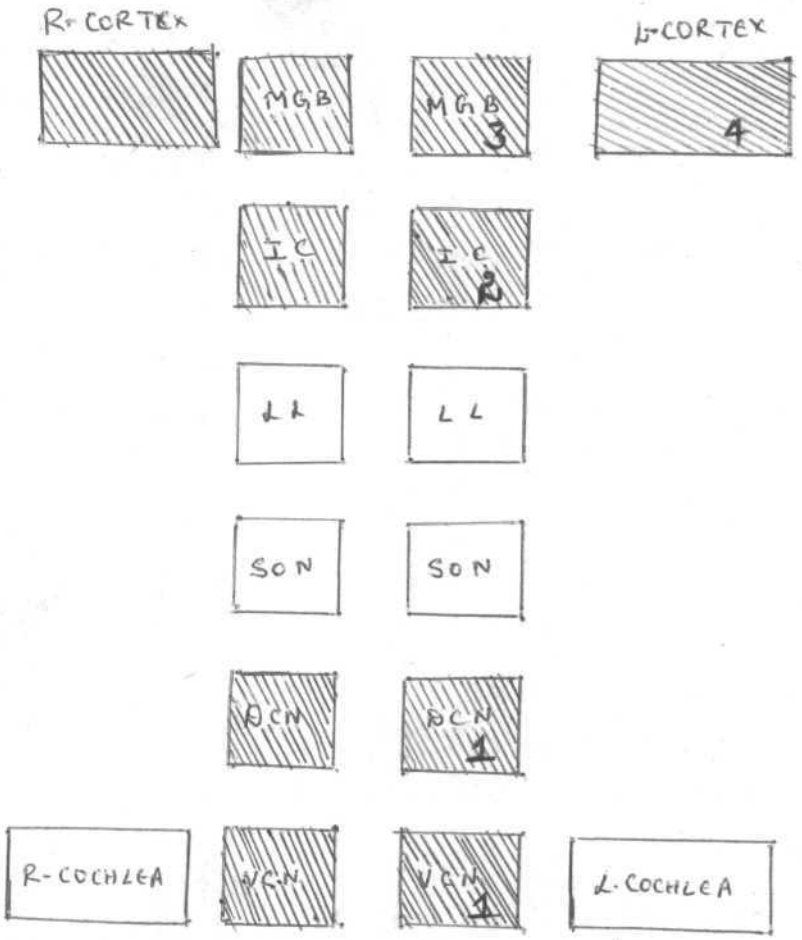
(A) Anteroventral cochlear nucleus.
(B) Brachium fibres.
(C) Commissural fibres.
(D) Dorsal cochlear Nucleus.
(E) Efferent.
(F) Fusiform cell.
(H) Heschl.
(I) Inferior colliculus.
(L) Lateral Leminiscus.
(M) Medial Geniculate Body.
(0) Octopus Cell.
(3) Periolivary nuclei.
(K) Restiform Body.
(S) Superior olivary complex.
(T) Temporal
(U) Uncrossed olivo cochlear bundle
(V) Ventral
(W) Wernicke.

C

(1) Contralateral
(2) Ipsilateral
(3) Lateral-Leminiscus.
(4) Trapezoid body
(5) Primary Auditory Cortex.
(6) Secondary Auditory Cortex.
(7) Contralateral IC.
(8) Time of arrival, phase & Intensity.
(9) Carpus callosum.
(10) LSO and MSO.

D

(1) Low
(2) High
(3) Low
(4) High
(5) Low
(6) High
(7) Low
(8) High
(9) High
(10) Low



Note: Only those areas where obligatory synapses occur have been shaded.

F

	Cell bodies	Place of Ascent
First Order Neurous	Spiral ganglion	Dorsal & ventral Cochlear Nuclei
Second Order Neurous	DCN & VCN	Lateral Leminiscus & Inferior Colliculus.
Third Order Neurous	Inferior colliculus	Medial geniculate body
Fourth Order Neurous	MGB	Auditory cortex area 41.

(Noback & Demarest, 1981)

G

(1) (a) Temporal lobe.
(b) Sylvian fissure
(c) Analyzes the Auditory Information.

(2) Primary auditory cortex.

(3) Auditory Association areas.

(4) AGNOSIA.

"Between the Creation
And the Convention
There lies the knowledge
that tries to b r i d g e the gap"

CHAPTER - VIII
HEARING THEORIES

A. Names and Theories

I. Group the following names associated with place theories and frequency theories.

Wever & Bray, Perrault, Bauhin, Duverney, Rutherford, Ranke, Hurst, Ewald, Shambangh, Watt, Reboul, Ayers, Hasse, Hardesty, ter Kuile, Bonnier, Bekesy, Meyer, Cotugno, Wrightson, Willis, Helmholtz, Ewald.

II. Associate the names with the theories proposed by them:

(1) Resonance Theory	(a) Meyer
(2) Standing Wave Theory	(b) Rutherford
(3) Displacement Theory	(c) Wever & Bray
(4) Non-analytic Theory	(d) Bauhin
(5) Volley Theory	(e) Bekesy
(6) Traveling Wave Theory	(f) Ewald
	(g) Wrightson

B Theories and Assumptions.

What assumptions are made by the following theories?

(1) Helmhaltz frequency theory
(2) Traveling Wave theory
(3) Frequency theory.
(4) Volley theory.

C Theories of Middle Ear Muscles.

Match the following:

(1) Protective theory	(a) describes the function of the Tympanic musculature as supplementing the suspensory ligaments in maintaining the appropriate position of the ossides.
(2) Frequency Theory	(b) asserts that the Tympanic musculature can, by various degrees of contraction, produce a change in pressure in the Inner ear.
(3) Fixation Theory	(c) supposes that the muscles contract in response to certain critical levels of sound intensity.
(4) Labyrinthine pressure	(d) supposes that the muscle contraction acts as a damping mechanism which selectively absorbs sound energy, thereby increasing the sensitivity of hearing.

D Bone Conduction Theories.

Fill in the blanks.

(1) Bone conduction signal is a measure of the_____ of the SN system.

(2) Bone conduction sensitivity is not_____of the state of the middle ear.

(3) The_____in the post operative BC levels correspond to mechanical changes in the ossicular system and not to cochlear modification.

(4) According to classical theories, stupedial fixation should impair _____ BC with a loss primarily in the low and not the high frequencies.

(5) There is _____ of the threshold at 2kHz due to elimination of the ossicular chain.

E Questions and answers.

(l) What are the two modes of BC?
At what frequencies do they operate?

(2) What are the three mechanisms given by Tonndorf as contributing to the total BC response?

(3) What is the explanation given by Tonndorf for 2KHz dip due to elimination of ossicular chain?

F Theories of productions of cochlear Microphonics (cm).

Which theories make the following assumptions.

(1) The voltage drop, which is a result of alteration of resistance brought about by the Mechanical shearing of the Hair Cell tops, across the hair cell is recorded as Cochlear Microphonics.

(2) Alteration of the surface charge, brought about by deformation of the wall of the hair cell, is recorded as CM.

(3) CM arises due to oscillation of potential between the tectorial membrane &. the surface of the cilia.

(4) The potentials resulting from many transitions between two stable stales of the Membrane correspond to the graded CM.

(5) Potential displacements which occurs due to the movement of negatively charged molecular chains and the potassium ions of the endolymph is recorded as CM.

ANSWERS

A I Place theory: Bauhin, Willis, Perroult Duverney, Cotugno, Ranke, Reboul, Hasse, Ter. Kuile, Hurst, Shambaugh, Ewald, Watt, Helmholtz.

Frequency Theory: Rutherford, Wever & Bray, Ayers, Bonnier, Hardesty, Meyer, Wrightson.

II 1-d, 2-f, 3-a, 4-b, 5-c, 6-e

B Helmholtz Resonance Theory

There are resonators present within the cochlea. These resonators vibrate maximally in resonance to tones of its frequencies. Depending on the place of stimulation of the Basilar Membrane, pitch perception - occurs. (Newby, 1970)

2. Traveling Wave Theory (Bekesy)

The sound travels within the cochlea from base to apex, amplitude of the wave is maximum at a particular point along the Basilar Membrane. This point corresponds to the frequency of the stimulus. Resonance occurs at this point and the pitch is perceived. (Newby, 1970).

3. Frequency Theory

This theory explains pitch perception for frequencies upto 5000 Hz. Explanation of pitch perception is based on the frequency of occurrence of impulses in the Auditory nerve. At low frequencies, auditory nerve is capable of firing as a whole. At frequencies above 1000 Hz, pitch perception occurs by the synchronized action of several nerve fibres discharging slightly at different times. (Newby, 1970)

4. Wever & Bray (1930) explain pitch perception combining frequency and place theory. According to them, frequency theory serves for low tones as the rate of nerve discharge is synchronous. The place theory on the other hand seems to hold for frequencies above 5000 Hz. At mid frequencies between 4OO-5OOO Hz, both frequency and place theory operate (Zemlin, 1968).

C 1-c, 2-d, 3-a, 4-b.

D (1) Integrity
(2) Independent
(3) Improvements
(4) Inertial
(5) Increase

E The two modes of BC are

(a) compression
(b) Inertia.

(1) The compressional BC operate at high frequencies whereas the inertial BC operate at low frequency.

(2) The three mechanisms given by Tonndorf are:
(a) The reception of sound energy radiated into the external canal.
(b) the inertial response of the ME ossides and Inner ear fluids.
(c) the compressional response of the inner ear spaces (Glaltke, 1978).

(3) Tonndorf (1966) through his experiments demonstrated that ME contribution need not be confined to low frequencies due to missing inertial component. He through his experiments found the resonant frequency of the ossicular chain to be around 2000 Hz during vibration. He reasoned out that a missing ossicular chain should result in a maximal BC loss corresponding to that frequency area. (Glaltke, 1978).

F (1) Resistance Modulation Theory

(2) Wever's Hair Cell Theory

(3) Naftalin's Biological Semi conductor Theory

(4) Tasaki's two State Theory

(5) Dohlman's Molecular Theory

"Measurement gives always a meaningful pattern"

CHAPTER IX

PROCEDURES AND POTENTIALS

A Definition and use of electrophysiologic testing

(1) What is an electrophysiologic approach?

(2) What are its uses?

B Test Environment during Electrophysiologic testing

(1) What precautions are to be taken in a sound treated room for performing Electrophysiological tests?

(2) How should a subject be positioned during the test?

(3) What ideal condition is required of the patient during the test?

C Placement of Electrodes in Electrophysiologic testing.

(1) Name the electrodes used and their site of placement?

(2) In what way does Ecochg differ from other methods with reference to the type of electrodes used.

(a) What are the two sites of placement of electrodes in Ecochg?

(b) What are their advantages and disadvantages?

(c) Is it possible to measure the Brain stem and cortical responses with the electrode placement used in Ecochg?

(3) What are the preliminary measures taken for electrode placement?

Why are these measures taken?

D Stimuli used during electrophysiologic testing

(1) What type of a stimulus is used?
Why are such stimulus used?

(2) Why are not higher repetition rates used in Electro-physiologic methods.

(3) What is used to separate action potentials from Cochlear Microphonics?

E Classification of Electrophysiolocric Responses

(1) Into how many categories is the AER classified?

(2) What are the two different responses observed in Brain Stem?

F Origin of Cochlear Potentials

(1) C M
(2) Endocochlear Potentials
(3) Intracellular Potential
(4) Summating Potential
(5) AP

G Characteristics of Cochlear Potentials:

Which of the following
(1) R P (2) S P (3) C M (4) A P

(1) are dc potentials
(2) dependent on Sound Stimulus
(3) Have no threshold
(4) are graded potentials
(5) can be divided into EP & IC
(6) reach saturation point
(7) occurs as a shift in dc baseline in response to sound stimulus.

H Give reason:

(1) What is necessary for the emergence of AP?

(2) What is responsible for the occurrence of CM?

(3) On what does the magnitude of AP depend on? Why?

(4) What is the reason for the CM curves being not exact with the BM displacement curves?

(5) With increase of intensity why does the CM magnitude shift toward the base?

I Cochlear content changes and its effect on potentials

(1) What is the effect of:

(a) Reneval of Na^+ ions from perilymph on AP.
(b) decreased K^+ ion content in Scala media on EP, CM, AP.
(c) Replacement of Na^+ ions with K^+ ions in the perilymph on AP, CM, EP.
(d) Removal of cat from the perilymph on CM, AP.
(e) Lowering temperature on CM
(f) Anoxia on EP, SP, CM, AP.

(2) What content of the fluid when changed affects.
(1) CM (2) AP.

(3) Which potential remains unaffected even after drawing all the fluid from the cochlea?

ANSWERS

A

(1) An electrophysiologic approach consists of surface electrode recordings of electrical responses of various parts of the Auditory nervous System to acoustic stimuli.

(2) (a) An objective approach to testing hearing.
(b) Contributes to Differential Diagnosis & site of lesion.

B

(1) (a) A sound treated room with electrical shielding and provision for visual and auditory monitoring is an ideal testing environment.

(b) It is better if they are tested under dim light conditions.

(2) The subject should be placed in a comfortable reclining chain or cot to reduce neck and shoulder tension which may introduce myogenic potentials.

(3) Relaxed condition is required of the patient during the test.

C (1) Electrodes used are the recording or pick up electrode, reference electrode and the ground electrode.

Recording or pick up electrode is placed on the vertex, reference electrode on the mastoid on earlobe and the ground electrode on the forehead.

(2) The type of electrode used in Ecochg is the needle electrode whereas in other methods disc type of electrodes are used.

(a) Two recording sites in Ecochg are
(1) Promontory
(2) External Auditory meatus.

(b) Advantage of the promontory

(1) Evoked response amplitudes are larger.

(2) amplitudes are adequate to provide reliable records at or within 10 dB of an Individual's voluntary threshold for the same auditory signal.

(3) Large response amplitudes help to preserve the response wave form, thereby providing additional diagnost information.

Disadvantages of Transtympanic approach

- There is greater risk to the patient.
- The costs of personnel and hospital space required for the transtympanic membrane approach are considerable.

Advantages of Intrameatal approach.

- They are less dangerous and less costly than the previous approach.
- Only sedation is required, while local or general anesthesia is not necessary.
- The likelyhood of complications due to electrode placement is very slight.

Disadvantages of Intrameatal approach.

- They yield small evoked responses which contribute to enormous threshold estimates.

(c) Brain Stem activity cannot be recorded as negative waves of more or less the same amplitude are cancelled by the differential amplifier,Cortical evoked potential cannot be recorded since they do not use a scalp electrode. (Feinmesser & Sohmer, 1976)

3 (a) The preliminary measures taken for electrode placement are:

(1) Cleaning of the skin with acetone or spirit.
(2) Use of electrode paste.
(3) attachment of the electrode using tape (Skinner, 1978)

(b)1.Cleaning of the skin is necessary for proper contact.

2.Electrode paste is used bo serve as an electrolyte to conduct the potentials b/w the scalp and the electrode.

3.attachment of the electrode by tape is used to prevent actifacts from physical displacements (Skinner, 1978)

D (1) Stimuli which have a short and abrupt onset are used to elicit auditory evoked responses. They are used for they provide the degree of synchronous neural discharges necessary to obtain the evoked response.

(2) The higher repetition rate brings about adaptation of the cochlear nerve faster and disappearance of the Action potential. Hence the number of repetition rates used are limited.

(3) Series of AP mixed with CM is separated by using an averaging computer which has a split memory.

E (1) Responses can be classified into 3 types.

(a) Based on Latency (in msec)

Early	-	0-8 msec
Middle	-	0-50 msec
Late	-	50-300 msec
vary late	-	300 msec & beyond.

(b) Based on response waveform.

Fast	:	with relatively rapid or high frequency components.
Slow	:	with low frequency components.
very slow	:	A prolonged DC shift in the base line of the recordings.

(c) Based on the probable site of origin

Auditory nerve

Brain Stem

Brain Stem/Primary cortical projection.

Primary cortical projection and secondary association areas.

Prefrontal cortex and secondary association areas.

(Skinner & Glaltke, 1977)

(2) Two different BS responses observed are

(a) FFR (Worden & Maish, 1968)

(b) Jewelt waves composed by several individual wavelets (Jewett, 1972).

F (1) Cilia of the HC's

(2) Stria Vascularis

(3) from within the cell

(4) unknown

(5) nerve fibres

G (1) RP, SP, CM

(2) SP, CM, AP.

(3) SP, CM.

(4) SP, CM.

(5) RP.

(6) SP, CM.

(7) SP.

H (1) Synchronous firing of a large number of fibres is necessary for the emergence of AP. (Dallos,1973.)

(2) Integrity of Hair Cells is necessary for the occurrence of CM.

(3) The magnitude of the AP is related to the number of fibres discharging simultaneously. This is because Auditory nerve fibres are uniform in diameter. This results in uniform conduction velocity. From any given region all firings arrive at the recording electrode at the same time and summate. (Dallos,1973)

(4) The CM curve is wider, less peaked than BM tuning curve. This is because the electrode picks up CM responses, generated by thousands of Hair cells in its general vicinity rather than by just those at its precise print of insertion. This is the reason for the two curves being different. (Gelfand, 1981)

(5) As intensity is increased, CM's from the sensitive place along the BM become saturated faster than do the responses from more basal regions. Therefore, CM magnitude shifts toward the base. (Gelfand, 1981)

(l)(a) AP - Input-output function at the low intensity segment is affected the most.

(b) EP - Declines slowly on reducing the K^+ ion content in Scala media.

CM & AP- Decrease rapidly on decreasing the K^+ ion content in Scala media.

(c) EP - Increases on replacement of Na^+ ions with K^+ ions in the perilymph.

CM & AP- Rapid depression of these potentials is seen on replacing the Na^+ ions with K^+ ions in the perilymph.

(d) CM - on removal of Ca^+ from the perilymph slow developing, nonreversible depression of CM can be observed.

AP - decreases rapidly due to the effect of Ca^+ lack in extracellular fluid

(e) CM - Magnitude of CM decreases in an orderly fashion as cochlear temperature is lowered.

(f) EP - Drops from high +ve to Zero, then changes its polarity. After reaching the maximum negativity it slowly returns to Zero. EP recovers completely once 0_2 is re-established.

SP - Declines and changes its polarity from -ve to +ve. After re-establishment of 0_2, SP shows large but variable super normality.

CM - On 0_2 deprivation, CM_1 decreases immediately upon the expiration of the animal, CM_2 decrease very slowly. CM_1 & CM_2 are called aerobic and anaerobic. CM recovery depends on the duration of occlusion.

AP - With anexia, AP disappears completely.

(2) (1) CM response is affected by changes in the K^+ ion concentration in the endolymph and unaffected by removal of Na^+ ions from the perilymph.

AP is affected by Na^+ free solutions. (Dallos, 1973)

(3) EP remains even after draining all the fluid from the cochlea. (Gelfand, 1981)

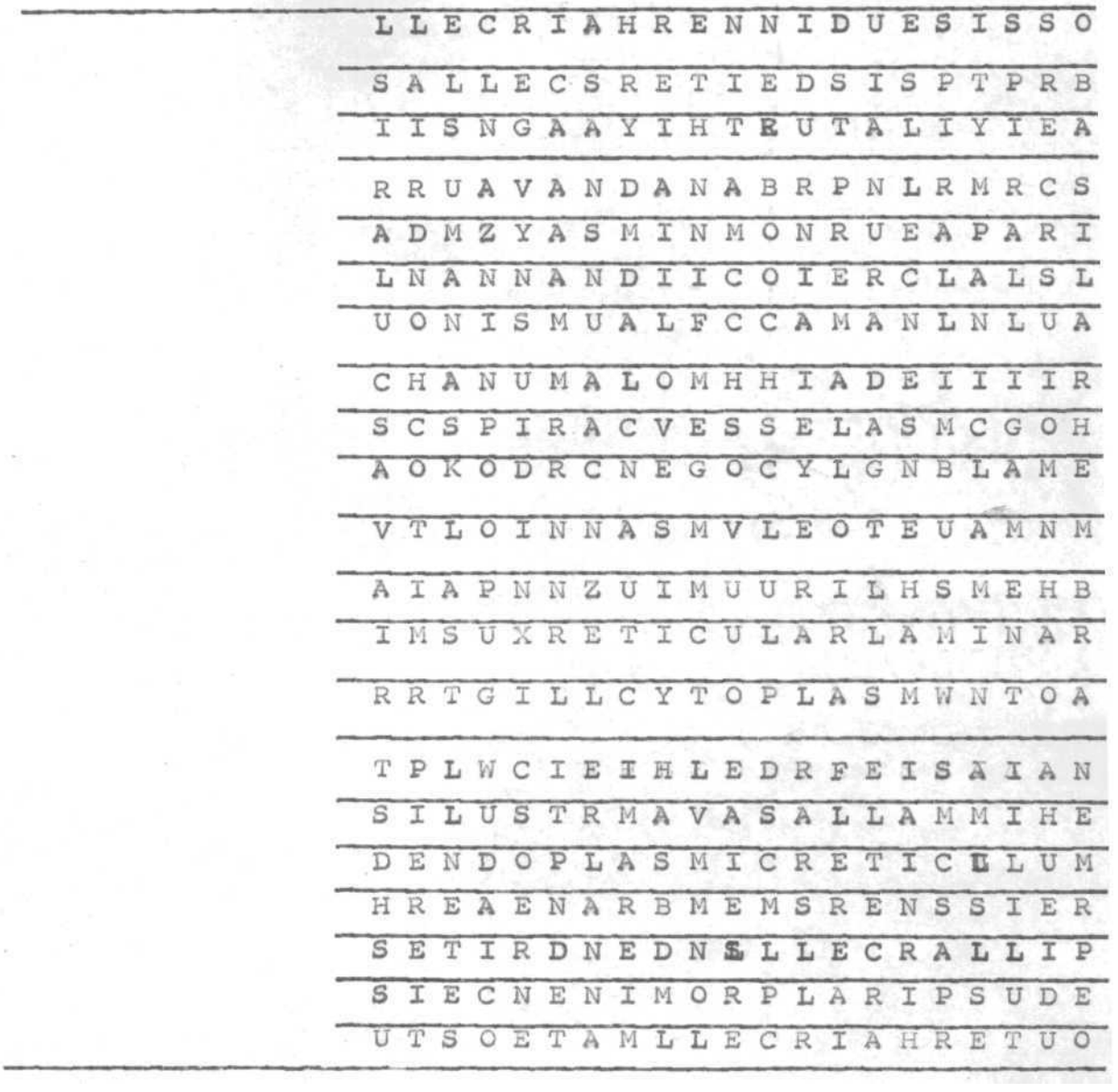
NOISE: 'Youx may ignore.
'But your ears don't

CHAPTER X

SOUND AND DAMAGE

A. Noisy - knowledge

Morevertically, horizontally, diagnelly and backwards and find the inner ear structures which undergo changes due to noise exposure.



B. Nature and onset

1. What are the 2 ways in which noise may damage the ear?

   a. In which category is the conductive loss produced?

2. What are the 4 mechanisms through which damage to the auditory system can be brought about?

C. Noise and Symptoms

3. Which symptom of NIHL is an indication of the possible hearing loss?
2. What are the speech problems associated with NIHL?
3. What symptoms related to the vestibular system are evident in NIHL?

D. Rows and Turns.

1. Which hair cells are damaged more? Earlier due to noise exposure?
2. Which row of outer hair cell is damaged first due to noise exposure?
3. Which turn of the cochlea is damaged due to

   (a) Impulse noise
   (b) Continuous noise

4. In which turn is the loss of tympanic lamina found due to noise exposure?

E. Structures and changes.

Indicate the changes occurring in the following structures due to noise exposure.

1. Tympanic Membrane
2. ME ossicles
3. Eustachian Tube
4. Hair Cells
5. Nerve fibers and endings

6+ Blood vessles

7. Inner ear fluids.

F. Give explanation for the following

1. Inverse correlation exists between rupture of tympanic membrane and hair cell loss during noise exposure
2. Middle ear structures change due to blast waves
3. Broad band noise produces uneven damage on the cochlea due to noise exposure
4. Dendrites swell due to noise exposure
5. Basal end is more damaged than the apical end during noise exposure.

G. Say True or false

Correct the false statements.

1. Noise exposure produce greater apical end damage than the basal end
2. The entire cochlea has to be examined for noise damage
3. Noise exposure produces greater inner hair cell damage than the outer hair cells
4. Afferent fibres of the inner hair cells are damaged to a lesser extent than that of the outer hair cells due to noise exposure
5. Noise exposure results in greater high frequency damage than low frequency
6. Owing to the greater volume of the scala tympanic, ionic changes occur.
7. Pure tone configurations do not give the full picture of cochlear integrity.
8. Impulse noise is less damaging than continuous noise
9. High intensities of long duration is more damaging to the structures than low intensities of short duration.

H. Histological Examination.

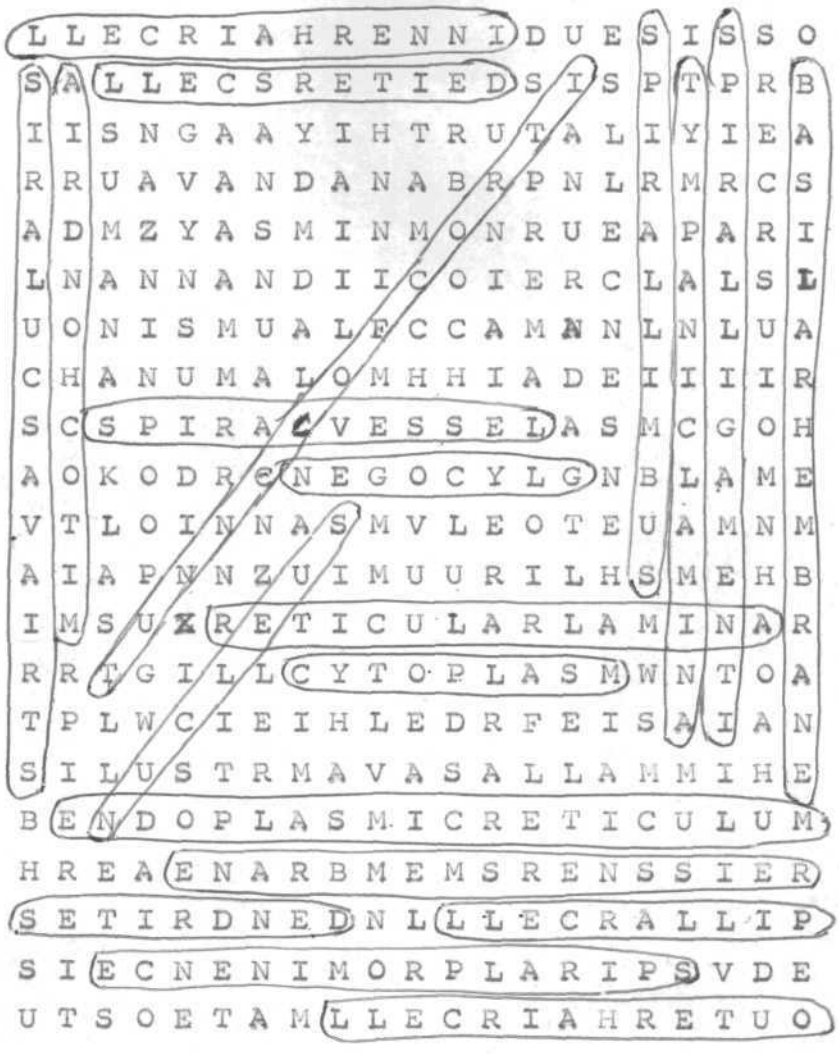
1. What is the importance of looking at Hair Cell damage in noise exposed animals?
2. What are the different technique employed in histological studies of the ear?
3. What are their relative merits and demerits?

I. Types of changes occurring in the inner ear structures due to SN Loss. - Rearrange the letters in column (B) to match with the structures given column (A).

Structures (A)	Histological change (B)
1. Sensory cells	(1) NNAEEGEODITR
2. Stria vascularis	(2) EOOINSGSCT
3. Reissner's membrane	(3) TTOEIINNDS
4. Tectorial membrane	(4) RRTTNAEOIC
5. Spiral Limbus	(5) OHAYRPT
6. Spiral ligament and scalae	(6) OOUAAIVCNTL
7. Utricle, Saccule cristae	(7) SSAEIOHDN
8. Wall of membranous labyrinth	(8) iiissooFCTNA
9. Spiral gaglion, Scarpa's gaglion and geniculate ganglion	(9) AAHHRREBMGO
10. Auditory nerve	(10) NN^iGCTKHE
11. Otic capsule	(11) OOOSSSRTLEIC

ANSWER

A.


L L E C R I A H R E N N I D U E S I S S O
S A L L E C S R E T I E D S I S P T P R B
I I S N G A A Y I H T R U T A L I Y I E A
R R U A V A N D A N A B R P N L R M R C S
A D M Z Y A S M I N M O N R U E A P A R I
L N A N N A N D I I C O I E R C L A L S L
U O N I S M U A L E C C A M A N L N L U A
C H A N U M A L O M H H I A D E I I I I R
S C S P I R A C V E S S E L A S M C G O H
A O K O D R C N E G O C Y L G N B L A M E
V T L O I N N A S M V L E O T E U A M N M
A I A P N N Z U I M U U R I L H S M E H B
I M S U X R E T I C U L A R L A M I N A R
R R T G I L L C Y T O P L A S M W N T O A
T P L W C I E I H L E D R F E I S A I A N
S I L U S T R M A V A S A L L A M M I H E
B E N D O P L A S M I C R E T I C U L U M
H R E A E N A R B M E M S R E N S S I E R
S E T I R D N E D N L L L E C R A L L I P
S I E C N E N I M O R P L A R I P S V D E
U T S O E T A M L L E C R I A H R E T U O

B. 1 (a) Acoustic Trauma
(b) Slow in process

(a) Acoustic trauma produces conductive loss

2.(a) Mechanical
(b) Metabolic
(c) Vascular
(d) Ionic changes

C. 1. Tinnitus
2. Voice problems - soft voice
3. Giddiness, headache, loss of balance, vertigo

D. 1. Outer hair cells are damaged to a greater extent than the Inner hair cells. These hair cells are the first to be affected as a result of noise exposure.
2. Damage to the outer hair cells is most common in the 3rd row and less prevalent in the 1st and 2nd rows (Lipscomb, Anelsson and Vertes, 1976)
3. (a) 1st quadrant of the basal turn (Lipscomb, AXelsson and Vertes, 1976)
(b) 2nd quadrant of the basal turn (Lipscomb, A)(elson and Vertes, 1976)
4. (e) 2nd cochlear turn (Spoendlin, 1971)

E. 1. Tympanic Membrane
(a) Rupture of the Tympanic Membrane (Engstrometal, 1970)
(b) Perforation
(c) Rupture of the radial fibers of the Middle drum layer with intact drum (Eames et al, 1975)
2. Ossicular chain discontinuity (Engstrom et al, 1970)
3. Tubal oedema (Eames et al, 1975)
4. Hair cell changes after noise exposure can be classified into 3 types
I. Outward appesance of the Hair cells
II. Sensory cell content changes
III. Changes in the stereocilia

I. Outward apperance of the Hair cells.

(a) Cell disintegration in their proper position within the organ of corti

(b) Cell or group of cells may be thrown off the Basular membrane (Engstrom etal, 1970)

(c) Distortion of the inner and the outer hair cells.

(d) Irregulataties of the outer hair cell in the apical turn

(e) Apparent reduction seen beyong 30 mm point in all of the ears regarded as normal

(f) Less damage observed in the Inner hair cells than outer hair cells (Lipscomb, Axelsson & Vertes 1976)

(g) Pronounced damage in the basal coil of the cochlea accompanied by loss of outer hair cell (Engstrom et al 1970)

II. Sensory cell content changes.

(a) Proliferation and vesiculation of the endoplasmic Reticulum

(b) Swelling of the Mitochondria

(c) Rupture of the cell membrane at the cuticular, pore and outflow of eytoplasmic material into the endolymphatic space. (Spoendlin, 1976)

(d) Apperance of lysosomes, (Engstrom et al 1970)

(e) Displacement of the nucleus towards the upper surface of cells (Lipscomb, Axelsson, & Verts, 1976)

III. Stereocilia changes.

(a) Disappearance and degeneration of the stereocilia

(b) Fusion of the stereocilia (Spoendlin, 1971)

(c) Cilia tilted to either side of the hair cells, (Lipscomb, Axelsson & Vertes, 1976)

5. Nerve fibres and endings:

(a) Swallen afferent nerve fibres and endings below inner hair cell

(b) Retrograde neural degeneration of the dendrites attached to the Inner hair cells (Spoendlin, 1970)

(c) Enlarged Mitochondria in afferent terminals on Inner hair cells. (Lim and Melnick, 1971)

(d) Commencement of degeneration of the myclinated nerve fibres soon after the rupture of the afferent dendrites without

destruction of the inner hair cells (Wright 1974)

(e) The afferent fibres and endings of the outer hair cells remain unaltered even after hair cell damage (Spoendlin, 197

6. Blood vessels:

(a) Accumulation of mass in the capillary wall of the stria vascularis (Kellarhals, 1972)

(b) Reduction of the RBC in the vicinity of the inner hair cell (Merle Lawrence)

(c) Capillary lumen constriction as a result of endothelial cells swelling.

(d) Vaso contriction and loss of capillaries in the spiral ligament.

(e) Occasional narrowings of the spiral prominence vessels (Hawkins, 1971)

7. Inner ear fluids.

(a) Increased sodium concentration and decreased potassium concentration in the endolymph

(b) Slight increase of the potassium and slight decrease of the sodium in the scala vestibuli

(c) No appreciable increase or decrease of Sodium and potassium concentration in the scala tympani (Nakashima etal 1970)

(d) Endolymph gains access to fluid spaces of organ of corti..

F. (1) Peak pressure Impulses between 155 - 166 dB SPL produces Tympanic Membrane rapture. Rupture of the tympanic membrane reduces the efficiency of transmission through the Middle Ear, thereby lessening the Inner Ear damage and the Hair cell loss. (Eames et al, 1975)

(2) Middle Ear structures possess properties of their own. A blast wave forces the structures to vibrate, beyong that permitted by its own properties and therefore causes change in these structures.

(3) The external and Middle Ear possess resonant frequencies in the range from 1000 - 4000 Hz, because of this the energy in the mid frequency range is emphasized. Therefore the spectrum of noise reaching the cochlea is not flat but is shaped. Structural properties of the cochlea and basilar membrane, apart from external and middle ear are responsible for uneven damage produced by the broad band noise (Keith, 1980)

(4) Dendrites swelling occurs as a result of disturbance of the membrane permeability which is due to lack of oxygen and metabolic disturbance (Spoendlin, 1971)

(5) Asymmetrical stiffness of the basilar membrane produces asymmetry in the traveling wave and leads to spread 6f damage more at the basal end than at the apical end (Keith, 1980)

G. (1) False: Apical end is less damaged due to noise exposure than the basal end.

(2) True

(3) False: Noise exposure results in greater outer hair cell damage than Inner hair cell

(4) False: Afferent fibres of the inner hair cells are damaged to a greater extent than that of the outer hair cells due to noise exposure

(5) True

(6) False: Owing to the greater volume of the scala tympani ionic changes do not occur.

(7) True

(8) False: Impulse noise is more damaging than continuous noise

(9) True

H. 1. (a) To identify the parameters of sound stimuli which will produce a given amount and pattern of hair cell damage

(b) To obtain inferential information about the pattern of stimulation produced by known characteristics of sound (Stockwell etal 1969)

2. The major histologic preparation methods currently in use are

(a) Serial sectioning method
(b) Surface preparation method

3. Serial sectioning method: Advantages.

(a) Structures of the specimens are made readily visible and can be studied in great detail.
(b) Specimens can be stained diferentially to highlight their structure.
(c) The serial sectioning method is compatible with both transmitted light and electron microscopic observatior needs.

Disadvantages:

(a) Serial sectioning is a time consuming method
(b) Artifacts are common in the serial sectioning method
(c) A great deal of the specimen is lost in the process in the serial sectioning method (Lipscomb 1974)

Surface preparation method: Advantages.

(a) Surface preparation method is quite a rapid method for microscopic observation.
(b) The method is versatile. Sections can be placed on the slide with face up can be viewed with a micro-scope. Specimens can be turned over and viwed again from the underside.
(c) This technique facilitates cell counting to determine the percentage of cells damaged by some experimental factor.

(d) The method is compatible with transmitted light microscopy, transmitted electron microscopy and scanning electron microscopy.

Disadvantages.

(a) Through preparation accident on entire specimen can be lost in surface preparation method

(b) Artifacts produced by occasional dissection accidents cannot be lessened.

(c) Supportive and associated structures are lost in the surface preparation technique. (Lipscomb, 1974)

I. (1) Degeneration
(2) Cogestion
(3) Distention
(4) Retraction
(5) Atrophy
(6) Vacuolation
(7) Adhesions
(8) Ossification
(9) Haemorrhage
(10) Thickening
(11) Otosclerosis

There are stairs below us which we have ascended; there are stairs above us, which we still have to ascend

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