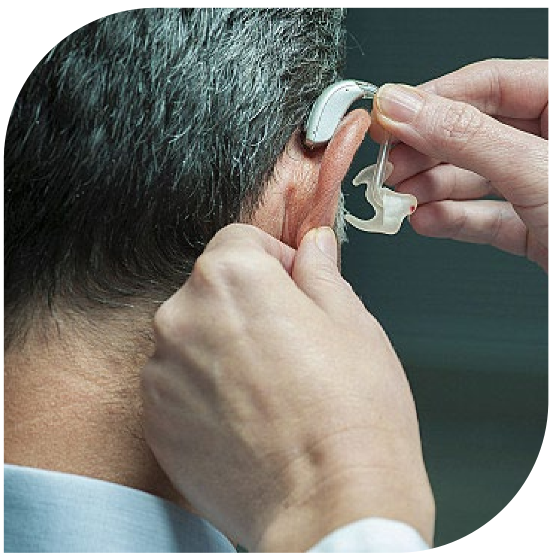
HEARING AID ACADEMY

2022 STUDENT MANUAL

BOOK #1



CALL US AT : **(903) 487-0097**
WWW.HEARINGAIDACADEMY.COM

Table of Contents – Book 1 of 2

Welcome & Introduction	2
Chapter 1: Geriatric Otolaryngology	9
Chapter 2: Psychology & Psychosocial	38
Chapter 3: Anatomy & Physics	44
Chapter 4: Adult SNHL	83
Chapter 5: Cochlear Physiology	126
Chapter 6: Assessment of Peripheral & Central Auditory Function	143
Chapter 7: Acoustical Fundamentals	174
Chapter 8: Basic Hearing Disorders	187
Chapter 9: Measurement of Hearing Loss – Audiometry	195
Chapter 10: Understanding & Interpreting the Audiogram	217
Chapter 11: Masking	232
Chapter 12: Hearing Instruments	247
Chapter 13: Outcome Verification Technology	317

HEARING AID
ACADEMY

WELCOME AND INTRODUCTION

Welcome And Introduction

A Personal Message From the Hearing Aid Academy

HEARING AID
ACADEMY

It is our pleasure to welcome you to the Hearing Aid Academy.

We want you to know that as you begin your education with us, you will have a special group of professionals standing by and ready to help support you and your efforts. The Academy has put together a course of study for you that has been designed to uniquely prepare you for a successful career in the hearing healthcare field. Each of us stands ready to help you as you progress toward your goals.

As you progress through this comprehensive program, you will learn a special skill set that goes far beyond merely knowing enough to pass your state's licensure examination. The Hearing Aid Academy promises that you will learn to think and perform as a professional with the intangible skills and insights that will set you apart in your community. This program was carefully charted to provide a pathway for you to successfully achieve your goals within this growing profession.

We believe that your personal goals are tied closely with the goals of our Academy and we take that responsibility very seriously. Our mutual goals are for you to pass your state licensure examination, to become successfully established in your profession, and for you to become a leader and active contributor in the hearing healthcare field. When you have reached those goals, we will have succeeded together.

We wish you the best of luck and the highest level of success as you embark on this journey.

Study Guide

About Your Training

As you begin your studies and become more familiar with the hearing health care industry, you will come to fully understand just how unique this course of instruction is. We have prepared the most complete and comprehensive online training available for Hearing Instrument Specialists.

One important goal will be for you to successfully pass your state's licensure requirements and examination. You will find that your training is unusually rich in content, providing you with the education you will need in each of the subjects to be covered in your state examination and the hands-on practical exam.

The content of the video lectures and the assignments go beyond the requirements for licensure. For example, we have provided you with a background of information that will enable you to better interface and cooperate with your patient's family doctor in order to better serve the needs of your patient, to work closely with others in the healthcare field, and to encourage professional referrals from your local medical community. Doctors are quick to perceive and separate dispensers who are merely selling hearing aids from those who are providing hearing instruments as an integrated part of broader hearing healthcare services.

You will be serving a community of people with hearing loss that is growing fast, and they will expect the highest levels of quality service and will have the highest expectations for successful results. Here is where that rich content of your training comes to the forefront. This program features over 80 hours of personal video instruction and is supported by some of the leading text books available today. Several updates and modifications have been made to insure that this program exceeds all current teachings and information to provide you the latest and most advanced information in the industry.

Getting Started

To get started, we recommend that you login to your user dashboard. You can access this at https://www.hearingaidacademy.com/login or you can simply go to the home page of the website and click on the big yellow button in the upper right corner that says LOGIN. Use your user name and password to gain access to the full education program.

Once logged in, look at the panel on the right side of the screen. This is where you will find:

1. How to contact a LIVE Instructor
2. Links to download your books and materials
3. How to Access the Simulation Software

On the left side of your screen, you will find the introduction section of the program, followed by links to all the training modules for the Hearing Aid Academy Licensing Program.. This is where you will navigate the online training. If you have any questions about accessing the training, please call (903) 487-0097 for assistance.

Setting Your Schedule

The Hearing Aid Academy recommends that you try to set a regular education schedule for yourself while you go through this program. The program is designed to be self-paced and we want you to progress at a speed you are comfortable with. The goal is to learn the information you are being taught. By memorizing the key facts is the best way for you to pass your licensing exam.

Schedule studies at times when it won't interfere with times that may cause a lot of interruptions from family or friends.

Try not to schedule your study right after your evening meal. Better to delay, or better yet to use a five or ten-minute break between study periods to snack on wholesome foods that will supply energy but not put you to sleep: fruit, vegetable drink, light sandwich. Make it a real break by going to a different area for your snack, instead of eating while reading or viewing a lecture.

Plan breaks in your extended study periods. Students typically do better and enjoy their studies more when study periods are limited to 30 minutes. Take a break, eat an apple, go for a five minute walk… Then return for another 30-minute study period. There is a power that comes from self-discipline: it motivates, it validates, and it provides a sense of purpose and accomplishment.

Set your study schedule and stick to it. (This is the one factor that all successful students share)

When something relatively unimportant comes up that tempts you to skip or reschedule study, have your decision made ahead of time that you know temptations like this are going to come up and you are going to resist the temptation and instead work toward your future.

Give your mind the time to work its magic. Do not rush, overload or cram. Pick a schedule and study plan that is geared for how you personally learn best.

The key to success with this training and in passing your state's licensure examination or ILE examination is to remain on the subject, explore, review and research the topic until you can explain and demonstrate it to someone else. One day soon, that person will be your state examiner.

Your Training Resources

Text Books

Your textbooks have been selected for their comprehensive content and compatibility with the goals of this course of instruction. You will see that the texts contain some subjects that you may recognize as dealing with information and technology from past decades. Be assured that many of these subjects will appear on your state licensure examination. You will be expected to be equipped to counsel persons with older instruments and to repair such devices.

We recommend that you study the appropriate reading assignment before viewing the associated video lecture. It will enable you to see the new words, carefully read and maybe reread concepts for comprehension, and see traditional graphics that illustrate systems. Then when viewing the lecture, you will be able to more easily follow along, take notes and appreciate the practical and broader issues provided in the lecture.

We refer to your texts by their corresponding numbers in the course syllabus.

#	Title	Edition	Pub
1	Hearing Instrument Science & Fitting Practices (PDF Version)	Second	IHS
2	STUDY GUIDE TO HEARING AND HEARING AIDS, FIFTH EDITION, Wayne J. Staab, Ph.D. Publisher, 287 pages. ISBN 1-881148-13-0. Tel: 435-574-0061	Fifth	WJ Staab
3	BASIC MASKING: AN EXPLANATION AND PROCEDURE, Wayne J. Staab, Ph.D., Publisher, 1992, 22 pages. Tel: 435-574-0061	First	WJ Staab
4	Basic Training Manual for Successful Hearing Aid Dispensing by Max Stanley Chartrand, Ph.D. Text Only 719-251-4391	Third	Max Chartrand

Video lectures - Web Access

80 hours of training video sessions divided into 31 Chapters with varying numbers of 20-minute sections are posted at the eLeap website (see below). These lectures were prepared from noted sources and designed to convey fundamental concepts and philosophies that are essential to your success. The lectures are intended to provide you with a practical sense of the materials, their importance and an understanding of how they relate to application in the field. All slides appearing in the video lectures are reproduced here in your study manual for clarification and for your use in making appropriate lecture notes for review and reference.

You will be tested on the content of both the texts and the video lectures. The titles of the video lectures by Chapter and Section, with their corresponding reading assignments, are provided in this manual.

Web Searches

In many ways, the Academy has adopted the spirit of medical universities in its approach to student research of materials. We encourage you to seek additional sources of information. You will be asked to search the web for supplemental visibility and explanations of subjects and terms. We want you to get in the habit of going to the internet as a resource for enriching your studies and expanding your base of knowledge on your particular areas of interest.

Grading

In general, there is no specific grading scale or score that you will receive from this program. You can expect to be tested at the end of each chapter and section of the training. You are required to score an 80% or better in order to pass that chapter or module and unlock the next module in order to advance through the program to the next section.

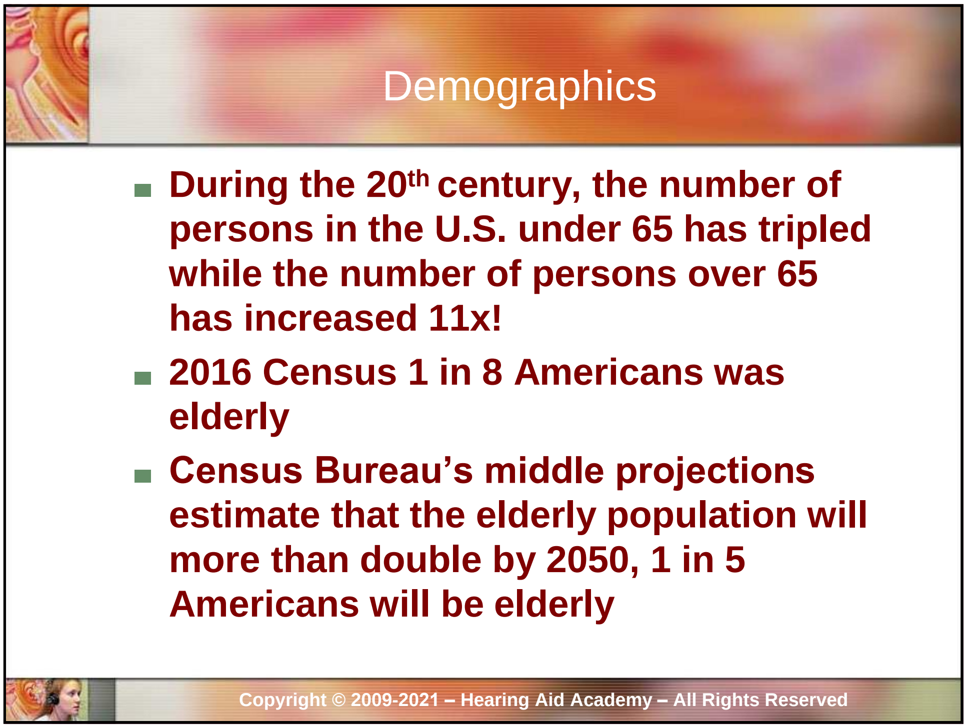
Contact Us

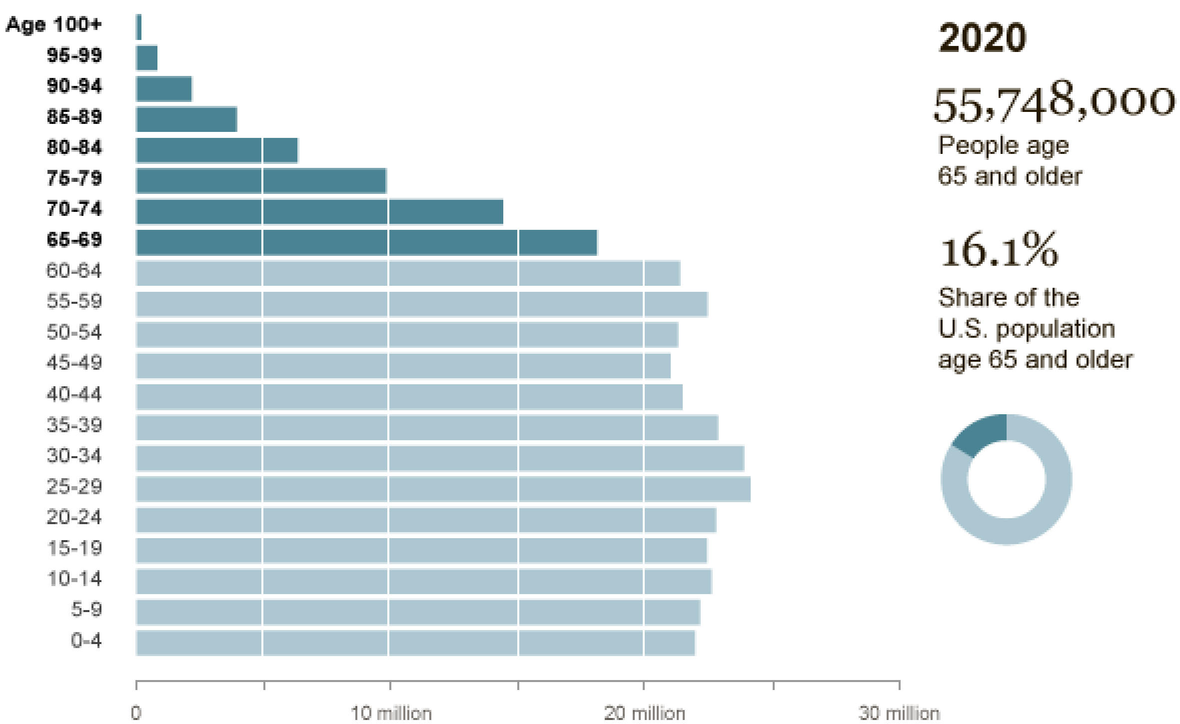
If you have any questions, you may always call the main number (903) 487-0097. For curriculum related questions, please call your instructor or submit a ticket for our team of instructors to receive assistance within 24-hours (usually much quicker).

You may also submit an email to support@hearingaidacademy.com for any questions you have.

COURSE	TITLE	TEXT	UNIT/CHAPTER AND PAGES
1	Geriatric Otolaryngology	1	XII (793 – 840)
2	Psychology and Psychosociology	1	XI (741 – 786)
3	Anatomy and Physics	1	Unit I (11 – 35)
4	Adult Sensorineural Hearing Loss		
5	Cochlear Physiology	1	Unit I (29 – 35)
6	Assessment of Peripheral and Central Auditory Function	1	Unit II (85 – 140)
7	Acoustic Fundamentals	1	Unit I (1 – 11)
8	Basic Hearing Disorders	1	Unit XII (794 – 806)
9	Measurement of Hearing Loss – Audiometry	1	Unit II (73 – 175)
10	Understanding and Interpreting the Audiogram		
11	Masking	1	Unit III (187 – 231)
12	Hearing Instruments	1	Unit IV (237 – 328)
13	OVT [Outcome Verification Technology]	1	Unit VIII (597 – 642)
14	BTE Earmolds and Couplers	1	Unit V (351 – 424) Unit VI (562
15	Programming and Troubleshooting	1	Unit IV (268 – 317) Unit IX (647 – 693)
16	NIHL – Noise-Induced Hearing Loss	1	Unit II (170 – 171)
17	Otolaryngology and Audiology		
18	Meniere's Disease	1	Unit II (170)
19	Infections of the External Ear	1	Unit XII (794 – 804)
20	Tympanoplasty		
21	Cochlear Implants		
22	Putting It All Together		
23	Competency Building 2		N/A
24	Competency Building 3		N/A
25	Ethics and Legal Considerations	1	Unit XIV (905 – 929)
26	"Sales" and Marketing Techniques	1	Unit XIII (850 – 901)
27	New Born Baby Story		

Chapter 1: Geriatric Otolaryngology





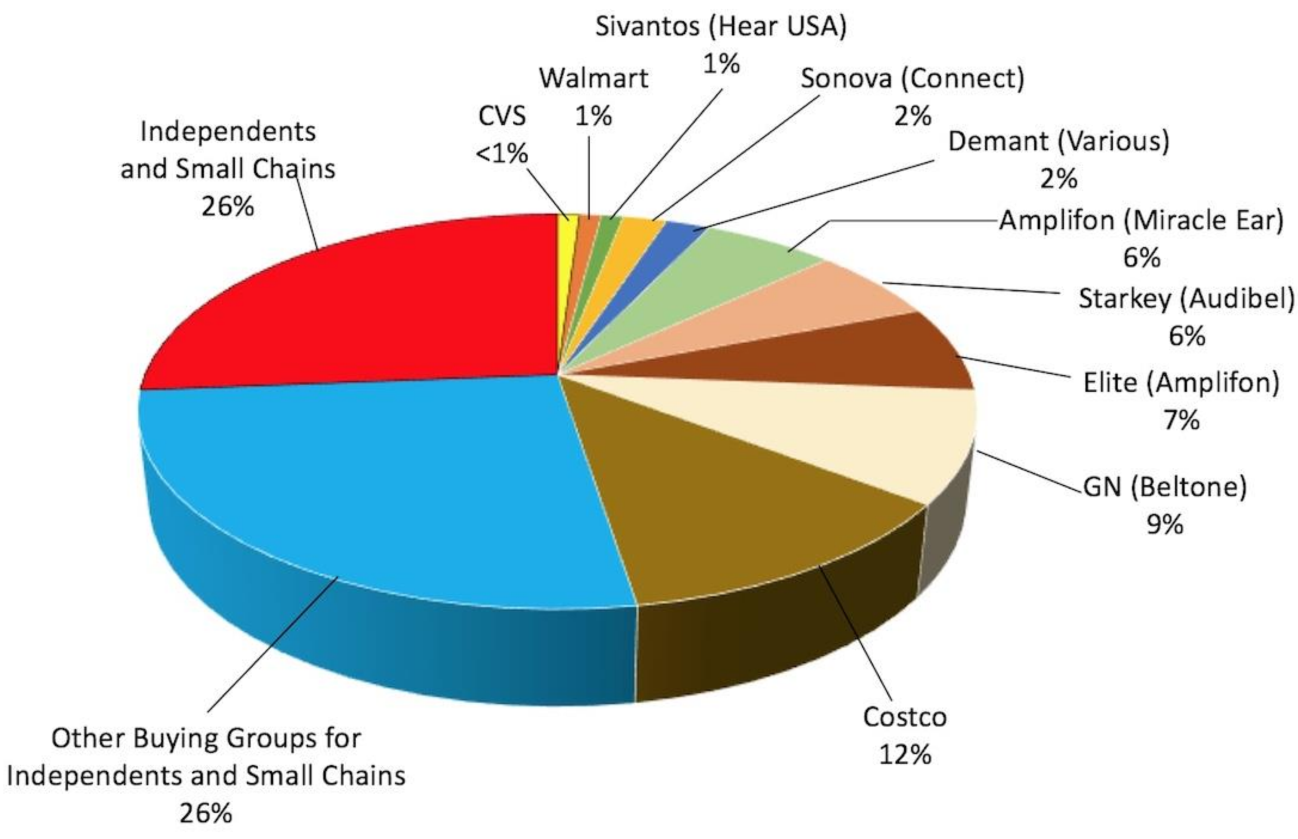
The Census Bureau estimates 55.75 million seniors over the age of 65 by year 2020 which will be 16.1% of the population of the United States.

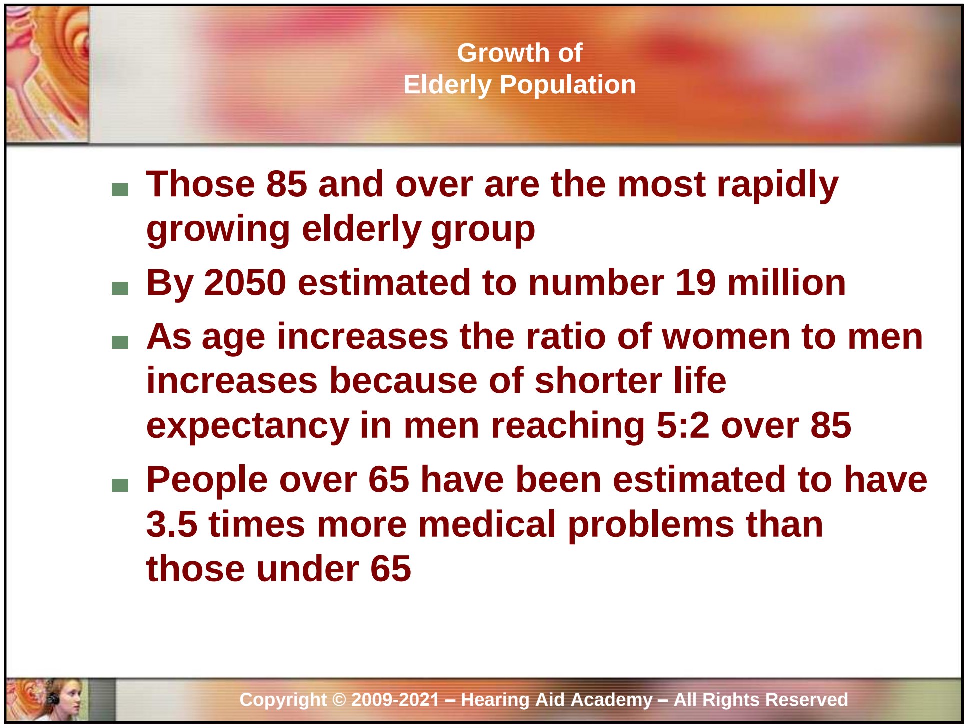
Table I

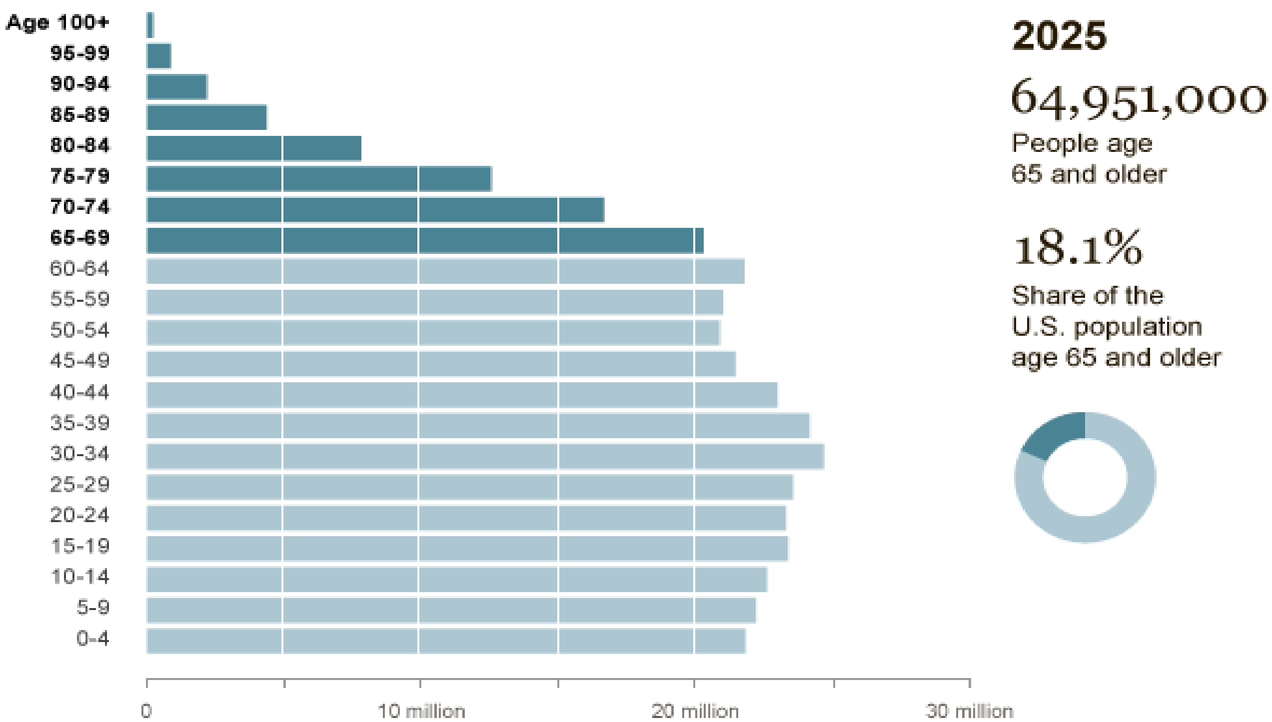
Yearly Percentage Growth of U.S. Hearing Aid Sales

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	2%	0%	-1%	5%	7%	3%	8%	2%	-1%	9%	3%	3%	3%	5%	4%	7%	5%
VA	7%	18%	-1%	22%	12%	-6%	5%	9%	10%	28%	11%	4%	3%	7%	10%	5%	2%
Private	1%	-2%	-1%	3%	7%	4%	8%	1%	-2%	5%	1%	3%	3%	4%	3%	8%	6%

Private U.S. Hearing Aid Market by POS (2016)







The Census Bureau estimates 64.95 million seniors over the age of 65 by year 2020 which will be 18.1% of the population of the United States. This is a 2% growth rate in the 5 years between 2020 and 2025.

Factors in the care of the elderly

- **Multiple medical problems**
- **Multiple medications**
- **Increased sensitivity to medicines**
- **Psychosocial factors**
  - **Diminished independence**
  - **Diminished social interaction**
  - **Limited financial resources**

Common Otolaryngologic Problems

- Presbycusis
- Dysphagia
- Balance disorders (presbystasis)
- Tinnitus
- Nasal complaints
- Voice
- Cancer
- Cosmetics

Hearing loss

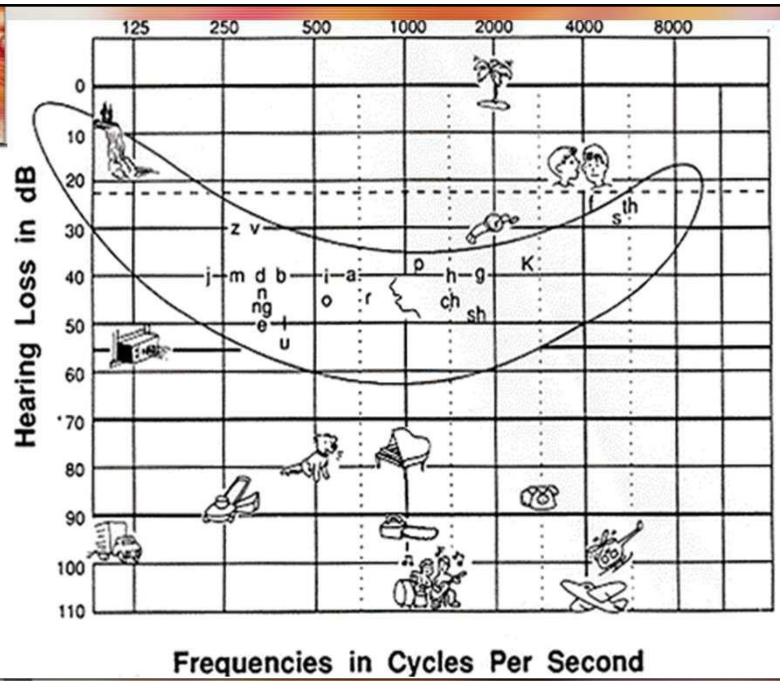
- Presbycusis
- Aging of the auditory system
- Diet, nutrition, metabolism, cholesterol levels, blood pressure, arteriosclerosis, exercise, smoking, noise, emotional stress, genetic factors, toxin exposure
- Symmetric, bilateral sensorineural hearing loss with greatest loss in high frequencies

Hearing Loss

- 60% people over age 70 have at least a 25 dB hearing loss
- Estimated 30% have a hearing deficit that adversely affects their receptive communication ability
- Age related hearing loss affects quality of life, can lead to isolation
- Elderly commonly also have increasing problems with vision making hearing problems more of a handicap

Types of Presbycusis

- Sensory Presbycusis
  - High frequency down-sloping SNHL
  - Speech discrimination remains good
  - Degeneration a basal portion of Organ of Corti (predominately outer hair cells)
- Neural presbycusis
  - Flat audiogram
  - Rapid hearing loss
  - Poor speech discrimination
  - Loss of spiral ganglion cells



Types of Presbycusis

- Metabolic Presbycusis
  - Slowly progressive
  - Flat audiogram
  - Good speech discrimination
  - Atrophy of stria vascularis
- Conductive Presbycusis
  - Thickening of basilar membrane
  - Gradual downsloping high frequency
    hearing loss

Presbycusis

- Progressive
- Speech discrimination for similar pure tone hearing is worse in older patients than younger patients

Treatments

Repeat testing

Assistive devices

- Vibrating alarm clocks
- Flashing telephone and door signalers
- Television listening systems
- Personal amplifiers

Hearing aids

Hearing aids

- An estimated 10.2 million hearing aid users
- Only 6 - 8% who could use them do
- Over 20% of people who have them don't wear them
- Cost is prohibitive to many elderly patients

Hearing Aid Types

Body Aids
Behind-the-ear
(BTE) Open Fit
(BTE) RIC in Canal
(ITE) Full Shell
In-the-canal (ITC)
Completely in canal (CIC)
(IIC)

Hearing aid styles

There's a hearing solution just right for you.

-

- for iPhone

- 

Invisible

- 

Receiver-In-Canal

- 

Completely-In-Canal

- 

Behind-The-Ear

- 

In-The-Canal

- 

In-The-Ear

- 

Tinnitus

- 

Single-Sided Hearing

- Hearing Amplifiers

Types of Hearing Aid Circuitry

- No more Analog
- Digital
- Digital sound processing
- DSP

Dysphagia

- Phases of swallowing
  - Oral (reduced facial muscle strength, decreased masticatory strength, reduced tongue control, missing dentition)
  - Pharyngeal (delayed in elderly subjects, decreased pharyngolaryngeal sensory discrimination, abnormal UES function, increased penetration and silent aspiration)
  - Esophageal (decreased or absent secondary peristalsis)

Evaluation

- History: Feeding problem vs. swallowing disorder
  - Liquids vs. solids
  - Globus, halitosis, wet vocal quality, reflux, odynophagia, recurrent pneumonia, hoarseness, dysarthria
- Physical Exam
  - Examine oral cavity and upper aerodigestive tract, saliva quality/dentition/dentures
  - Neurological evaluation including arousal, orientation, cognition, cranial nerves

Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

- Most important determination is assessment of risk of aspiration
- Bedside swallowing evaluation (fails to identify 33-50% of aspiration)
- Barium swallow (anatomic lesions)
- Modified barium swallow (dynamic view of swallowing from oral cavity to lower esophageal sphincter)
- FEES – Functional endoscopic evaluation of swallowing (abnormal laryngeal elevation, epiglottis inversion, pooling, aspiration)

Causes of dysphagia

- Stroke
- Neuromuscular disease - Parkinson's disease (pill-rolling tremor, bradykinesia, cog-wheeling rigidity), Amyotrophic lateral sclerosis
- Medications (xerostomia, mental status change, dyskinesia, GERD, esophagitis)
- Cricopharyngeus dysfunction (functional, structural, "bar" on barium swallow)
- Zenker's diverticulum (regurgitation)
- Neoplasms

Treatments

- Swallowing therapy
- Dietary modifications
- Eliminate or reduce medications
- Gastrostomy tube placement
- Cricopharyngeal myotomy, BoTox injection of cricopharyngeal bar
- Surgical repair of Zenker's (open vs. endoscopic)

Balance Disorders

- Difficulties with sensory function, central nervous system integration, neuromuscular and skeletal function
- 30-50% persons 65 and older fall in a given year
- 50% per year fall age 80 or older
- 1% of falls suffer hip fractures, 5% some type of fracture
- Roughly half of hip fractures are estimated to never recover normal function again

Vestibular Changes with Age

- Termed presbystasis
- Loss of hair cells primarily in the ampulla
- Total number of vestibular nerve axons is 37% than younger patients
- Loss of neurons in vestibular nuclei of 3% per decade age 40-90
- Reduction in gain of VOR, smooth pursuit, increase in saccade latencies

Postural stability

Sensory (visual, hearing, vestibular, proprioceptive)

Musculoskeletal

Cognitive

Integrative function

Other factors in balance disorders

- Cerebellar degeneration, Parkinson’s disease, Huntington’s disease, vitamin B12 deficiency, dementia, diabetic neuropathy, brain and spinal cord tumors, postural hypotension, cerebrovascular disease, atherosclerosis, musculoskeletal disease, metabolic disorders, cardiovascular disorders, medications, visual impairment

- **History**
  - **Dizziness, dysequilibrium, vertigo**
  - **Onset, duration, frequency, severity, provocation, associated symptoms, falls**
  - **Medications, medical conditions**
- **Physical exam**
  - **Examine sensory functions, posture, gait, neurological function**
- **Adjunctive testing**
  - **Audiogram, electronystagmography, MRI, posturography**

Treatments

Disorder	Treatment
Vestibular labyrinthitis and/or Neuronitis	Acute Antibiotics or surgery if bacterial Antiemetics, vestibular suppressants Chronic Vestibular rehabilitation
Vestibular trauma	Vestibular rehabilitation
Vertibrobasilar insufficiency	Antiplatelet and anticoagulation medications
Cerebellar infarction	Antiplatelet medications Surgery PRN for decompression Vestibular rehabilitation
BPPV	Particle repositioning maneuver Additional vestibular rehabilitation PRN
Meniere's disease	Low sodium diet and diuretic Surgery Transtympanic aminoglycoside antibiotic nerve section, sac decompression; followed by vestibular rehabilitation
Autoimmune inner ear disease	High-dose steroids, cytotoxic drugs
Perilymphatic fistula	Bed rest, surgery
CP angle tumor	Surgery followed by vestibular rehabilitation
Ototoxicity	Vestibular rehabilitation, substitution strategies
Presbyastasis	Vestibular rehabilitation (head and eye movement exercises, gait and balance training)
Anxiety	Anxiolytic medications or counseling Exposure therapy

BPPV = benign paroxysmal position vertigo; CP = cerebellopontine angle.

TABLE I. Common Age-Related Vestibular Disorders and Treatments.

Tinnitus

- **40 million affected in the U.S.**
- **10 million severely affected**
- **Objective versus subjective tinnitus**

Objective -Pulsatile tinnitus

- Arteriovenous malformations
- Vascular tumors
- Venous hum
- Atherosclerosis
- Ectopic carotid artery
- Persistent stapedial artery
- Dehiscent jugular bulb
- Vascular loops
- Cardiac murmurs
- Pregnancy
- Anemia
- Thyrotoxicosis
- Paget's disease
- Benign intracranial hypertension

Objective tinnitus

- Idiopathic stapedial muscle spasm
- Palatal myoclonus
- Patulous eustachian tube

Subjective tinnitus

- Presbycusis
- Noise exposure
- Meniere's disease
- Otosclerosis
- Head trauma
- Acoustic neuroma
- Drugs
- Middle ear effusion
- TMJ problems
- Depression
- Hyperlipidemia
- Meningitis
- Syphilis

Treatments

- Multiple treatments
- Avoidance of dietary stimulants: coffee, tea, cola, etc.
- Smoking cessation
- Avoid medications known to cause tinnitus
- Reassurance
- White noise from radio or home masking machine

Nasal Complaints

- Nasal obstruction
- Rhinorrhea
- Epistaxis
- Olfactory dysfunction

Causes

- Inflammation: decrease immune function, mucociliary dysfunction, allergy, dehydration with thickening of secretions
- Dystrophic changes: both atrophy of nasal mucosa and increase in vasomotor rhinitis are common
- Neoplasia: nasal obstruction, pain, epistaxis, rhinorrhea
- Trauma: old traumas, previous surgery
- Endocrine-metabolic disorders: hypothyroidism, decreased vitamin A and zinc
- Pharmacologic effects: diuretics, tricyclic antidepressants, antihistamines

Voice changes

- Estimated 12% of the elderly have vocal dysfunction
- Fundamental frequency of the male voice tends to increase with age
- Fundamental frequency in females decreases with age

Voice changes

- Common vocal cord findings
  - Atrophy
  - Bowed cords
  - Edema
  - Loss of collagen and elastic fibers, decrease in density of fibroblasts, atrophy of submucous glands, fibrosis, disorganization of collagen fibers

Voice changes

- Cricoarytenoid joint
  - Reduction of ground substance and cartilage matrix
  - Increase in collagen fiber density in the cartilage
- Laryngeal muscles
  - Atrophy

Neurological disorders with voice changes

- **Essential tremor**
- **Parkinson's disease: low volume, breathy, and monotonic**
- **Stroke**
- **Myasthenia gravis**
- **Amyotrophic lateral sclerosis**

Treatments

- Speech therapy
- Medialization thyroplasty
- Diagnosis and treatment of underlying disorder

Cancer

- Squamous cell cancers
- Thyroid malignancies
  - Well differentiated have worse course
  - Anaplastic or undifferentiated more common
- Salivary gland malignancies
- Lymphomas

- Clayman et al examined complication rates in patients 80 and older versus patients 65 and under and found no significant differences in major or minor complications
- Blackwell et al : compared free flaps in octogenarians versus younger patients and found major complications in 62% vs. 15%

Cosmetics

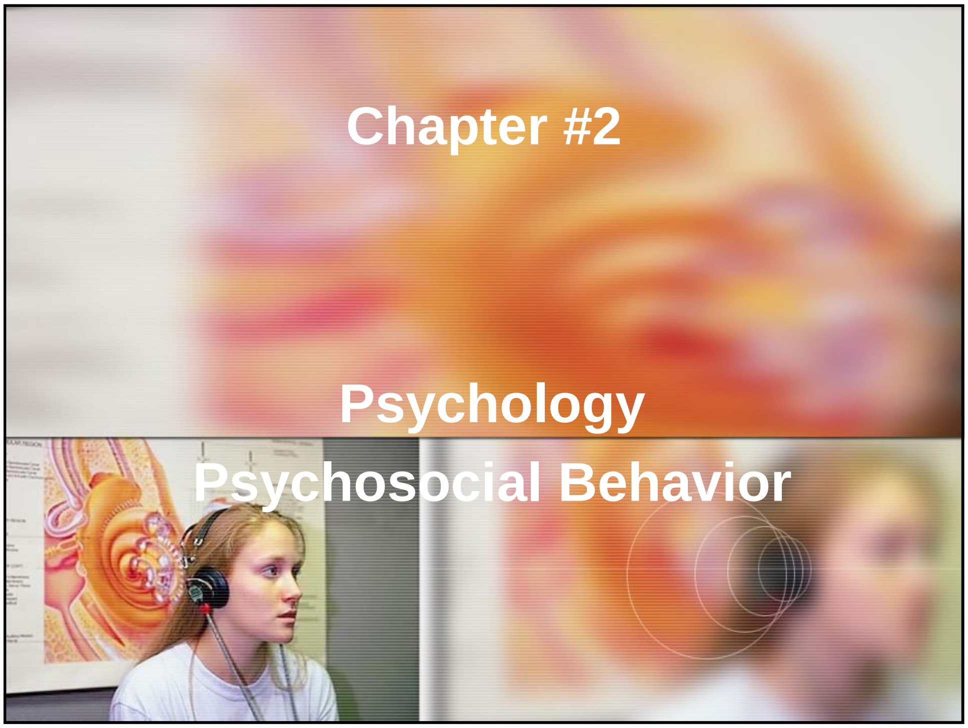
- Elderly are leading more active lives for much longer than in the past
- With the explosive growth of cosmetic facial plastic surgery paired with the explosive growth of the elderly population there will be many more “elderly” cosmetic patients

- Skin- loss of tone, dynamic and static wrinkling, thinning, pigmentary changes, gravitational descent of soft tissues
  - Chemical peel, laser resurfacing
  - Botox injection
  - Rhytidectomy
- Upper third-ptosis of eyebrows and forehead
  - Direct brow lift
  - Pretrichial/coronal/endoscopic

Conclusions

- With the expected explosive growth of the elderly population, this group will become a larger proportion of patients
- The otolaryngologist must consider the patient's health and well being as a whole especially in this group of patients who often have multiple problems

Chapter 2: Psychology & Psychosocial



Outline

- Coping skills & normal hearing
- The Conflict of Self Diagnosis
- Onset of a loss of confidence
- Onset of psychological symptoms & the coping skill gradient
- Confusion
- Anxiety
- Embarrassment
- From uncertainty to withdrawal
- From withdrawal to isolation
- Paranoia
- Dynamic flow of consequences
- Obstacles to Rx

Coping Skills

1. Normal and Necessary
2. Everyday Use
3. Communication Aids
4. Unremarkable

Conflict of Self Diagnosis

1. Is it noisy?
2. Is someone mumbling?
3. Is someone talking softly?
4. Was I paying attention?

Onset of Loss of Confidence

1. **Communication from close family members**
2. **Defense without merit**
3. **Frequency of errors**
4. **Inadequate coping skills**
5. **Multiple conflicts**
6. **Multiple confrontations**

Coping Skill Gradient and the Onset of Psychological Symptoms

1. **Overwhelming speed of conversation**
2. **Positioning**
3. **Second guessing**
4. **Anticipation**
5. **Confusion**

From Uncertainty To Social Isolation

1. Confusion to Embarrassment
2. Anxiety and Worry
3. Paranoia
4. Social Dilemmas
5. Withdrawal
6. Social Isolation
7. Victim Levels

Obstacles to Treatment

1. Denial
2. Ability to cope
3. Self Diagnosis
4. Expense of hearing instruments
5. Doubt of value
6. Distrust in marketplace
7. Self prescription

- 8. Stigma
- 9. Vanity, vanity
- 10. Opinions of others
- 11. Cost of opportunity
- 12. Knowledge of poor results

Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

The Dispenser's Role

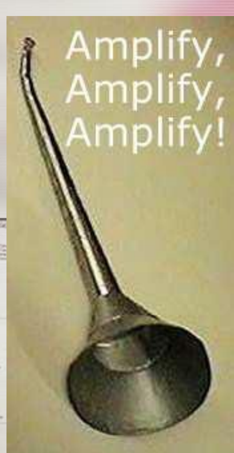
1. Focusing on pre-patient & patient education
2. Removing stigma in your market area
3. Establishing trust
4. Maximizing your clinic's potential
5. Communicating realistic expectations

Chapter 3: Anatomy & Physics

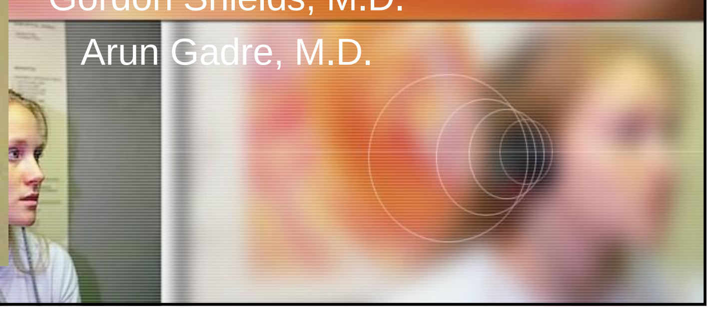
Chapter #3

ASNHL

Adult SNHL: Hearing Aids and Assistive Devices



Gordon Shields, M.D.
Arun Gadre, M.D.



Intro

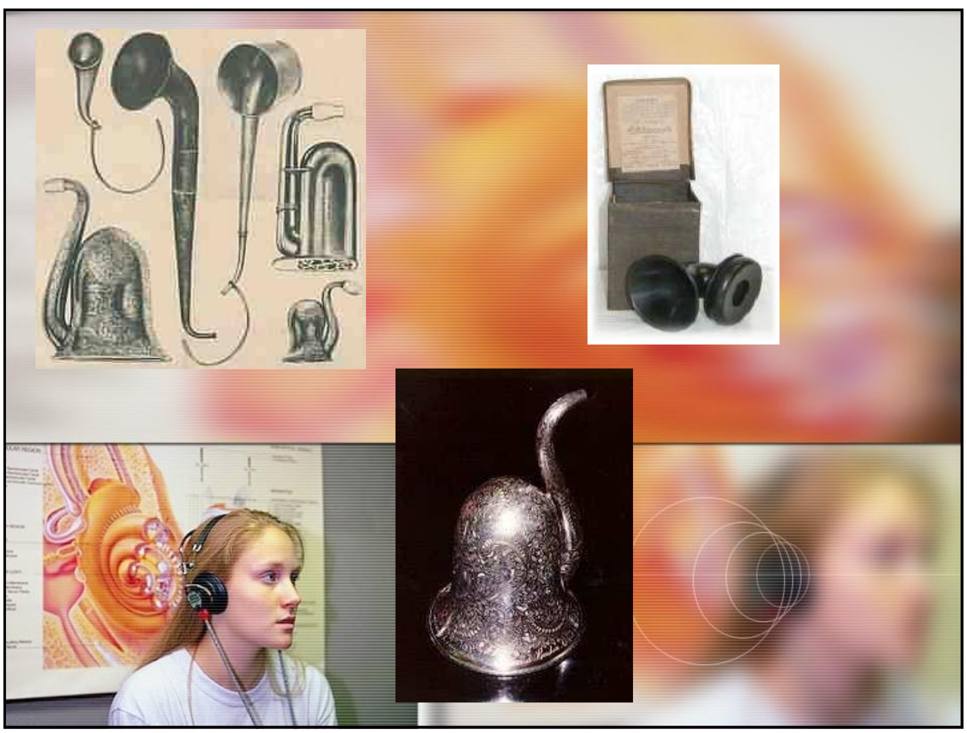
- Hearing loss affects 32 million Americans
- Sensorineural Hearing loss over 20 million
- People with hearing loss suffer emotional, social and communicative dysfunction
- Only to increase with aging population

History

- 1551-Bone conduction device consisting of metal shaft or spear
- 1670- Sir Samuel Moreland, England invented a large speaking trumpet
- 1892-first patent for electric hearing aid in the U.S.
- 1912-first volume control for a hearing aid

History

- 1931-first electric hearing aid eyeglass patent
- 1937-first wearable vacuum tube HA in US
- 1953-first all-transistor hearing aid



SNHL

Attenuation

Recruitment

Distortion

Attenuation

Loss of auditory sensitivity

Recruitment

A large increase in the perceived loudness of a signal produced by relatively small increases in intensity above threshold

Distortion

- Qualitative effect: when sound is heard sufficiently loud, its quality in other terms may be poorer than for normal hearing listener
- Makes hearing in background noise difficult

Conventional Hearing Aids

- Only 10-20% use hearing aids
- 4.5 million hearing aid users
- 12% who have them don't wear them
- Only 58% "very satisfied"

Basic Hearing Aid Structure

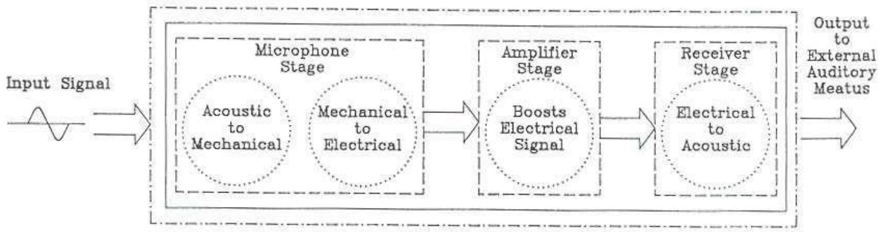


FIGURE 155.1. Basic components of a hearing aid system.

Hearing Aid Types

- Body Aids
- Behind-the-ear (BTE)
- Behind-the-ear (RIC)
- Behind-the-ear (Open)
- All-In-the-ear (ITE)
- In-the-canal (ITC)
- Completely-in-canal (CIC)
- Deep Insertion (IIC)
- CROS and BICROS

BTE

- Attached to earmold
- Powerful
- Wide range of HL
- Can have open earmolds
- Less repair problems
- Less feedback
- Telecoils

Disadvantages

- Large size
- Does not take advantage of pinna and concha benefit
- Vulnerable to scalp perspiration
- Microphone above pinna

ITE

- Fits in concha
- Microphone at ear canal level
- Mild to severe HL

Disadvantages

- Visible
- Does not take advantage of pinna and concha
- One piece design
- Need some dexterity to insert

ITC

- Only faceplate sticks out into concha
- Wide range of HL
- Microphone at opening of ear canal
- Takes advantage of most of the auricle

Disadvantages

Easily dislodged

Need dexterity for insertion, removal, and adjustment

CIC

- Hidden in canal
- Full effect of auricle
- Receiver closer to tympanic membrane so requires less amplification

Disadvantages

- Patient needs good dexterity to place and remove
- Easily lost because of small size
- Some circuitry not available in this size
- Feedback can be a problem

CROS

- Contralateral routing of signal
- Use with good hearing ear with a bad ear on opposite side
- Prevents “head shadow effect”
- Microphone at bad ear sends signal to good ear

BiCROS

- Used with bad hearing ear and poorer hearing ear
- Same routing of signal from poorer hearing ear as a CROS
- Provides amplification to both ears

Circuitry

- Analog
- Linear
- Compression
- Digitally controlled analog
- Digital signal processing DSP

Analog

- The majority of hearing aids are digitally signal processors DSP
- Receivers and Mic’s are analog
- Circuits are Digital DSP
- Converts acoustic to mechanical to electrical signal and then back

Linear amplification

- Oldest type of hearing aid amplification
- Amplifies all inputs same amount
- Does not address nonlinear nature of loudness growth in SNHL
- Uses peak clipping to prevent reaching LDL
- Causes some distortion at high input levels

Compression

- Control of hearing aid output to within dynamic range
- Weak intensity inputs are amplified more than high intensity
- Nonlinear relationship
- Cuts down on distortion and uncomfortable output levels

Compression

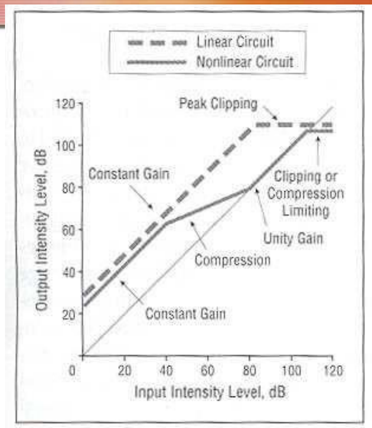


Figure 2. *Input-output function of a hearing aid with linear amplification and peak clipping and a hearing aid with nonlinear dynamic range compression and compression limiting (adapted from Killion[1]).*

Digitally controlled analog

- Multiple parameters can be adjusted under computer control
- Allows more options in smaller size aids
- One size fits all production
- Can adjust HA easily as hearing loss progresses or fluctuates
- Memories for special listening situations

Digital Signal Processing

- Latest technology
- Converts sound to numerical data
- Higher fidelity "CD quality sound"
- Allows for more complex algorithms for control of environmental and noise

Microphones

- Directional versus omni-directional
- Using Directional can be helpful in noisy situations
- The best hearing aids can switch between the two.
- Dual microphones can zoom in on speaker

Assistive Listening Devices

- Provide assistance for special situations
- Alarm devices and communication devices
- Include devices for listening to television or radio, being made aware of a fire alarm, doorbell ringing, TTY
- FM systems in which input to a microphone is sent to a headset or directly to HA
- Bluetooth connection to iPhone and Android phones
- Bluetooth wireless mics for picking up speakers at across room etc.

TV Ears ®


Volume
off
on
Tone
TV · EARS
TV · EARS
ANALOG

CaptionCall is the world's best captioning telephone

designed to help people with hearing loss use the phone to stay socially connected with loved ones, conduct important business, and best of all, maintain confident communications for a longer, happier, healthier life.

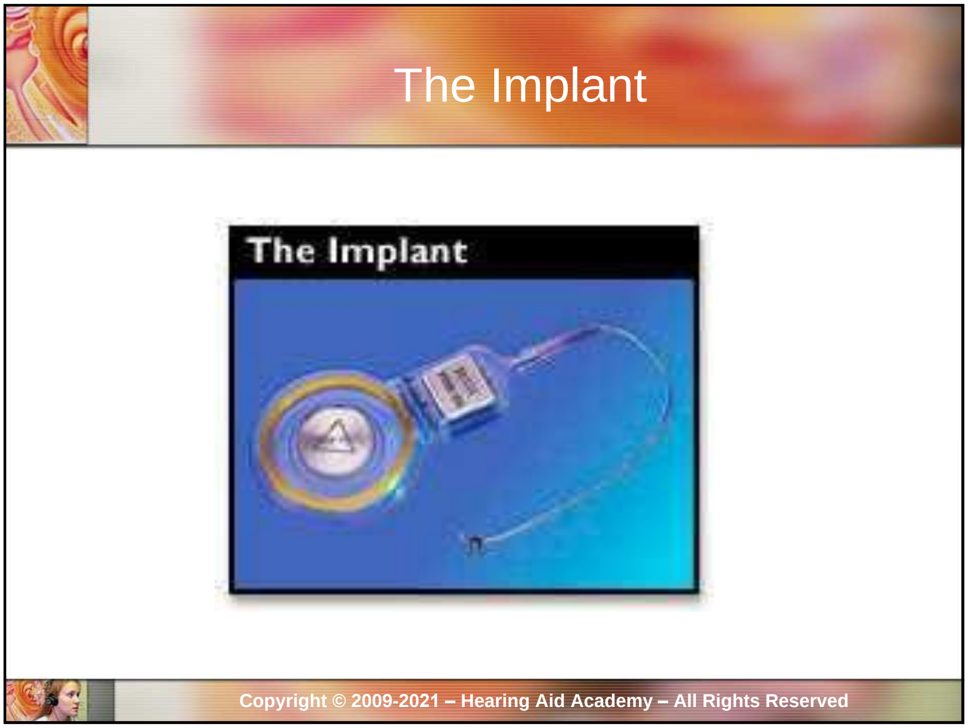
Request Phone

Implantable Devices

- Bone anchored hearing aids (not for SNHL)
- Middle ear implants
- Canal implants next to TM
- Cochlear implants

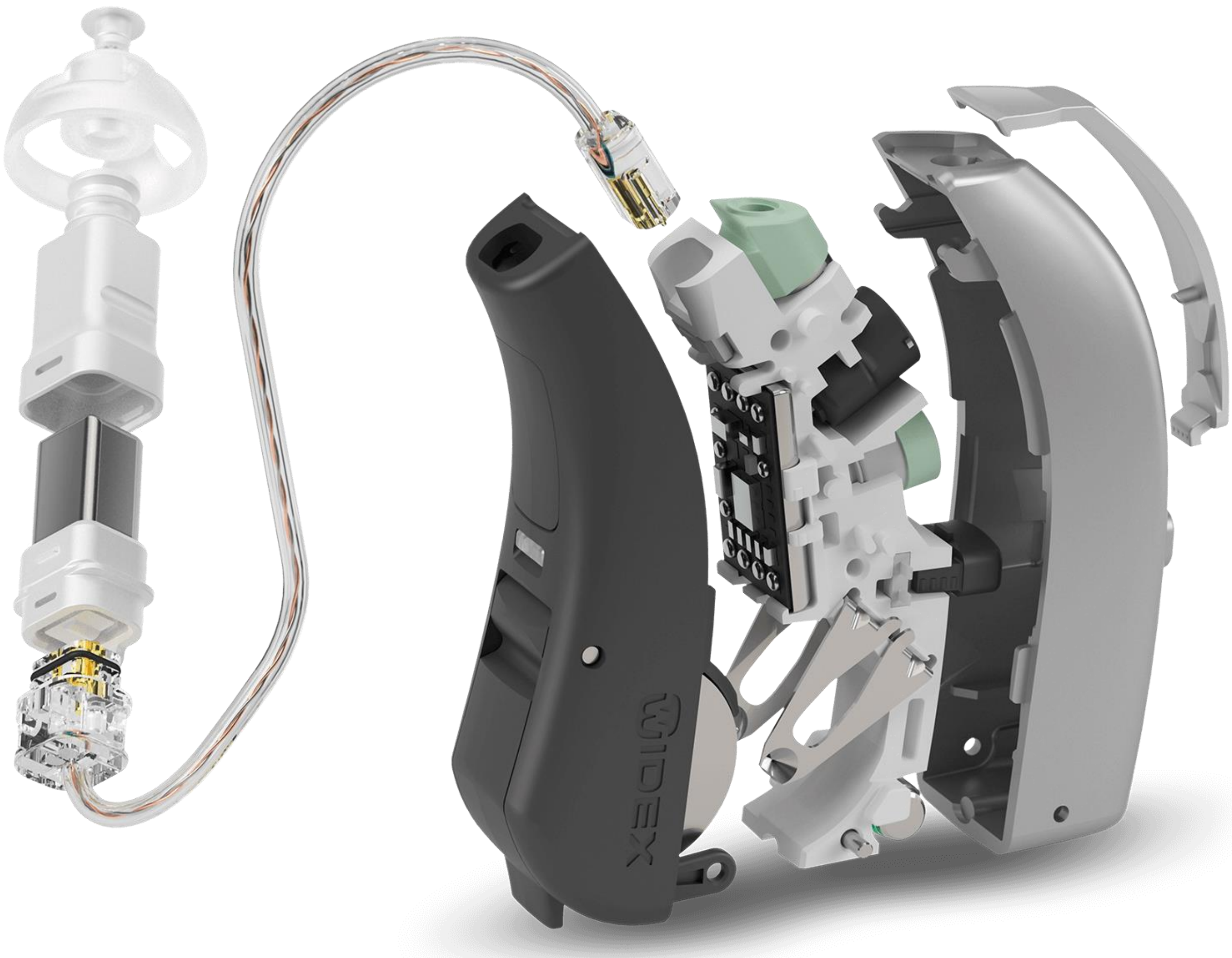
Middle Ear Implants

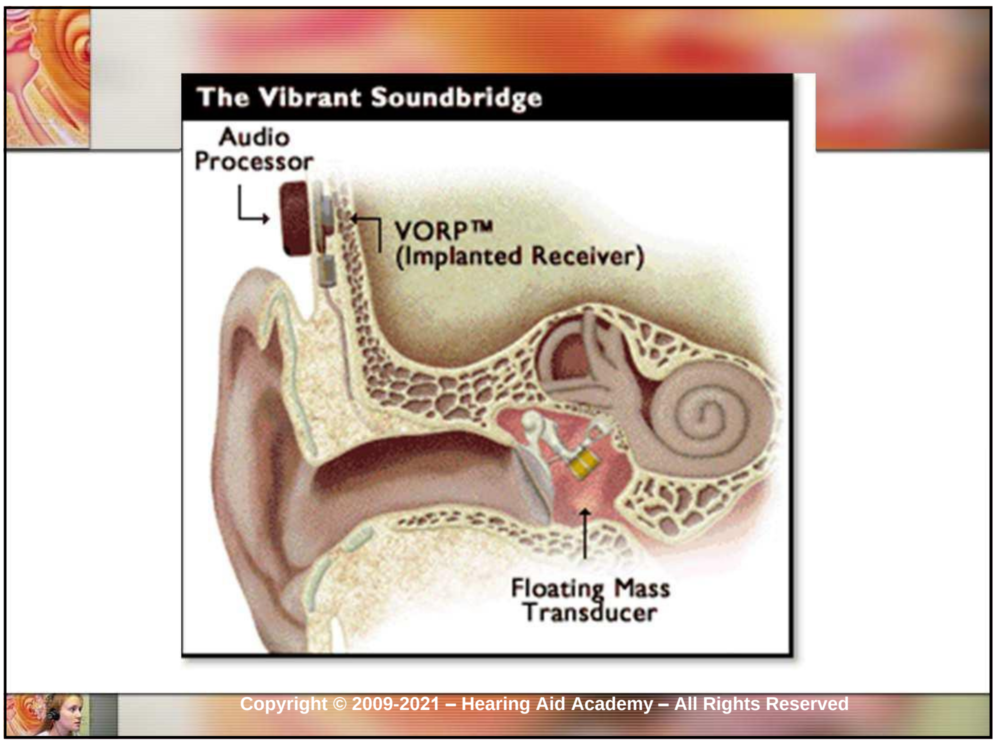
- Devices attach to the tympanic membrane, ossicular chain, even the round window membrane
- Transformation of sound to vibrations via electromagnetic device which directly move the ossicular chain
- Eliminates feedback, occlusion effect, cuts down on distortion

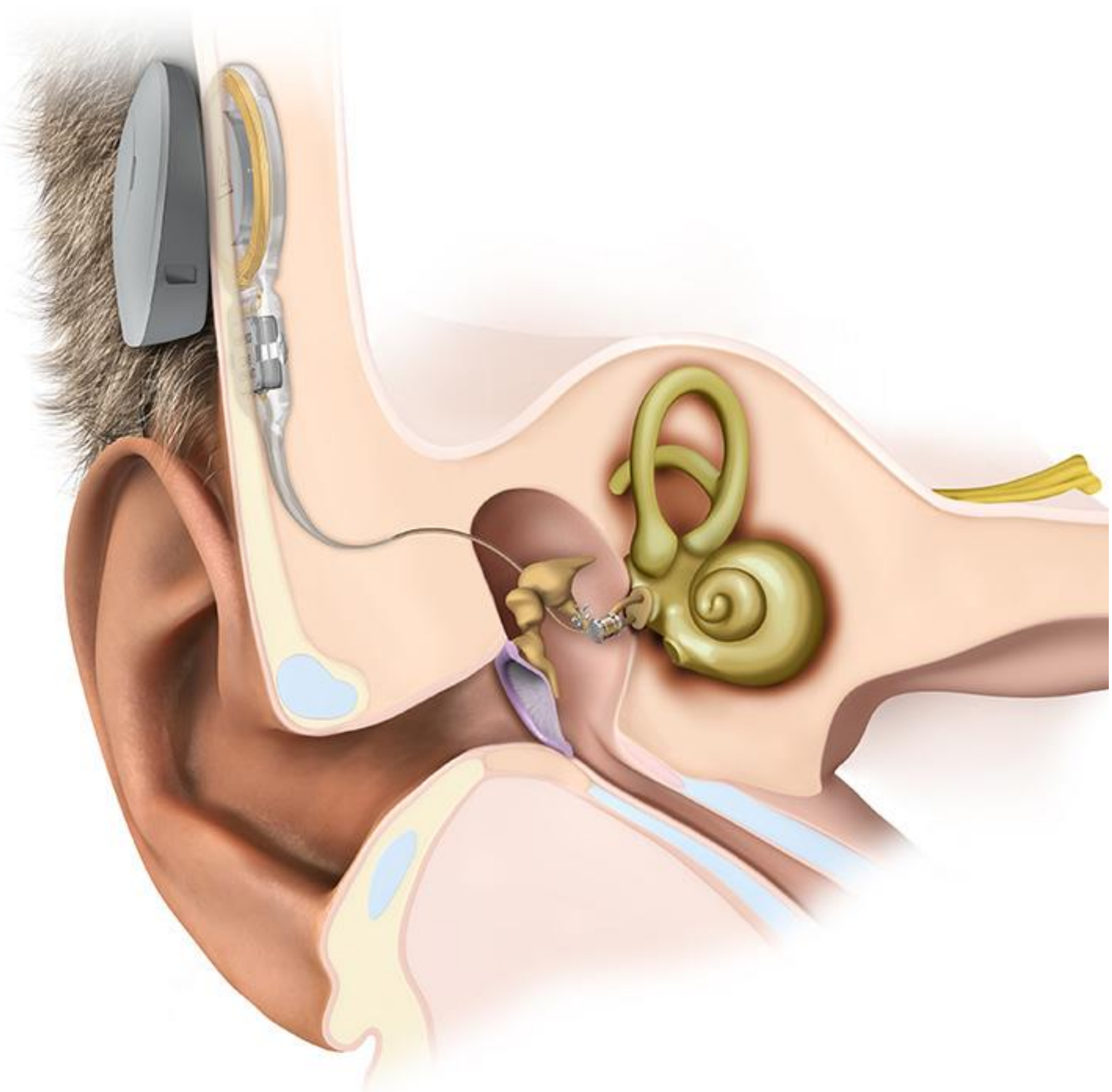

The Implant
The Implant
Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

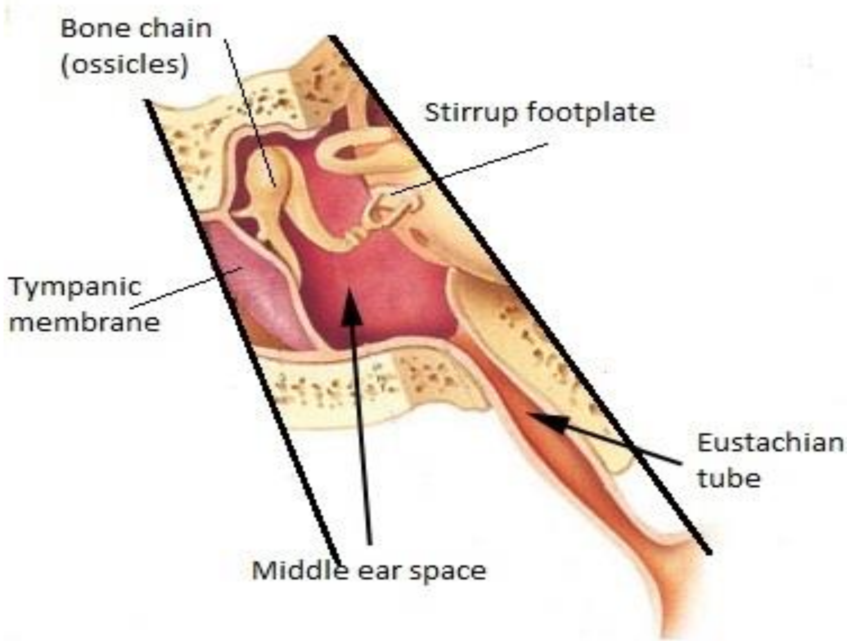

Cochlear Slimline Coil
Microphones and microphone protectors
Cochlear Magnet
Indicator light
Coil cable
Cochlear Earhook
Processing unit
Control button
Serial number
Battery module

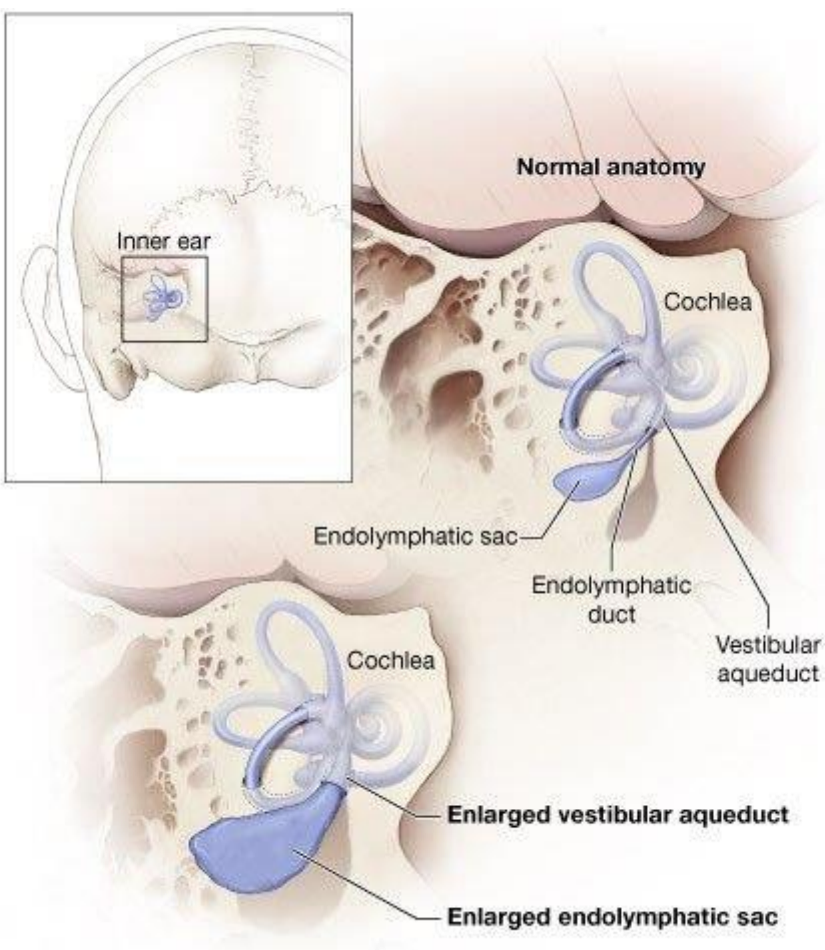
FMT


WIDEX


The Vibrant Soundbridge
Audio Processor
VORP™ (Implanted Receiver)
Floating Mass Transducer
Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved




Bone chain
(ossicles)
Stirrup footplate
Tympanic
membrane
Eustachian
tube
Middle ear space


Inner ear
Normal anatomy
Cochlea
Endolymphatic sac
Endolymphatic
duct
Vestibular
aqueduct
Cochlea
Enlarged vestibular aqueduct
Enlarged endolymphatic sac


The Audio Processor Is Easily Concealed
Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

Cochlear Implants

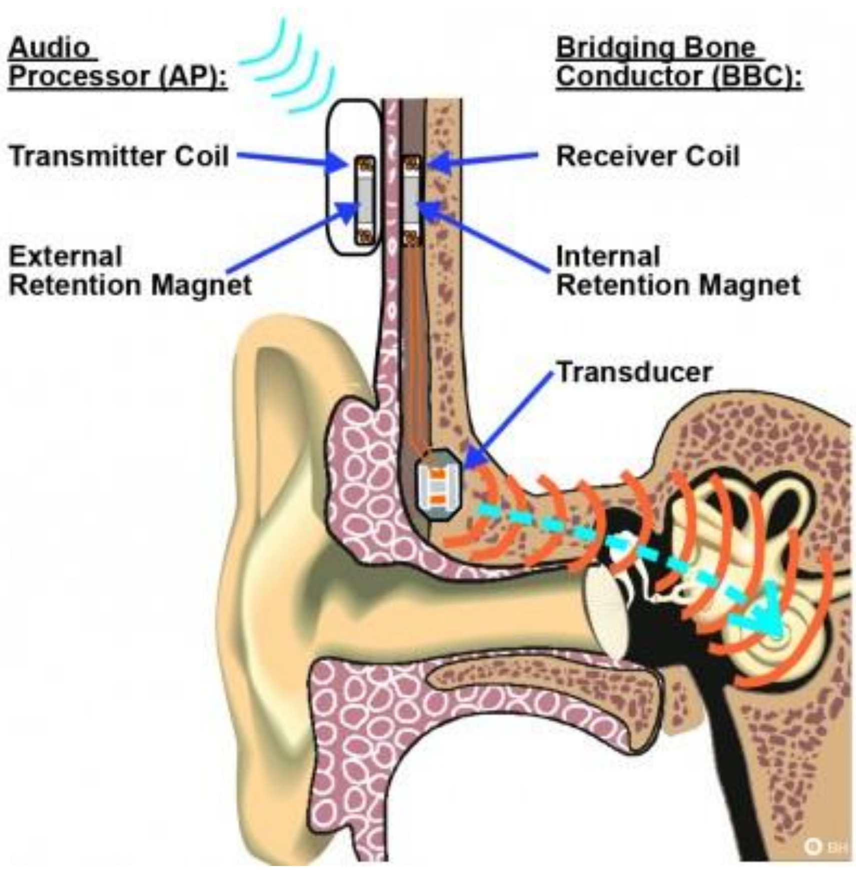
- Adult Selection Criteria
- Bilateral severe-to-profound hearing loss
- Minimal benefit from conventional hearing aids
- No medical contraindications for surgery
- Results best in post-lingual deaf

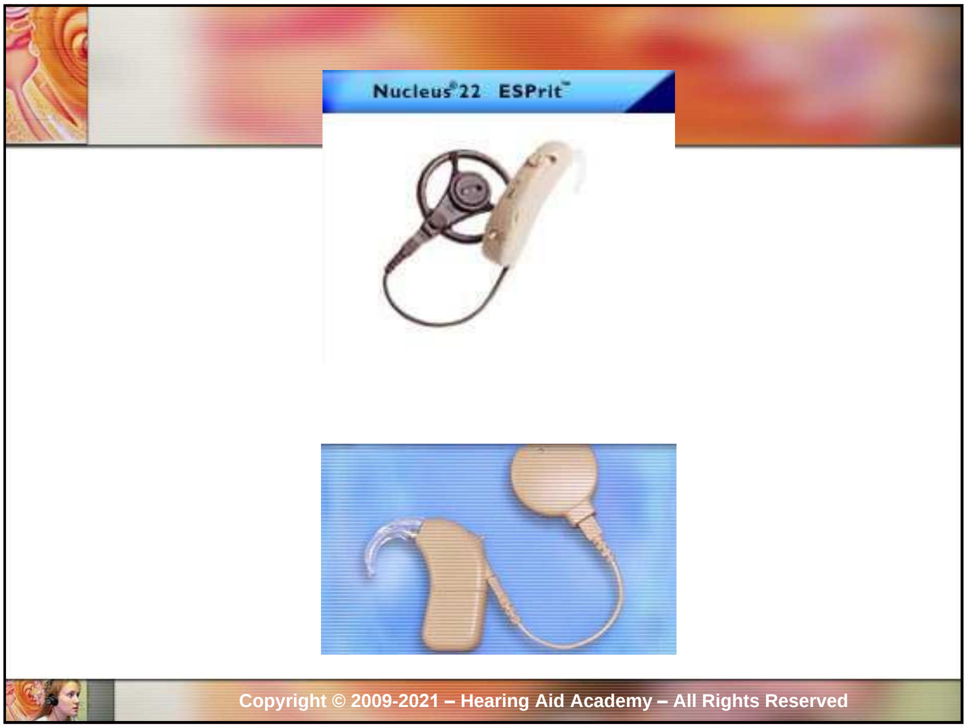
Cochlear™ Nucleus® 7 Sound Processor

Mechanics

- Contain 3 main parts:
- Microphone
- Speech processor
- Implanted electrode array

- Inner coil is placed in a cavity created in the skull during surgery
- Electrode array is place through a cochleostomy into the scala tympani
- Multichannel, multielectrode implants take advantage of the tonotopic organization of the cochlea



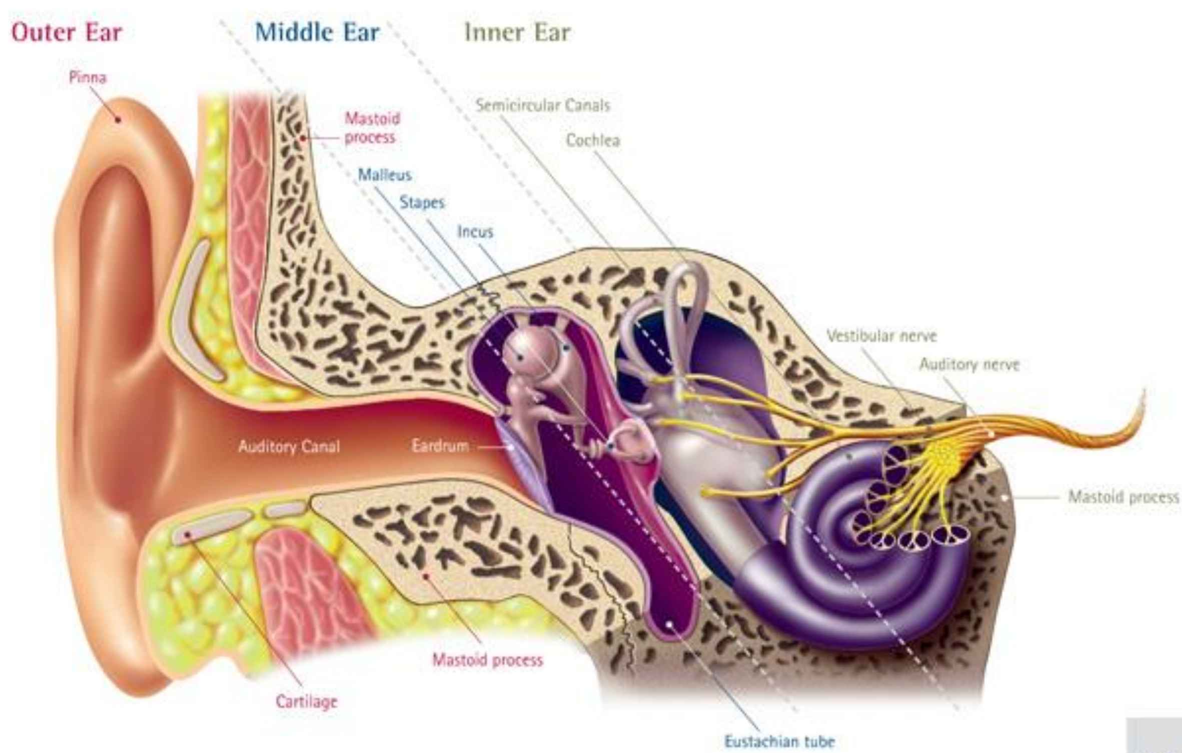


1. Coil
2. Coil Magnet
3. Coil Cable
4. Dual Omni Directional Microphones
5. Indicator Light
6. In-Built Telecoil
7. Buttons
8. Earhook
9. Processing Unit
10. Serial Number

Benefits

- Patient is able to hear conversation and environmental sounds at comfortable levels
- Detection of warning signals
- Almost all have improved lip reading
- Improved communication in quiet and noise without lip reading
- 35-51% can, with limited ability use the telephone.
- Sentence recognition scores improve in the majority of patients

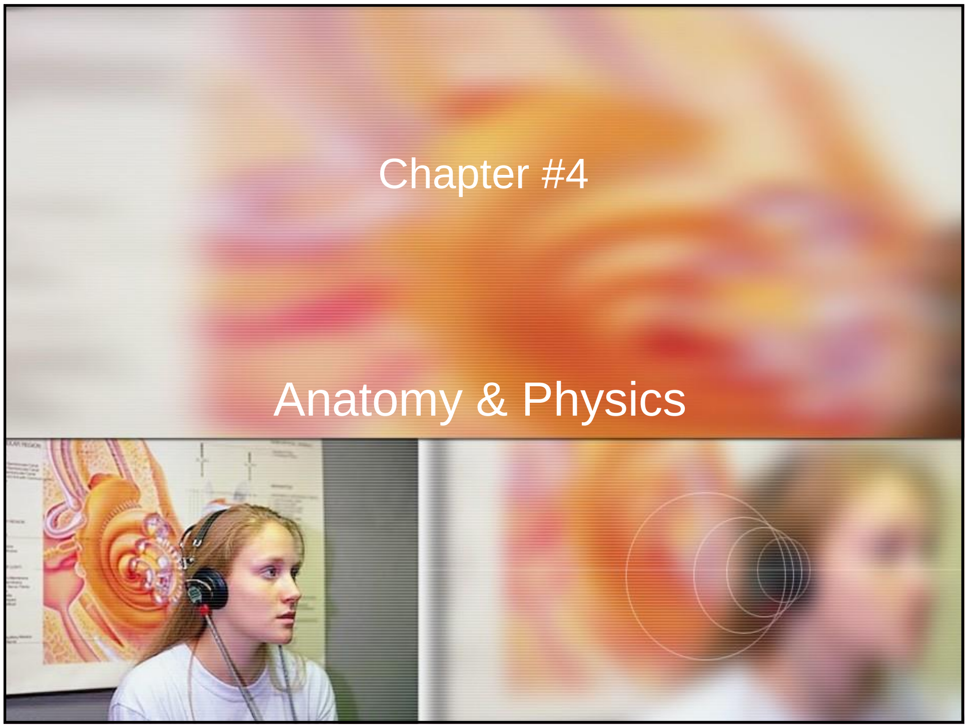
Anatomy of the Ear

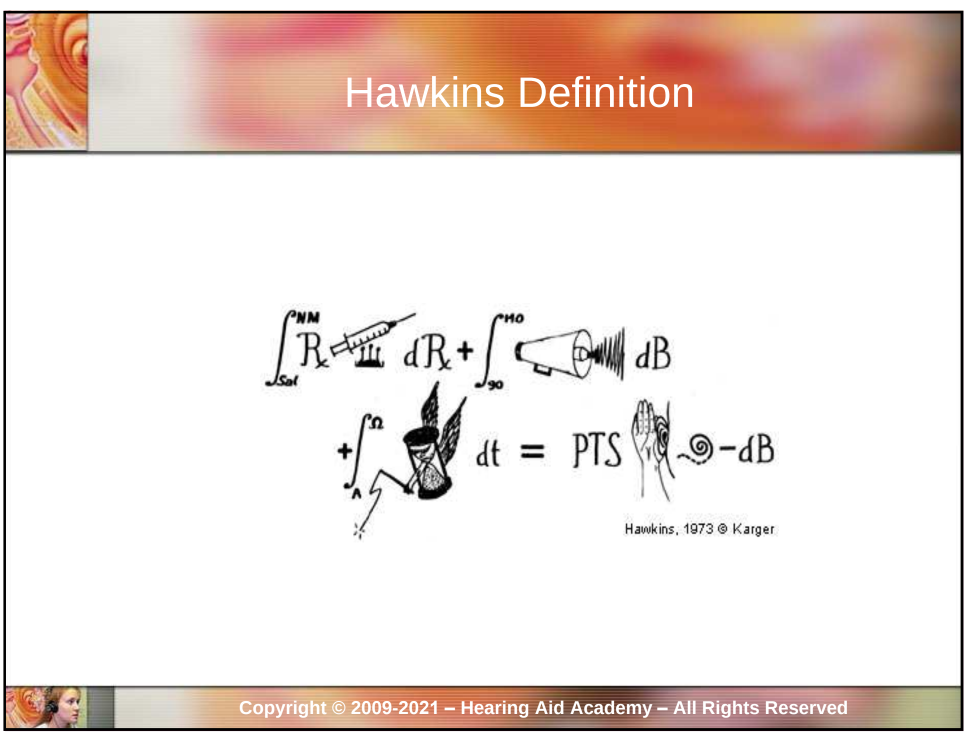


PHONAK life is on

www.phonak.co.uk

Chapter 4: Adult SNHL

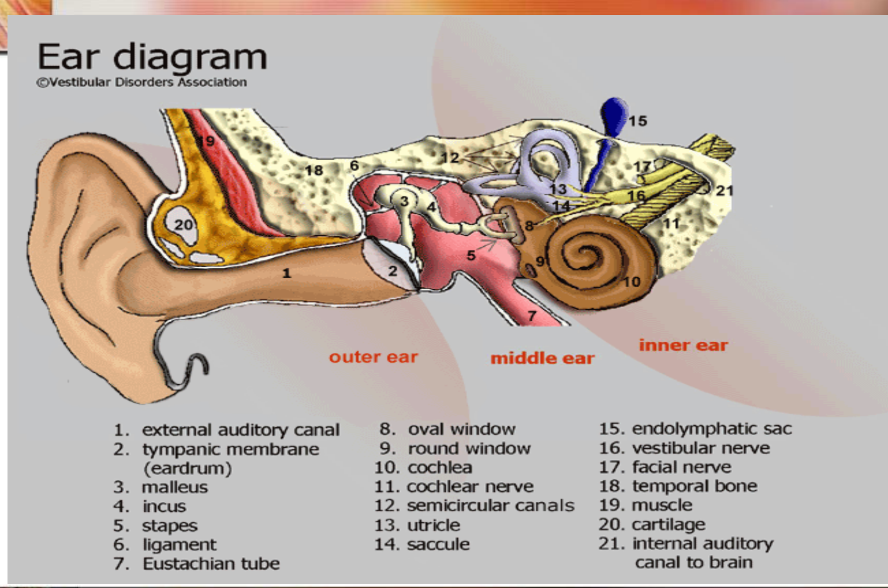




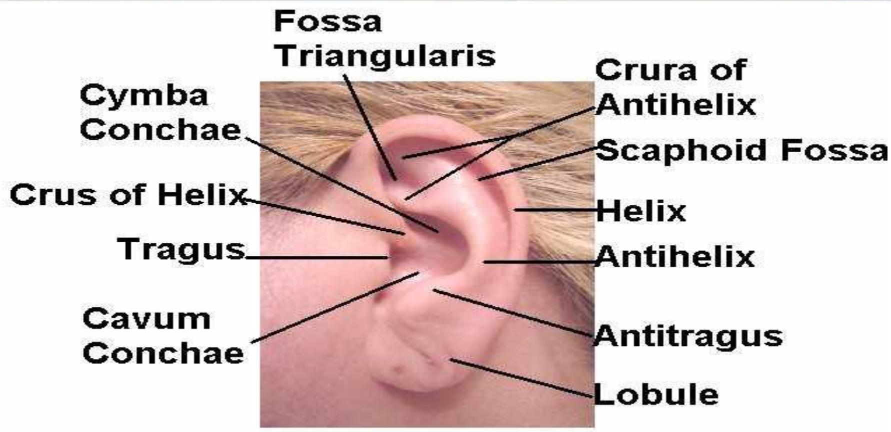
Anatomy & Physics

- Anatomy of the Ear
  - Outer (external)
  - Middle
  - Inner
  - Organ of Corti
  - Hair Cells
  - Auditory Pathways
- Physics of Sound
  - Basic Sound Waves
  - Intensity
  - Velocity
  - Wavelength (λ)
  - Frequency
  - Intensity
  - Measuring Sound

Anatomy – The Ear

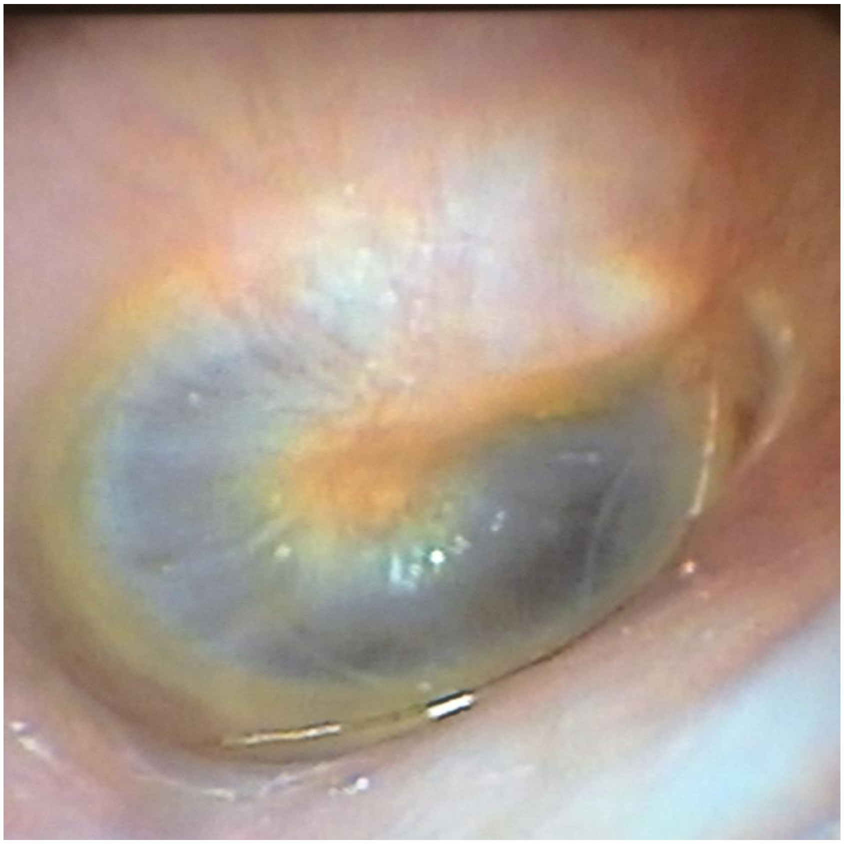


Detail View



Anatomy of the Pinna

Tympanic Membrane



Dennis Gunn's TM with white area at 2 o'clock!
It went away using Miracell ProEar drops!

Middle Ear

Incus (Anvil)

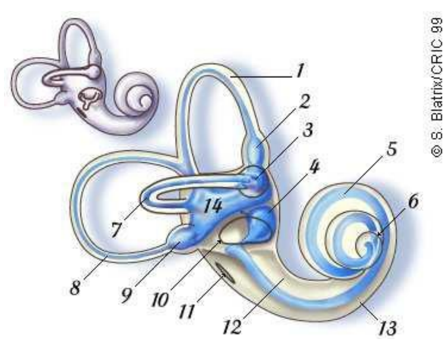
Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

Middle Ear

Stapes (Stirrup)

Inner Ear

Cochlea

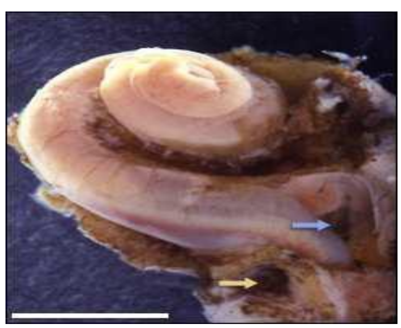


Cochlea

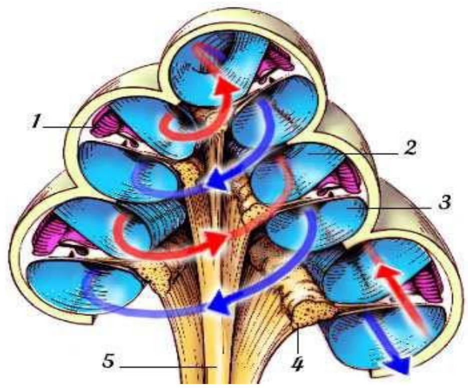
1. Anterior semicircular canal
2. Ampulla (superior canal)
3. Ampulla (lateral canal)
4. Sacculus
5. Cochlear Duct
6. Helicotrema
7. Lateral (horizontal) canal

8. Posterior canal
9. Ampulla (posterior canal)
10 Oval window
11. Round window
12. Vestibular duct (scala vestibuli)
13. Tympanic duct (scala tympani)
14. Utricle

Fetal Cochlea (20 Weeks)



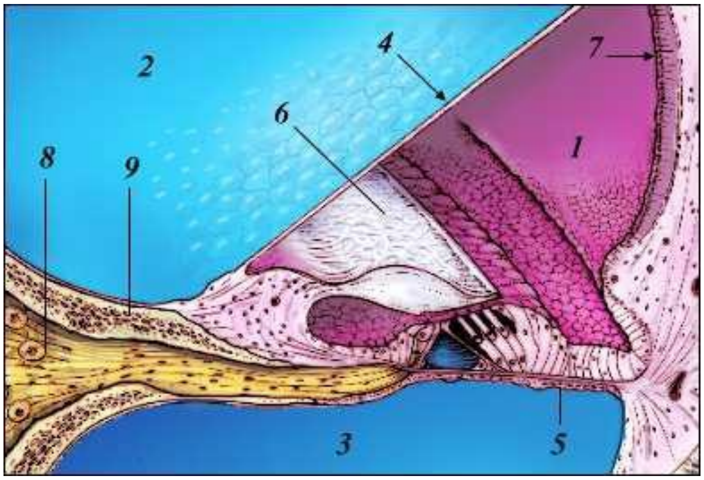
Cochlear Cross Section



CCS

This section shows the coiling of the cochlear duct (1) which contains endolymph, and the scala vestibuli (2) and scala tympani (3) which contain perilymph. The red arrow is from the oval window, the blue arrow points to the round window. Within the modiolus, the spiral ganglion (4) and auditory nerve fibers (5) are seen.

Cochlea – Single Turn

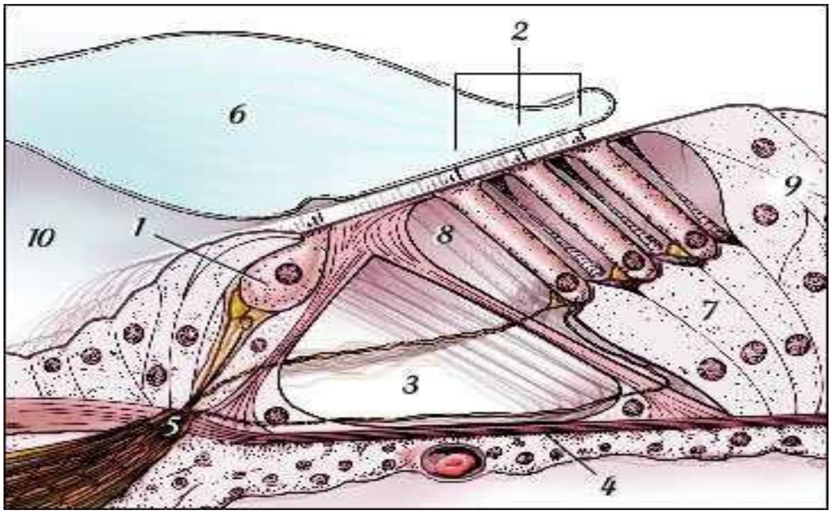


CST

(1) The cochlear duct is isolated from the

(2) scala vestibuli and (3) scala tympani by (4) Reissner's and (5) basilar membranes respectively. The organ of Corti is covered by the (6) tectorial membrane floating in the endolymph. The (7) stria vascularis and the (8) fibers going to the spiral ganglion through the bony (9) spiral lamina are also shown.

Organ of Corti



Organ of Corti

Seated on the basilar membrane, it is composed of the sensory cells, called hair cells, neurons, and several types of support cells.

1. Inner hair cells
2. Outer hair cell
3. Tunnel of Corti
4. Basilar membrane
5. Habenula perforata
6. Tectorial membrane
7. Deiters' cells
8. Space of Nuel
9. Hensen's cells
10. Inner spiral sulcus

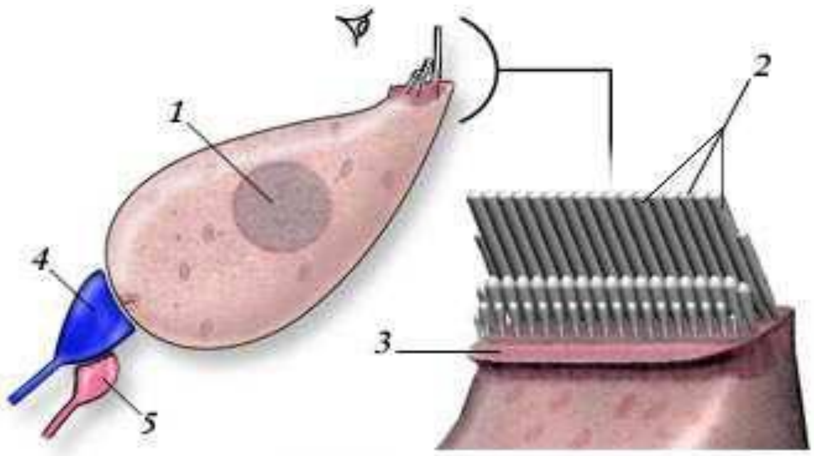
Hair Cells

Cochlear, as well as vestibular, sensory cells are called hair cells because they are characterized by having a cuticular plate with a tuft of stereocilia bathing in the surrounding endolymph.

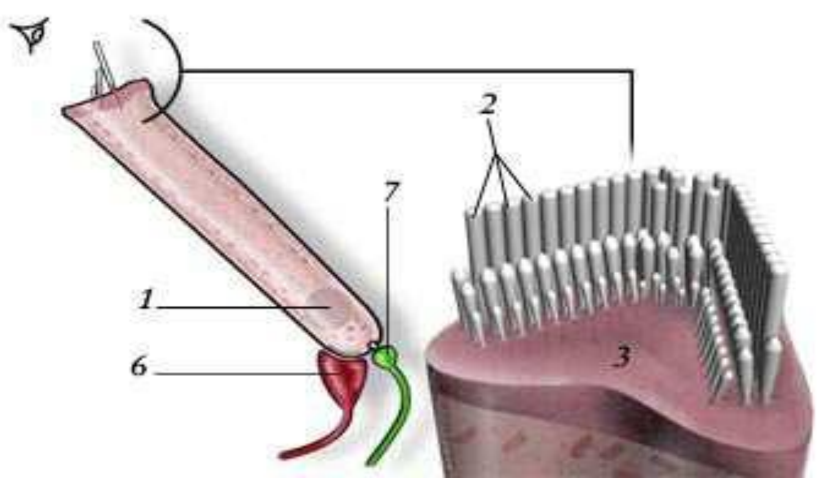
Hair Cells

The cell body itself is localized in the perilymph compartment. Schematically, both types of cells, inner hair cells (IHC's) and outer hair cells (OHC's), differ by their shape and the pattern of their stereocilia.

Inner Hair Cells



Outer Hair Cells



Inner Hair Cells

1 . Nucleus
2. Stereocilia
3. Cuticular plate
4. Radial afferent ending (dendrite of type I neuron)
5. Lateral efferent ending
6. Medial efferent ending
7. Spiral afferent ending (dendrite of type II neuron)

Note on Hair Cells

In the human cochlea, there are 3,500 IHC's and about 12,000 OHC's. This number is ridiculously low, when compared to the millions of photo-receptors in the retina or chemo-receptors in the nose! In addition, hair cells share with neurons an inability to proliferate after they are differentiated. This means that the final number of hair cells is reached very early in development (around 10 weeks of fetal gestation); from this stage on our cochlea can only lose hair cells.

Auditory Pathways

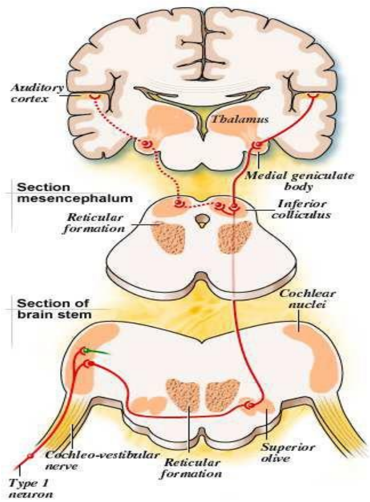
Auditory messages are conveyed to the brain via two types of pathway: the primary auditory pathway which exclusively carries messages from the cochlea, and the non-primary pathway (also called the reticular sensory pathway) which carries all types of sensory messages.

Primary Auditory Pathway

Schematically, this pathway is short (only 3 to 4 relays), fast (with large myelinated fibers), it ends in the primary auditory cortex.

The pathway carries messages from the cochlea, and each relay nucleus does a specific work of decoding and integration.

Primary Auditory Pathway



PAP

The first relay of the primary auditory pathway occurs in the cochlear nuclei in the brain stem, which receive Type I spiral ganglion axons (auditory nerve); at this level an important decoding of the basic signal occurs: duration, intensity and frequency.

PAP

The second major relay in the brain stem is in the superior olivary complex: the majority of the auditory fibres synapse there having already crossed the midline.

PAP

Leaving this relay, a third neuron carries the message up to the level of the mesencephalic (superior colliculus). These two relays play an essential role in the localization of sound.

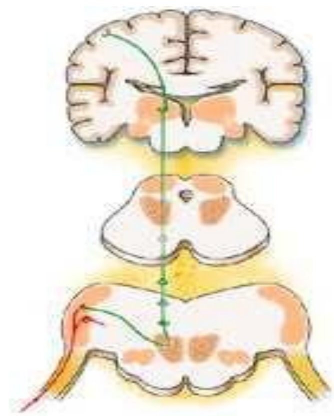
PAP

The final neuron of the primary auditory pathway links the thalamus to the auditory cortex, where the message, already largely decoded during its passage through the previous neurons in the pathway, is recognized, memorized and perhaps integrated into a voluntary response.

PAP

A final relay, before the cortex, occurs in the thalamus (median geniculate body); it's here that an important integration occurs: preparation of a motor response (eg vocal response).

Non-primary Auditory Pathway



NPAP

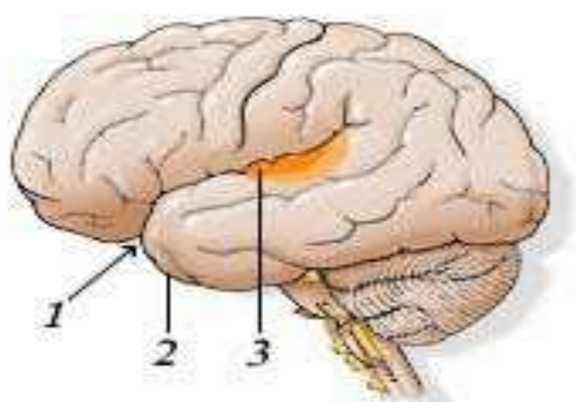
From the cochlear nuclei, small fibers connect with the reticular formation where the auditory message joins all other sensory messages. The next relay is in the non-specific thalamus nuclei before the pathway ends in the poly sensory (associative) cortex.

NPAP

The main function of these pathways, also connected to wake and motivation centers as well as to vegetative and hormonal systems, is to select the type of sensory message to be treated first. For instance, when reading a book while listening to a record, this system allows the person to pay attention alternately to the most important task.

Primary Auditory Cortex

The primary auditory cortex (3) is located in the temporal area (2) within the lateral sulcus (1).

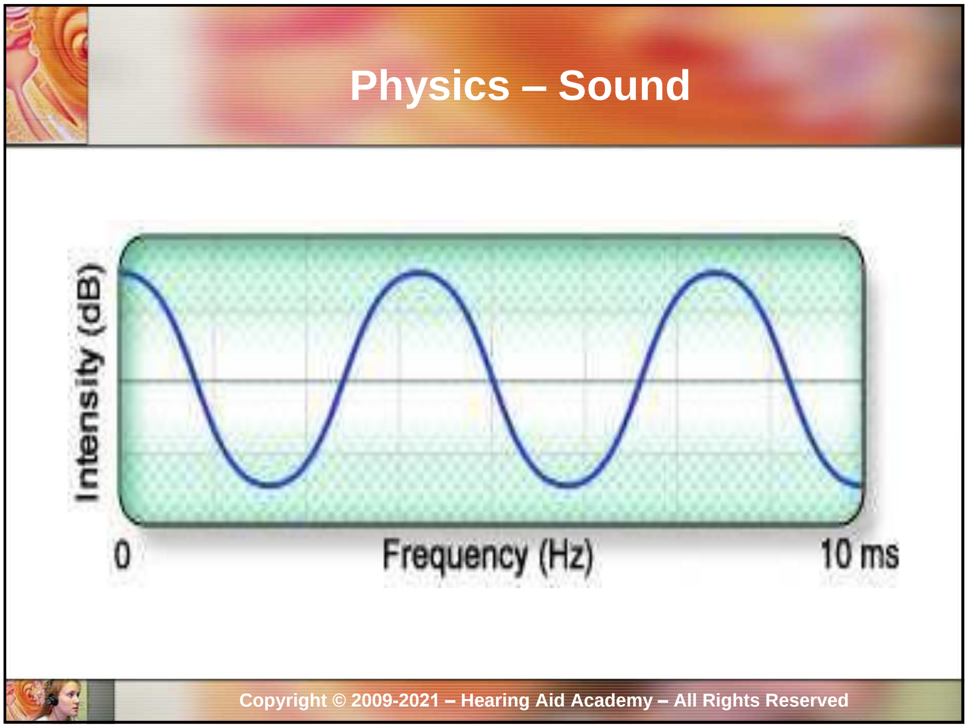


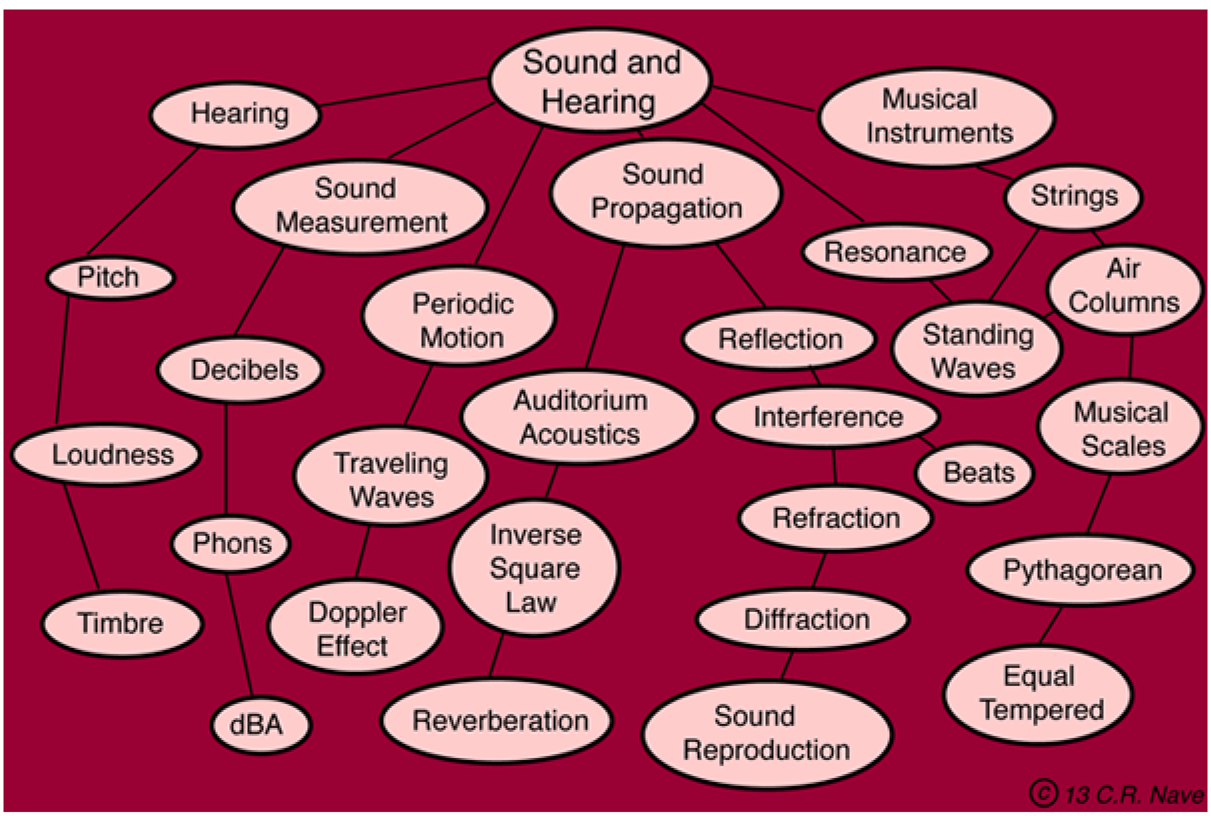
Sensation & Continuous Perception

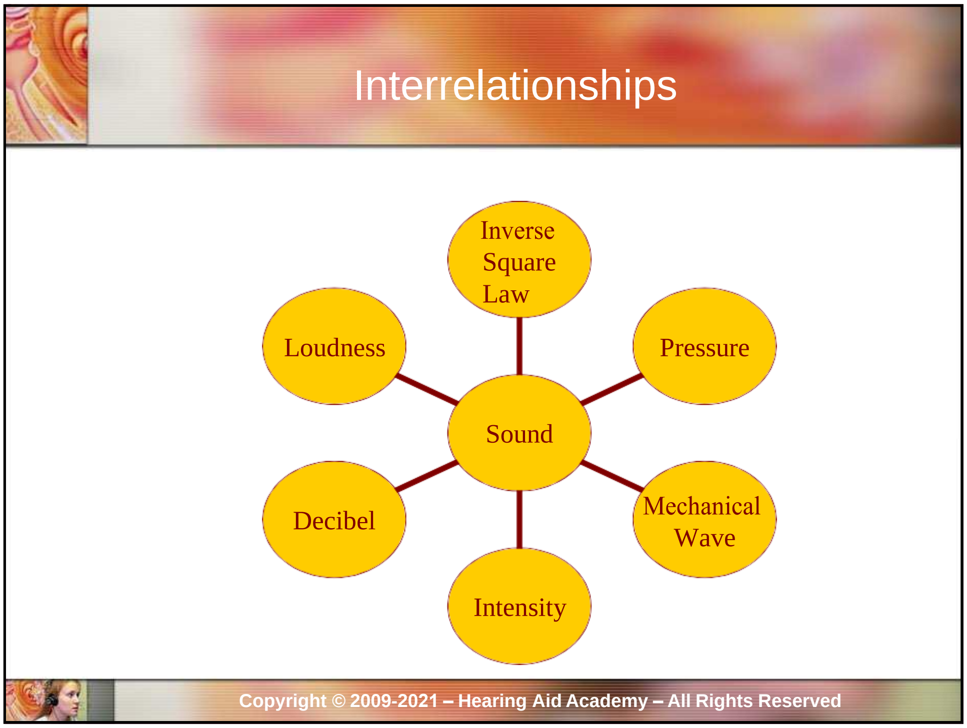
Conscious perception requires the integrity of both types of pathways. For instance, during sleep the primary auditory pathway functions normally, but no conscious perception is possible because the link between reticular pathways and wake motivation centers is inactive.

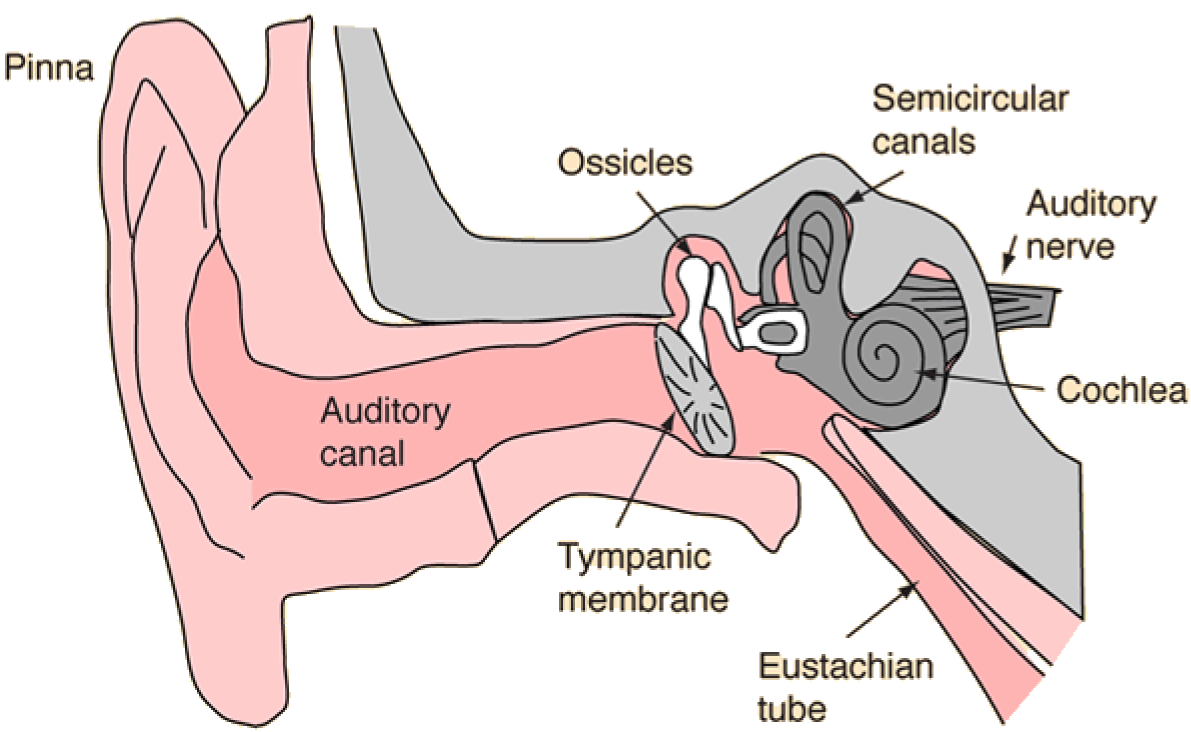
Sensation

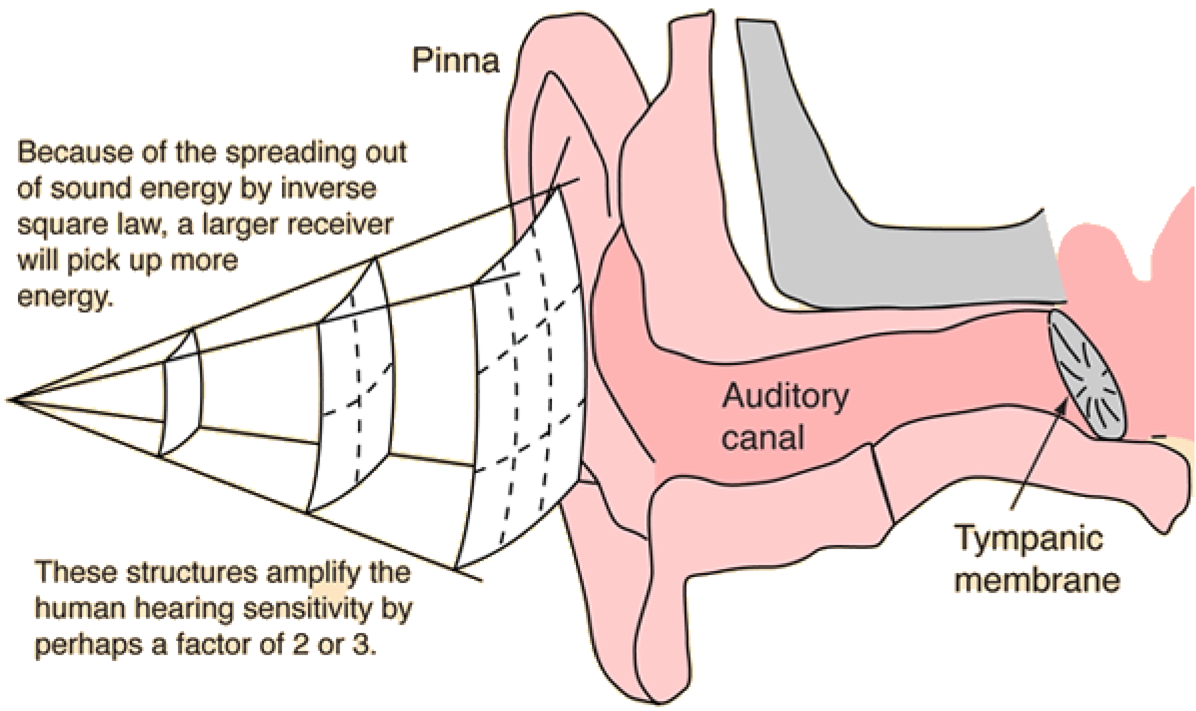
Conversely, trauma affecting the cortex may suppress the conscious perception, while the continuing integrity of the non- primary pathways may result in vegetative reflex reactions to sound. Because the brain stem and midbrain are intact, Preyer reflexes are still present.

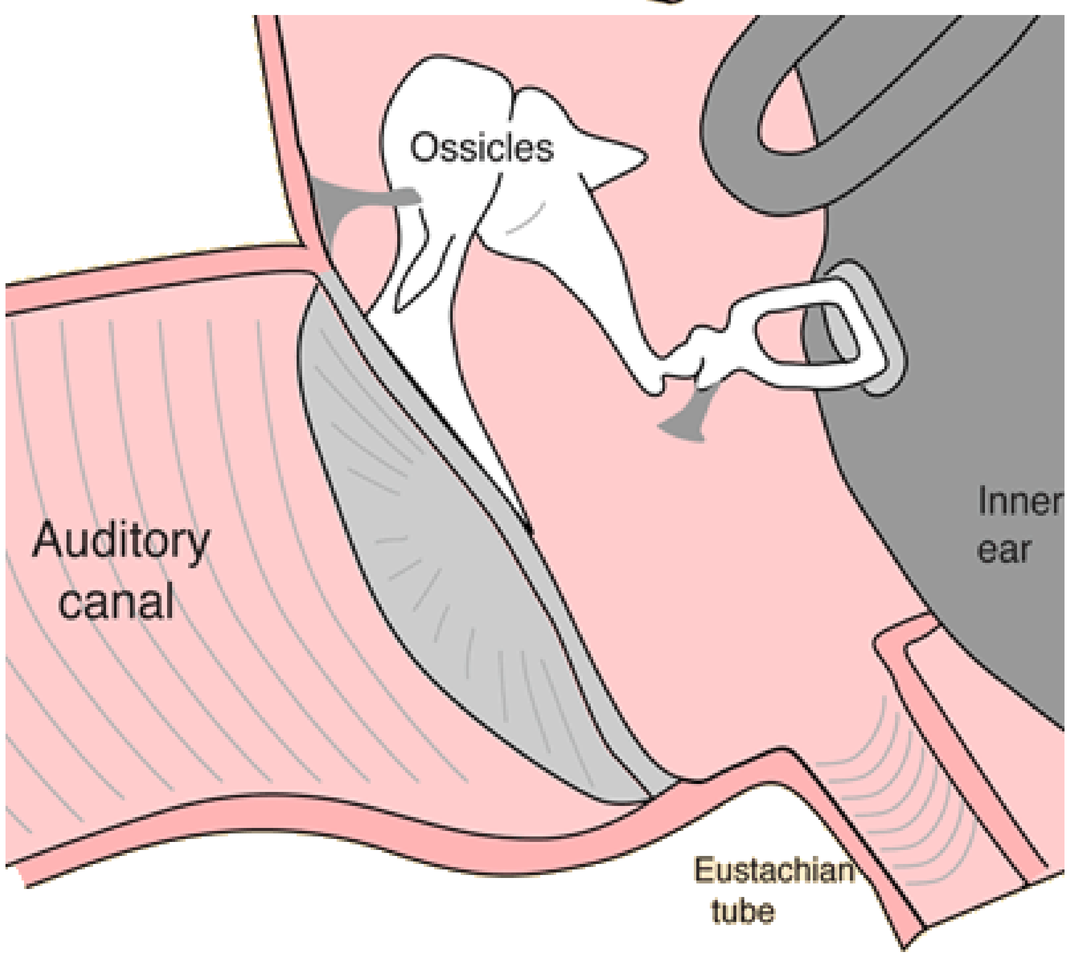

Physics – Sound
Intensity (dB)
0
Frequency (Hz)
10 ms
Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

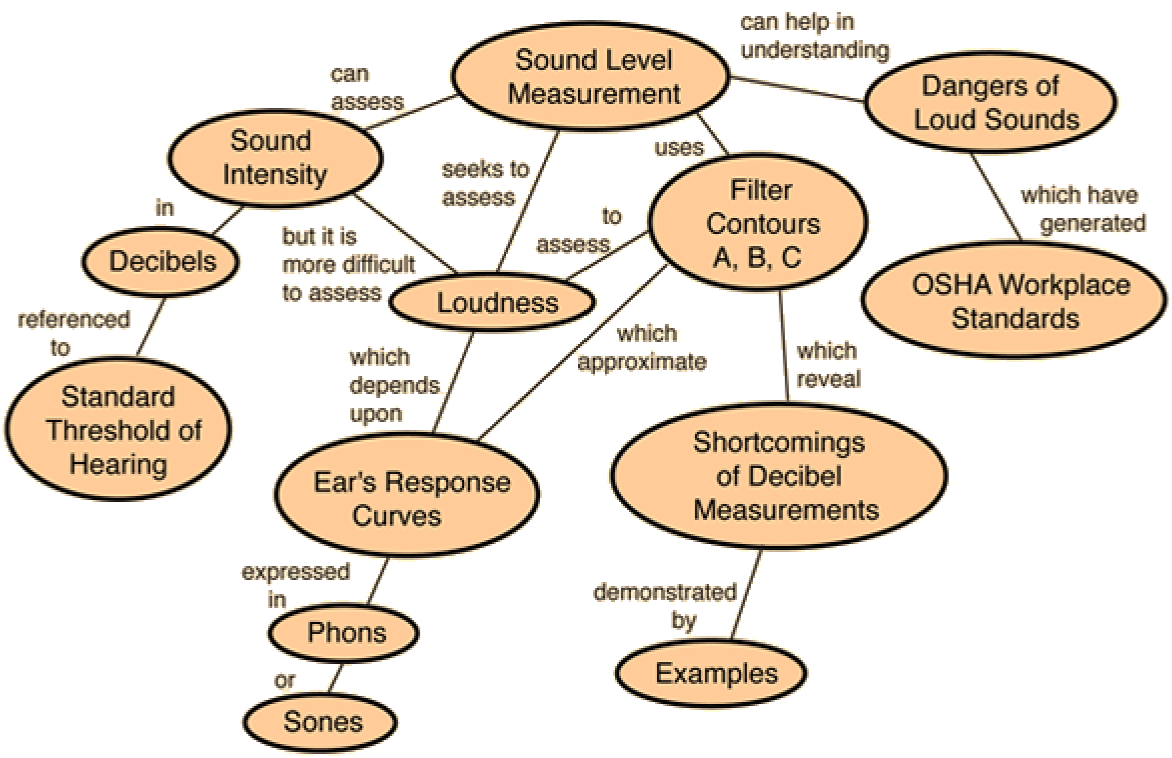

Sound and Hearing
Hearing
Musical Instruments
Sound Measurement
Sound Propagation
Strings
Pitch
Resonance
Air Columns
Periodic Motion
Reflection
Standing Waves
Decibels
Auditorium Acoustics
Interference
Musical Scales
Loudness
Traveling Waves
Beats
Phons
Inverse Square Law
Refraction
Pythagorean
Timbre
Doppler Effect
Diffraction
Equal Tempered
dBA
Reverberation
Sound Reproduction
© 13 C.R. Nave

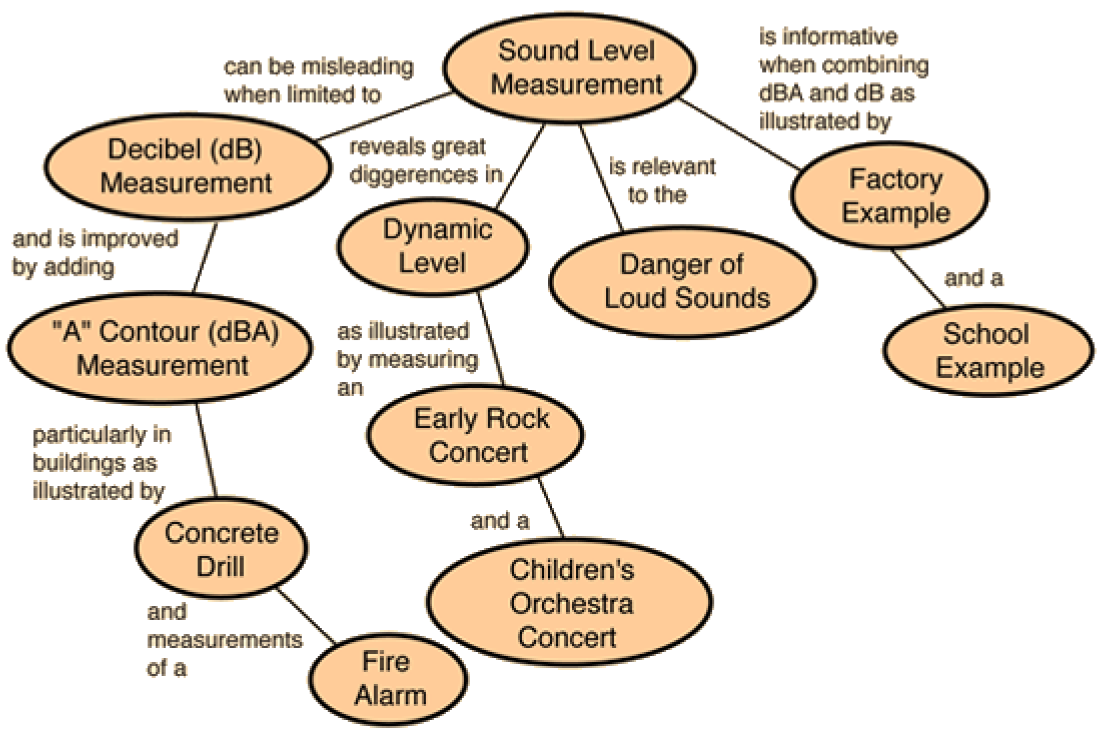

Interrelationships
Inverse Square Law
Loudness
Pressure
Sound
Decibel
Mechanical Wave
Intensity
Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved


Pinna
Semicircular canals
Ossicles
Auditory nerve
Cochlea
Auditory canal
Tympanic membrane
Eustachian tube


Pinna
Because of the spreading out of sound energy by inverse square law, a larger receiver will pick up more energy.
These structures amplify the human hearing sensitivity by perhaps a factor of 2 or 3.
Auditory canal
Tympanic membrane


Ossicles
Auditory canal
Inner ear
Eustachian tube





http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Definition of Sound

Usually "sound" is used to mean sound which can be perceived by the human ear, i.e., "sound" refers to audible sound unless otherwise classified.

Sound

A reasonably standard definition of audible sound is that it is a pressure wave with frequency between 20 Hz and 20,000 Hz and with an intensity above the standard threshold of hearing.

If sound is increased in intensity by a factor of 10,000, what is the change in decibels?

Decibels are based on the power of 10

$I_A \Rightarrow 10{,}000\ I_A \qquad 10^4$

40 dB

Why the factor of 10?

That makes it decibels. The change would be 4 Bels (named after Alexander Graham Bell). But 40 to 41 decibels is about the just noticeable difference in sound intensity. This makes the decibel a conveniently sized unit.

Decibels and Logarithms

The decibel scale is a reflection of the logarithmic response of the human ear to changes in sound intensity:

$$I(dB) = 10\log_{10}\left[\frac{I}{I_0}\right] \quad \text{Intensity in decibels}$$

The logarithm to the base 10 used in this expression is just the power of 10 of the quantity in brackets according to the basic definition of the logarithm:

$$\log_{10} x = \text{ the power to which you raise } 10 \text{ to get } x$$

Examples:

$$\log_{10} 100 = 2 \text{ since } 10^2 = 100 \qquad \log_{10} 10 = 1 \text{ since } 10^1 = 10$$

$$\log_{10} 1000 = 3 \text{ since } 10^3 = 1000 \qquad \log_{10} 1 = 0 \text{ since } 10^0 = 1$$

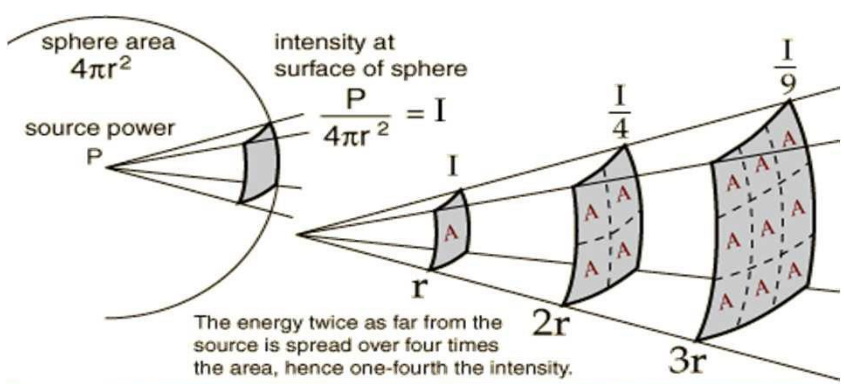
$$\log_{10} 1{,}000{,}000 = 6 \text{ since } 10^6 = 1{,}000{,}000$$

Definition of Sound

Since the ear is surrounded by air, or perhaps under water, the sound waves are constrained to be longitudinal waves. Normal ranges of sound pressure and sound intensity may also be specified.

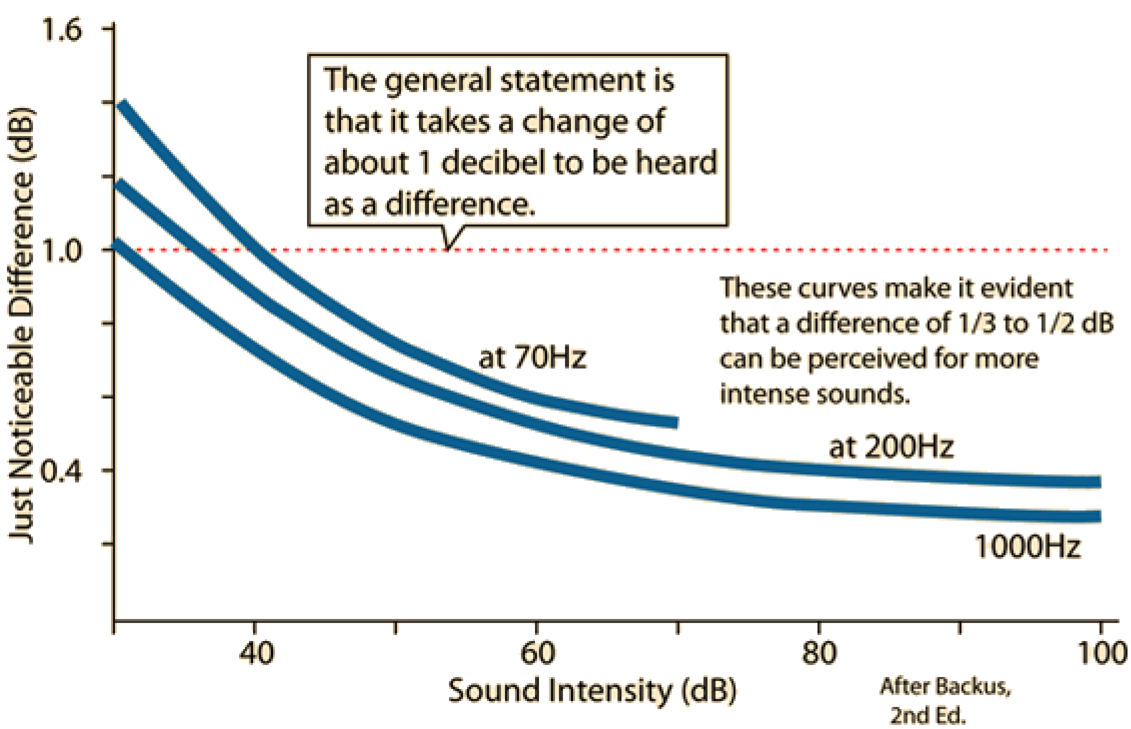
The Power of Sound

Sound's power declines over time due to how it radiates from its source in space.



Sound as a Mechanical Wave

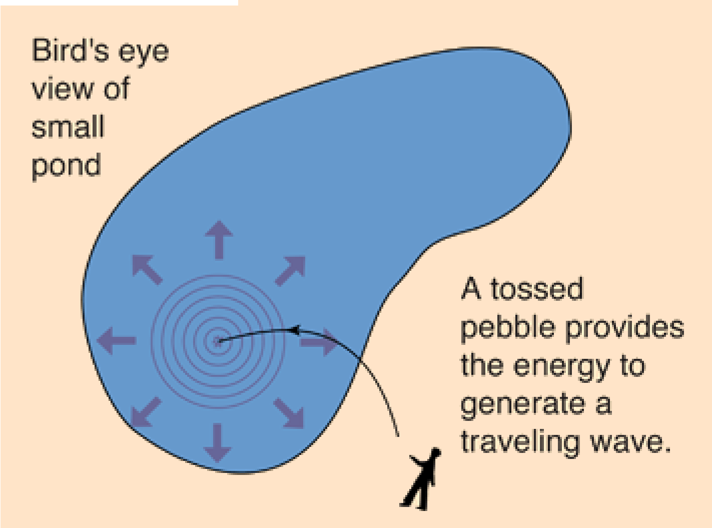
A mechanical wave is a wave which is not capable of transmitting its energy through a vacuum. Mechanical waves require a medium in order to transport their energy from one location to another. A sound wave is an example of a mechanical wave. Sound waves are incapable of traveling through a vacuum.



Sound as a Mechanical Wave

Slinky waves, water waves, stadium waves, and jump rope waves are other examples of mechanical waves; each requires some medium in order to exist. A slinky wave requires the coils of the slinky; a water wave requires water; a stadium wave requires fans in a stadium; and a jump rope wave requires a jump rope**.**

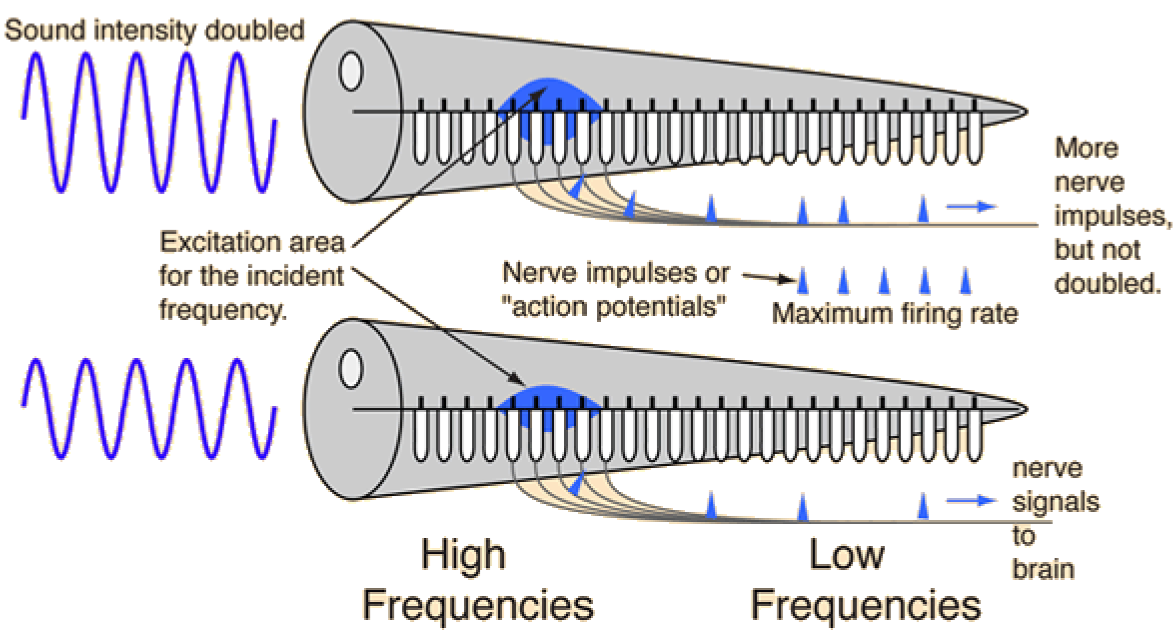
Waves on a Pond



Intensity

Sound intensity is defined as the sound power per unit area. The usual context is the measurement of sound intensity in the air at a listener's location. The basic units are watts/m^2 or watts/cm^2 . Many sound intensity measurements are made relative to a standard threshold of hearing intensity I_0:

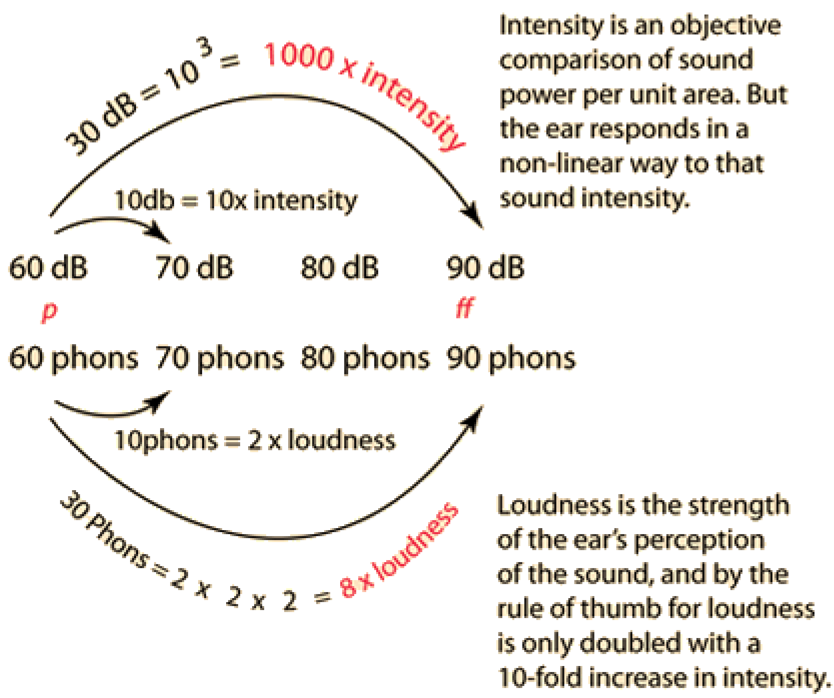
$$I_{o} = 10^{-12} \text{ watt/m}^2$$



Intensity

The most common approach to sound intensity measurement is to use the decibel scale:

$$I\ (dB) = 10 \log_{10} [I/I_o]$$



Intensity

Decibels measure the ratio of a given intensity I to the threshold of hearing intensity , so that this threshold takes the value 0 decibels (0 dB). To assess sound loudness, as distinct from an objective intensity measurement, the sensitivity of the ear must be factored in.

Decibels

The logarithm involved is just the power of ten of the sound intensity expressed as a multiple of the threshold of hearing intensity. Example: If I= 10,000 times the threshold, then the ratio of the intensity to the threshold intensity is 10^4, the power of ten is 4, and the intensity is 40 dB:

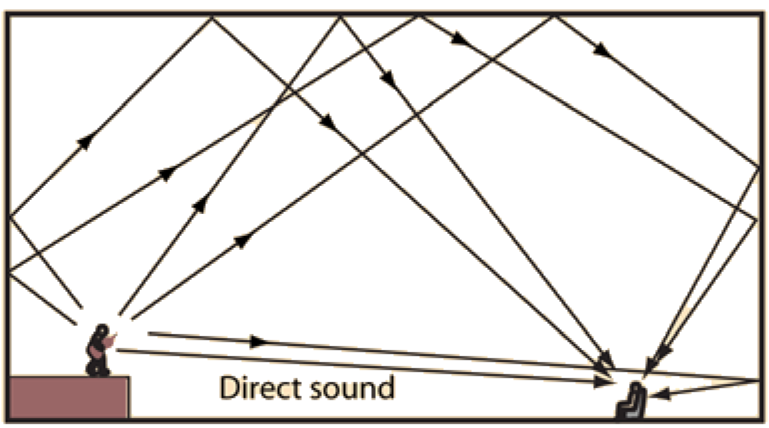
$$I(dB) = 10\log_{10}\left[\frac{10{,}000 I_0}{I_0}\right] = 10x4 = 40dB$$

Logarithms

$$I(dB) = 10 \log_{10} [10{,}000 I_o / I_o] = 10 \times 4 = 40 \text{ dB}$$

In this equation, the sound is increased by a factor of 10,000. What is the change in decibels? Decibels are based on the power of 10. Why the factor of 10? 10 decibels equal one Bel.

Since 40 to 41 decibels is about the just noticeable difference in sound intensity, the decibel becomes the most convenient unit to use.



Reflection of Sound

Intensity vs. Loudness

Loudness is <u>not</u> simply sound intensity!

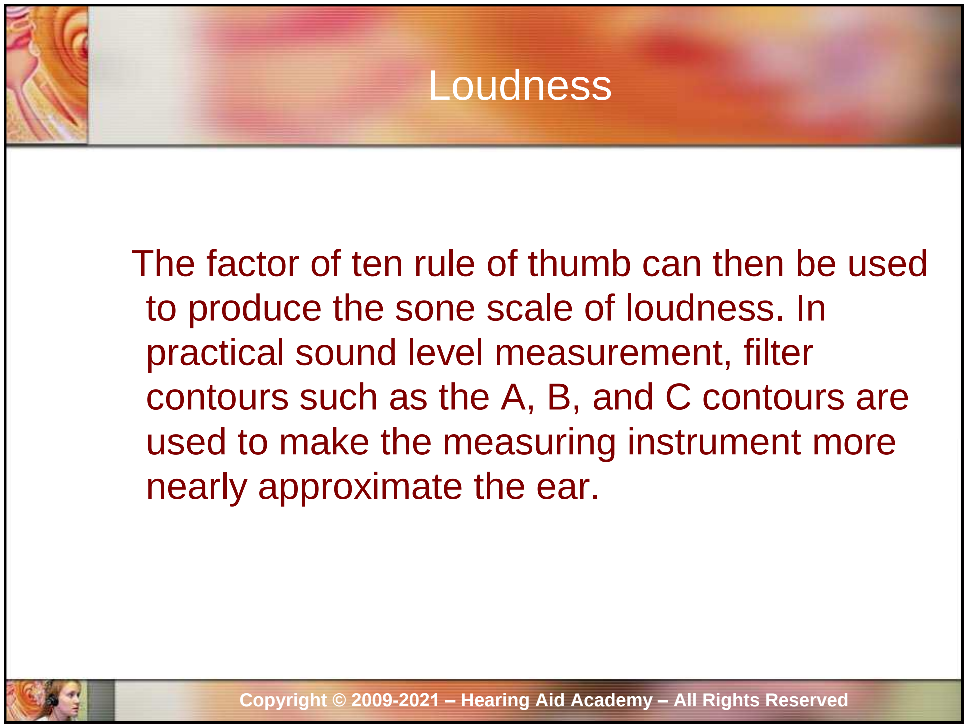
Sound loudness is a subjective term describing the strength of the ear's perception of a sound. It is intimately related to sound intensity but can by no means be considered identical to intensity.

Intensity

The sound intensity must be factored by the ear's sensitivity to the particular frequencies contained in the sound. This is the kind of information contained in equal loudness curves for the human ear. It must also be considered that the ear's response to increasing sound intensity is a "power of ten" or logarithmic relationship.

Loudness

This is one of the motivations for using the decibel scale to measure sound intensity. A general "rule of thumb" for loudness is that the power must be increased by about a factor of ten to sound twice as loud. To more realistically assess sound loudness, the ear's sensitivity curves are factored in to produce a phon scale for loudness.



Phons

Two different 60 decibel sounds will not in general have the same loudness

Saying that two sounds have equal intensity is not the same thing as saying that they have equal loudness. Since the human hearing sensitivity varies with frequency, it is useful to plot equal loudness curves which show that variation for the average human ear. If 1000 Hz is chosen as a standard frequency, then each equal loudness curve can be referenced to the decibel level at 1000 Hz. This is the basis for the measurement of loudness in phons. If a given sound is perceived to be as loud as a 60 dB sound at 1000 Hz, then it is said to have a loudness of 60 phons.

60 phons means "as loud as a 60 dB, 1000 Hz tone"

The loudness of complex sounds can be measured by comparison to 1000Hz test tones, and this type of measurement is useful for research, but for practical sound level measurement, the use of filter contours has been commonly adopted to approximate the variations of the human ear.

Phons

Two different 60 decibel sounds will not in general have the same loudness.

Saying that two sounds have equal intensity is not the same thing as saying that they have equal loudness. Since the human hearing sensitivity varies with frequency, it is useful to plot equal loudness curves which show that variation for the average human ear.

Phons

If 1000 Hz is chosen as a standard frequency, then each equal loudness curve can be referenced to the decibel level at 1000 Hz. This is the basis for the measurement of loudness in phons. If a given sound is perceived to be as loud as a 60 dB sound at 1000 Hz, then it is said to have a loudness of 60 phons.

Phons

60 phons means "as loud as a 60 dB, 1000 Hz tone."

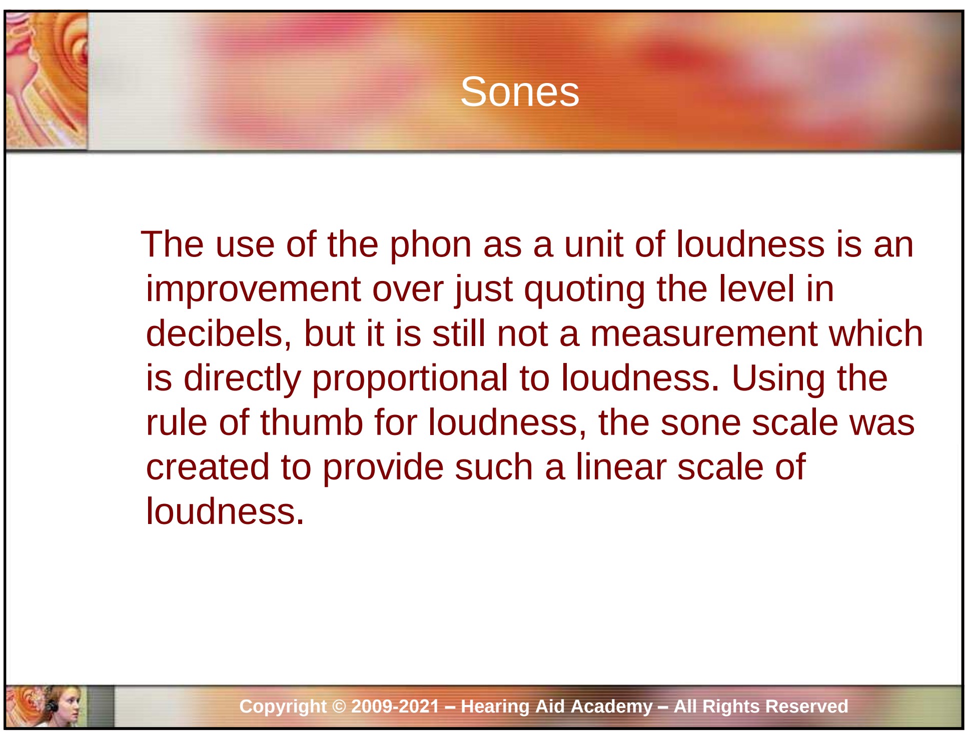
The loudness of complex sounds can be measured by comparison to 1000Hz test tones, and this type of measurement is useful for research, but for practical sound level measurement, the use of filter contours has been commonly adopted to approximate the variations of the human ear.

Sones

The use of the phon as a unit of loudness is an improvement over just quoting the level in decibels, but it is still not a measurement which is directly proportional to loudness. Using the rule of thumb for loudness, the sone scale was created to provide such a linear scale of loudness. It is usually presumed that the standard range for orchestral music is about 40 to 100 phons. If the lower end of that range is arbitrarily assigned a loudness of one sone, then 50 phons would have a loudness of 2 sones, 60 phons would be 4 sones, etc.

Dynamic Level	Phons	Sones
fff	100	64
...	90	32
f	80	16
...	70	8
p	60	4
...	50	2
ppp	40	1

http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

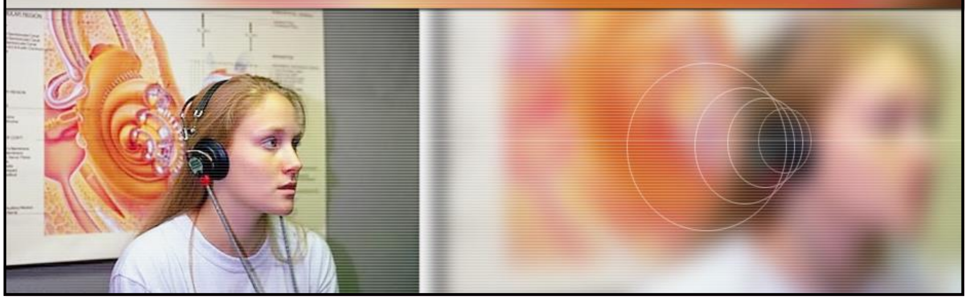


Sones

It is usually presumed that the standard range for orchestral music is about 40 to 100 phons. If the lower end of that range is arbitrarily assigned a loudness of one sone, then 50 phons would have a loudness of 2 sones, 60 phons would be 4 sones, etc.

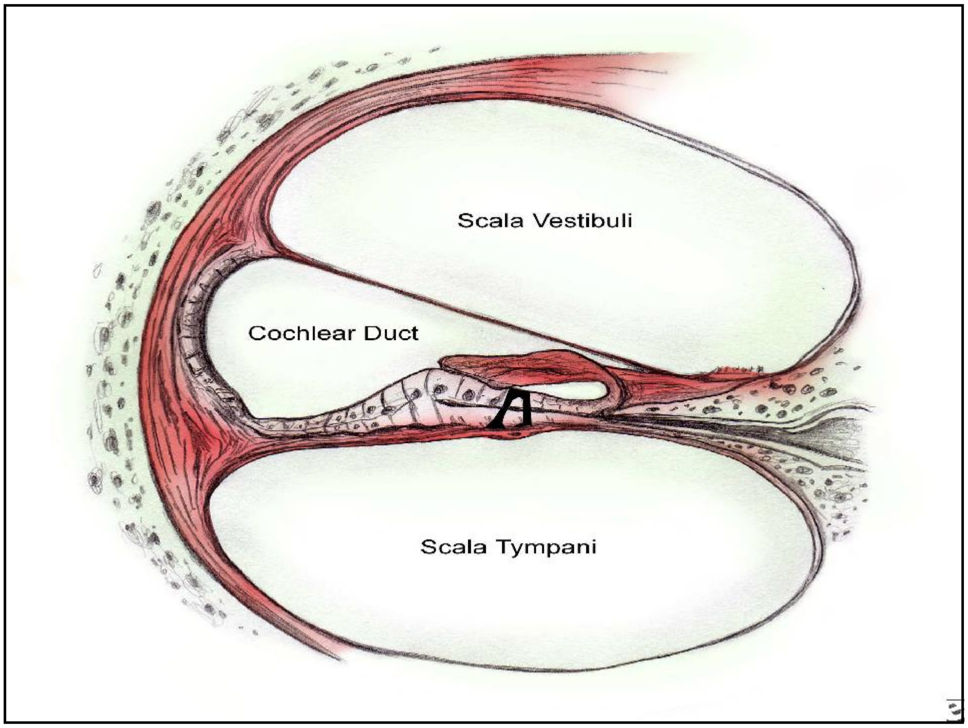
Chapter 5: Cochlear Physiology

Chapter #5
Cochlear Physiology



Introduction

- Function
- Conversion/Transduction
- Cochlear Focus



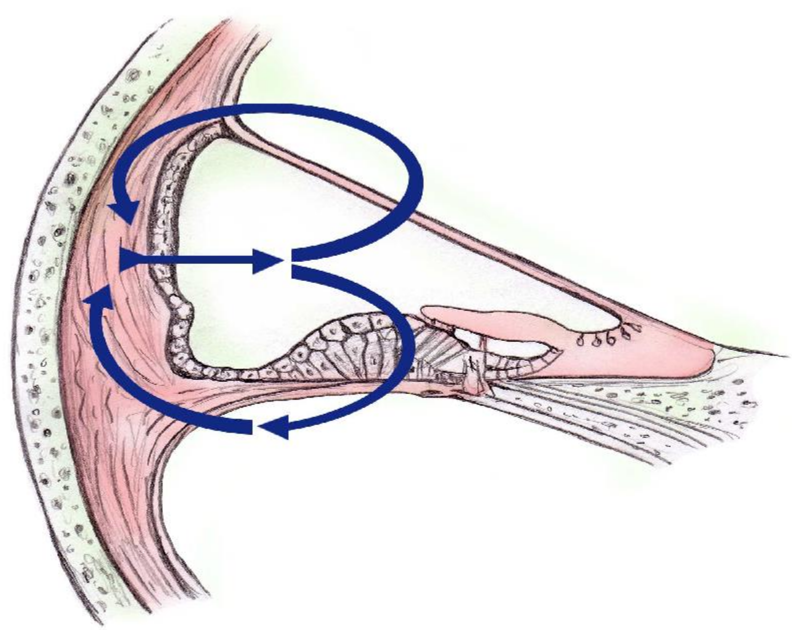
Cochlear Fluids

- Endolymph – Similar to intracellular fluids
- High in K^+ (Potassium)
- Low in Na^+ (Sodium) and Ca^{++} (Calcium)

- Perilymph – Similar to extracellular fluid
- High in Na^+ (Sodium)
- Low in K^+ (Potassium)

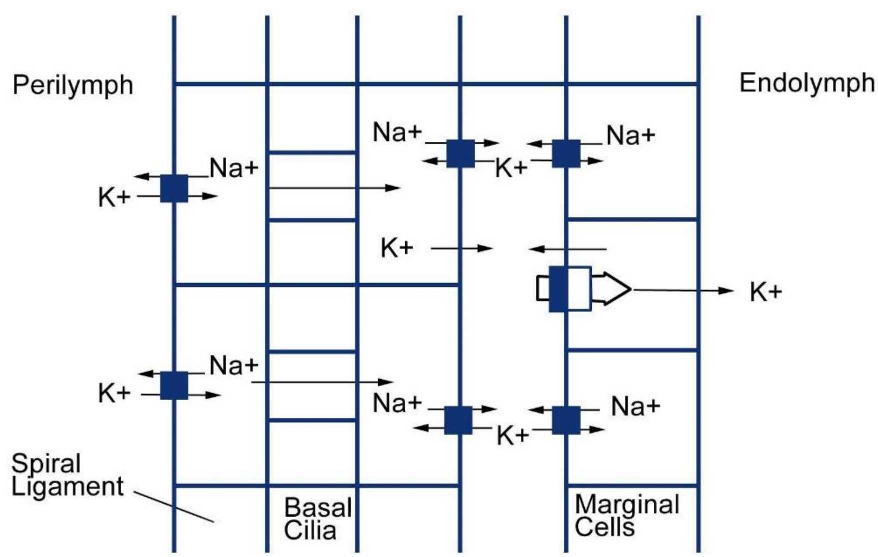
Electrolytic Content

- Radial flow of electrolytes

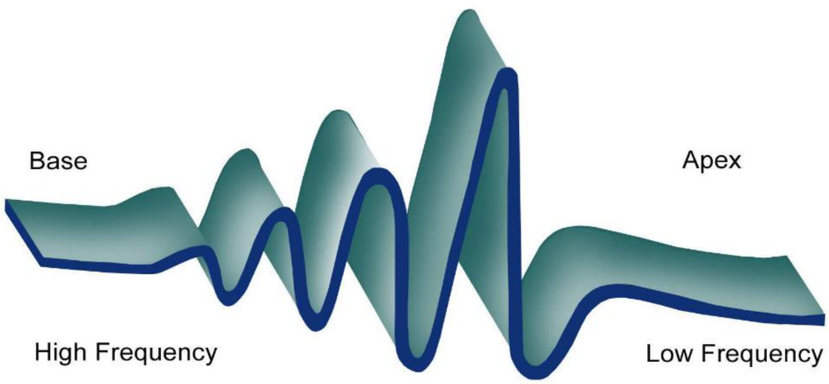


Divisions of Stria Vascularis

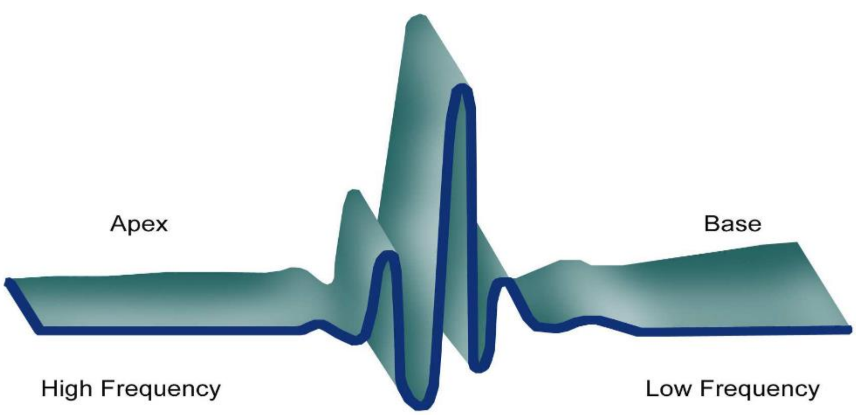
- Ionic Flow



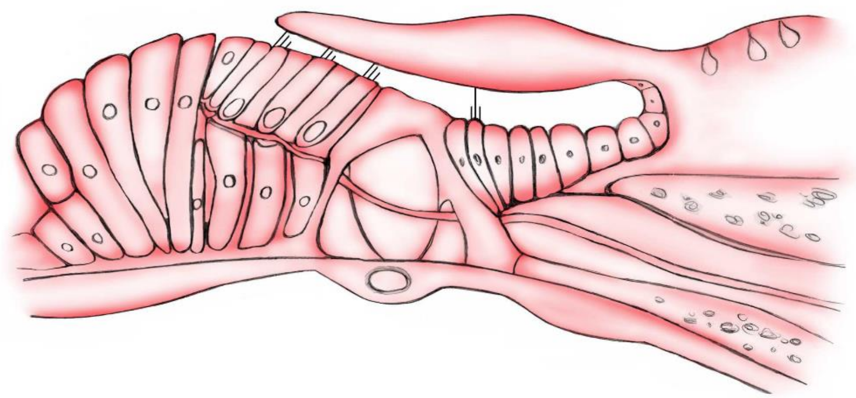
Basilar Wave Motion
Transduction of Signal



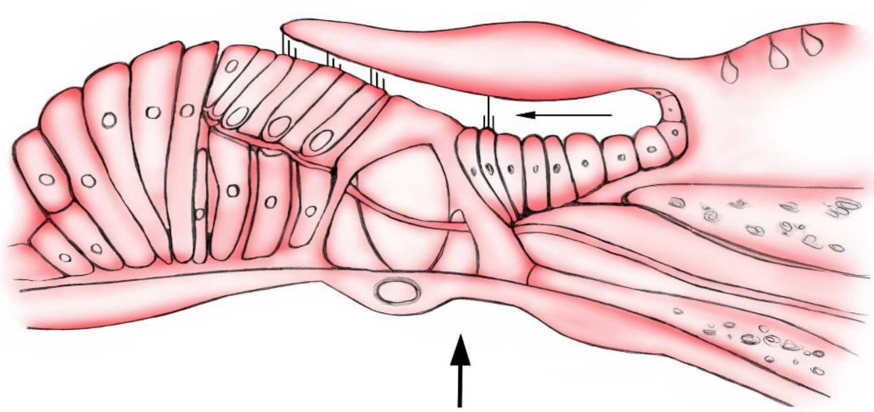
Basilar Membrane Function



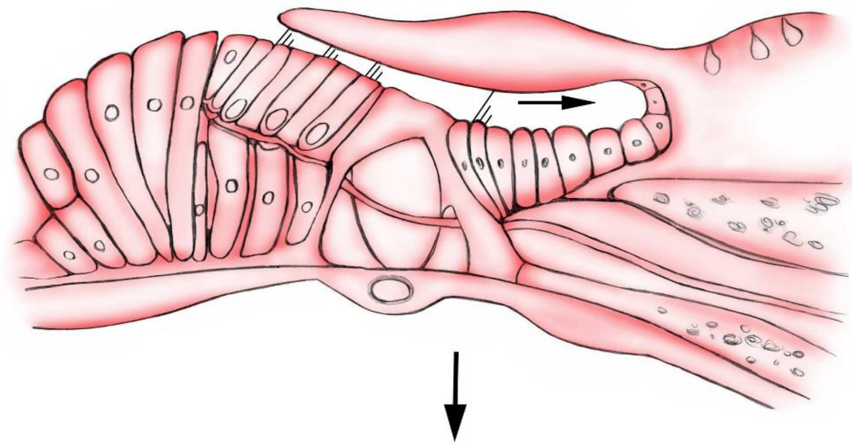
Organ of Corti at rest



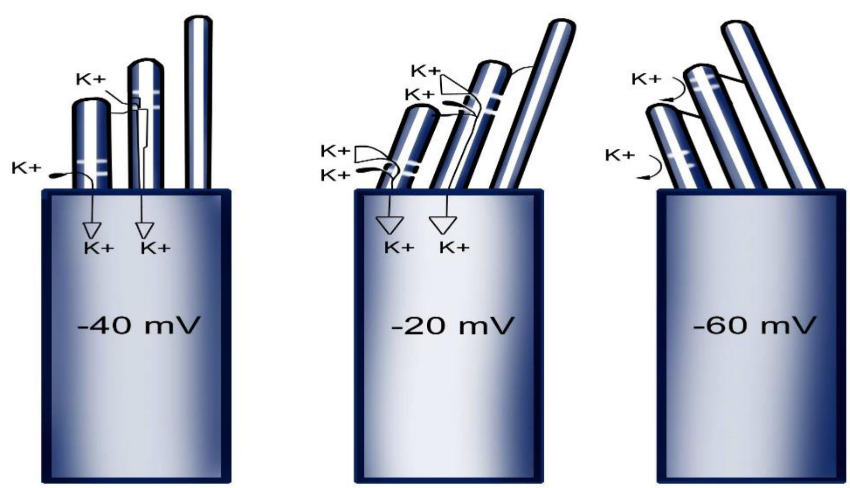
Organ of Corti during Depolarization



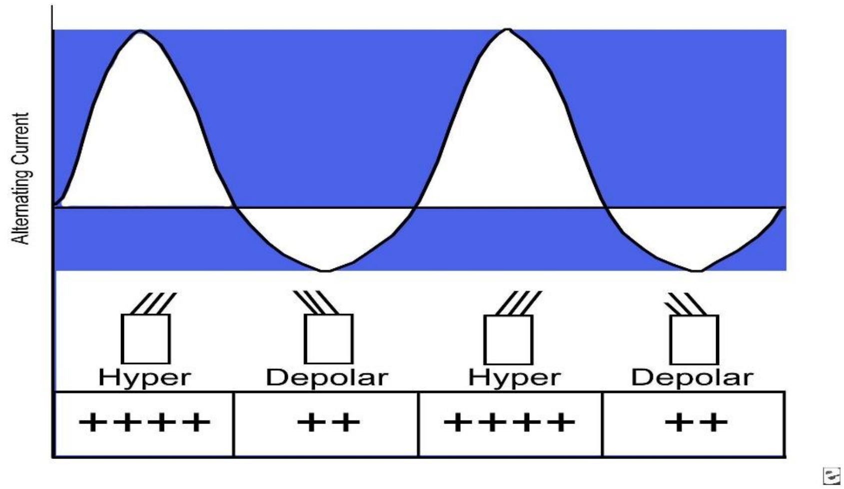
Organ of Corti during Hyperpolarization



Hair Cell Movement



Cochlear Current



Depolarization of Hair Cells

- Acoustic stimulation leads to depolarization of the hair cells.
- Depolarization magnitude is dependent upon stimulus intensity until saturation.
- Upon saturation, receptor potential does not change.
- The AC potential parallels f of stimulating sound wave.

Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

Stereociliar Motion

- Results in depolarization – hyperpolarization of HC.
- DC current shift in the baseline of HC potential can be recorded, too.
- Deflection of stereocilia ⇒ depolarization or hyperpolerization depending on the direction of the ciliar deflection.
- Magnitude of depolarization > magnitude of hyperpolarization.

Stereociliar Motion

- Thus, sine wave stimulation always results in a net DC depolarization of the cell.

Consequences – Depolarization of Inner Hair Cells

- Main role of IHC is to transduce acoustic stimulus into an electrochemical one where it ends at the CNS.
- 95% of afferent nerve terminals synapse on IHCs and transmit the SENSORY signal.
- Results in activation of voltage-dependent ion channels on lateral cell membranes.

Consequences – Depolarization of Inner Hair Cells

- Results in efflux of K+ from cell and influx of Ca++. Influx activates glutamate from cell's base.
- Glutamate, one of the salts of the proteinogenic amino acids, glutamic acid and is the most abundant excitatory neurotransmitter in the mammalian nervous system.

Glutamate

- At chemical synapses, glutamate is stored in vesicles. Nerve impulses trigger release of glutamate from the pre-synaptic cell. In the opposing post-synaptic cell, glutamate receptors, such as the NMDA receptor, bind glutamate and are activated. Because of its role in synaptic plasticity, it is believed that glutamic acid is involved in cognitive functions like learning and memory in the brain.

Glutamate

- Glutamate transporters[3] are found in neuronal and glial membranes. They rapidly remove glutamate from the extracellular space. In brain injury or disease, they can work in reverse and excess glutamate can accumulate outside cells.

What tastes so good?

- Ever hear of MSG, monosodium glutamate?
- Yep, same stuff. Discovered in 1908 by the Japanese.

Consequences – Depolarization of Inner Hair Cells

- Glutamate binds with the afferent nerve terminals at the base of the hair cell ⇒ AP down the nerve fibers. GLAST pick up the glutamate
- Action is key to sound localization

Consequences – Depolarization of Outer Hair Cells

- Depolarization of OHCs is similar to IHCs.
- OHCs are heavily innervated by efferent nerve fibers.
- OHCs provide cochlea with its fine tuning properties to the extent that specific tonotopic regions along the basilar membrane are tuned into one frequency.

Consequences – Depolarization of Outer Hair Cells

- OHCs amplify the incoming acoustic signal as a result of their capacity to change their lengths.
- The result of their change in length is □ E.
- Elongation and contraction from depolarization and depolarization displaces BM.
- IHC depolarization "(BM displacement which is dependent on [stimulus] and amplification of OHC.
- Amplification OHCs provide is frequency specific.

Movement of Outer Hair Cells

- OHCs have two types of motile response.
  - HF response driven by delta E (changes in CL^- concentration) which allows a 5% change in length.
  - Acetylcholine and protein motors act to change cell length due to changes in CL^- concentrations.

Movement of Outer Hair Cells

- This HF response works to mediate amplification of the acoustic stimulus.
- Depolarization ⇒ shortening and thickening of lateral cell membrane.
- Hyperpolarization ⇒ lengthening and thinning.

Fine Tuning of Hair Cells

- BM is tonotopic with a gradual decline of specific f's from base to apex.
- HCs respond to a specific resonance. This resonant f is due to the mechanical and electrical characteristics of the HC.

Effects of Efferent Stimulation on Cochlear Function

- CNS impacts cochlear function via olivocochlear bundles in the SOC.
- Medial olivocochlear bundles (myelinated) synapse on OHCs (efferent).

Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

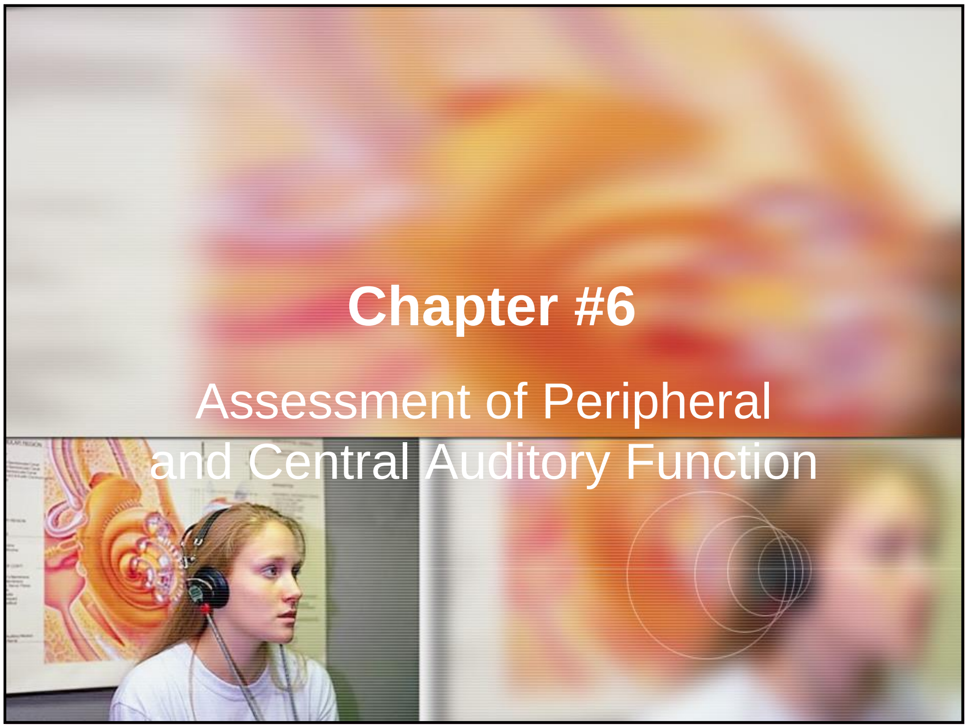
Effects of Efferent Stimulation on Cochlear Function

- Stimulation of these fibers decreases amplification provided by OHCs and stimulates release of ACh.
- This neurotransmitter, acetylcholine, mediates a change OHC receptor potential which decreases its ability to amplify basilar membrane motion.

Monitoring the Cochlear Response to an Acoustic Stimulus

- As far back as the 1970's, it was learned that OAEs generated in the OHC.
- A sinusoidal wave originating from BM vibration generated by OHC reversed its normal path and traveled back to the TM.

Chapter 6: Assessment of Peripheral & Central Auditory Function



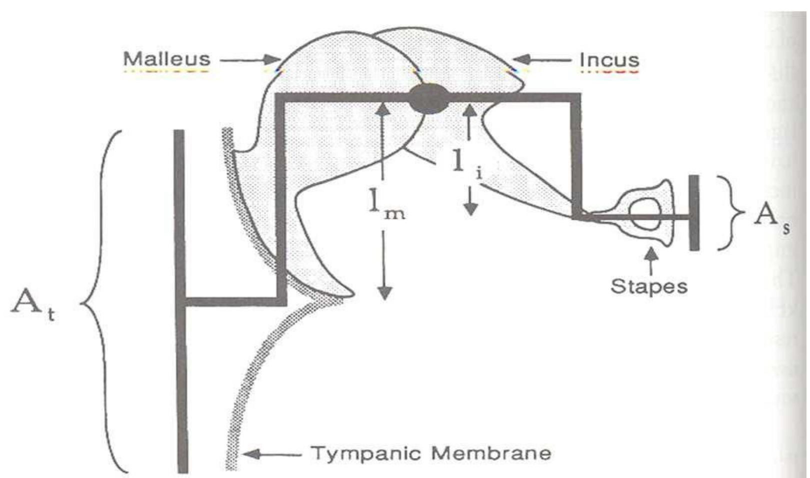
Objectives

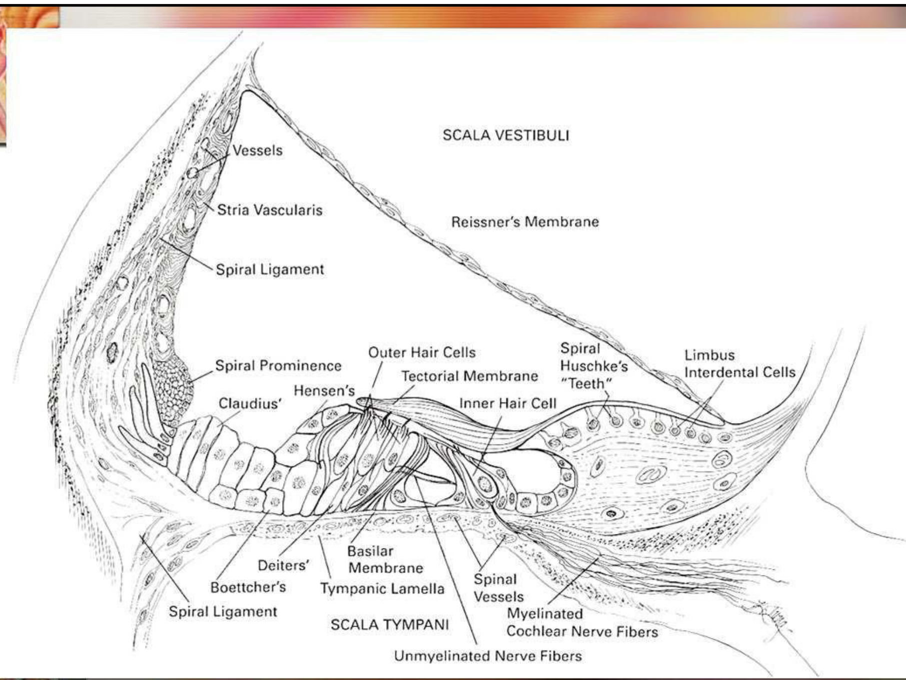
- Auditory Function
- Anatomy
- Tonotopic Organization
- Peripheral Auditory Assessment
- Key
- Audiogram Levels
- Speech Banana
- Crossover
- Masking
- Speech Audiometry
- Acoustic Immittance
- Tympanometry A,B, & C
- Acoustic Stapedial Reflex
- Auditory Brainstem Responses
- Electrocochleography EcoG
- OAE
- Central Auditory Processing

Auditory Function

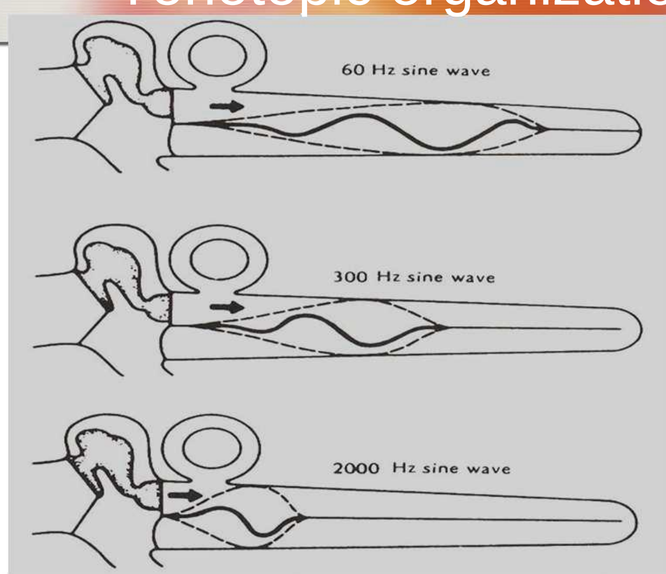
- Complex auditory pathway
- Peripheral Auditory Assessment
  - Basic armament of the otolaryngologist
- Central Auditory Assessment
  - Relatively new interest
  - Multidisciplinary

Ossicular Amplification





Tonotopic organization



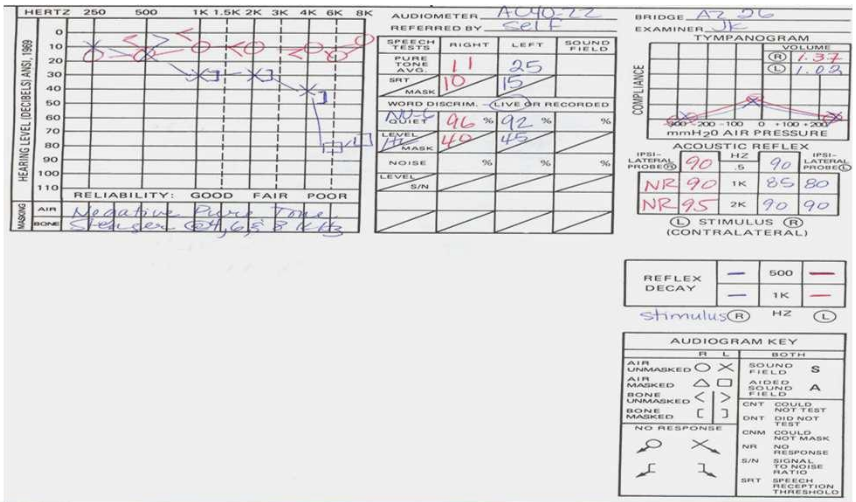
Peripheral Auditory Assessment

- Pure Tone Audiometry
- Speech Audiometry
- Acoustic Immittance
- Auditory Brainstem Responses
- Electrocochleography
- Otoacoustic Emissions

Pure Tone Audiometry

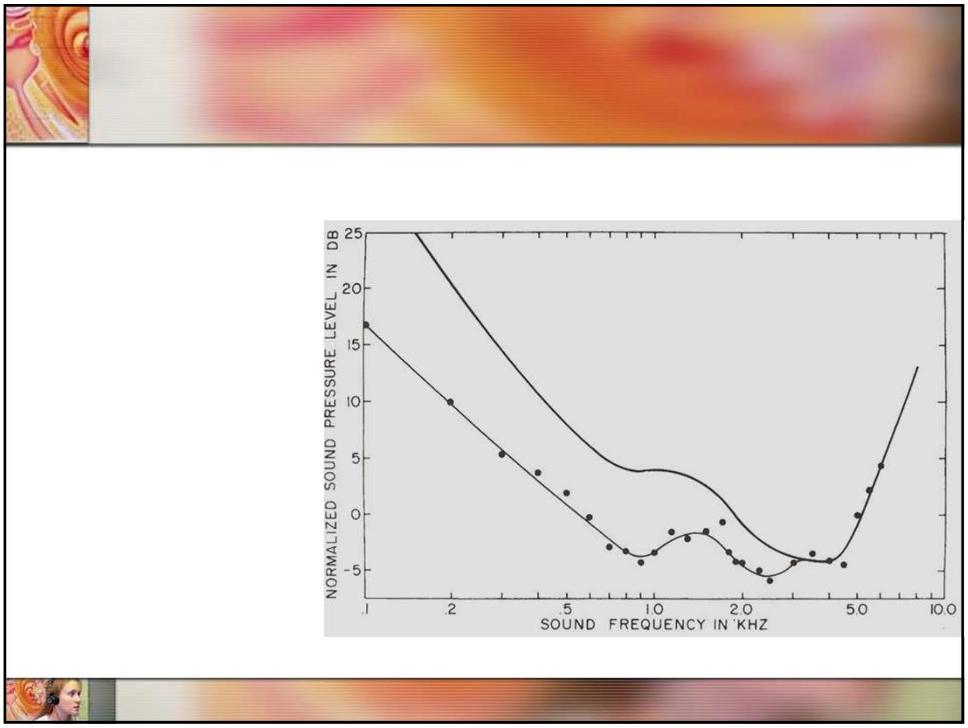
- Most common
- Pure tones (sinusoids) are tonotopically maintained by the cochlea.
- Air conduction testing
  - Octave frequencies
  - Interoctave frequencies
- Bone conduction testing

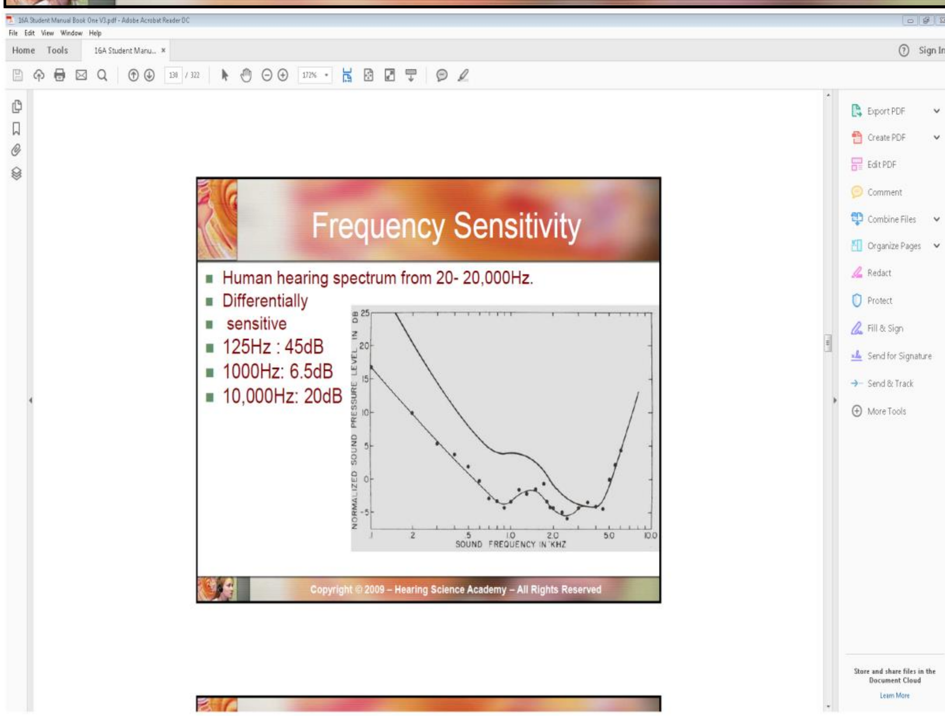
Pure Tone Audiometry



Decibel Scale

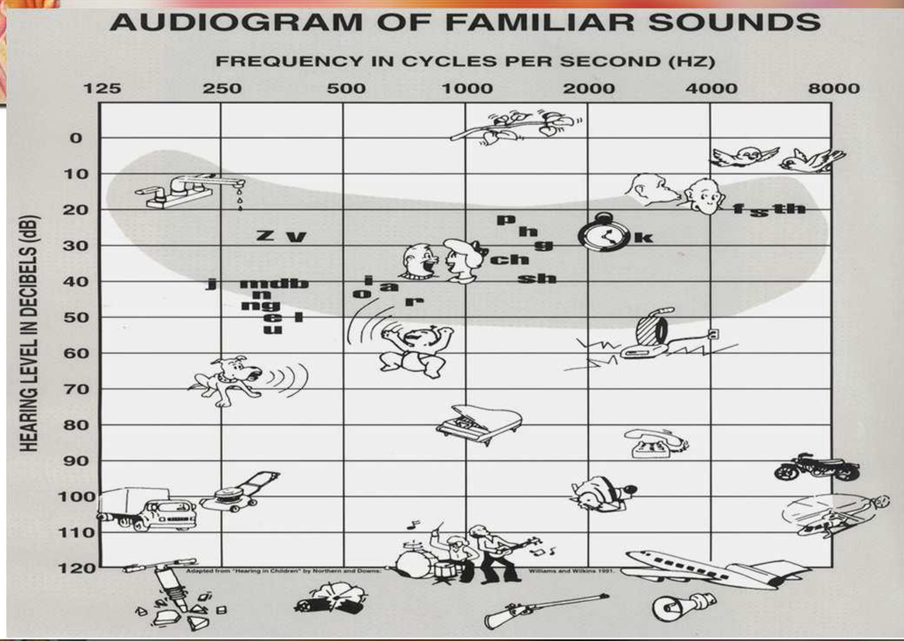
- Audiologic units
  - dB SPL: sound pressure level
  - dB HL: hearing level
  - dB SL: sensation level
- Audiometric 0
- dB= 10 log 10


NORMALIZED SOUND PRESSURE LEVEL IN DB
25
20
15
10
5
0
-5
.1
.2
.5
1.0
2.0
5.0
10.0
SOUND FREQUENCY IN KHZ


Frequency Sensitivity
Human hearing spectrum from 20- 20,000Hz.
Differentially
sensitive
125Hz : 45dB
1000Hz: 6.5dB
10,000Hz: 20dB
SOUND FREQUENCY IN KHZ
Copyright © 2009 – Hearing Science Academy – All Rights Reserved
Export PDF
Create PDF
Edit PDF
Comment
Combine Files
Organize Pages
Redact
Protect
Fill & Sign
Send for Signature
Send & Track
More Tools
Home
Tools
Sign In

Audiogram Levels

- Normal
  - 0 - 20dB
- Mild
  - 20 - 40dB
- Moderate
  - 40 – 60dB
- Severe
  - > 60 dB



Crossover

- Audiometric results are only valid when the results are actually of the test ear.
- Interaural attenuation reflects crossover.
- Air conduction from 40-80dB
- Bone conduction even at 0dB

Masking

- The audiometric technique used to eliminate responses by the non-test ear.
- An appropriate noise is presented to the non-test ear while the test ear is being tested.
- Masking level must exceed the non-test ear threshold, but not create crossover.

Speech Audiometry

- Determines how well a person hears and understands speech.
- Spondee words
- SRT
- SRT should be in close correlation with PTA.

132

Speech Audiometry

- Word recognition scoring %
- 20-50 Phonetically balanced words
- Conductive hearing loss
  - Excellent WRS
- Sensorineural hearing loss
  - Poor WRS
- Rollover

Auditory behavior index for infants

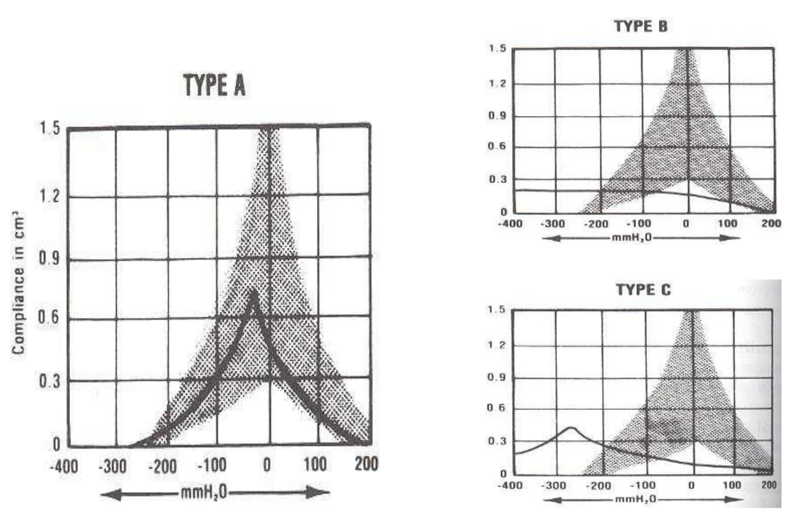
Table 5.3.
Auditory Behavior Index for Infants: Stimulus and Level of Response[a]

Age	Noisemakers (Approx. SPL)	Warbled Pure Tones (Re: dB HL)	Speech (Re: dB HL)	Expected Response	Startle to Speech (Re: dB HL)
0–6 wk	50–70 dB	78 dB	40–60 dB	Eye-widening, eye-blink, stirring or arousal from sleep, startle	65 dB
6 wk–4 mo	50–60 dB	70 dB	47 dB	Eye-widening, eye-shift, eye-blinking, quieting; beginning rudimentary head turn by 4 mo	65 dB
4–7 mo	40–50 dB	51 dB	21 dB	Head-turn on lateral plane toward sound; listening attitude	65 dB
7–9 mo	30–40 dB	45 dB	15 dB	Direct localization of sounds to side, indirectly below ear level	65 dB
9–13 mo	25–35 dB	38 dB	8 dB	Direct localization of sounds to side, directly below, ear level, indirectly above ear level	65 dB
13–16 mo	25–30 dB	32 dB	5 dB	Direct localization of sound on side, above and below	65 dB
16–21 mo	25 dB	25 dB	5 dB	Direct localization of sound on side, above and below	65 dB
21–24 mo	25 dB	26 dB	3 dB	Direct localization of sound on side, above and below	65 dB

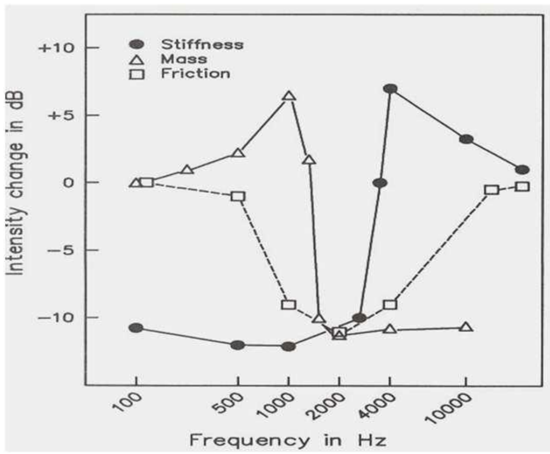
Acoustic Immittance

- Impedance: resistance to acoustic flow
- Admittance: ease of acoustic flow
- Tested by:
  - Tympanometry
  - Acoustic Stapedial Reflex

Tympanometry by Jerger



Stiffness vs. Mass



Acoustic Stapedial Reflex

- Lowest intensity required to elicit a stapedial muscle contraction.
- 3 primary acoustic reflex characteristics
  - Presence or absence of the reflex
  - Reflex threshold
  - Reflex Decay

Acoustic Reflex Decay

- Measures the ability of the stapedius muscle to maintain sustained contraction.
- Lower frequency tone/noise for 10 seconds

Acoustic Reflex in Cochlear Disorders

- Primarily determined by the degree of hearing loss.
- Less than 50dB: normal
- Between 50-80dB: proportionally elevated
- Greater than 50dB: absent

Acoustic Reflex
Tone vs. Noise

- Broadband Noise usually has 20-25dB lower thresholds than the reflex thresholds for tones.
- Physiologically not possible to have behavioral thresholds higher than acoustic reflex thresholds for tones. (malingerers)

Facial Paralysis

- Absent or abnormal stapedial reflex when the recording probe is ipsilateral to the side of the lesion.
- Can also be helpful in locating lesions proximal or distal to the stapedial muscle.

Eighth nerve lesions

- Absent reflexes when stimuli is presented to the affected ear.
- Reflexes in eighth nerve lesions are not dependent on the degree of hearing loss.
- Rapid reflex decay

Objectives

- Auditory Function
- Anatomy
- Tonotopic Organization
- Peripheral Auditory Assessment
- Key
- Audiogram Levels
- Speech Banana
- Crossover
- Masking
- Speech Audiometry
- Acoustic Immittance
- Tympanometry A,B, & C
- Acoustic Stapedial Reflex
- Auditory Brainstem Responses
- Electrocochleography EcoG
- OAE
- Central Auditory Processing

Auditory Brainstem Responses

- Impulses that are generated by the auditory neural pathway that can be recorded on the scalp.
- Not a direct measure of hearing.
- Detected as early as 25wks gestation.
- Not affected by sleep, sedation, or attention.

Click or Transient Evoked ABR

- Most widely used
- Moderate intensity levels with resultant firing of a wide range of neural frequency units.
- Repeatable Wave V to within 10dB of behavioral responses.
- Limited by frequency specificity

Tone Burst ABR

- More accurate results than click-evoked ABR
- Increased latency periods than click-evoked.

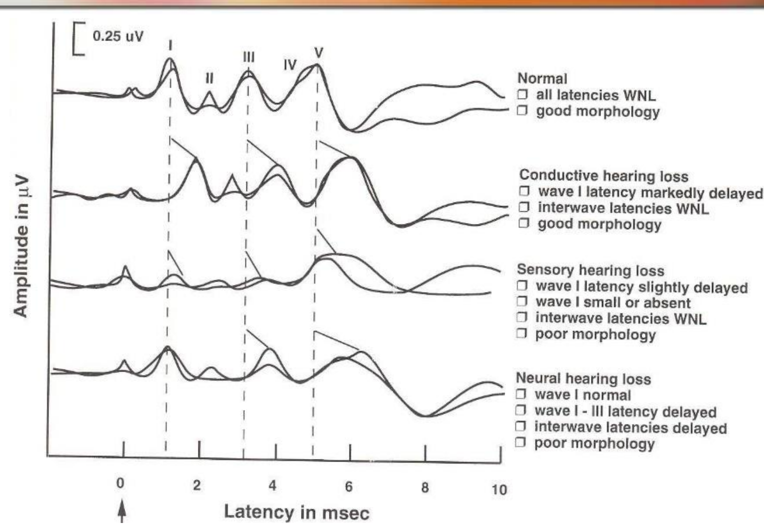
Bone Conduction ABR

- As reliable and repeatable as air conduction ABR.
- Particularly useful in structural abnormalities
-
  - Canal Atresia or stenosis: Absence of the ear canal or failure of the canal to be tubular or fully formed

ABR

- Primary goal is a clear and reliable Wave I
  - Wave I : distal 8th nerve
  - Wave II : proximal 8th nerve
  - Wave III : cochlear nuclei
  - Wave IV : SOC
  - Wave V : Lateral Lemniscus

ABR



ABR
Infant vs Adult

- Less waveform morphology
- Increased absolute and interwave latencies
- Should correct by 18-24 months of age.

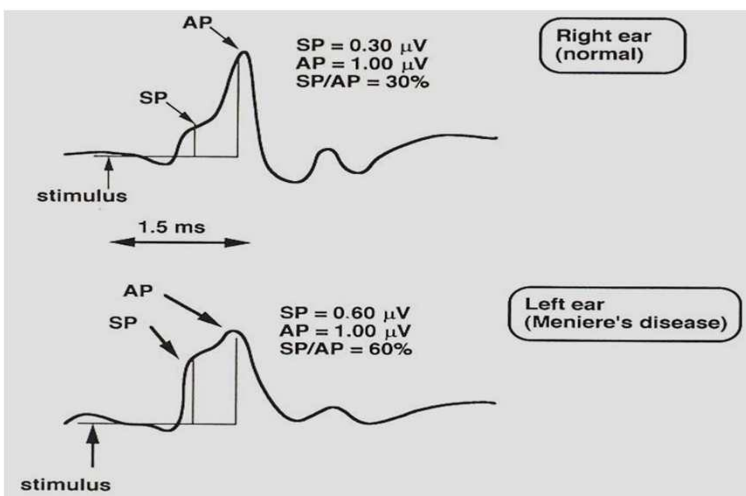
Electrocochleography
EcoG

- Measures stimulus related potentials of the most peripheral portions of the auditory system.
-
- 3 major components:
  - Cochlear microphonic
  - Summating potential
  - Action potential

EcoG
Electrode placement

- Noninvasive
  - Ear canal
    - >50%
  - Tympanic membrane
    - >40%
- Invasive
  - Transtympanic
    - >30%

EcoG
Meniere's disease



Otoacoustic Emissions

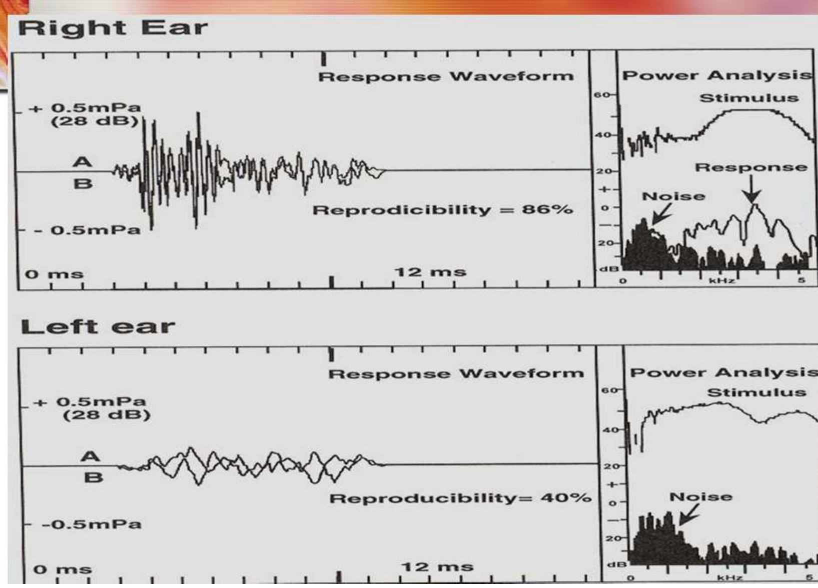
- Low energy sounds produced by the cochlear outer hair cells.
- Cochlear amplification.
- Spontaneous emissions
  - Not present in greater than 25dB hearing loss.
- Evoked Emissions
  - Transient evoked
  - Distorted Product

TEOAE

- Transient stimuli, clicks, evoke emissions from a large portion of the cochlea.
- Generally present when hearing thresholds are below 35dB.
- Advantages
  - Reliable separate normal from abnormal at 20-30dB
  - Fast
- Disadvantages
  - Poor at higher frequencies

DPOAE

- DP are additional tones that are created when two tones are presented. f1 and f2
- DP occurs at 2(f1-f2) by a nonlinear process.
- Generally present when hearing thresholds are below 50dB.
- Advantage is higher frequency (6000Hz)



OAE and Middle Ear Pathology

- Transmission properties of the middle ear directly influence the OAE characteristics.
  - Otitis media
  - Newborns
  - Tympanic membrane perforations

Central Auditory Processing

- No accepted definition of CAP.
- Task Force on CAP consensus and development
  - Sound localization
  - Auditory discrimination
  - Auditory pattern recognition
  - Temporal aspects of audition
  - Auditory performance decrements with competing and degraded acoustic signals.

CAPD Categories

- Decoding
- Tolerance Fading Memory
- Integration
- Organization

Buffalo Model

- Takes into account the classification of CAPD as well as speech and language evaluation and academic characteristics.
- CAP battery
  - Staggered Spondaic Word (SSW) test
  - Phonemic Synthesis (PS) test
  - Speech-in-Noise (SN) test
  - Masking Level Difference (MLD) test

Decoding Category

- Most common (50%)
- Breakdown of auditory processing at the phonemic level.
- Difficulty reading and speaking & Articulation Errors “r” & “l”
- Posterior temporal lobe

Decoding category

- Management strategies center on improving phonemic and metaphonemical skills.
  - Hooked on Phonics and Phonemic Synthesis Skills program
  - Clear and concise instructions
  - Outlining objectives
  - Written instructions

Tolerance-fading Memory Category

- Second most common (20%)
- Poor auditory memory and difficulty understanding speech in adverse conditions.
- Deficits in expressive language and writing.
- Impulsive responders, short attention spans.
- Auditory continuous performance test can screen for ADHD.
- Linked to Broca’s area of the inferior frontal lobe.

Tolerance-fading memory

- Management focuses on improving the signal to noise ratio and strengthening short term memory skills.
- FM system is beneficial.
- Noise desensitization.
- Earplugs and quiet study areas.

Integration Category

- Difficulty integrating auditory information with visual and nonverbal aspects of speech.
- Deficits of the corpus callosum and angular gyrus.
- Dyslexics and poor reader
- Management
  - Improving signal to noise ratio
  - Structured phonetically based reading exercises

Organizational category

- Least common category.
- Characterized by reversals and sequencing errors.
- Individuals are often disorganized at school and at home.
- Management
  - Improving sequencing skills and organizational habits.
  - Consistent routines, checklists, calendars.

CAPD

- Multidisciplinary approach
  - Otologist
  - Speech Pathologist
  - Audiologist
  - Schools

Conclusion

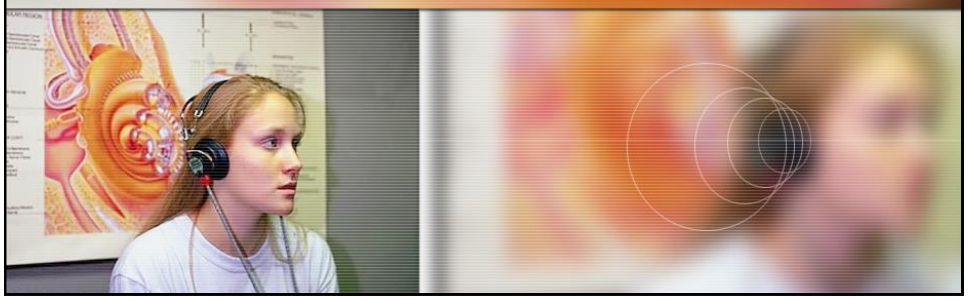
- Peripheral Assessment
  - Measures of objective hearing
  - Measures of physiologic hearing
- Central Assessment

Bibliography

- Ge X, Shea J. Transtympanic electrocochleography: a 10 year experience. Otology and Neurotology. 2002 Sept; 23(5): 799-805.
- Hall J, Antonelli P. Assessment of the peripheral and central auditory function. In: Bailey BJ, et al, eds. Head & Neck surgery- Otolaryngology. Philadelphia: Lippincott, 2001; 1659-1672.
- Katz J, Stecker N, Henderson D, (Eds). Central auditory processing: A transdiscliplinary view. St. Louis: Mosby. 1992.
- Katz J, Masters M, Stecker N. Central auditory processing disorders: Mostly management. Needham Heights: Allyn & Bacon. 1998.
- Rovinett M, Glattke T. Otoacoustic emissions; Clinical Applications. New York: Theime. 1997.
- Willeford J, Burleigh J. Handbook of central auditory processing disorders in children. Orlando: Grune & Stratton. 1985.
- Wiley T, Fowler C. Acoustic Immittance measures in clinical audiology. San Diego: Singular Publishing Group. 1997.

Chapter 7: Acoustical Fundamentals

Chapter #7
Acoustical Fundamentals



Outline

- Constituents of sound
- Hertz (cycle per second)
- Indians and railroads
- Wavelength
- Frequency
- Frequency & Wavelengths
- Harmonics
- Intensity (Objective)
- Loudness (Subjective)
- Amplitude
- Threshold of Hearing
- Frequency (Objective)
- Pitch (Subjective)
- Decibel Measurements

Constituents of Sound

- It's Creation – vibrations of matter
- The Medium it Travels Through
- How it's Heard

Hertz

- Compression & Rarefaction
- Through air (347 meters per second) (770 mph)
- Water (1500 mps) (3060 mph)
- Steel (5960 meters/sec) (13330 mph)

Wavelength & Frequency

- Distance the wave travels in one cycle (second)
- The relationship between wave and frequency
- 20Hz to ~ 20,000 Hz
- Pure vs. Complex Tones

Definition

Wavelength – Distance between maximum compressions

Frequency – the rate at which the waves pass a given point

Relationship

VELOCITY = WAVELENGTH * FREQUENCY

Since the velocity is about the same for all wavelengths through air, frequency is used to describe the effects of wavelengths.

Relationships

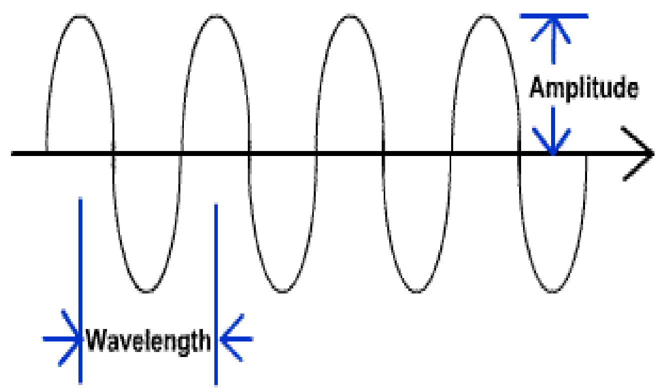
Amplitude & Frequency are independent of each other. Let's look at these examples.

Vibrating the Air

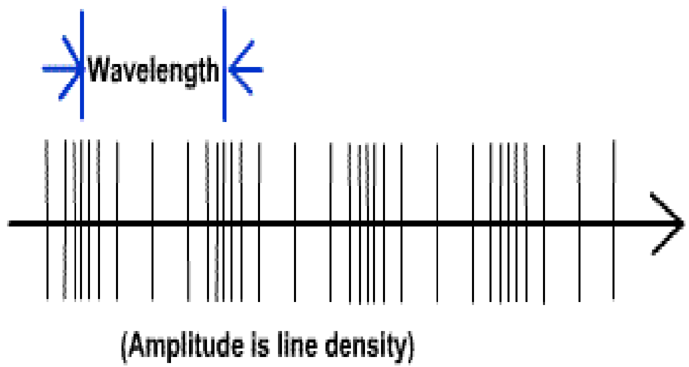
At 100 times each second, you have created a 100 Hz airwave at WHATEVER intensity. Let your vocal chords prove it to you…

Say the letter 'b' very softly, less softly, moderately loud, loud, very loud…

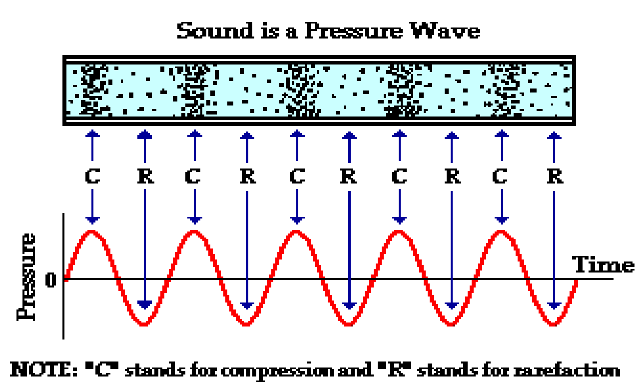
Amplitude & Wavelength



Amplitude & Wavelength



Sound as a Pressure Wave



Harmonic (no 'a')

- The Lowest Frequency = Fundamental Harmonic Frequency (of a_)
- 256 Hz = Middle C on the Piano = First Harmonic = Fundamental Frequency
- Double that = 512 Hz = One Octave > Middle C = Second Harmonic
- Double that = 1,024 = Two octaves > Middle C = Third Harmonic

$$fH_{2 = \frac{1}{2}} fH_1$$

Amplitude

The amplitude of a sound wave is the amount of compression the stimulus evokes. Sound is a compression wave. Thus, you will see the term compression amplitude.

Intensity

- Intensity and Amplitude
- Amplitude = Peak Compression Point
- Intensity Amplitude
- 1 x 10^{-16} Watts (a unit of power)/cm^2 (distance) = sound that moves particles of air one billionth of a centimeter = Normal Threshold of Hearing Intensity = Zero Decibels = 0 dB

Loudness

- Warm, cool, chilly, cold, freezing
- Soft, normal, a little too loud, loud
- It’s all relative. It’s all subjective.
- All normal observers would agree that. . .

Frequency & Pitch

- Frequency is measurable and objective.
- Pitch is not measurable, thus subjective.

Alexander Graham Decibel (1/10th of the man)

Δύναμις

No, it doesn't have to be all Greek

- δύναμις = power = a unit of FORCE = 1 dyne
- 0.0002 δύναμις/cm^2 = 0 dB
- dB dynes/cm^2 = dB Sound Pressure Level (SPL)

Sound Pressure Level

When you add dB SPL's, you do NOT sum them as you would apples and bananas. In the case of SPL measurements, which are ratios, you only add the exponents. In this case, 50 dBSPL + 50 dBSPL = 56 dBSPL. Whenever you double decibels in SPL, you add 6 to get the total SPL.

Perceived Loudness

For every increase in Intensity of 10 dB, the average increase in loudness increases by a factor of two. Loudness effectively doubles from one 10dB to the next on your audiogram.

Perceived Loudness

The practical misinterpretation on the audiogram by the prospective patient is this: “Oh, that’s not too much of a loss. . .” While a curve may not seem dramatic, this is something that can be avoided through education beforehand.

What is a Decibel?

It is a ratio between a reference sound on a convenient scale. For audiometric purposes, you will use dB Hearing Level (dB HL) values, not dB Sound Pressure Level (SPL), the term you use when referring to hearing instruments and other sounds.

Decibels continued

- The human ear is sensitive to frequencies which deliver speech sounds and amplify sounds between 1,000 and 5,000 Hz, where most speech sounds are recorded.
- For this reason, it would be very difficult to use dB SPL levels to test human thresholds. Thresholds are frequency specific..

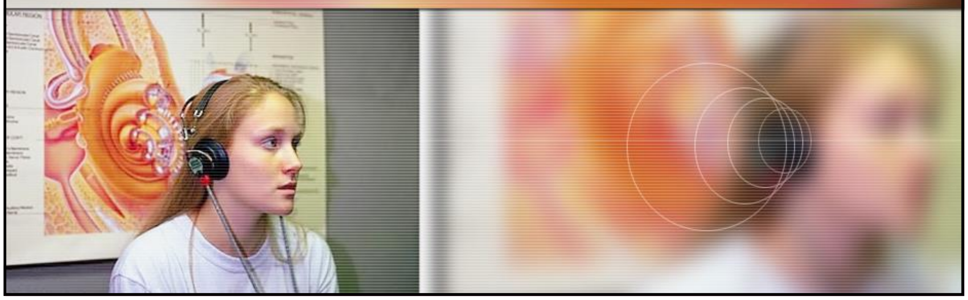
Decibels continued

For the last 5 decades, differentials in sound pressure levels have been calibrated for and compensated by the establishment of ASA standards. Thus, every frequency on your audiometer has already taken into consideration the SPL for that frequency. This is why dB HL is used for testing hearing sensitivity.

Chapter 8: Basic Hearing Disorders

Chapter #8

Basic Hearing Disorders



Objectives

- Outer Ear Disorders
- Middle Ear Disorders
- Inner Ear Disorders
- Disorders Requiring Medical Referral
- Basic Hearing Loss Types
  - Conductive
  - Sensorineural
  - Mixed C/S

Signs of Hearing Disorders
Medical Red Flags

- FDA Mandates

1. Visible deformity in the outer ear
2. Visible evidence of cerumen impaction or significant accumulation or lodged foreign body within the ear canal
3. History of active drainage (otorrhea) within 90 days
4. History of sudden onset of hearing loss within 90 days

Signs of Hearing Disorders
Medical Red Flags

- 5. Acute or chronic (persistent and lasting) symptoms of dizziness
- 6. Onset of monaural (one ear) hearing loss of a duration of 90 days or less
- 7. Pain or discomfort within the ear
- 8. Gap of more than 15 dB between air and bone conduction at 500 Hz, 1000 Hz, and 2000 Hz

Outer Ear Disorders

- Occlusion of Ear Canal
- Otitis Externa
- Deformation
- Cholesteatoma
- Collapsed Ear Canal

Middle Ear Disorders

- Otosclerosis
- Otitis Media
- Cholesteatoma

Inner Ear Disorders

- Meniere’s Disease
- Acoustic Neuroma VIII Nerve Tumor

Hearing Disorders

- Presbycusis (SNHL)
  - Acoustical Assault
  - Ototoxins
  - Location in Cochlea
  - OHCs

Hearing Disorders

- Noise Induced Hearing Loss (NIHL)
  - Precipitous HFHL

Hearing Disorders

- Meniere's Disease
  - Tinnitus
  - Episodic vertigo
  - Hearing Loss
  - Potentially sudden, monaural HL

Hearing Loss Categories

- Conductive Hearing Loss
  - Origin in Middle Ear
  - Example – Otosclerosis
  - Example – Otitis Media
- Treatment Options
  - Medical Intervention
  - Hearing Instruments
  - Surgical Intervention

Hearing Loss Categories

- Sensorineural (SNHL)
  - Cochlear in origin
  - Symmetrical
  - Usually less than 60 dB
  - 95% of population of persons with HL
- Treatment Options
  - Medical Intervention (Ototoxic Component)
  - Hearing Instruments

Mixed Hearing Loss

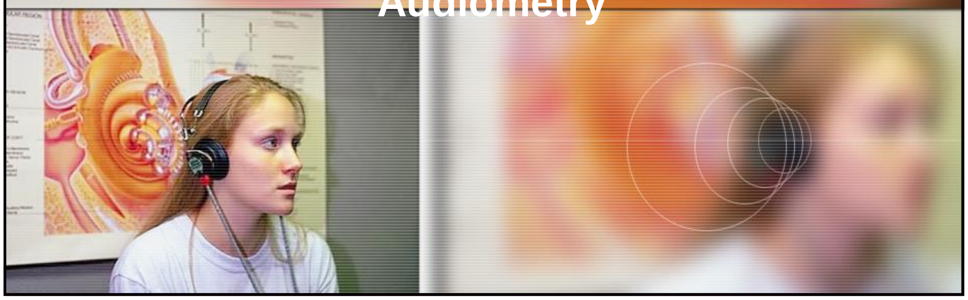
- Conductive and Sensorineural Components
- Treatment Options
  - Medical Intervention
  - Surgical Intervention
  - & Hearing Instruments

Chapter 9: Measurement of Hearing Loss – Audiometry

Chapter #9

Measurement of Hearing Loss

Audiometry



Objectives

- Case History
- Otoscopy
- Audiometry Test Battery
  - Pure Tone Air Conduction
  - Pure Tone Bone Conduction
  - Speech
  - Masking

Case History

- Medical Red Flags (7 of 8)
- Symptoms
- Attitudes
- Circumstances
- Coping Mechanisms
- Areas of Concern
- Fears, Hopes, and Expectations

Otoscopy

- Goals
- Complications
- Techniques
  - Introduction to Patient
  - Explanation
  - Use of Hands
  - Explanation

Otoscopy

- Process
  - Explain medical red flags as conditions to continue with hearing examination.
  - Wash and disinfect your hands.
  - Examine outer ear.
  - Turn otoscope on to maximum light.
  - Select (new) speculum to fit patient's ear canal.
  - Brace and bridge otoscope.
  - Gently place speculum into canal while lifting pinna back and upward with other hand. Keep speculum tip away from canal wall.

Otoscopy

- Insert speculum.
- Note condition of external canal. Note possibilities of foreign body, cholesteatoma, blood, scratches, otorrhea, and cerumen.
- Note condition of canal.
- Focus on TM (tympanic membrane). Healthy TM is light gray, translucent with cone of light on bottom half of TM. Malleus should be prominent.
- Healthy canal is smooth, pink.

Otoscopy

- Make a comprehensive note in patient file on condition of external ear.
- Confirm absence or presence of 7 of the 8 medical red flag conditions.
- State your findings regarding the flags.
- Proceed with further examination.

Pure Tone Air Conduction

- Goal – To determine the patient's threshold of hearing through the air
- Equipment – Audiometer
- Explanation to patient

  "Mr./Mrs. Jones, I am going to place these ear phones snugly over your ears." If the patient has earrings on, take them off. Pressure from the ear phones can cause pain or distraction.

Pure Tone Air Conduction

- **"I am going to send different tones to your ears, one at a time. I will start with your right ear. These tones will sound like different notes on the piano. Some will be easy to hear.**
- **Others will sound far away and soft. So, when you hear a sound, such as beep, beep, beep, simply [push the button one time/raise your hand/hit your husband]. Then, wait for the next sound."**

Pure Tone Air Conduction

- "Even if the sound is so faint that you can barely hear it, push the button. Okay?"
- Seat the individual so that audiometer dials are not visible or predictable.
- Push hair away from the ear phones. Remove glasses, earrings, and hearing aids (if worn).

Pure Tone Air Conduction

- Set the frequency dial/selector to 1000 Hz and the tone selector to 50 dB unless you have a reason to increase the intensity due to suspected severity. This first tone must be easily heard.

- Make sure the earphone diaphragm on each side encircles the ear. Red is right. Blue is the only one LEFT.

Pure Tone Air Conduction

- **Tighten the headband.**
- **Present the pulse tone for 1 – 2 seconds.**
- **The intervals between tones must be random to prevent prediction responses.**
- **Once you are below the patient's threshold, raise the intensity by 5 dB until you receive a response.**

Pure Tone Air Conduction

- **If NR (no response), raise intensity 5 dB.**
- **When response is positive, begin reducing the tone in 10 dB steps until you receive NR.**
- **As soon as you receive a response, lower the intensity by 10 dB. (Down by 10 and up by 5. That's the rule.) If you receive no response, raise the intensity by 5 dB until you receive a response.**

Pure Tone Air Conduction

- The threshold is the lowest level of intensity which elicits a response 2 times out of 3 attempts.
- As soon as you determine the threshold, record it on the audiogram. A Blue 'X' is used to record Left ear air conduction responses; A red 'O' denotes right ear air conduction responses.

Pure Tone Air Conduction

- Change the frequency in ascending order to 2000 Hz. Test same ear using same technique described above. Upon reaching 2000 Hz threshold, test at 4000 Hz, and 8000 Hz.

- After completing the higher frequencies, repeat the test at 1000 Hz.

Pure Tone Air Conduction

- If the second ‘reliability’ measurement at 1000 Hz is not within 5 dB of the first measurement, re-educate patient and re-test from the beginning.
- If the second measurement at 1000 Hz is within 5 dB, descend to 500 Hz, and 250 Hz.

Pure Tone Air Conduction

- Use exactly same measurement method on the other ear.
- Record each level as you reach threshold. Be patient and unpredictable in your presentation.
- There are circumstances when sounds presented in the ear being tested (test-ear) are received in the non-test ear. The term used for this occurrence is ‘crossover.’

Masking and Air Conduction

- Interaural attenuation is defined as the reduction in intensity, at one ear, of an acoustic stimulus presented to the other ear canal as the sound is transmitted through the head; for air conduction, the reduction approximates 35 dB, but for bone conduction, it is 10 dB or less.

Masking and Air Conduction

- Crossover occurs when an air conduction tone is so intense that, via bone conduction, that sound is heard by the non-test ear.
- When this occurs, masking technique must be employed to sufficiently distract the more acute ear in order to obtain an accurate test result from the less acute ear.

Masking and Air Conduction

- Using headphones, the IA (interaural attentuation) via air is 40 dB and 70 dB using inserts.
- If air conduction thresholds exceed 40 dB, masking is imperative to derive accuracy in air conduction testing.

Masking and Air Conduction

- Masking must meet the following criteria:
  - The masking noise employed must have an intensity level to effectively cover the stimulus.
  - The masking noise must not be so intense as to cover the test stimulus.
  - The level must not exceed the patient's UCL.

Masking and Air Conduction

- Effective Masking (EM) is defined as the masking level required to produce a shift in the threshold of the non-test ear.

Masking and Air Conduction

- Plateau Method
  - Determine threshold for both ears, evaluating the better ear first.
  - Determine need to mask based on Interaural Attenuation (IA) levels.
  - To the NTE (better ear), add a 10 dB pad onto the threshold of the NTE, thus the masking noise will be audible to the NTE.

Masking and Air Conduction

- Begin the TE tone at the obtained unmasked threshold. If response occurs within 10 dB of masking noise, increase masking noise in 5 dB increments until an increase of 15 – 20 dB in the NTE results in no change in response from the TE. This is your plateau.

Masking and Air Conduction

- Hit or Myth Method
  - Set masking at 50 to 70 dB. Test. This works in situations with no variables. Refer to HIS pp. 211 – 215 for elaboration.

- Procedure
  1. Position headphones.
  2. Set masking channel for continuous Narrow Band Noise (NBN) in NTE.
  3. Masking level target is 5 dB > AC threshold for the NTE.

Pure Tone Bone Conduction

- A pure tone bone conduction test essentially bypasses the contribution of the middle ear. By gently scratching your scalp, you experience hearing with bone conduction.
- When you listen to yourself on a tape recorder, aside from saying, “That’s not really my voice,” you are also listening to your voice as others hear you. Others only hear you via the air, thus, through air conduction.

Pure Tone Bone Conduction

- The difference between the sound of your own voice and your voice as heard on the tape recorder is simply due to the presence or absence of the contribution of bone conduction generated sound.
- By eliminating the outer and middle ear contributions, bone conduction testing scores indicate the capacity of the cochlea to receive sound. From the difference in air and bone

Pure Tone Bone Conduction

- conduction scores, we deduce whether the middle ear contributes to a reduced hearing capacity. If bone conduction scores are normal while air conduction scores are reduced by over 15 dB from bone scores, a medical red flag condition exists.
- At that juncture, stop the test and offer a pre-arranged referral to a medical physician.

Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

Pure Tone Bone Conduction

- If bone conduction scores are symmetrical to air conduction scores and are within 15 dB of air conduction scores, you have evidence of sensorineural hearing loss. You then can proceed to test and fit hearing instruments.
- If bone conduction scores indicate at least a mild hearing loss and air scores indicate poorer overall hearing than bone scores, a mixed loss is indicated.

Pure Tone Bone Conduction

- This requires judgment regarding how to proceed. A decision must be taken at this point to stop and refer, or to explain a medical waiver and seek the family's decision on how to proceed.

Pure Tone Bone Conduction

- BC scores are attained by testing each octave between 250 Hz and 4000 Hz and from 70 dB to 0 dB.
- You will use the bone conduction oscillator to conduct a Weber Test in the center of the forehead to determine the more sensitive inner ear. Once you have determined the more sensitive ear, proceed as with air conduction, only within the limits of the audiometer.

Pure Tone Bone Conduction

- Instruction the patient on the differences and similarities between air and bone conduction.
- Place the concave side of the oscillator on the mastoid process, set the frequency at 1000 Hz and intensity at 20 dB above the appropriate air conduction threshold. If NR, raise the BC intensity by 20 dB until response is reached.

Pure Tone Bone Conduction

- Repeat the ‘Down by 10 and Up by 5’ technique to obtain the threshold.
- Ascend in frequencies 2000 Hz and 4000 Hz. Then descend from 500 Hz to 250 Hz.
- Move to the other right ear and repeat.
- Symbols used in bone conduction are: a Red < for Right and Blue > for Left.

Bone Conduction Masking

- Place bone oscillator on mastoid process (knot up and behind ear).
- Place headphone used to mask NTE directly over the ear.
- Place other headphone above and to the front of the bone conduction oscillator.
- Neither the oscillator nor the headphone next to it should touch anything but the patient’s head.

Bone Conduction Masking

- Set NBN masking to 'on.'
- Increase intensity of masking to EM level which is AC threshold of NTE + 10 dB at 250 and 500 Hz (to account for OE [occlusion effect]).
- Introduce tone. If you have a response, masking procedure is effective.
- Record the threshold and EM level on audiogram.
- If NR, increase intensity in 5 dB steps until you receive a response. If still no response, you must plateau.

Plateau

- Set NBN for NTE to EM level.
- Raise TE tone in 5 dB steps until response is positive.
- After positive response, raise intensity 3x in 5 dB increments.
- After 3 consecutive positive responses, you have your EM plateau.

Speech Recognition Threshold Testing

- SRT procedure confirms PT threshold reliability.
- Ideally, SRT will be within 15 dB of PT thresholds at 500 Hz – 2000 Hz.
- Use two syllable spondees instead of pure tones.
- Instructions to patient: "Now I am going to give you words instead of tones. Say what you hear even when the words get soft and faint, just like the tones. Alright?"

Speech Recognition Threshold Testing

- Present word "mousetrap" at 30 dB.
- If NR, increase intensity to 50 dB.
- If NR, increase intensity by 10 dB steps.
- When you receive a response, decrease by 10 dB until Pt (patient) cannot repeat the word.
- Increase intensity in 5 dB steps until Pt repeats spondee. Two correct out of three different spondees presented identifies your threshold.
- Record your SRT on the audiogram.

Word Recognition

- A Simple Test to determine residual auditory capacity in a non-complex acoustical environment.
- Conducted at MCL
- Single syllable phonetically balanced words (PB's)
- 65 – 75 dB test level on average
- Volume is not limited except for UCL

Word Recognition

- NU – 6
- CID W-22
- 50 words with 2% weight per word
- "Say the word . . ."
- Instructions to the patient

MCL

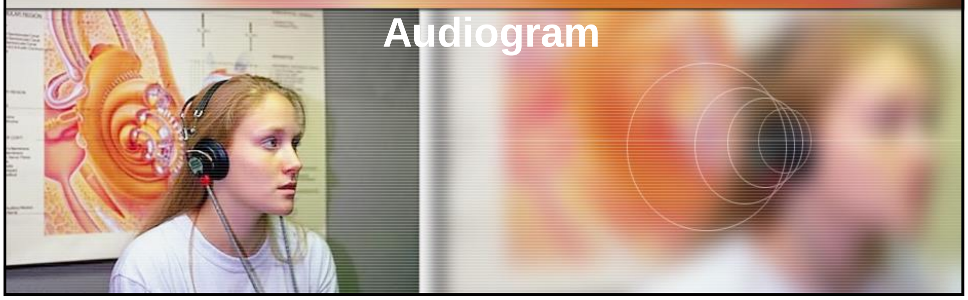
- Most comfortable level
  - Used to help determine optimum gain
  - Speech presented under different intensities (Rainbow)
  - Subjective measurement
  - Category of Loudness selection by patient as tests runs

UCL

- Uncomfortable Loudness Level
- Too loud for listening
- Pure Tone stimuli (500 – 2000Hz)
- One second rule
- Used to determine maximum output levels for some hearing instruments

Chapter 10: Understanding & Interpreting the Audiogram

Chapter #10
Understanding & Interpreting the Audiogram

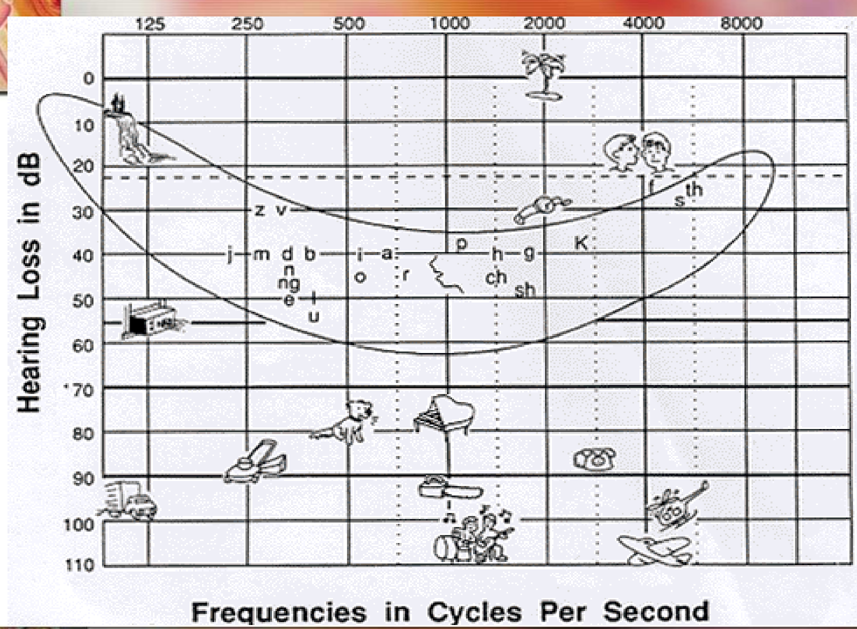


Objectives

- Symbols and Keys
- Concepts
- Measurement of Loss
- HL Patterns
- Hearing and Understanding
- Interpretation

Symbols and Keys

- Air conduction Right O (Red)
- Air conduction Left X (Blue)
- Masked AC Right □
- Masked AC Left "
- Bone conduction Right <
- Bone conduction Left >
- Masked BC Right 0
- Masked BC Left •

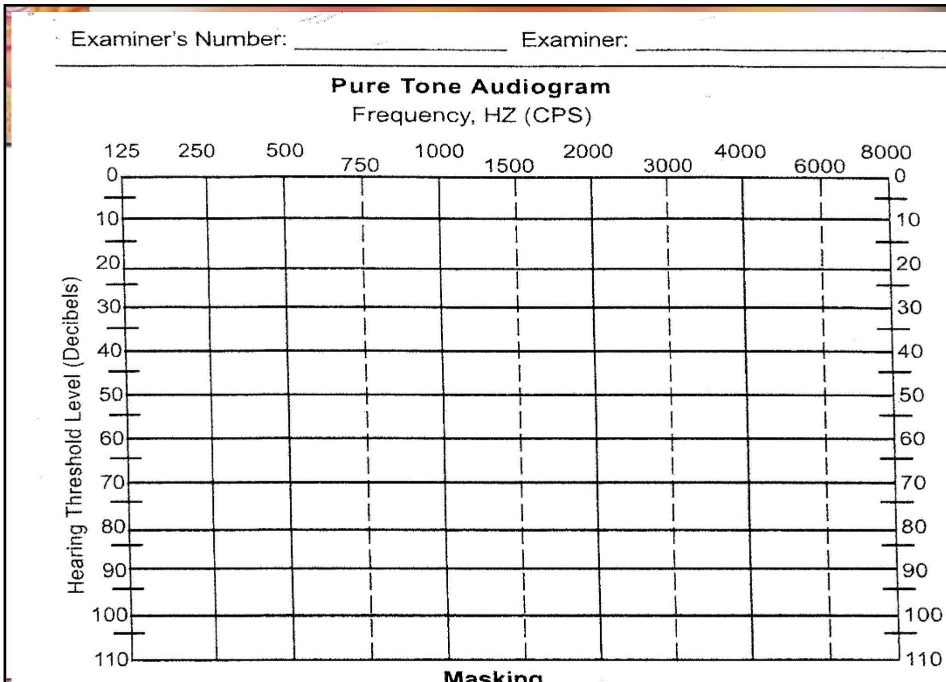


Concepts

Hearing vs. Understanding

Explaining HL Levels to Patients

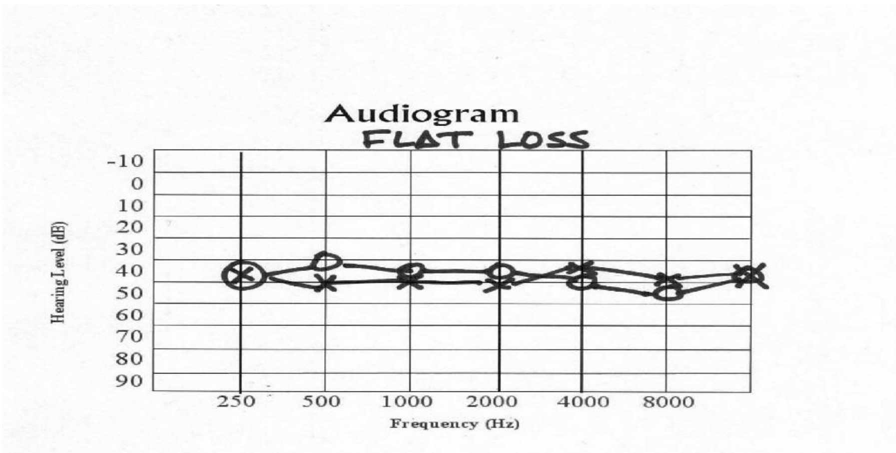
Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved



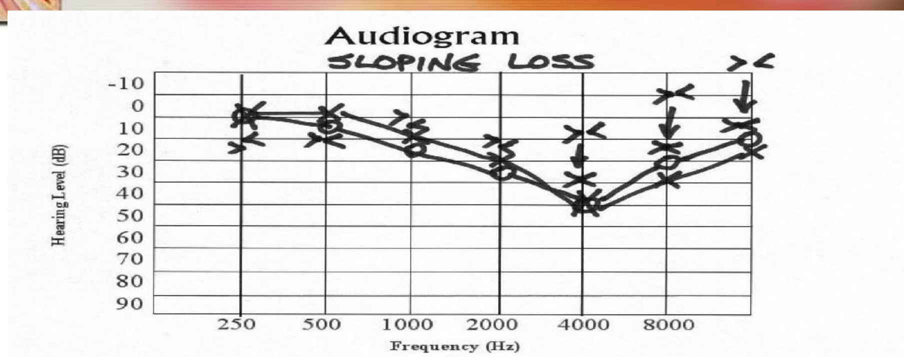
Hearing Loss Patterns

- Sensorineural
- Conductive
- Mixed Loss
- Others

Flat Loss

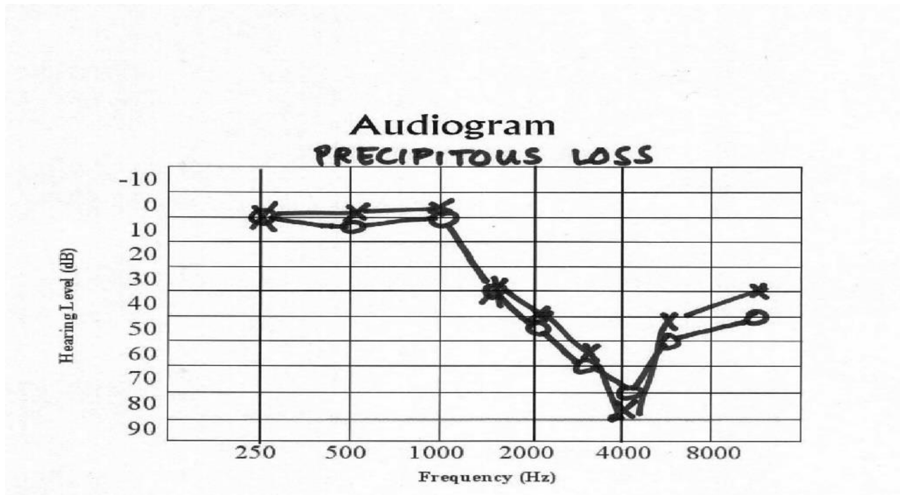


Sloping Loss

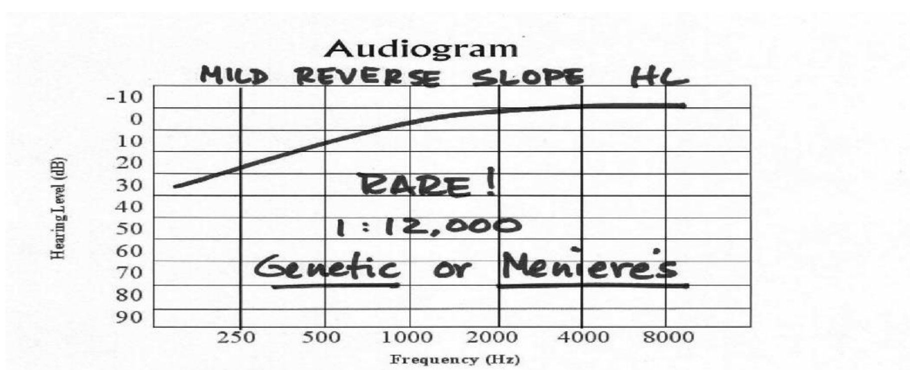


O = Right (in Red) Air Cond.
X = Left (in Blue)
< = Right BC
> = Left BC

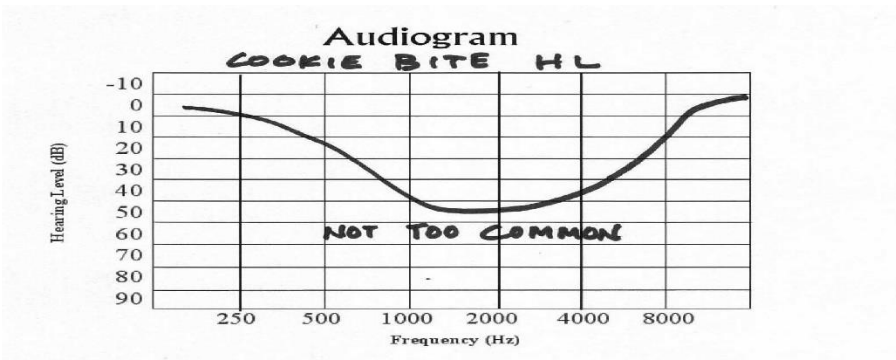
Precipitous Loss



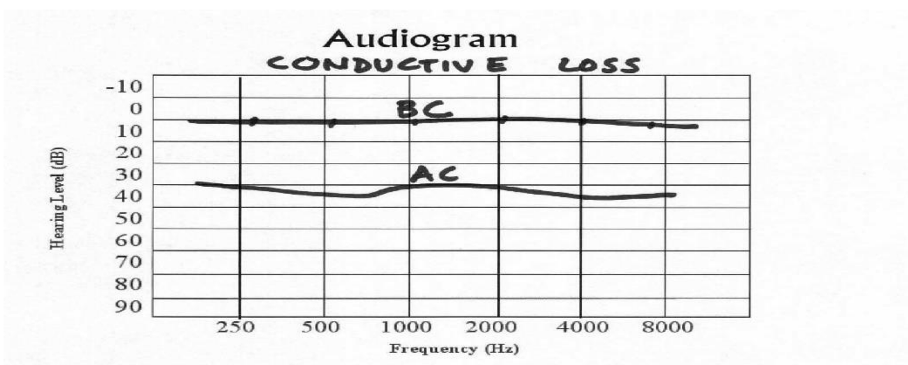
Reverse Slope Loss

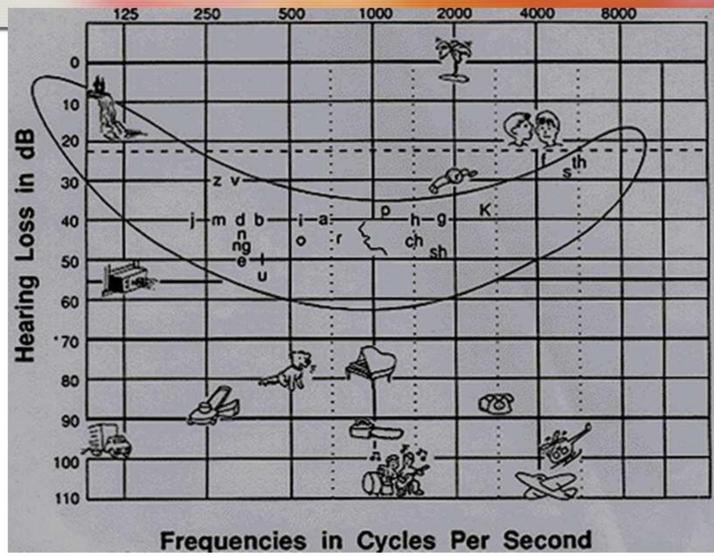


Cookie Bite Loss



Conductive HL





Using the Speech Banana

- Frame of reference
- Explanation of general fitting goals
- Bridge between hearing and understanding
- Visual used to introduce 3-part responsibility
- Transition from general education to fitting prescription

Speech Reception Threshold

- Pure Tone Average threshold = average of 3 or 4 octaves/3 or 4
- Speech Reception Threshold = dB level where

  Pt (patient) correctly hears Spondees 50% of

  the time during the test.
- SRT +/- 15 dB = PTA = Reliably correct audiogram.

Speech Reception Threshold

- UCL = that dB level which cannot be tolerated for more than about 5 seconds.
- Area between UCL and SRT = range in which you must program instruments to augment (amplify) sound…

  HL = Dynamic Range = Residual Hearing Capacity

Speech Discrimination

- Taken at MCL = comfortable listening levels, speech discrimination (also called Word Recognition Scores) measures how understandable speech is.
- It is not a measure of how clearly it is heard.
- It is a measure of whether simple, mono-syllabic words are understood easily and naturally at a short distance.

Speech Discrimination

- Scoring is proportional to predictable success with hearing instruments without therapeutic

  measures.
  - Excellent – 90 – 100%
  - Good to Average – 70 – 89%
  - Fair – 50 – 69%
  - Poor - <50%

Speech Discrimination

- This test is very helpful in developing Reid Protocol progressive fitting stages.
- Poorer responses will require additional fitting plateaus as you ascend toward an optimum fitting between PTA and UCL.

SIN

- Speech in Noise testing offers a complex acoustical test parameter for determining how a Pt understands in noise. This is also helpful in determining realistic expectations.
- In-house training will include SIN test training.

Audiogram Examination

- First, be neat, precise, and complete.
- Calculate PTA, SRT, SDS (WRS).
- Compare SRT to PTA. Re-administer AC and BC (if necessary).
- SDS must be symmetrical. If not, you may need to medically refer your Pt.

HI Candidacy

- Only the complete audiogram will empower you to:
  - **Offer realistic expectations**
  - **Enter into a bilateral agreement**
  - **Describe the responsibilities of the Pt.**
  - **Explain the consequences of UHL.**
  - **Develop an Independent Treatment Plan.**

HI Candidacy

- Take asymmetrical SDS/PTA contours, Mixed, and Conductive Losses very seriously in terms of potential medical intervention.
- SNHL, which accounts for the large majority of the HL population, will be your primary focus.

HI Candidacy

- Audiograms represent the complete battery of required tests.
- Add case history, ‘significant other’ and ‘patient’ concerns, hopes, goals, etc., and you can determine how to communicate your recommendations.

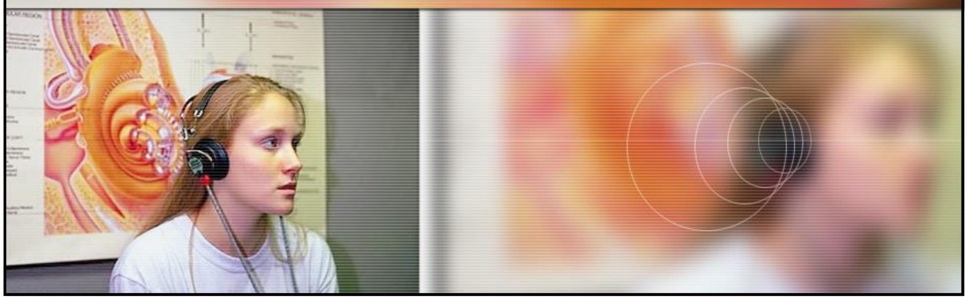
HI Candidacy

- Psychosocial behavior, coping skills, and defensive obstacles may arise at this stage.
- The more comprehensive you have been in education and ‘validation,’ the easier it will be to move through this stage into a fitting.
- Be conservative and careful to suggest realistic stages of improvement, in light of information the audiogram and other tests indicate.

Chapter 11: Masking

Chapter #11

Masking



New Terms

- Definition
- Interaural Attenuation/Crossover
- Bone Conduction
- Occlusion
- Plateau Technique
- Non Test Ear (NTE)

Definition

- **In its simplest terms, masking is an acoustical technique which presents sounds designed to keep one ear busy while you test the other ear.**

 3

Interaural Attenuation

- Interaural attenuation occurs when a sound presented to one ear crosses over to the other ear, where it is heard.

 4

Masking

- A narrow band of noise is presented at a calculated intensity to occupy the inner ear while a test is performed on the other ear.

Occlusion Effect

- Two important points:

- 1. To mask, you simply use a method of keeping the non-test ear busy with sounds generated by Air Conduction (AC) while you test the other ear with the bone conduction oscillator.

Occlusion Effect.

- Below 2000 Hz, when the outer ear of the TE is occluded by a headset, bone conduction is more sensitive than in a natural state. This is why you place the TE headphone well above and behind the test ear. Failing that, you will receive false positive scores.

Steps to Eliminate Occlusion

- 1. Only occlude the NTE with your headset.
- 2. This is not the case for AC or SDS when masking is warranted.
- 3. You add 15 dB to the beginning masking level by AC in the NTE at 250 and 500 Hz, and 10 dB at 1000 Hz is you test those freq's.

Central Masking

- This is a phenomenon whereby low levels of masking are produced by CNS during tests.
- This can increase any masked score by 5 – 15 dB. By convention, this is not compensated for on tests.

Using the Plateau Method

- IA (AC) through headsets = 40 dB
- IA (speech) through headsets = 40 dB
- IA (BC) = through headsets = 0 dB
- These numbers are accurate assumptions generally used.

Plateau Method

- Your textbook HIS states that you should add 10 dB to your masking level to “make the starting level more audible.”
- Other texts suggest that the 10 dB pad not be used; that, you start at AC level of Masked NTE.

Plateau Method

- Part One: Under masking
- Part Two: Plateau ☺
- Part Three: Over masking

Undermasking

- Not enough NBN intensity (dBs)
- Crossover still may occur.
- AC masking MUST start out within 40 dB of the starting level in the TE. Simple. The final level
- level will be within 40 dB from the positive response of the TE.

 13

Plateau

- **Remember, we assume IA of 40 dB.**
- **To obtain a true threshold, a 15 to 20 dB increase in masking noise while simultaneously recording the same threshold in TE, is required. This allows and compensates for an actual IA different than 40 dB.**

 14

Plateau

- Your text recommends that you increase the NTE masking noise in 5 dB steps, then test, then increase, 5 dB, and repeat until you have 3 straight positive responses.

Overmasking

- You guessed it. Too much masking crosses over and masks the TE tone. Threshold is falsely increased.
- Maximum masking is reached when: Masking dB > BC threshold of TE by 40 dB. Ergo, MM = BC + 35 dB.

Masking Dilemma

- This occurs when both L & R ears have AB Gap of at least 40 dB.
-
- This is a non-starter. Refer to ENT in cases such as these, which are uncommon!

AC Masking

- The Pt will usually get a confused look on her or his face when crossover occurs. You will likely be told that the sounds have crossed over. This is one reason that instructions are SO important.

AC Masking

- Remember, IA for AC is 40 dB.
- Masking Rule: When the difference between the poorer AC threshold and the better ear AC threshold is 40 dB.

AC Masking

- 1. Use plateau method.
- 2. Mask NTE with NBN at dB = AC threshold of that NTE. You could > 10 dB to start.
- 3. Present TE tone and NBN at same time.
- 4. > NBN in 10 dB steps if tone is heard (Hood).

AC Masking

- 5. Or > PT in 5 dB steps if tone is not heard.
- 6. Stop when threshold is found by 3 consecutive positive responses with a 15 – 20 dB increase in NBN.

BC Masking

1. Mask when ABG is =/> 15 dB in that ear.
2. NBN presents in NTE by way of AC headset at intensity of AC score of NTE at the frequency being tested on TE. You can add 10 dB to the start, again. .

BC Masking

- 3. Add 15 dB at 250 and 500 Hz
- and 10 dB at 1000 Hz to compensate for occlusion.
-
- 4. Begin Plateau. Present BC PT's via BC oscillator at level = unmasked BC score at that freq.

 23

BC Masking

-
- 5. Final masking level = BC of TE + 35 dB

 24

SRT Masking

- Crossover for speech is also assumed at 40 dB.
- Substitute SRT for Pure tone and use plateau method.

SDS Masking

- No plateaus used in this test!!
- Present masking at presentation of word level (MCL) – 40 dB. Present PB word list to TE at MCL.

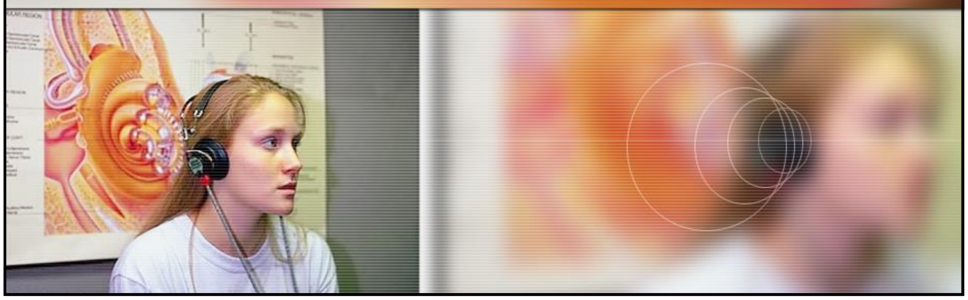
Told You

- It was going to be easy.
- The key to academic masking study is to review more than you may think. When at the classroom, it will all come together pretty quickly if you review this several times.

Chapter 12: Hearing Instruments

Chapter #12

Hearing Instruments



Finally

- The hearing instrument is an electronic device which AUGMENTS residual auditory capacity with tones designed and prescribed to be compensate for the individual's loss of hearing acuity.

Hearing & Understanding

- While hearing and understanding are at times used interchangeably, it is a colossal mistake to presume these two terms represent nothing more than a distinction without a difference.
- This why we call them hearing aids rather than understanding aids.

Point

- As you reflect on the legitimately giant developments in hearing instrument technology over the last 10 years or so, which you will learn in this lesson, keep in mind that hearing is accomplished by the hearing organ.
- Interpretation, processing, and understanding are accomplished by the brain. See the New Born Baby Story

Point

- While the hearing instrument may and can augment residual hearing capacity, it in no way guarantees the reversal of the resultant deficit in communication. The hearing instrument only makes it possible for that communication to be relearned, reprocessed, and re-interpreted.

 5

Acoustics

- Is very simply the alphabet of acoustical language. It is the hearing instrument and its ingenious corrective potential that make residual communication possible.
- For communication to be improved, much is up to, you. . .

 6

Hearing Instruments

- And how you manage their implemen-tation in patients will be crucial to the Pt’s overall satisfaction with improvement in personal communication.

- Hearing aids simply process then amplify sound.

 7

The Law Regarding

- In most states, hearing instruments can be returned within 30 days for a full or 90% refund for any reason.
- Patients tie this law to satisfaction.
- Key elements to dealing with this *financially* based satisfaction law are:
  - Education
  - Realistic Expectations
  - Three Part Guaranty

 8

Generally, how does this happen?

1. Sound enters the instrument through the microphone, strikes the diaphragm and is transduced from an acoustical wave into an electrical current.
2. With respect to current instrument development, this current of electricity moves on to an analog – to – digital converter.

And

- 3. It is changed from an electrical signal into 1's and 0's in computerese."Digital"
- 4. From there, it basically moves into an amplifier
- 5. Beyond the amplifier, the bits and bytes are processed via digital – to – analog conversion back into an electrical current

Again, and

- 6. Is processed back into acoustic waves via an analog receiver and sent to the TM.

 11

Components

1. Power Source: Zinc air battery with average of 1.4 V.
2. #675 for power BTEs, #13and #312 for small BTEs, ITEs, #312 for ITCs, #10 for CICs and small IICs.
3. Rechargeable Lithium Ion Battery “30 hour charge”
4. Life of the battery in hours: mA hours/mA

 12


Z|power
Z power
MADE IN USA

Components

- 1. Transducer: electronic device which changes energy into a different form.
- 2. Microphone: Changes acoustical wave into an electrical analog wave.
- 3. It acts as soon as a sound is received or is put into the instrument. Thus, it is an input transducer.
- 4. Main component is a diaphragm which holds an electric charge

 13

Component

- 5. Omni-directional microphones are constructed to receive sound equally in a 360^{A} circle (as in normal hearing).
- 6. Directional microphones may be made up of single microphones with ports or multiple microphones. This type is designed to receive sounds more or less in the periphery of the person wearing it.

 14

Components

- 7. Polar plots are used to describe the particular patterns available to the specialist programming the function of the microphone. Cardioid, hyper-cardioid, and super-cardioid are the main schemes for directional mikes.
- 8. A telecoil is also a transducer which changes the electromagnetic energy present in telephones into an electrical

 15

Component

- 8 cont.: signal which the hearing aid can process as sound. This development allows Pts who otherwise cannot understand on the phone, due to telephone-hearing instrument mike feedback, to hear and hopefully understand.

 16

Components

- Construction of Directional mikes
- Effectiveness of DMs
  - Distance between ports
  - Time delay in rear port
  - Alignment in lab on faceplate

Measurement of DMs

- Polar plots
- Directivity Index (DI)
- Articulation Index (AI)
- AI - DI

DI

- Ratio of mike output directly in front of listener compared to sounds coming from everywhere around.
- It is measured in dB.
- It represents the important factor, Signal-to-noise ratio, ie. the measured intensity of the desired signal compared to the surrounding noise.
-

SNR

- A high positive SNR means that the desired signal is X times more prevalent than noise. This ratio indicates the relative helpfulness of that particular microphone scheme.

AI-DI

- AI - % of speech energy available for audiometric configuration (focus is on critical speech areas)

- AI-DI – Frequency weighted factors combined with DI will indicate a relative ease of understanding.

Back to [illegible]

- Receivers also have a diaphragm and operate on magnetic basis.
- Magnets in the speaker react to the amplified electric signal.
- Diaphragm vibrates in response, creating, of all things, acoustical wave forms.

Amplifiers

- Microphone receives acoustical signal.
- Amplifier amplifies (thus, providing acoustical GAIN) that signal and sends it to the analog receiver.

 23

Amplifier

- Current technology design of amp's include a 3 stage process.
- 1. Pre-amplifier
- 2. Digital signal processor
- 3. Output

 24

Amplifier Types

1. Circuit Board – Integrated circuit containing resistors, transistors, and other electrical components.
2. Analog – linear reproducers of initial waves.
3. Digital – Added to the IC are ATD and DTA converters.

Measurement of Hearing

- The measurement of hearing instruments is achieved both in the lab when the instrument is made, in your clinic before you fit it, and in the ear of the person you prescribed it to.

Concepts

1. How much sound does the instrument augment? This is the GAIN which is measured in dB.
2. How much sound energy is recorded at the receiver? This is the OUTPUT of the instrument and also is measured in dB SPL.
3. Input (natural sounds) + gain = output

 27

Concepts

- In today's technology, output relative to input is described by the term

  - Compression

- Increased input leads to reduced output. Louder sounds are artificially compressed.

 28

Linear Hearing Aids

- Linear hearing aids are made up of circuits which create an equal amount of gain to all input.
- While it is advantageous to limit the output of very loud sounds, the only method for linear aids is to chop off the peaks of those sounds which are too strong for the amplifier.

Linear Hearing

- This peak clipping technique also serves to remove a portion of the input simply because it is too loud and beyond the limits of the hearing instrument. This results in missing information and unnatural quality of sound.

Compression Hearing Aids

- The concept with compression hearing instruments is based on the fact that the louder the signal the less amplification is needed to insure the output of the instrument remains within the dynamic range of the wearer, that is, within the functional auditory capacity of the wearer.

Compression Hearing

- Compared to linearly constructed instruments, the problems associated with peak clipping are averted.

- Where linear instruments continue to linearly increase gain, thus output, of HIs, Compression Aids are constructed to reduce the output by a percentage.

Compression Hearing Aids

- At whatever level of input, once a certain level is reached (compression threshold), output is reduced by a ratio. After that particular level, called a kneepoint, is reached, a 10 dB input may result in only a 3 or 5 dB output.

 33

New Terms

- Compression Threshold (CT)
- Compression Kneepoint (CK)
- The above are one and the same.
- Compression Ratio (CR)

 34

Compression Threshold

- Is defined as the point at which amplification is no longer linear, and the lowest point of input which will trigger a 2 dB reduction of gain.
- This amplification algorithm operates over a range called the Compression Range.

Attack and Release

- It is sound intensity which causes the compression amplifier to react.
- The delay from the sound input causing compression until the instrument reaches the new output level is called “Attack Time.”
- The interval between compression amplification and return to linear amplification is called “Release Time.”

Compression Amplification

- Compression amplifiers sample sound passing through the microphone, detect intensities, and when appropriate (at the CK), variably reduces gain.
- The CK can be changed depending on how the instrument is created.

I/O

- If the sampling loop is in front of the VC, the compression dictates that the CK remains a constant.
- If the sampling loop is behind the VC, gain and CK change but output remains constant.

Circuits

- Compression limiting circuits limit the output. The objectives are to:
  - Govern output (like governor on a vehicle)
  - Reduce high-input level distortions
  - Function as a linear HI over the majority of the range spectrum

Circuits 2

- Criteria to accomplish CL
  - Setting of High CK 80 dBSPL or greater.
  - Short A&R
- 2nd Gen Circuitry
- Only used to supplant Analogs

WDRC

- Current, state of the industry circuitry
- Dynamic control capability
- Enhanced therapeutic manipulability
- Must be used in conjunction with progressive fitting to reaching optimum communication potential

 41

WDRC

- Criteria which elicit optimum performance are
  - Lower CRs
  - Short A&R times
  - Lower CKs
- I recommend the use of this circuit on anyone with up to moderate severity who is also active in life.

 42

WDRC

- Multiple compression channels allow the dispensing professional to mimic the auditory centers to a small degree by splitting input signals into multiple channels.
- The instrument combines them at the output.
- Steeply sloping and block loss configurations are served well with

WDRC

- the use of this capability.
- Level Dependent Frequency Response (LDFR) circuitry
- Base Increases at Low Levels (Bill)
- Treble Increases at Low Levels (Till)
- Programmable Increases at Low Levels (PILL)

Final Comments on Circuitry

- 1st Generation Analog
- Laboratory Feedback
- Developmental Criteria
- Power
- Range of Responses
- Engineering
- How We Learned to Hear

 45

COMPETENCY BUILDING

- 1) Through which medium or mediums can sound NOT travel:
- A. gas
- B. vacuum
- C. gas or solid
- D. solid or liquid

 46

2) Sound waves travel:

- A. according to the NAL formula
- B. beneath the surface of steel in a vacuum
- C. spherically in all directions .
- D. along a directional polar plot

3) The branch of physics that deals with sound is:

- A. acoustics
- B. Otolaryngology
- C. Otoproctology
- D. Audiology
- E. Geriatrics

4) The speed of sound waves in air at sea level is:

- A. 340 meters/second
- B. 900 miles/hours
- C. 1,100 miles/hours
- D. 1,200 feet/second
- E. Dependent on reflection and refraction

5) The number of times a vibrating body completes a p[illegible]of compressions and rarefactions per second is the:

- A. cycle of a sound
- B. frequency of a sound
- C. wavelength of a sound
- D. amplitude of a sound
- E. Intensity of a sound

6) What do we call a sound that consists of only one frequency?

- A. specific frequency sound
- B. pure tone
- C. complex tone
- D. all of the above
- E. harmonic

7) What is the interval between two frequencies when the higher frequency is doubled the lower frequency?

- A. harmonic
- B. fundamental
- C. overtone
- D. octave

8) The lowest frequency that makes up most complex sounds is:

- A. usually the loudest
- B. said to predominate
- C. called the fundamental frequency
- D. All of the above

9) A graphic representation of the relative strengths of the harmonics of complex tone is called:

- A. pitch analysis
- B. quality graph
- C. harmonic analysis
- D. line spectrum
- E. x-y plot

10) The decibel:

- A. is an absolute measure of sound intensity
- B. is used only as a measure of hearing loss
- C. should never be qualified as a reference to a standard
- D. none of above
- E. was named after Thomas Edison

 55

Tympanic Membrane

- 11) The tympanic membrane receives acoustic energy in the form of sound waves and changes it to:
- A. Kinetic energy
- B. Hydraulic energy
- C. Electro-chemical energy
- D. Mechanical energy
- E. Transduction waves

 56

12) The sound of an approaching train can be heard through the rail before it can be heard through the air because:

- A. sound will not travel through a steel rail
- B. sound travels faster through the rail than through the air
- C. the Indians are curious
- D. the frequency of the sound is higher through the rail

 57

13) During rarefaction the molecules are:

- A. closer together at a state of decreased pressure
- B. further apart at a state of decreased pressure
- C. closer together at state of increased pressure
- D. further apart at a state of increased pressure

 58

14) A formant is:

- A. a frequency region within which certain harmonics have relatively large energy
- B. a graph showing the amplitude and frequency of a complex sound
- C. the fundamental frequency plus all harmonics
- D. the relative strength of all frequencies in a complex sound

 59

15) Lower frequencies are analyzed in the cochlea:

- A. 2 mm from the oval window
- B. Approaching and at the apex
- C. Near the tonotopic median
- D. Above the round window

 60

16) The organ of Corti is located in the:

- A. scala vestibuli
- B. scala tympani
- C. tympanic cavity
- D. scala media
- E. Deiter's media

17) The most popular theory of hearing is:

- A. Frequency theory
- B. Anatropic theory
- C. Traveling wave theory
- D. Place theory
- E. Topotonic isolation quadrant

18) A mixed HL is identified by:

- A. Reduced air and bone scores with at least 15dB AB gap
- B. Reduced air and bone scores with inverted AB gap
- C. Normal AC scores and reduced bone scores
- D. Normal bone scores and at least 50 dB AC thresholds

 63

19) A hearing aid:

- 19) A hearing aid:
- A. is an absolute necessity for those people who can't learn to read lips
- B. improves the signal to noise ratio
- C. amplifies sound
- D. improves your hearing
- E. improves the quality of life

 64

20) Noises in the head such as roaring, hissing, buzzing, ringing, etc, are:

- A. Incidents of tinnitus
- B. Due to high aspirin use
- C. Of idiopathic etiology
- D. Due to recruitment
- E. From foreign substances in the canal

21) The outer rim of the auricle is the:

- 21) The outer rim of the auricle is the:
- A. pinna
- B. tragus
- C. concha
- D. helix
- E. afferent arc of troma

22) What type of accessory or modification of a hearing aid might assist the patient in hearing more clearly in a noisy restaurant?

- A. variable gain control
- B. directional microphone
- C. plugging the vent in the earmold
- D. external receiver

 67

23) Body aids provide more amplification than BTEs because:

- A. microphone is much larger
- B. battery is larger
- C. microphone is further from the receiver
- D. it is located in the bra or in a pocket to prevent middle ear shock

 68

24) What is the main difference between water and sound waves?

- A. water waves are planar; sound waves are non-linear
- B. water waves expand; sound waves contract
- C. water waves compress sound; sound waves are incompressible
- D. water waves travel in expanding "circles" on the surface of the water; sound waves travel in all directions away from the source

25) The eustachian tube is opened via:

- A. the Valsalva maneuver
- B. yawning
- C. swallowing
- D. All of the above

26) The normal condition of the eustachian tube is:

- A. usually closed, but opens 1,000 times in 24 hours
- B. usually open
- C. causes infection at the Articulation Index
- D. opens only when needed

 71

27) Fourier spectral analysis determines

- A. periodic sound waves from stimuli
- B. Simple, pure tones of different frequencies, each having amplitude and phase which make up complex frequencies
- C. Aperiodic waves from transformers
- D. compression and rarefaction

 72

28) The manubrium is part of:

- A. malleus
- B. incus
- C. stapes
- D. All of the above

 73

29) Any complex sound can be broken down into individual frequencies by a technique known as:

- A. standing wave analysis
- B. stable molecular movement analysis
- C. fourier spectral analysis
- D. transverse wave energy analysis

 74

30) How many octaves are there between 128 Hz and 2048 Hz?

- A. 4 octaves
- B. 3 octaves
- C. 2 octaves and a hemi-tone
- D. 6 octaves

31) The speed of sound, in feet per second at sea level is:

- A. 2,000
- B. 2,500
- C. 1,500
- D. 1,100

32) If the fundamental frequency is 400 Hz the neat harmonic would be:

- A. 700 Hz
- B. 500 Hz
- C. 600 Hz
- D. 800 Hz

33) What does the term 70 dB mean?

- A. nothing without a reference
- B. sound pressure level of 70 dB
- C. half the total range of intensities
- D. 70 dB of dynamic range

34) The decibel:

- A. is an absolute measure of sound loudness
- B. is an absolute value of 100 Bels.
- C. is used only as a measure of hearing loss
- D. is a logarithmic ratio between two sound pressures or intensities

 79

35) At what effective sound pressure, for normal ears, does sound become painful?

- A. 1,000 dynes/cm^2
- B. 140 dB SPL
- C. 100 dB HL
- D. 1,100 dynes/cm^2
- E. Sound cannot damage hearing

 80

36)________waves propagate in a spherical direction:

- A. sound in water
- B. sound as it only comes off a iron beam
- C. longitudinal
- D. elongated

37) The weakest sound which the best human ears can hear in the most sensitive frequency range is at an effective sound pressure of about:

- A. 0.02 dynes/cm^2
- B. 0.0002 dynes/cm^2
- C. 0.00004 dynes/cm^2
- D. 0.4 dynes/cm^2

38) The normal human ear is most sensitive in the approximate range of:

- A. 5000 to 6000 Hz at the EAM
- B. 20 to 20000 Hz at sea level
- C. 100 to 1000 Hertz per second
- D. 3000 to 4000 cycles per second

39) $I=P^2$ is:

- A. the direct relationship between IL and SPL
- B. the hearing threshold level and sound pressure level
- C. what occurs with sound in a vacuum
- D. the indirect relationship between IL and SPL

40) The cochlea performs a type of analysis on sounds entering the auditory system. It separates them into individual frequencies similar to:

- A. frequency responder
- B. fourier analysis
- C. transcranial analysis
- D. none of the above

41) Theoretically, the increase in sound pressure provided by the middle ear structure is about:

- A. 12 dB
- B. 27dB
- C. 22 dB
- D. 15 dB

42) The footplate of the stapes fits into the:

- A. promontory
- B. round window
- C. oval window
- D. Incus
- E. Cochlear saddilarius

43) The unconscious raising of one's voice in the presence of noise due to:

- A. Lombard Effect
- B. Interaural natural amplification
- C. Hearing loss
- D. SSNHL or NIHL

44) The main purpose of the semi-circular (vestibular) canals are to provide:

- A. Hearing above 10000 Hz
- B. A one layer stria vascularis
- C. the ability to detect rotational movement in any direction
- D. A sense of forward movement

45) The annular ligament:

- A. Ligates the stapes to the external auditory meatus wall
- B. Attaches the tympanic membrane to the external acoustic meatus
- C. Connects the tympanic membrane to the malleus
- D. Ligates the footplate of the stapes to the bony wall of the oval window

46) The annulus is the:

- A. fastener of the footplate of the stapes to the bony wall of the oval window
- B. One aspect of the acoustical battery
- C. Determiner of the age of the adult tympanic membrane
- D. Ring around a directional microphone

 91

47) The diameter of the external auditory canal is about that of a:

- A. ordinary lead pencil (#2)
- B. head of a straight pin
- C. dime
- D. pipe cleaner

 92

48) The anatomical division between the external ear and middle ear is the:

- A. Malleus
- B. Eustachian tube
- C. Oval window
- D. tympanic Membrane
- E. Reissner's Membrane

49) The tympanic cavity contains the:

- A. eustachian tube, ossicles and cochlear apex
- B. malleus, incus and stapes
- C. ossicles, eustachian tube and L nare
- D. ossicles, concha, and first layer of vestibular stria

50) The auditory meatus is an irregular tube that varies in length from approximately:

- A. 1 inch to 2½ inches
- B. 1 inch to 1½ inches
- C. ½ inch to 1 inch
- D. none of the above

51) A healthy TM will present:

- A. dull red to bright red tones
- B. pearly gray translucence
- C. white to dark gray striations
- D. pink to dull red around the perimeter

52) The measurement across the base of the human cochlea is about:

- A. 1 inch
- B. 1 cm
- C. 1 inch
- D. 5 mm

53) The length of the human cochlea from base to apex is about:

- A. 10 cm
- B. 1¾ inches
- C. 5 cm
- D. 1 inch

54) The total number of neural fibers or neurons in the human auditory system nerve is between:

- A. 20000 to 30000
- B. 200 to 20000
- C. 10000 to 20000
- D. 3000 to 400000

55) In a cross section of the cochlea, the number of rows on hair cells that can be seen is:

- A. 5
- B. 6
- C. 3
- D. 4

56) The basilar membrane separates:

- A. the scala media and scala vestibuli
- B. the scala vestibuli and scala tympani
- C. the scala vestibuli and organ of corti
- D. the scala media and scala tympani

 101

57) The scala tympani is filled with:

- A. endolymph
- B. hair cells
- C. cerumen
- D. perilymph
- E. Intracellular fluid

 102

58) The scala media has what kind of fluid?

- A. none of the below
- B. perilymph
- C. endolymph
- D. cerebral spinal

59) The nerve fibers of the hearing nerve, at the point of maximal stimulation of the basilar membrane, will discharge and recover at the rate of:

- A. 250 cycles/sec
- B. 500 cycles/sec
- C. 750 cycles/sec
- D. 1,000 cycles/sec
- E. Glutamate reuptake and [C^{++}]

60) The fact that the cochlea acts as a frequency analyzer, by distributing acoustic stimuli to loci along the basilar membrane according to increasing frequency, forms the basis of well known hypothesis called the:

- A. square wave theory
- B. spectral theory of displaced particles
- C. place theory of tonotopic organization
- D. split frequency theory

61) The Place Theory relies upon:

- A. nerves firing in volleys
- B. nerves firing at same rate as the frequency
- C. killion compression
- D. tonotopic organization

62) Which of the following is a result of neural tissue and structural damage?

- A. distortion of perception of frequencies
- B. a threshold shift
- C. disturbance of perception of loudness
- D. All of the above

63) A head injury can cause:

- A. hypo-membranic atresia
- B. ossiculuar discontinuity
- C. otosclerosis
- D. Yellow mucosal otitis media
- E. Vestibular reorientation

64) Typanosclerosis results in:

- A. the removal of cholesteatomic spots
- B. a sensorineural hearing loss
- C. perforation of the tympanic membrane
- D. white chalky looking deposits on the tympanic membrane

65) Endolymphatic hydrops is:

- A. Build up of the endolymph fluid
- B. Linked to conductive hearing loss
- C. The removal of the endolymph fluid
- D. A CAPD

66) Central deafness maybe caused by:

- A. Rh incompatibility
- B. syphilis
- C. multiple sclerosis
- D. All of the above

67) Atresia is a term which refers to:

- A. Swollen and itching condition of the EAM
- B. Branching of TM tissue
- C. Perforation of the ear drum
- D. Closure of the external auditory canal

68) A cholesteatoma:

- A. may perforate the eardrum
- B. is usually accompanied by a constant odorous discharge
- C. is a tumor which may occur in the middle ear
- D. All of the above

69) Perforation of the eardrum can be caused:

- A. by a bone fracture
- B. by a infection
- C. by a nearby explosion
- D. All of the above

Copyright © 2009-2021 – Hearing Aid Academy – All Rights Reserved

70) Otosclerosis:

- A. occurs more often in Caucasians than other races
- B. appears to be inherited
- C. occurs more often in women than men
- D. All of the above

71) A sensorineural hearing loss is due to a disorder in the:

- A. middle ear
- B. eustachian tube
- C. inner ear
- D. ossicles
- E. Sensory function of IHCs

72) A symptom of recruitment is:

- A. intolerance for loud sounds
- B. tinnitus and vertigo
- C. presbycusis
- D. Hyper cardiod polarity

73) Malingering is a category of :

- A. non-organic
- B. sensorineural loss
- C. presbycusis
- D. All of the above
- E. Standing on the corner pretending not to hear

74) Meniere's syndrome consists of :

- A. central deafness, aphasia and vertigo
- B. tinnitus, vertigo, nausea and hearing loss
- C. presbycusis and tinnitus
- D. noise trauma and vertigo
- E. Genetic coding loss among the French

75) An organic disorder describes damage to :

- A. the hearing mechanism
- B. the neural pathways
- C. the brain
- D. Any of the above

76) A person with a non-organic hearing loss may:

- A. have some true hearing loss along with non-organic loss
- B. will always be faking
- C. have a longitudinal problem
- D. b and c

77) A person who purposefully pretends to have a hearing loss but knows that there is really nothing wrong with his hearing is:

- A. a faker
- B. a person who maybe involved in a lawsuit
- C. a malingerer
- D. All of the above

78) In pure tone testing, threshold means:

- A. the point at which the client reports the sound as most comfortable
- B. the sound has a loudness of zero dB in a 2 cc coupler
- C. the intensity at which the client correctly hears 50% of the tones given
- D. the intensity at which the client correctly hears 50% of the words given

79) ANSI means:

- A. Alternate Non Sensory Intensities
- B. Amplitude Narrowing in Strial Increments
- C. American National Standards Institute
- D. American National Safety Institute

80) The audiometer is designed so that zero on the attenuator dial represents the:

- A. level that the best human ear can hear
- B. average level of normal hearing for the frequency
- C. level of normal hearing for that frequency
- D. All of the above

 125

81) Before hearing testing is begun:

- A. You must remove impacted cerumen.
- B. Examine the ears using an ear light or otoscope
- C. Hand the earphones to the person so that he or she can put them easily
- D. None of the above

 126

82) The descending technique in pure tone audiometry is preferred because it :

- A. can prevent "hearing fatigue"
- B. is easier to hear when a sound stops than when it begins
- C. is the easiest for the operator to explain to the client
- D. All of the above

83) Begin testing at 1000 Hz because it:

- A. has good test and retest reliability
- B. is the center frequency of those most important to understanding speech
- C. provides the opportunity for the subject to become accustomed to the procedure
- D. All of the above

84) The air conduction testing should incorporate masking when there is a difference between the air conducted threshold for the test ear and the bone conducted threshold of the non-test ear of:

- A. 20 dB
- B. 30 dB
- C. 50dB
- D. 40 dB

85) The SSPL90 curve measures:

- A. all the tones across frequency
- B. the intensities of a tone until it saturates at 90 dB
- C. only the three frequencies necessary for HFA
- D. the frequency and intensity of the loudest tone below 90 dB

86) All ANSI instrument measurements are:

- A. SPL
- B. HL
- C. 0.02 dynes/cm^2
- D. SL

 131

87) Input sound pressure is measured:

- A. at the microphone opening of the hearing instrument
- B. at the receiver opening of the hearing instrument
- C. at the microphone of the 2 cc coupler
- D. at the tip of the 2 cc coupler

 132

88) Gain control is another name for:

- A. amplifier
- B. input at the microphone
- C. output potentiometer
- D. volume wheel

89) A small pressure vent (0.020 to 0.030) in an earmold will:

- A. have little or no effect on frequencies above 400 Hz
- B. reduce atmospheric pressure build-up
- C. generally reduce levels at frequencies below 200 Hz
- D. all of the above

How to Study this Material

- Take notes – carry them everywhere
- Familiarize over lunch, dinner, days off.
- Memorize and recite, memorize and recite. Repeat, just like using shampoo. Go for it.
- Use more than one of your senses.
- Challenge yourself to become an expert. Earn it.

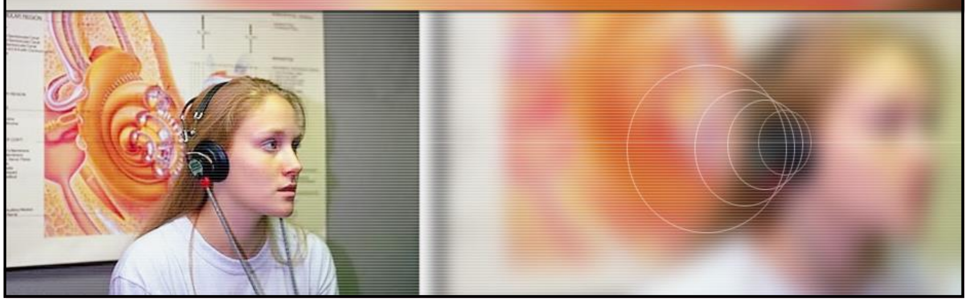
How to Study this

- Access outside resources for supplementary learning.
- Flood Google with key words.
- Buy more toner for your printer. Print, print, print… Build a reference book. Keep a journal.
- When you think you've got it, set it aside for a few days, then RIAB.

Chapter 13: Outcome Verification Technology

Chapter #13

Outcome Verification Technology



Think, "Extension…"

- No, not one.
- No, not two.
- Yes, however many until the work is finished.

Introduction

- You have just completed the lesson on hearing instruments. You may wonder what drove research from the 1950's to the present.
- The answer is: Complaints
- You may wonder why that is true.

 3

Introduction

- It is true for a myriad of reasons.
- Satisfaction is a subjection phenomenon. No one has the right to disagree or agree. It is not an objective issue. A person with hearing aids decides on satisfaction or otherwise.
- Feedback was verification of performance. . .

 4

Introduction

- So was sound field testing. And it was all we had to measure improvement with the use of hearing instruments; that is, until
- Probe Microphone Technology came along.
- Which evolved into Real Ear Measurement. . .

Introduction

- Which, by the way, was developed in the U.S. in the 1980's, thanks to George Frye and his blessed mother.
- Around the world, the motivation to develop a means to verify the performance of hearing instruments, while on and in the ear, was moving forward.

Introduction

- Why, you may ask, was/is this a necessary or worthy goal?
- The reason is simple: Feedback to the manufacturers remained constant despite technological advances. The set of complaints remained virtually the same.
- We were missing something in our field.

And what was that?

- Users still had troubles instantly hearing and understanding clearly.
- Users still complained about hearing and understanding clearly in noisy situations.
- Users still had difficulties understanding despite every effort we could make to reverse that.

Getting to Why

- Faint sounds remained beyond their grasp.
- Communication remained elusive.
- Sometimes, hearing was made worse with hearing aid insertion.
- Sure, it was new and different, and some sounds were better, but. . .

 9

Now, Why

- What we didn't realize, as an industry, was that hearing instrument testing in laboratory (*in situ*) conditions was not the same as hearing instrument testing *in vivo*.
- Nor had we given credence to the possibility that therapeutic re-training or re-learning was necessary for re-gaining the ability to understand clearly in all situations.

 10

So What?

- Despite the advances in power cells, microphones, and circuitry, the set of sources of dissatisfaction remained constant.
- So, what did we discover?
- That the performance of hearing instruments change the instant they are inserted.

What about Lab Results?

- They remain valid within the parameters of their testing.
- They confirm the construction and performance of the instruments as far as the manufacturer is involved.

Okay. . .

- Yet, we learn that inserting a hearing instrument can create a hearing loss. Wow.
- Think about it.

That's Right

- It plugs up the ear and sends sounds through and around skin, cartilage, bone and other tissue.
  - Occlusion
  - Tortuosity

What about Sound Field?

- It's a very good plateau-measuring technique.
- What about communication and the brain?
- What about hearing?
- Why is this not simple?

Sound Field

- Position the Pt three feet from the speakers, which are at ear level and at an angle of 45 degrees. VC is set at quiet comfort level.
- Is your audiometer calibrated for sound field or for head phones?
- Use your dial for approximate threshold if not calibrated for sound field.

Sound Field

- Sound Field assesses hearing acuity by the presentation of acoustic signals through sources other than the audiometer, ie. through speakers.
- The purpose of sound field is to measure functional gain in the hearing instruments.
- Standards used are international.

 17

Sound Field

- Types of tones presented in ascending and descending format are:
- Pure tones
- Warble tones
- NBN

 18

Sound Field

- To determine your functional gain, or target gain, you must use a formula such as NAL-R, POGO, Berger, or one of the fractional gain rules.
- If you are from TX or CA, you may be asked this on your licensing exam.
- Refer to HIS & FP Chapter VII.

 19

Probe Microphone

- George Frye originally developed PMT to discover whether the new hearing instrument he designed for his mother was providing the augmentation he designed and built. The essential magic of the design was built around the question:
- How do I know it's doing what it's supposed to be doing?

 20

Probe Microphone Technology

- From the earliest days of the First Generation of modern technology applied to hearing instruments, laboratory measurements were deemed sufficient and settled.

- But, they weren't. Many researchers instinctively knew that "something" else was going on. George essentially brought the hearing instrument X-ray to the industry.

Probe Microphone

- As PMT technology applications grew, so did the terminology.
  - List of S3 Standards – October 2008
- **ANSI S3.1-1999 (R 2003) American National Standard Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms.**
- **ANSI S3.2-1989 (R 1999) American National Standard Method for Measuring the Intelligibility of Speech over Communication Systems.**
- **ANSI S3.4-2007 American National Standard Procedure for the Computation of Loudness of Steady Sounds.**

Terminology

1. REUR – Real Ear Unaided Response Measurement with probe tube inserted into open ear canal. Determines ear canal resonance.
2. REUG – Real Ear Unaided Gain
3. Measurement of the difference between SPL as a function of frequency at a measurement point within the canal and SPL at the field reference point for a sound field with canal open, ie. unoccluded. Used with REAG to determine REIG.

Terminology

- 3. REOR – Real Ear Occluded Response
- Measurement of the effects of venting; hearing instrument is inserted into the ear and OFF.

- 4. REOG – Real Ear Occluded Gain
- Measurement of the difference in dB between SPL and SPL at the field reference point for a specified sound field. Again, instrument is turned OFF for this measurement.

Terminology

- 5. REAR – Real Ear Aided Response
- Measurement of SPL with hearing instrument in place and ON.

- 6. REAG – Real Ear Aided Gain
- Measurement of difference in dB as a function of frequency between the SPL at the field reference point for a specified sound field with hearing instrument in place and ON. This validates/invalidates prescription and is used to determine if compression is working as programmed.

PMT

- PMT yields a visual representation of what we cannot hear or measure otherwise and records for us the *in vivo* performance of the instruments. As you will learn with experience, there are as many differences between *in situ* and *in vivo* measurements as there are ears. The use of PMT is the only method known to approach an optimum, valid fitting.

2000 Hz

- Whatever you do to manage intensities as you work with your Pt, keep 2000 Hz in your thinking as a special frequency. It is a critical speech frequency and will be the most important one in arriving at satisfactory levels with your Pt.

 27

Terminology

- 7. REIG – Real Ear Insertion Gain
- Measurement of difference between REAG and REUG.
  - REIG = REAG – REUG
  - REIR = REAR – REUR

 28

ANSI Standards

- ANSI S3.5-1997 (R 2007) American National Standard Methods for Calculation of the Speech Intelligibility Index.
- ANSI S3.6-2004 American National Standard Specification for Audiometers.
- ANSI S3.7-1995 (R 2003) American National Standard Method for Coupler Calibration of Earphones.
- ANSI S3.13-1987 (R 2007) American National Standard Mechanical Coupler for Measurement of Bone Vibrators.
- ANSI S3.20-1995 (R 2003) American National Standard Bioacoustical Terminology.
- ANSI S3.21-2004 American National Standard Methods for Manual Pure-Tone Threshold Audiometry.

 29

ANSI Standards

- ANSI S3.22-2003 American National Standard Specification of Hearing Aid Characteristics.
- ANSI S3.25-1989 (R 2003) American National Standard for an Occluded Ear Simulator.
- ANSI S3.35-2004 American National Standard Method of Measurement of Performance Characteristics of Hearing Aids under Simulated Real-Ear Working Conditions.
- ANSI S3.36-1985 (R 2006) American National Standard Specification for a Manikin for Simulated *in situ* Airborne Acoustic Measurements.

 30

ANSI Standards

- **ANSI S3.37-1987 (R 2007) American National Standard Preferred Earhook Nozzle Thread for Postauricular Hearing Aids.**
- **ANSI S3.39-1987 (R 2007) American National Standard Specifications for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Immittance).**
- **ANSI S3.41-1990 (R 2001) American National Standard Audible Emergency Evacuation Signal.**
- **ANSI S3.42-1992 (R 2007) American National Standard Testing Hearing Aids with a Broad-Band Noise Signal.**

ANSI Standards

- ANSI S3.44-1996 (R 2006) American National Standard Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment.
- ANSI S3.45-1999 American National Standard Procedures for Testing Basic Vestibular Function.
- ANSI S3.46-1997 (R 2007) American National Standard Methods of Measurement of Real-Ear Performance Characteristics of Hearing Aids.

BPP

- It takes time and practice to become capable with real ear measurements, especially if you fit therapeutically.
- Best practice protocol defines and outlines methods of prescriptive approaches to fitting patients and arriving at high levels of satisfaction. It will be up to you to spend the required and necessary energy to develop a protocol that:

 33

BPP

1. Puts the needs of your patients first.
2. Accounts for all possible avenues to arrive at an optimum fitting level.
3. Takes into account the fact that despite plasticity issues in older individuals, we must give the auditory center every possibility to re-learn and re-process what was lost over generally a long period of time.
4. Takes into account that communication was a learned process that took billions of inputs before the first word could be uttered.

 34

BPP

- 5. Blends your objective goals for your patient with subjective goals you learn from your patient.
- 6. Rises above the traditional protocol which was based on first generation fitting technology and accepted practice techniques.