Video-Based Aural Rehabilitation Guide

Enhancing Communication in Children and Adults Who Are Deaf or Hard of Hearing

SECOND EDITION

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Preface

This second edition of the *Video-Based Aural Rehabilitation Guide: Enhancing Communication in Children and Adults Who Are Deaf or Hard of Hearing* is an extension and expansion of the first edition, with a new chapter dedicated to serving persons from diverse backgrounds, inclusion of all communication modes, additional content in every chapter, and 50 new videos. The topics and videos cover a multitude of aspects of aural rehabilitation (AR) perspectives and practices featuring infants through adults who are deaf or hard of hearing (DHH). The video-based book is intended to educate undergraduate- and graduate-level university students in speech-language pathology, audiology, and education of the deaf and hard of hearing; expand the knowledge and clinical skills of practicing professionals; and assist persons who are DHH, their families, and communication partners in understanding hearing loss and the many facets of AR. In addition, the compilation of information and the extensive videos makes this a one-of-a-kind educational and clinical resource. Together, these features will enhance the knowledge and clinical skills of undergraduate and graduate students in instructional courses and aural rehabilitation practica.

The chapters and videos represent essential, state-of-the-art concepts and practices in AR that are applicable to the widely heterogeneous group of children and adults who are DHH. The videos illustrate AR practices of audiologists, speech pathologists, Listening and Spoken Language Specialists, teachers of the deaf and hard of hearing, and other practitioners who collaborate in interprofessional practice. The videos illustrate the wide range of services that AR and related practitioners provide in settings such as clinics, schools, hospitals, and the community. Topics covered in the chapters and videos include the following: an overview of AR; many academic areas that comprise the field; hearing loss and hearing assessment; current technologies to improve listening and communication; AR procedures for infants, school-age children, and adults who are DHH and their families; factors that affect intervention and outcomes; fundamentals of communication assessment; educational supports; psychosocial well-being of persons with hearing loss; and considerations for serving persons and families from diverse backgrounds.

In this book, the term *aural rehabilitation* refers to the broad range of professional services that aim to optimize communication in infants, children, and adults who are DHH and use a continuum of communication modes, identifying with the Deaf culture, the hearing culture, or both. A similar term *audiologic (re)habilitation* is often used in other works to reflect professional practices for improving communication skills in persons who are DHH who have both prelinguistic (habilitation) and postlinguistic (rehabilitation) hearing loss. To retain inclusiveness of all communication modes and preferences for identifying with the Deaf and hearing cultures, the term *aural rehabilitation* is used in this book. Communication modes based on various sensory modalities (e.g., auditory, visual, and/or tactile) are discussed in the text and videos, with emphasis on a family-based approach to intervention.

Several chapters of this book focus on hearing technologies and teaching strategies to enhance listening and spoken language because hearing technologies and verbal communication are used by most children and adults who are DHH. Information on personal hearing devices and other hearing assistive technology systems, along with strategies to enhance listening and spoken communication, are presented as they relate to improving communication functions and increasing one's participation in the hearing-speaking culture. Improved communication can expand one's opportunities in life and lead to more fulfilling experiences in the contexts of socialization, education, employment, and recreation. Whereas verbal communication underlies most human interactions, the roles and needs of communication partners (e.g., family, friends, coworkers) are discussed along with their involvement in the AR process.

With the professional expertise of AR practitioners, including clinical audiologists, rehabilitative audiologists, Listening and Spoken Language Specialists, speech-language pathologists, and teachers of the deaf and hard of hearing, and related professionals, greater competence in the use of spoken language can lead to enhanced quality of life for many children and adults who are DHH.

This book is intended for university students in speech-language pathology, audiology, and education of the deaf and hard of hearing. As an introductory text, it is not intended to be an exhaustive work. Due to the various disciplines that are involved in AR such as medicine, communication sciences, rehabilitation, education, and psychology, numerous books and courses would be needed to provide comprehensive information on the topic. This book provides an overview of key topics in the field of AR and videos to illustrate the application of state-of-the-art concepts and practices. The videos are for illustrative purposes and are not intended to be exemplary practices for use with any particular person other than the children and adults who are featured: The activities and procedures in each video were selected for the person seen in the video and may or may not be applicable to another child or adult who is DHH. All AR services should be completely individualized to meet the needs of the client and family. The reader is encouraged to view other resources and expand their knowledge beyond what this guide and its videos offer. It is our hope that this video-based book and videos will inspire future and practicing professionals to assist people who are DHH in improving their communication and expanding their opportunities in life. With presently available AR perspectives, technologies, and clinical procedures, many children and adults who are DHH are afforded self-determination in their lives based on their own talents, interests, and choices.

—Linda L. Daniel and Sneha V. Bharadwaj

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1

Overview of Aural Rehabilitation

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Learning Objectives

After reading the chapter, readers will be able to:

1. Describe the basic anatomy and physiology of the auditory system.
2. Explain types, levels of severity, and common configurations of hearing loss.
3. Outline possible effects of auditory deprivation on brain reorganization, speech perception, and speech production.
4. Apply the WHO ICF model to a person who is deaf or hard of hearing.
5. Summarize the scope of aural rehabilitation.

Introduction

Across the globe, 466 million children and adults (5% of the world's population) have hearing loss that requires rehabilitation (World Health Organization, 2024). The World Health Organization (WHO) also estimates that this number will increase to 10% by 2050. According to the Centers for Disease Control and Prevention (CDC), hearing loss occurs in 1.7 out of every 1,000 babies screened in the United States (CDC, 2023). Additionally, 5 out of 1,000 children in the age range of 3 to 17 years are identified with hearing loss (CDC, 2023). The prevalence of hearing loss in adults between the ages of 20 and 69 years is approximately 14% (Hoffman et al., 2017).

Untreated hearing loss leads to substantial personal and economic costs (i.e., societal burden). Personal costs of untreated hearing loss often include ramifications on communication, wearable technologies, education, family life, employment, financial status, physical health, mental health, and quality of life. Societal costs are incurred by intervention services, educational services, and the economic burden of the condition (e.g., reduced income levels of some persons who are deaf or hard of hearing [DHH]). The societal costs of hearing loss increase with severity of hearing loss, communication delay or disorder, and the presence of additional disabilities (Chorozoglou et al., 2018; Grosse et al., 2018). The impact of hearing loss on individuals and society may be partially mitigated with the provision of best practices in medicine, fitting of hearing assistive technology systems, and participation in aural rehabilitation (AR) services.

Terminology Related to Hearing Loss

Terminology used to describe hearing status continues to evolve. Currently, the American Speech-Language-Hearing Association (ASHA, n.d.) recommends the use of the culturally sensitive term, *deaf or hard of hearing (DHH)*, whenever possible. According to ASHA, this term includes all persons with all types and degrees of hearing loss and cultural identities. According to ASHA (n.d.), *hard of hearing* refers to people who have hearing thresholds between 26 and 55 dB HL, whereas "*d*" deaf refers to people who have hearing thresholds in the severe to profound range. The use of "*D*" Deaf refers to individuals who identify themselves with the Deaf culture, regardless of hearing levels or use of hearing technologies. The term *hearing loss* continues to be used in the medical and audiologic fields in the context of diagnosis, assessment, and rehabilitation. The terms *hearing impaired* and *hearing impairment* are used by individuals who self-identify in this way and, in general, are to be avoided unless in the context of the Individuals with Disabilities Education Act (IDEA) or reimbursement. In this book, we will use DHH to refer to persons who are deaf or hard of hearing, inclusive of those who identify with the Deaf and hearing cultures.

Aural rehabilitation services are provided in a number of settings. The acronym *AR* will be used throughout this book to refer to both habilitative and rehabilitative services. Depending on the setting, a person who is DHH is typically referred to as a patient (hospitals and physician offices), a client (private practices or clinics), or a student (schools). Therefore, the usage of these terms in this book depends on the focus of the chapter. In general, the reader may interpret the usage of persons/client/patient/child/student as referring to *persons who are DHH*. Similarly, terms such as *practitioner* and *health care provider* are used interchangeably to denote professionals who work with persons who are DHH. The term *caregiver or communication partner* is used when referring in general terms to those who are responsible for and spend significant time with the person who is DHH.

In addition, to support positive perspectives on human diversity, the terms *differences*, *comorbidities* (i.e., co-occurring conditions), and *comorbid conditions* are used in some contexts, replacing the terms *disorders*, *deficiencies*, *delays*, and *disabilities*. Exceptions to this are the use of terms in the context of laws or models.

Overview of Anatomy and Physiology of the Auditory System

Anatomy of the Auditory System

The human auditory system comprises the peripheral and central auditory mechanisms. The peripheral auditory system includes the outer ear, the middle ear, and the inner ear (Figures 1–1, 1–2, and

1–3); the central auditory mechanism includes the nuclei and the ascending pathways and descending auditory pathways (Figure 1–4).

Peripheral Auditory System

As shown in Figure 1–1, the outer ear consists of the pinna, the ear canal, and the tympanic membrane. Medial to the tympanic membrane, the middle ear is a small, air-filled space that consists of three middle ear bones (ossicles), two muscles, and the eustachian tube. The ossicles consist of the malleus, the incus, and the stapes. The handle of the malleus is attached to the medial side of the tympanic membrane, and the head of the malleus attaches to the incus at the incudo-malleolar joint. The incus attaches to the stapes at the incudostapedial joint. The stapes has a footplate that is situated against the oval window, which is the beginning of the inner ear. The tensor tympani and stapedius are the two muscles in the middle ear. These muscles contract in response to loud sounds of certain frequencies, thereby limiting the movement of the ossicles, which is thought to protect the ear from loud sounds (Lass & Woodford, 2007). The contraction of middle ear muscles alone does not completely protect the ear from damage due to loud noise. The eustachian tube connects the middle ear space to the nasopharynx and helps equalize air pressure.

The inner ear consists of the cochlea and the vestibular apparatus. The cochlea is responsible for hearing, and the vestibular system contributes to our sense of proprioception and equilibrium. This section focuses on hearing and hence the cochlea. The cochlea is a snail-shaped structure that winds two and a half turns around its cribriform bony core, called the modiolus. Within the cochlea is the organ of Corti, which is called the end organ of hearing (see Figure 1–2). The cochlea contains three compartments, called scala vestibuli,

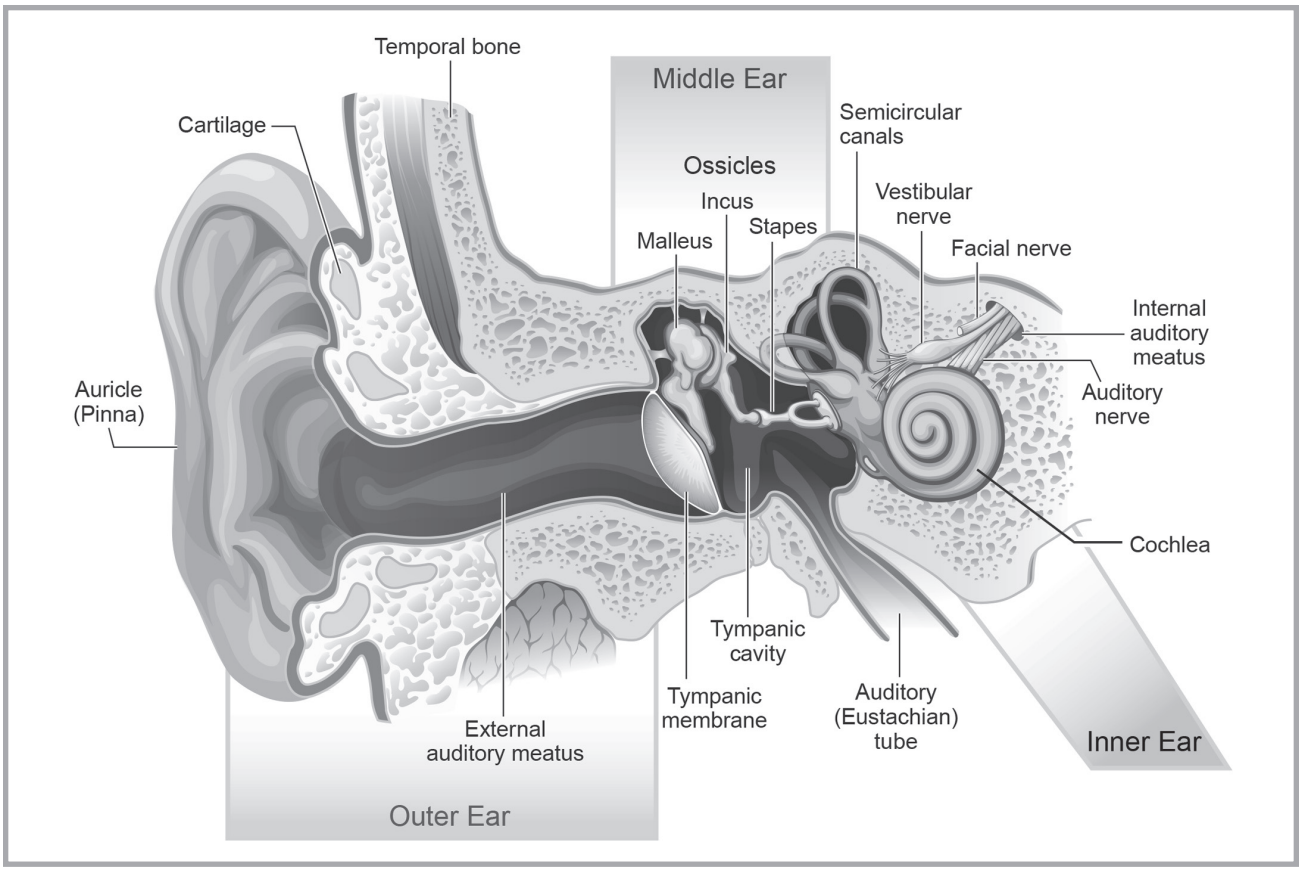

Figure 1–1. Anatomy of the human ear. Figure 1-1: From *Preclinical Speech Science: Anatomy, Physiology, Acoustics, and Perception, Third Edition* by Thomas J. Hixon, Gary Weismer, and Jeannete D. Hoit. Copyright © 2020 Plural Publishing, Inc. All rights reserved.

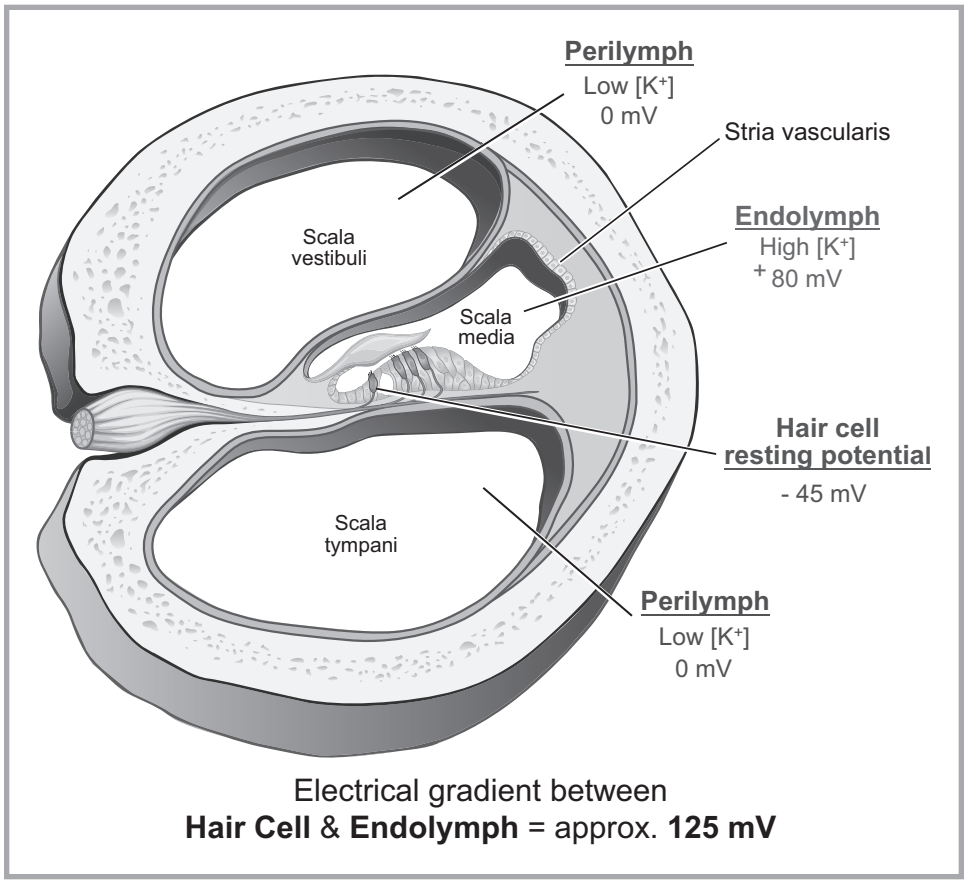

Figure 1–2. Cross-sectional view of the cochlea. From *Neuroscience Fundamentals for Communication Sciences and Disorders* by Richard Andreatta. Copyright © 2020 Plural Publishing, Inc. All rights reserved.

scala media, and scala tympani. The scala vestibuli and scala media are separated from each other by Reissner's membrane, whereas the scala media and the scala tympani are separated by the basilar membrane (Seikel et al., 2015). The basilar membrane is relatively stiffer at the basal end, where it responds maximally to high-frequency sounds, and relatively less stiff at the apical end, where it responds maximally to low-frequency sounds. This frequency specificity of the basilar membrane is known as tonotopicity. Tonotopicity is maintained throughout the auditory system. The three compartments of the organ of Corti are filled with ionically charged fluids (see Figure 1–2). The scala vestibuli and scala tympani are filled with sodium-rich perilymph (Kramer & Brown, 2019). The scala media is filled with potassium-rich endolymph.

The organ of Corti is positioned on the basilar membrane and contains hair cells, supporting cells, and the tectorial membrane (see Figure 1–3). The gelatinous tectorial membrane overlies the inner and outer hair cells of the organ of Corti and extends the entire length of the cochlea, parallel to the basilar membrane. Typically, there is one row of inner hair cells, and there are three to five rows of outer hair cells. These cells contain hair-like projections called stereocilia. The inner and outer hair cells vary in number, shape, and innervation. There are approximately 3,500 inner hair cells and approximately 12,000 outer hair cells. The inner hair cells are flask shaped, and the outer hair cells are cylindrical in shape (Sahley & Musiek, 2015). The inner hair cells are innervated by relatively more afferent (sensory) nerve fibers, whereas the outer hair cells are innervated by relatively more efferent (motor) nerve fibers. Ninety percent of the auditory nerve fibers are made up of Type I fibers that connect to the inner hair cells, and 10% of the nerve is made up of Type II fibers that connect to the outer hair cells (Sahley & Musiek, 2015).

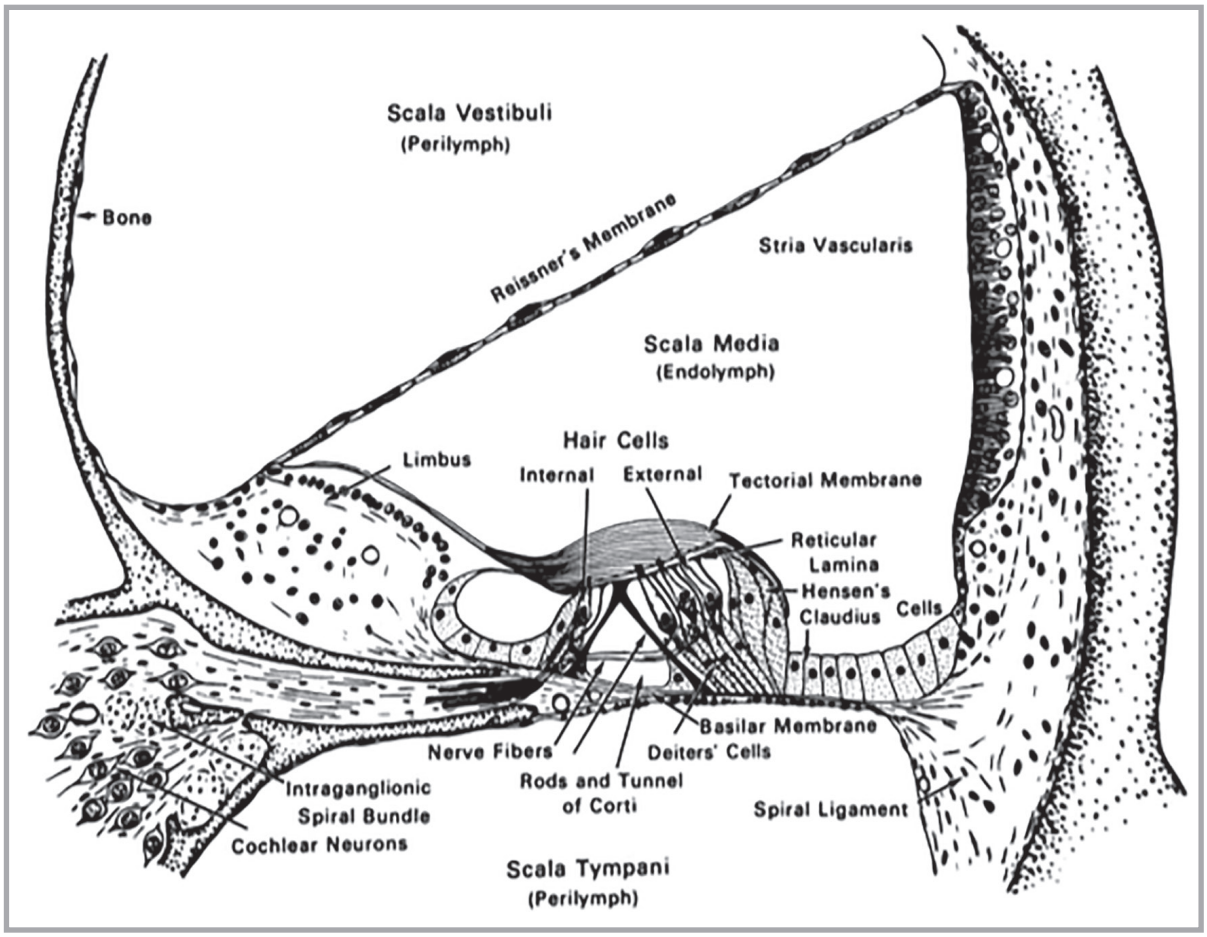

Figure 1–3. Organ of Corti. From *Basics of Audiology: From Vibrations to Sounds* by Jerry Cranford.

Together these nerve fibers form the cochlear portion of the eighth cranial nerve, which is 22 to 26 mm long and connects the cochlea to the brainstem. The afferent cochlear nerve fibers exit the inner ear through the internal auditory meatus/canal (IAC), enter the brainstem at the junction of the pons and medulla oblongata, and synapse with the cells of the cochlear nucleus.

Central Auditory System

The central auditory mechanism includes the nuclei and the ascending and descending auditory pathways. Figure 1–4 shows the ascending central auditory pathway. As shown in the figure, the afferent pathway is complex and involves connections between various nuclei, which are collections of specialized cell bodies within the brainstem and cortical regions. The auditory nuclei in the ascending central auditory pathway are the cochlear nuclei, the superior olivary complex, the lateral lemniscus, the inferior colliculus, and the medial geniculate body. As seen in the figure, there is an ipsilateral ascending pathway (i.e., synapses between the nuclei on the same side of the brain) coursing from the cochlear nucleus to the medial geniculate body. There are also contralateral connections (i.e., synapses between nuclei on the opposite side) throughout the central auditory pathway, projecting from the superior olivary complex. From the medial geniculate body, there are ipsilateral connections to the auditory reception area (i.e., Heschl's gyrus) of the temporal lobe. In addition to the ascending central auditory pathways, there are descending central auditory pathways from the cortex to the cochlear nucleus. The descending pathways serve to inhibit and modulate the initial processing of auditory information.

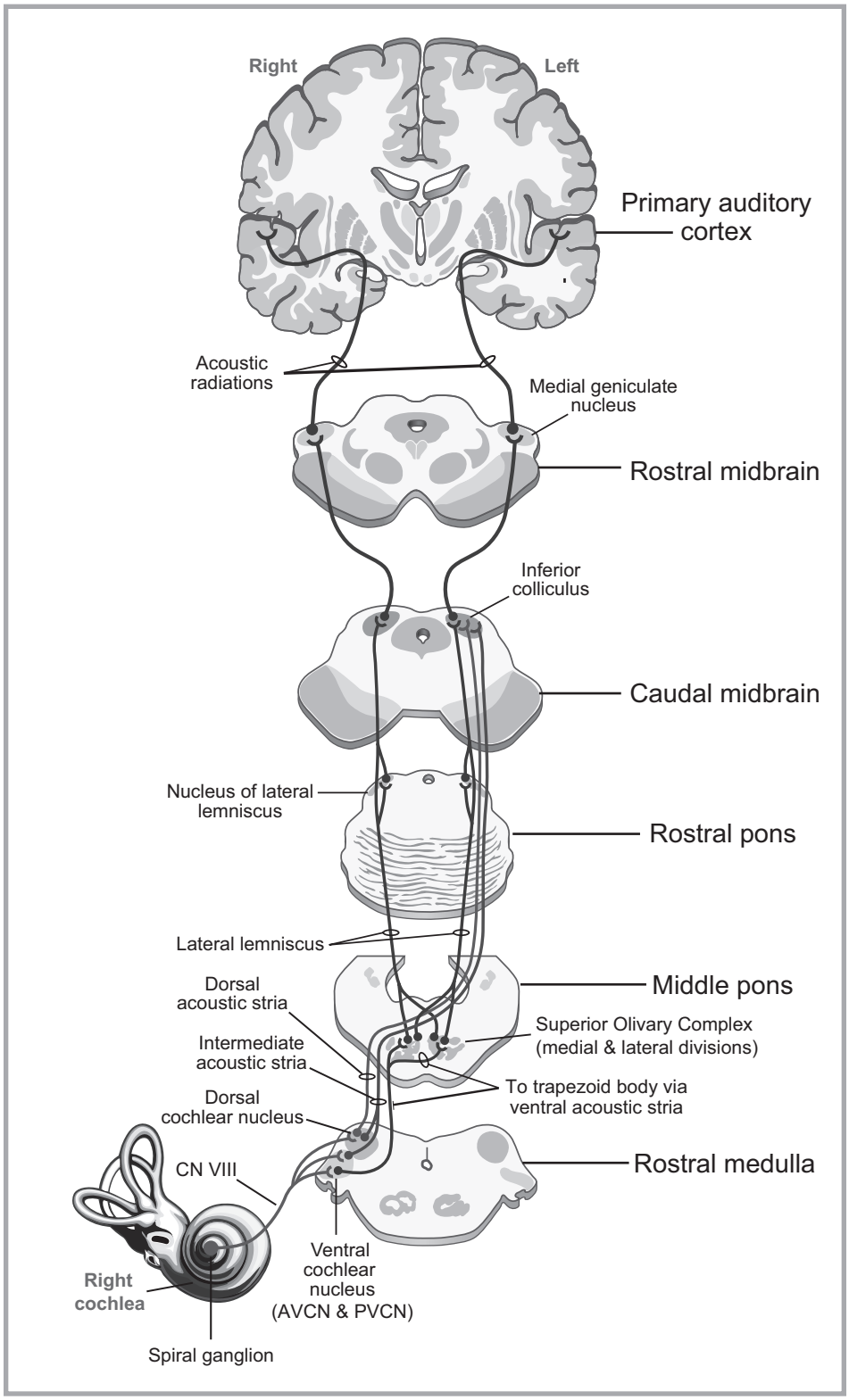

Figure 1–4. Ascending auditory pathway. From *Neuroscience Fundamentals for Communication Sciences and Disorders* by Richard Andreatta. Copyright © 2020 Plural Publishing, Inc. All rights reserved.

Physiology of the Auditory System

Hearing entails the transformation of energy from acoustic → mechanical → hydraulic → electrochemical energy. When sound enters the ear, it is modified (i.e., filtered) by the shape and size of the head, pinna, and ear canal. For example, the ear canal provides natural amplification (approx. 10–30 dB gain) in the region of 2700 Hz, which is important for the perception of speech (Lass & Woodford, 2007). This filtering action is also known as the *head-related transfer* function (Yost, 2007). The position of the two ears in conjunction with the filtering action aids in the localization of sound.

Sound that funnels through the ear canal impinges on the tympanic membrane, causing certain sections to vibrate. The acoustic energy of the vibrating air molecules is converted into mechanical energy at the tympanic membrane. The motion of the tympanic membrane is transferred to the malleus, the incus, and the stapes. The middle ear also has the important function of *impedance matching* (Kramer & Brown, 2019; Lass & Woodford, 2007). When mechanical energy travels from an air medium (middle ear) to a fluid medium (cochlea), it can be absorbed, reflected, or conducted through the fluid medium. The middle ear structures counteract the reduced energy by boosting the sound pressure of the incoming sound via the *area ratio and lever ratio*. The vibration of the relatively larger tympanic membrane is transferred to the relatively smaller oval window, resulting in an increased sound pressure on the oval window (aka area ratio). Additionally, the middle ear bones act as a system of levers. That is, small movements of the malleus result in very large movements of the stapes (aka lever ratio). Together, this results in a net gain of 25 dB in sound pressure (Kramer & Brown, 2019).

The in-and-out movement of the stapes footplate against the oval window leads to the movement of fluid within the cochlea, converting mechanical energy to hydraulic energy. The disturbance of the perilymph in the scala tympani leads to movement of the organ of Corti within the scala media. The outer hair cells of the organ of Corti contract and stretch in response to the motion of the endolymph, amplifying the movement of the basilar membrane and sharpening the frequency tuning. The basilar membrane responds maximally at certain regions along its length based on the frequency components of the incoming sound. This is known as *tonotopicity* (Lass & Woodford, 2007). The tonotopic organization of the basilar membrane is further discussed in Chapter 3. The maximal movement of the basilar membrane at certain regions results in the stereocilia of the inner hair cells in those regions making contact with the gelatinous tectorial membrane. When the stereocilia of the inner hair cells are bent (i.e., sheared) as they come in contact with the tectorial membrane, ion channels open, resulting in exchange of chemicals between the hair cells and the surrounding endolymph. This ion exchange leads to voltage changes within the hair cells, releasing neurotransmitters into the synaptic cleft (space between the junction of the inner hair cells and the auditory nerve fibers). The neurotransmitters are received by the nerve fibers, causing nerve impulses to travel through the central auditory pathway. The neurotransmitters are the last stage of energy transmission—from hydraulic energy to electrochemical energy (Kramer & Brown, 2019). Thus, at the level of the cochlea, the energy is transformed from hydraulic to electrical impulses, which are transmitted through the auditory nerve.

Tonotopicity is maintained in the nerve fibers by representing high frequencies in the outside of the nerve bundle and low frequencies in the inner nerve bundle (Sahley & Musiek, 2015). Processing the frequency, timing, and intensity of sound and coding incoming auditory stimuli for localization are accomplished at the level of the brainstem. Higher-level processing of sound (e.g., understanding speech, appreciating music, recognizing environmental sounds) occurs in the auditory association areas of the cortex.

Brief Review of Audiology

Etiology of Hearing Loss

There are numerous causes of hearing loss. As discussed in earlier sections, these include genetic hearing loss, which may be stable or progressive;

idiopathic (i.e., unknown) etiology; infections before or after birth; drug ototoxicity; head trauma; otitis media; noise exposure; sudden sensorineural loss; and genetic mutations that express at any age. Common etiologies and their corresponding types of hearing loss are presented in Table 1–1.

Genetic factors account for 50% to 60% of infant hearing loss (CDC, 2024). Genetic hearing loss is either syndromic or nonsyndromic. In syndromic hearing loss, visible ear malformations and/or other comorbidities are present. In nonsyndromic hearing loss, there are no comorbidities other than those associated with the ear/hearing (Shearer et al., 1997). Approximately 20% of infants with hereditary hearing loss have syndromic loss. Examples of syndromic genetic disorders that are associated with hearing loss are CHARGE syndrome (Coloboma, Heart defects, Atresia choanae, growth Restriction, Genital abnormalities, and Ear abnormalities), which has multiple physical manifestations; Pendred syndrome, which includes enlarged vestibular aqueduct and thyroid problems; and Usher syndrome Type I, which includes hearing loss and progressive loss of vision. An example of nonsyndromic hearing loss is the mutation of a gene encoding the gap junction protein, connexin 26 (Allen & Goldman, 2022). Video 1–1 shows an interview with a mother of two sons who are DHH and have genetic factors related to hearing loss.

Another common cause of sensorineural hearing loss present at birth is congenital cytomegalovirus (CMV), a virus that is passed from a mother to the fetus, occurring in 1 in every 200 births. Twenty percent of children born with CMV will have long-term health issues such as sensorineural hearing loss, seizures, birth defects, communication disorders, and developmental delays. Some states now mandate CMV screening of all newborns. Researchers propose adding high-sensitivity and high-specificity CMV screening to newborn hearing screening to mitigate the potential sequelae and lead to early intervention (Jin et al., 2022).

Diagnosis of Hearing Loss

As shown in Figure 1–5, the first step in the diagnosis of hearing loss in many children is newborn hearing screening. In 1994, the Joint Committee on Infant Hearing (JCIH) endorsed universal detection of hearing loss in newborns prior to discharge from the hospital. The most recent position statement of the JCIH (2019) specifies that (1) the hearing screening is to be performed before 1 month of age, (2) hearing loss is to be confirmed with detailed audiologic and medical evaluation by 3 months of age, and (3) children with confirmed permanent hearing loss are to

Table 1–1. Examples of Etiologies That Are Associated With Structures of the Ear

Structures Affected	*Examples of Etiologies*
Outer Ear	Impacted cerumen, foreign objects in the ear canal, stenosis and/or atresia of the ear canal, otitis externa, malformation of the pinna, tympanic membrane perforation
Middle Ear	Otitis media, otosclerosis, ossicular chain discontinuity, malformation of the ossicles
Inner Ear	Meniere's disease, ototoxicity, noise-induced hearing loss, presbycusis/socioacusis, agenesis of the cochlea, ototoxicity
Auditory Nerve and Central Auditory Pathways	Cochlear nerve deficiency, auditory nerve agenesis, tumors, cerebrovascular accidents, traumatic brain injury, meningitis, encephalitis, auditory neuropathy spectrum disorder

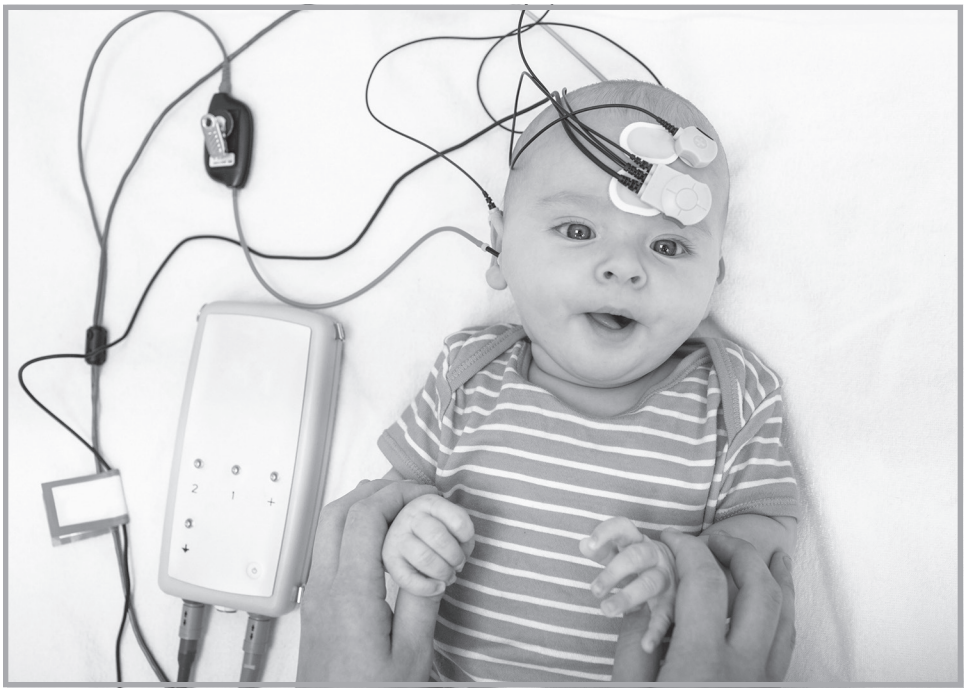

Figure 1–5. Infant hearing screening.

receive intervention by 6 months of age, including the fitting of personal hearing technology and initiation of intervention services that involve the caregivers and child. This sequence of actions is commonly referred to as the 1-3-6 plan. According to the JCIH (2019) position statement, states that have met this benchmark should strive for a 1-2-3 plan. Under the umbrella of the CDC, Early Hearing Detection and Intervention (EHDI) programs are to promote hearing screening for infants within the first few days of life, monitor hearing through follow-up evaluations, and provide early intervention services.

As a result of implementing the EHDI program throughout the United States, over 95% of all newborns are currently screened for hearing loss shortly after birth. The far-reaching goal of the EHDI programs is to maximize language, communication, and literacy outcomes in children with hearing loss. Video 1–2 shows a professor discussing the EHDI program. In Video 1–3, a mother with two sons who are DHH describes her second son's journey from newborn hearing screening to confirmation of the hearing loss.

Overview of Basic Audiometry: A Test Battery Approach

Air-Conduction and Bone-Conduction Audiometry

Air-conduction and bone-conduction audiometry are the standard tests performed to assess a person's hearing. Air-conduction audiometry measures the integrity of the entire auditory system from the outer ear to the cortex. Bone-conduction audiometry bypasses the outer ear and middle ear and assesses the sensorineural structures from the cochlea to the brain.

When conducting pure-tone audiometry, tones (i.e., beeps) are presented at specific frequencies via the air- or bone-conduction mechanisms, and patient responses are recorded. Air-conduction testing involves presenting stimuli to the ear canal via insert earphones, over-the-ear headphones, or a soundfield speaker and testing the integrity of the entire hearing system. Bone-conduction testing entails presenting stimuli via an oscillator placed on the forehead or the mastoid process of the