

THE PEARSON COMMUNICATION SCIENCES AND DISORDERS SERIES

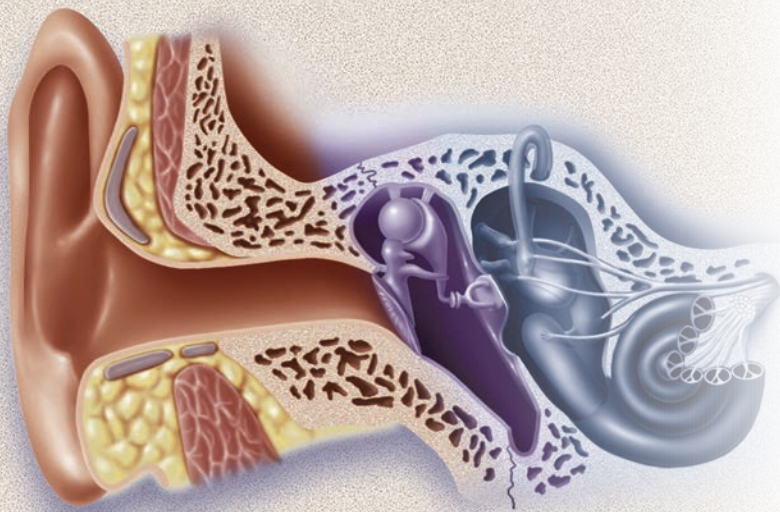
INTRODUCTION TO AUDIOLOGY



FREDERICK N. MARTIN • JOHN GREER CLARK



THIRTEENTH EDITION



Introduction to Audiology

THIRTEENTH EDITION

Frederick N. Martin

The University of Texas at Austin

John Greer Clark

University of Cincinnati



330 Hudson Street, NY 10013

Director and Publisher: Kevin Davis
Executive Portfolio Manager: Julie Peters
Managing Content Producer: Megan Moffo
Content Producer: Faraz Sharique Ali
Portfolio Management Assistant: Maria Feliberty and Casey Coriell
Executive Product Marketing Manager: Christopher Barry
Executive Field Marketing Manager: Krista Clark
Manufacturing Buyer: Deidra Smith
Cover Design: Carie Keller, Cenveo
Cover Art: Goa novi/Shutterstock
Editorial Production and Composition Services: SPi Global, Inc.
Full-Service Project Manager: Mohamed Hameed
Text Font: Sabon LT Pro

To obtain permission(s) to use material from this work, please visit <https://www.pearson.com/us/contact-us/permissions.html>

Copyright © 2019, 2015, 2012 by Pearson Education, Inc., or its affiliates. All Rights Reserved. Printed in the United States of America. This publication is protected by copyright, and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise. For information regarding permissions, request forms and the appropriate contacts within the Pearson Education Global Rights & Permissions department, please visit www.pearsoned.com/permissions/.

Unless otherwise indicated herein, any third-party trademarks that may appear in this work are the property of their respective owners and any references to third-party trademarks, logos or other trade dress are for demonstrative or descriptive purposes only. Such references are not intended to imply any sponsorship, endorsement, authorization, or promotion of Pearson's products by the owners of such marks, or any relationship between the owner and Pearson Education, Inc. or its affiliates, authors, licensees or distributors.

Library of Congress Cataloging-in-Publication Data

Names: Martin, Frederick N., author. | Clark, John Greer, author.

Title: Introduction to audiology / Frederick N. Martin, John Greer Clark.

Description: Thirteenth edition. | Boston : Pearson Education, Inc., [2019] |

Includes bibliographical references and indexes.

Identifiers: LCCN 2017041166 | ISBN 9780134695044 | ISBN 0134695046

Subjects: | MESH: Hearing Disorders | Audiometry--methods | Hearing Tests

Classification: LCC RF290 | NLM WV 270 | DDC 617.8--dc23 LC record available at <https://lcn.loc.gov/2017041166>



ISBN 10: 0-13-469504-6

ISBN 13: 978-0-13-469504-4

To Mary Catherine Martin—deeply loved and dearly missed.

This page intentionally left blank

Contents

PART I Elements Of Audiology 2



- 1 The Profession of Audiology 4**
 - 1.1 The Evolution of Audiology 5*
 - 1.2 People and Places 8*
 - Summary 15*
 - Websites 16*
 - Frequently Asked Questions 16*
 - Suggested Readings 16*

- 2 Sound and Its Measurement 17**
 - 2.1 Sound 18*
 - 2.2 The Decibel 31*
 - 2.3 Psychoacoustics 37*
 - 2.4 Sound Measurement 40*
 - Summary 52*
 - Frequently Asked Questions 54*
 - Suggested Readings 55*

PART II HEARING ASSESSMENT 56



- 3 The Human Ear, Hearing Loss, and Pure-Tone Hearing Tests 58**
 - 3.1 Basics of How the Ear Works and the Hearing Losses that May Disrupt Sound Reception 59*
 - 3.2 Testing Hearing 63*
 - 3.3 Air- and Bone-Conduction Hearing Tests 73*
 - 3.4 Audiogram Interpretation 86*
 - Summary 96*
 - Frequently Asked Questions 98*
 - Suggested Readings 100*

4	Speech Audiometry	101
4.1	<i>Requirements for Speech Audiometric Testing</i>	102
4.2	<i>Speech-Threshold Testing</i>	104
4.3	<i>Speech-Recognition Testing</i>	109
4.4	<i>Loudness Comfort, Discomfort and Sound Interference</i>	123
	<i>Summary</i>	127
	<i>Frequently Asked Questions</i>	131
	<i>Suggested Readings</i>	132
5	Masking	133
5.1	<i>Why Do We Mask and How Do We Do It?</i>	134
5.2	<i>Masking Speech Audiometry</i>	151
	<i>Summary</i>	157
	<i>Frequently Asked Questions</i>	158
	<i>Suggested Readings</i>	159
6	Physiological Tests of the Auditory System	160
6.1	<i>Acoustic Immittance</i>	161
6.2	<i>Otoacoustic Emissions (OAEs)</i>	177
6.3	<i>Auditory-Evoked Potentials</i>	180
	<i>Summary</i>	192
	<i>Frequently Asked Questions</i>	193
	<i>Suggested Readings</i>	194
7	Pediatric Hearing Loss Identification and Assessment	195
7.1	<i>Identifying Hearing Loss in Infants Under Three Months of Age</i>	196
7.2	<i>Pediatric Hearing Evaluation</i>	201
7.3	<i>Identifying Hearing Loss in the Schools</i>	215
	<i>Summary</i>	220
	<i>Frequently Asked Questions</i>	221
	<i>Suggested Readings</i>	221



PART III HEARING DISORDERS 222

8	The Outer Ear	224
8.1	<i>Anatomy and Physiology of the Outer Ear</i>	225

8.2	<i>Disorders of the Outer Ear and Their Treatments</i>	230
	<i>Summary</i>	242
	<i>Frequently Asked Questions</i>	243
	<i>Suggested Readings</i>	244
9	The Middle Ear	245
9.1	<i>Anatomy and Physiology of the Middle Ear</i>	246
9.2	<i>Disorders of the Middle Ear and Their Treatments</i>	252
	<i>Summary</i>	276
	<i>Frequently Asked Questions</i>	277
	<i>Suggested Readings</i>	278
10	The Inner Ear	279
10.1	<i>Anatomy and Physiology of the Inner Ear</i>	280
10.2	<i>Hearing Loss and Disorders of the Inner Ear</i>	290
	<i>Summary</i>	318
	<i>Frequently Asked Questions</i>	319
	<i>Suggested Readings</i>	321
11	The Auditory Nerve and Central Auditory Pathways	322
11.1	<i>Anatomy and Physiology of the Auditory Nerve and Central Auditory Pathways</i>	323
11.2	<i>Hearing Loss and the Auditory Nerve and Central Auditory Pathways</i>	325
11.3	<i>Tests for Auditory Processing Disorders</i>	338
	<i>Summary</i>	349
	<i>Frequently Asked Questions</i>	350
	<i>Suggested Readings</i>	350
12	Nonorganic Hearing Loss	351
12.1	<i>Patients with Nonorganic Hearing Loss</i>	352
12.2	<i>Testing for Nonorganic Hearing Loss</i>	356
12.3	<i>Management of Patients with Nonorganic Hearing Loss</i>	365
	<i>Summary</i>	368
	<i>Frequently Asked Questions</i>	369
	<i>Suggested Readings</i>	369

PART IV	AUDIOLOGICAL MANAGEMENT	370
13	Beyond Hearing: Management of Balance Disorders, Tinnitus, and Decreased Sound Tolerance	372
	13.1 <i>Disturbances of Balance</i>	373
	13.2 <i>Tinnitus and Its Management</i>	378
	13.3 <i>Decreased Sound Tolerance (DST)</i>	384
	<i>Summary</i>	386
	<i>Frequently Asked Questions</i>	386
	<i>Suggested Readings</i>	387
14	Amplification/Sensory Systems	388
	14.1 <i>Hearing Aid Development</i>	389
	14.2 <i>Types of Hearing Aids</i>	395
	14.3 <i>Implantable Hearing Assistance</i>	400
	14.4 <i>Hearing Aid Selection and Fitting</i>	407
	14.5 <i>Personal Sound Amplification Products and Hearing Assistance Technologies</i>	415
	<i>Summary</i>	422
	<i>Frequently Asked Questions</i>	423
	<i>Suggested Readings</i>	424
15	Patient Management	425
	15.1 <i>Gathering and Sharing Information</i>	426
	15.2 <i>Audiological Counseling</i>	434
	15.3 <i>Management of Adult Hearing Impairment</i>	442
	15.4 <i>Management of Childhood Hearing Impairment</i>	452
	15.5 <i>Management of Auditory Processing Disorders</i>	460
	15.6 <i>Multicultural Considerations</i>	463
	<i>Summary</i>	468
	<i>Frequently Asked Questions</i>	469
	<i>Suggested Readings</i>	470
	Glossary	471
	References	486
	Author Index	508
	Subject Index	512

Preface

The founders of audiology could not have envisioned the many ways in which this profession would evolve to meet the needs of children and adults with hearing and balance disorders. Breakthroughs continue to come in all areas of audiological diagnosis and treatment, resulting in a profession that is more exciting and rewarding today than ever before.

Treatment is the goal of audiology, and treatment is impossible without diagnosis. Some people have developed the erroneous opinion that audiology is all about doing hearing tests. Surely, testing the hearing function is essential, however, it might appear that many tests could be performed by technical personnel who lack the education required to be total hearing healthcare managers. Historically, the profession has rejected this approach and has developed a model wherein one highly trained, self-supervised audiologist carries the patient and family from taking a personal history through diagnosis and into management. Toward this end, the development of a humanistic, relationship-centered, approach to hearing care has evolved, one in which the audiologist guides patients and families to the highest success levels possible.

New to This Edition



With each new edition of this book, we strive not only to update the material to keep content current with recent research, but also to make it more user-friendly for students. Although a great deal of advanced material has been added, the primary target of this book continues to be the new student in audiology. While providing an abundance of how-to information, every effort is made to reveal to the novice that audiology can be a rewarding and fascinating career. In this edition, a number of features have been added or enhanced, including:

- A new chapter focusing on the diagnosis and management of balance, tinnitus, and sound tolerance problems
- A breakdown of *Check Your Understanding* questions available in the eText so that these follow each major section within each chapter rather than as a full presentation of all questions for the chapter at the end
- A brief, instructional feedback statement has been added for each *Check Your Understanding* question in the eText when the correct response is selected
- For better ease of review of key concepts, each learning outcome stated at the beginning of the chapters is numbered to correspond with the major heading within the chapter where that learning outcome is discussed

- Additional “Clinical Commentaries” appear throughout the text
- Four new instructional videos in the eText edition covering probe-microphone measures, immittance measures, hearing aids, and vestibulography
- A restructuring of material in many chapters for easier flow
- Updated references to reflect the most recent research



The eText Advantage

As with the twelfth edition, *Introduction to Audiology* is available as an eText. Publication in an eText format allows for several advantages over a traditional print format. In addition to greater affordability, this format provides a search function that allows the reader to locate coverage of concepts efficiently.

A variety of Activities designed to facilitate learning are placed at the ends of chapters and accessible through the eText. At the conclusion of each major heading within chapters, readers can access interactive eText multiple-choice *Check Your Understanding* questions to assess comprehension of key concepts. Immediate instructive feedback is provided after each question when correct responses are identified. We believe use of the *Check Your Understanding* questions and the chapter activities can increase confidence in preparation for examinations and other challenges. In their diagnostic form, these questions and activities can help identify points of knowledge and areas of weakness or knowledge gaps to direct students in their review of materials.

To further enhance assimilation of new information, links to twenty-two video clips are interspersed throughout the text and are available through the eText. These video clips demonstrate different aspects of audiological practice. They include illustration of otoscopic technique and basic hearing test procedures, as well as more advanced electroacoustic and electrophysiologic tests, earmold impression technique, hearing aid assessment measures, and more.

Bold key terms are clickable and take the reader directly to the glossary definition. Navigation to particular sections of the book is also possible by clicking on desired sections within the expanded table of contents. Sections of text may be highlighted and reader notes can be typed onto the page for enhanced review at a later date.

It is our hope that the eText format will enrich the student’s learning experience and further enhance the learning process. To learn more about the enhanced Pearson eText, go to www.pearsonhighered.com/etextbooks.



How to Use This Book

Throughout this book’s history of over four decades, its editions have been used by individuals in classes ranging from introductory to advanced levels. Students who plan to enter the professions of audiology, speech-language pathology, and education of children with hearing impairment have used it. All of these individuals are charged with knowing all they can learn about hearing disorders and their ramifications. To know less is to do a disservice to those children and adults who rely on professionals for assistance.

The chapter arrangement in this book differs somewhat from most audiology texts in several ways. The usual approach is to present the anatomy and physiology of the ear

first, and then to introduce auditory tests and remediation techniques. In this text, after an introduction to the profession of audiology and a review of the science of hearing in Chapters 1 and 2, a superficial look at how the ear works is provided as a conceptual beginning to aid in the understanding of the details of auditory tests as they relate to the basic mechanisms of hearing. Thus, with a grasp of the test principles, the reader is better prepared to benefit from the many examples of theoretical test results that illustrate different disorders in the auditory system.

The organization of this book has proved useful because it facilitates early comprehension of what is often perceived as difficult material. Readers who wish a more traditional approach may simply rearrange the sequence in which they read the chapters. Chapters 8 through 11, on the anatomy, physiology, disorders, and treatments of different parts of the auditory apparatus, can simply be read before Chapters 3 through 7 on auditory tests. At the completion of the book, the same information will have been covered.

The teacher of an introductory audiology course may feel that the depth of coverage of some subjects in this book is greater than desired. If this is the case, the primary and secondary headings allow for easy identification of sections that may be deleted. If greater detail is desired, the suggested reading lists at the end of each chapter can provide more depth. The book may be read in modules so that only specified materials are covered.

Each chapter in this book begins with an introduction to the subject matter and a statement of instructional objectives. Liberal use is made of headings, subheadings, illustrations, and figures. A summary at the end of each chapter repeats the important portions. Terms that may be new or unusual appear in **bold** print and are defined in the book's comprehensive glossary. Review tables summarize the high points within many chapters. For those who wish to test their ability to synthesize what they learn and solve some practical clinical problems, the Evolving Case Studies in selected chapters provide this opportunity. The indexes at the back of this book are intended to help readers to find desired materials rapidly.

Acknowledgments



The authors would like to express their appreciation to Kayla Whitaker for her immeasurable assistance in preparation of aspects of this edition of the text and its instructors' manual. Similarly, we are grateful to Brittany Gilb and Sarah Delaney for their assistance with the accompanying slide bank. The authors would also like to express their appreciation to the reviewers of this edition: Steve Bornstein, University of New Hampshire; Ashley L. Dockens, Au.D., Ph.D., Lamar University; Andrea Warner-Czyz, The University of Texas at Dallas.

This page intentionally left blank

About the Authors

Following a four-year enlistment in the U.S. Air Force, Frederick Martin returned to college to complete his bachelor's and master's degrees and embarked on a career as a clinical audiologist. After eight years of practice, he returned to graduate school and earned his Ph.D., then he joined the faculty at The University of Texas at Austin, where he taught and did research for 38 years. He is now the Lillie Hage Jamail Centennial Professor Emeritus in Communication Sciences and Disorders.



Frederick N. Martin

In addition to the thirteen editions of *Introduction to Audiology*, seven of which were co-authored by Dr. John Greer Clark, Martin has authored seven books, co-authored another seven, edited thirteen, and co-edited three. He has written twenty-four chapters for edited texts, 122 journal articles, 104 convention or conference papers, and five CD-ROMs. He served as a reviewer for the most prominent audiology journals and for years co-edited *Audiology: A Journal for Continuing Education*.

During his tenure at The University of Texas, Martin won the Teaching Excellence Award of the College of Communication, the Graduate Teaching Award, and the Advisor's Award from the Texas Alumni Association. The National Student Speech-Language-Hearing Association named him Professor of the Year in Communication Sciences and Disorders at The University of Texas for 2002–2003. He was the 1997 recipient of the Career Award in Hearing from the American Academy of Audiology, and in 2006, he was the first to receive the Lifetime Achievement Award from the Texas Academy of Audiology. In 2009, Martin was honored by the Arkansas Hearing Society with the Thomas A. LeBlanc Award. The text, *Introduction to Audiology*, was a finalist for the prestigious Hamilton Book Award of The University of Texas in 2006. He is a Fellow of the American Academy of Audiology and the American Speech-Language-Hearing Association and is an Honorary Lifetime Member of the American Speech-Language-Hearing Association and the Texas Speech-Language Hearing Association, and was the first and remains the only recipient of Honorary Lifetime Membership in the Austin Audiology Society. The College of Communication of The University of Texas at Austin established the Frederick N. Martin Endowed Scholarship in 2011 awarded annually to an outstanding graduate student at The University who plans to pursue a career in audiology.



John Greer Clark

Dr. Clark received his bachelor of science from Purdue University and his master's degree from The University of Texas at Austin. Following postgraduate studies at Louisiana State University, he completed his doctoral degree at the University of Cincinnati.

A recipient of both the Prominent Alumni and Distinguished Alumnus Awards from the University of Cincinnati and the Honors of the Ohio Speech and Hearing Association, Dr. Clark was elected a Fellow of the American Speech-Language-Hearing Association in 1996. He is a Past President of the Academy of Rehabilitative Audiology, Past Chair of the American Board of Audiology, and a Fellow of the American Academy of Audiology. He served four years on the Board of Directors of the American Academy of Audiology and the Ohio Academy of Audiology, and, with his wife, was co-founder of the Midwest Audiology Conference, which subsequently evolved into separate conferences for the states of Indiana, Ohio, and Kentucky. In 2017, he received the Distinguished Achievement Award from the American Academy of Audiology.

A presenter at local, state, national, and international association meetings and conventions, Dr. Clark has served as a faculty fellow for the Ida Institute in Naerum, Denmark, and as associate editor, editorial consultant, and reviewer for a number of professional journals. His more than 100 publications include three edited textbooks, a variety of co-authored texts, two single-authored books, sixteen book chapters, and a range of journal articles on various aspects of communication disorders. In 2013 his audiology counseling text, co-authored with Dr. Kristina English, was selected by the American Academy of Audiology as one of the top twenty-five audiology texts written in the past twenty-five years. His current research interests are within the areas of adult audiology rehabilitation, audiology counseling, and animal audiology.

Dr. Clark's professional career started with the Louisiana Department of Health and Human Resources, where he served as audiologist for the Handicapped Children's Program and coordinator for the Geriatric Pilot Project in Communicative Disorders. He was an Assistant Clinical Professor within the Department of Otolaryngology and Maxillofacial Surgery at the University of Cincinnati Medical Center before embarking on a successful private practice, which he left after fifteen years to serve as the Director of Clinical Services of Helix Hearing Care of America. He later returned to private practice with his wife for a number of years before returning to the University of Cincinnati. Currently, he is the Director of Audiology Education in Communication Sciences and Disorders at the University of Cincinnati.

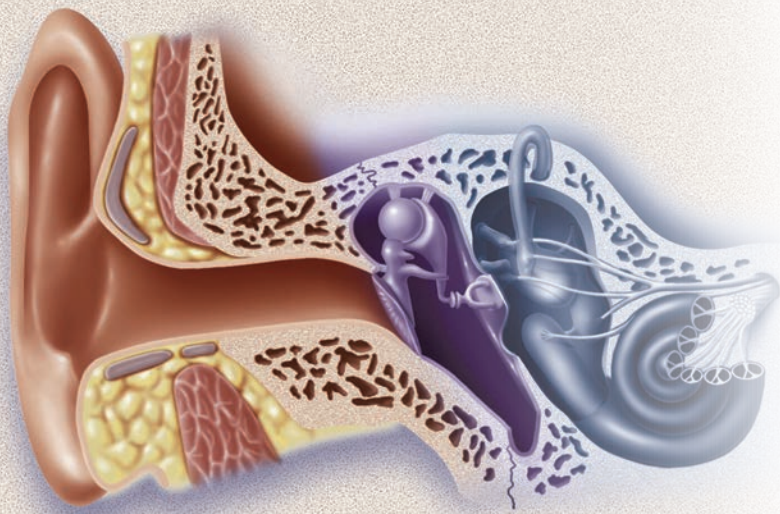
Introduction to Audiology

PART I

ELEMENTS OF AUDIOLOGY



The first part of this book requires no foreknowledge of audiology. Chapter 1 presents an overview of the profession of audiology, its history, and directions for the future. Chapter 2 discusses the physics of sound and introduces the units of measurement that are important in performing modern audiologic assessments. If you have had a course in hearing science you may find little new information in Chapter 2 and may wish to use it merely as a review. If this material is new to you, its comprehension is essential for understanding what follows in this text.



CHAPTER

1

The Profession of Audiology

LEARNING OUTCOMES

The purpose of this opening chapter is to introduce the profession of audiology, from its origins, through its course of development, to its present position in the hearing healthcare delivery system. At the completion of this chapter, you should be able to:

- 1.1** Describe the evolution of audiology as a profession.
- 1.1** Discuss the differences between licensure and certification and why an audiologist might choose to become certified.
- 1.1** Describe the reasons that speech-language pathologists may interact closely with audiologists as they provide services within their chosen professions.
- 1.2** Discuss the impact of hearing impairment on individuals and society.
- 1.2** List specialty areas within audiology and the employment settings within which audiologists may find themselves.

THE PROFESSION OF AUDIOLOGY has grown remarkably since its inception only a little more than seventy years ago. What began as a concentrated effort to assist hearing-injured veterans of World War II in their attempts to reenter civilian life has evolved into a profession serving all population groups and all ages through increasingly sophisticated diagnostic and rehabilitative instrumentation. The current student of audiology can look forward to a future within a dynamic profession, meeting the hearing needs of an expanding patient base.

1.1 The Evolution of Audiology



Prior to World War II, hearing-care services were provided by physicians and commercial hearing aid dealers. Because the use of hearing protection was not common until the latter part of the war, many service personnel suffered the effects of high-level noise exposure from modern weaponry. The influx of these service personnel reentering civilian life created the impetus for the professions of **otology** (the medical specialty concerned with diseases of the ear) and speech pathology (now referred to as **speech-language pathology**) to work together to form military-based **aural rehabilitation** centers (Figure 1.1).

These centers met with such success that, following the war, many of the professionals involved in the programs' development believed that their services should be made available within the civilian sector. It was primarily through the efforts of the otologists that the first rehabilitative programs for those with hearing loss were established in communities around the country, but it was mainly those from speech-language pathology, those who had developed the audiometric techniques and rehabilitative procedures of the military clinics, who staffed the emerging community centers (Hench, 1979).

Audiology developed rapidly as a profession distinct from medicine in the United States. While audiology continues to evolve outside the United States, most professionals practicing audiology in other countries are physicians, usually otologists. Audiometric technicians in many of these countries attain competency in the administration of hearing

FIGURE 1.1 Audiology had its genesis in the VA hospitals during WWII. Many veterans returning with noise-induced hearing loss were issued body-level hearing aids (a) and received extensive aural rehabilitation (b) to help them make use of their residual hearing to as great an extent as possible. (Source: Walter Reed Army Hospital.)



tests; however, it is the physician who dictates the tests to be performed and solely the physician who decides on the management of each patient. Some countries have developed strong academic audiology programs and independent audiologists, like those in the United States, but, with the exception of geographically isolated areas, most audiologists around the globe look to American audiologists for the model of autonomous practice that they wish to emulate.

The derivation of the word *audiology* is itself unclear. No doubt, purists are disturbed that a Latin root, *audire* (to hear), was fused with a Greek suffix, *logos* (the study of), to form the word *audiology*. It is often reported that *audiology* was coined as a new word in 1945 simultaneously, yet independently, by Drs. Raymond Carhart¹ and Norton Canfield, an otologist active in the establishment of the military aural rehabilitation programs. However, a course established in 1939 by the Auricular Foundation Institute of Audiology entitled “Audiological Problems in Education” and a 1935 instructional film developed under the direction of Mayer Shier titled simply *Audiology* clearly predate these claims (Skafta, 1990). Regardless of the origin of the word, an audiologist today is defined as an individual who has attained the education, training and license to provide an array of services for the identification, assessment, diagnosis, and treatment of those with auditory or vestibular impairment, as well as the prevention of such disorders (American Academy of Audiology, 2004).

Academic Preparation in Audiology

In the United States, educational preparation for audiologists evolved as technology expanded, leading to an increasing variety of diagnostic procedures and an expanded professional scope of practice (American Academy of Audiology, 2004; American Speech-Language-Hearing Association, 2004d). Audiology practices have grown to encompass the identification of hearing loss, the differential diagnosis of hearing impairment, and the non-medical treatment of hearing impairment and balance disorders. What began as a profession with a bachelor’s level preparation quickly transformed into a profession with a required minimum of a master’s degree to attain a state license, now held forth as the mandatory prerequisite for clinical practice in most states. Nearly forty-five years ago, Raymond Carhart, one of audiology’s founders, recognized the limitations imposed by defining the profession at the master’s degree level (Carhart, 1975). Yet it was another thirteen years before a conference, sponsored by the Academy of Dispensing Audiologists, set goals for the profession’s transformation to a doctoral level (Academy of Dispensing Audiologists, 1988).

Beginning in 1994 with the establishment of the first professional doctorate in audiology, academic programs transitioned to the professional doctorate for student preparation in audiology, designated as the doctor of audiology (Au.D.). At most universities, the Au.D. comprises four years of professional preparation beyond the bachelor’s degree, with heavy emphasis on didactic instruction in the early years gradually giving way to increasing amounts of clinical practice as students progress through their programs. The final (fourth) year consists of a full-time clinical placement, usually in a paid position.

Although the required course of study to become an audiologist remains somewhat heterogeneous, coursework generally includes hearing and speech science, anatomy and physiology, fundamentals of communication and its disorders, counseling techniques, electronics, computer science, and a range of coursework in diagnostic and rehabilitative services for those with hearing and balance disorders. Through this extensive background, university programs continue to produce clinicians capable of making independent decisions for the betterment of those they serve.

¹ Dr. Raymond Carhart (1912–1975), largely regarded as the father of audiology.

Licensing and Certification

As audiology evolved in the United States, like other professions, its practice has become governed through license or registration in every state of the union and the District of Columbia. Such regulation ensures that audiology practitioners have met a minimum level of educational preparation and, in many states, that a minimum of continuing study is maintained to help ensure competencies remain current. A license to practice audiology or professional registration as an audiologist is a legal requirement to practice the profession of audiology. Licensure and registration are important forms of consumer protection, and loss or revocation of this documentation prohibits an individual from practicing audiology. To obtain an audiology license, one must complete a prescribed course of study, acquire approximately 2000 hours of clinical practicum, and attain a passing score on a national examination in audiology.

In contrast to state licensure and registration, certification is not a legal requirement for the practice of audiology. Audiologists who choose to hold membership in the American Speech-Language-Hearing Association (ASHA) are required by ASHA to hold its Certificate of Clinical Competence in Audiology, attesting that a designated level of preparation as an audiologist has been met and that documented levels of continuing education are maintained throughout one's career. Many audiologists select certification from the American Board of Audiology as a fully voluntary commitment to the principles of lifelong continuing education. ABA certification is an attestation that one holds him- or herself to a higher standard than may be set forth by professional associations or in the legal documents of licensure or registration.

The use of support personnel within a variety of practice settings is growing. The responsibilities of these “audiologist’s assistants” have been delineated by the American Academy of Audiology (1997; 2014). Licensing laws in nearly half of the states define permitted patient care assignments for audiology assistants. Assistants can be quite valuable in increasing practice efficiency and meeting the needs of a growing population with hearing loss. It is audiologists’ responsibility to ensure that their assistants have the proper preparation and training to perform assigned duties adequately.

A Blending of Art and Science

Audiology is a scientific discipline based upon an ever-growing body of research on the fundamentals of hearing and balance, the physiologic and psychosocial impacts of disorders of these functions, and the technological aspects of both hearing and balance diagnostics and pediatric and adult treatments. Over the years, some have cautioned that audiology should avoid becoming mired in the technological aspects of service delivery. Indeed, as Hawkins (1990) pointed out more than a quarter of a century ago, the importance of the many technological advances seen in audiology may be of only minor importance to the final success with patients when compared to the counseling and rehabilitative aspects of audiological care.

The blending of the science of audiology with the art of patient treatment makes audiology a highly rewarding profession. The humanistic side of professional endeavors in audiology is what brings audiologists close to the patients and families they serve and makes the outcomes of provided services rewarding for both the practitioner and the recipient of care. All patients bring to audiology clinics their own life stories, personal achievements, and recognized (and unrecognized) limitations. Audiologists must learn to listen supportively, thus allowing patients to tell their own stories, so that both diagnostics and rehabilitation may be tailored to individual needs effectively (Clark & English, 2014).



**CHECK YOUR
UNDERSTANDING 1.1**

Clinical COMMENTARY

Speech-language pathologists often find that they work in close concert with audiologists. This may be true with children, whose hearing loss can have a direct impact on speech and language development, as well as with older adults, who have a higher incidence of age-related communication disorders. The frequent co-existence of hearing disorders and speech and language problems has led the American Speech-Language-Hearing Association to include hearing-screening procedures, therapeutic aspects of audiological rehabilitation, and basic checks of hearing aid performance within the speech-language pathologist's scope of practice (ASHA, 2001, 2004b).



1.2 People and Places

Audiologists serve patients of all ages ranging from neonates to those at the end stages of their lives. Those with hearing and balance disorders may be seen by audiologists within different professional settings and by professionals who serve as general audiology practitioners or who may have chosen to specialize primarily within a single area of audiology practice. To support audiologists, several associations have been founded to provide forums for information exchange in the broad field of audiology and its specialty areas. Many of these associations offer continuing education opportunities for practitioners to meet the requirements of licensure or voluntary certification.

Prevalence and Impact of Hearing Loss

Although the profession of audiology was formed under the sponsorship of the military, its growth was rapid within the civilian sector because of the general **prevalence** of hearing loss and the devastating impact that hearing loss has on the lives of those affected. The reported prevalence of hearing loss (see Table 1.1) varies somewhat depending on the method of estimation (actual evaluation of a population segment or individual response to a survey questionnaire), the criteria used to define hearing loss, and the age of the population sampled.

TABLE 1.1 Prevalence of Hearing Loss and Related Disorders

360 million (5.3%) persons in the world have a debilitating hearing loss
50 million (1.5%) Americans experience tinnitus (ear or head noises)
48 million (1.47%) Americans report some degree of hearing loss
30 million (0.9%) Americans are exposed to hazardous noise levels or ototoxic chemicals at work.
16 million (33%) Americans have a hearing loss at age 65 or older
14 million baby boomers (14.6%) have hearing problems
10 million (0.3%) Americans have some degree of permanent, noise-induced hearing loss
7 million (15%) school-aged children have some degree of hearing loss
6 million Generation Xers (7.4%) already have a hearing loss
5 out of 6 children (83%) in America experience ear infections by 3 years of age.
2-3 of every 1000 children (0.03%) in America are born with hearing loss in one or both ears

Sources: World Health Organization (www.who.int/pbd/deafness/WHO_GE_HL.pdf); Tinnitus Association of America (www.ata.org); Hearing Loss Association of America (www.hearingloss.org/content/basic-facts-about-hearing-loss); Centers for Disease Control and Prevention (www.cdc.gov/niosh/topics/noise/stats.html); Better Hearing Institute (www.betterhearing.org); Hear It (www.hear-it.org); National Institute of Occupational Safety and Health (www.cdc.gov/niosh/topics/noise); National Institute on Deafness and Other Communication Disorders (www.nidcd.nih.gov/health/statistics/quick-statistics-hearing); US Census Bureau (www.census.gov/popclock)

Using audiometric data from a national health and nutrition survey combined with population projection estimates for the United States, Goman, Reed, and Lin (2017) estimated the prevalence of bilateral hearing loss in 2020 among adults twenty years of age and older to be over 44 million (15 percent). This figure is projected to rise to over 73 million (22.6 percent of adults) by the year 2060. Increased hearing loss is greatest among older adults with estimates in 2020 exceeding 55 percent of adults 70 years of age and older. The number of children with permanent hearing loss is far lower than the number of adults. However, the prevalence of hearing loss in children is almost staggering if we consider those children whose speech and language development and academic performances may be affected by mild transient ear infections so common among children. While not all children have problems secondary to ear pathologies, 75 percent of children in the United States will have at least one ear infection before three years of age (National Institute on Deafness and Other Communication Disorders, 2010a).

For children with recurrent or persistent problems with ear infections, the developmental impact is uncertain. A variety of studies have shown that some children prone to ear pathologies may lag behind their peers in articulatory and phonological development, the ability to receive and express thoughts through spoken language, the use of grammar and syntax, the acquisition of vocabulary, the development of auditory memory and auditory perception skills, and social maturation (for review, see Clark & Jaindl, 1996). There is indication, however, that children with early history of ear infections, while initially delayed in speech and language, may catch up with their peers by the second year of elementary school (Roberts, Burchinal & Zeisel, 2002; Zumach, Gerrits, Chenault & Anteunis, 2010). Other studies have shown very little or no associations between recurrent otitis media and speech and language development for most children (Roberts, Rosenfeld & Zeisel, 2004). Even so, a study reporting no significant differences in speech understanding in noise between groups of third- and fourth-grade students with and without histories of early ear infections did, however, find a much greater range in abilities for those with a positive history of ear infections (Keogh et al., 2005).

The fact that many children with positive histories of ear infection develop no speech, language, or educational delays suggests that factors additional to fluctuating hearing abilities may also be involved in the learning process (Davis, 1986; Williams & Jacobs, 2009), but this in no way reduces the need for intervention. The impact of more severe and permanent hearing loss has an even greater effect on a child's developing speech and language and educational performance (Diefendorf, 1996) and also on the psychosocial dynamics within the family and among peer groups (Altman, 1996; Clark & English, 2014).

Often, the adult patient's reaction to the diagnosis of permanent hearing loss is to feel nearly as devastated as that of the caregivers of young children with newly diagnosed hearing impairment (Martin, Krall & O'Neal, 1989). Yet the effects of hearing loss cannot be addressed until the reason for the hearing loss is diagnosed. Left untreated, hearing loss among adults can seriously erode relationships both within and outside the family unit. Research has demonstrated that, among older adults, hearing loss is related to overall poor health, decreased physical activity, and depression. Indeed, Bess, Lichtenstein, Logan, Burger, and Nelson (1989) demonstrated that progressive hearing loss among older adults is associated with progressive physical and psychosocial dysfunction.

In addition to the personal effects and opportunity costs of hearing loss on the individual, the financial burden of hearing loss placed upon the individual, and society at large, is remarkable. The National Institute on Deafness and other Communication Disorders (2010b) reports that the total annual costs for the treatment of childhood ear infections may be as high as \$5 billion in the United States. When one adds to this figure