Applied Anatomy & Physiology for Speech–Language Pathology & Audiology

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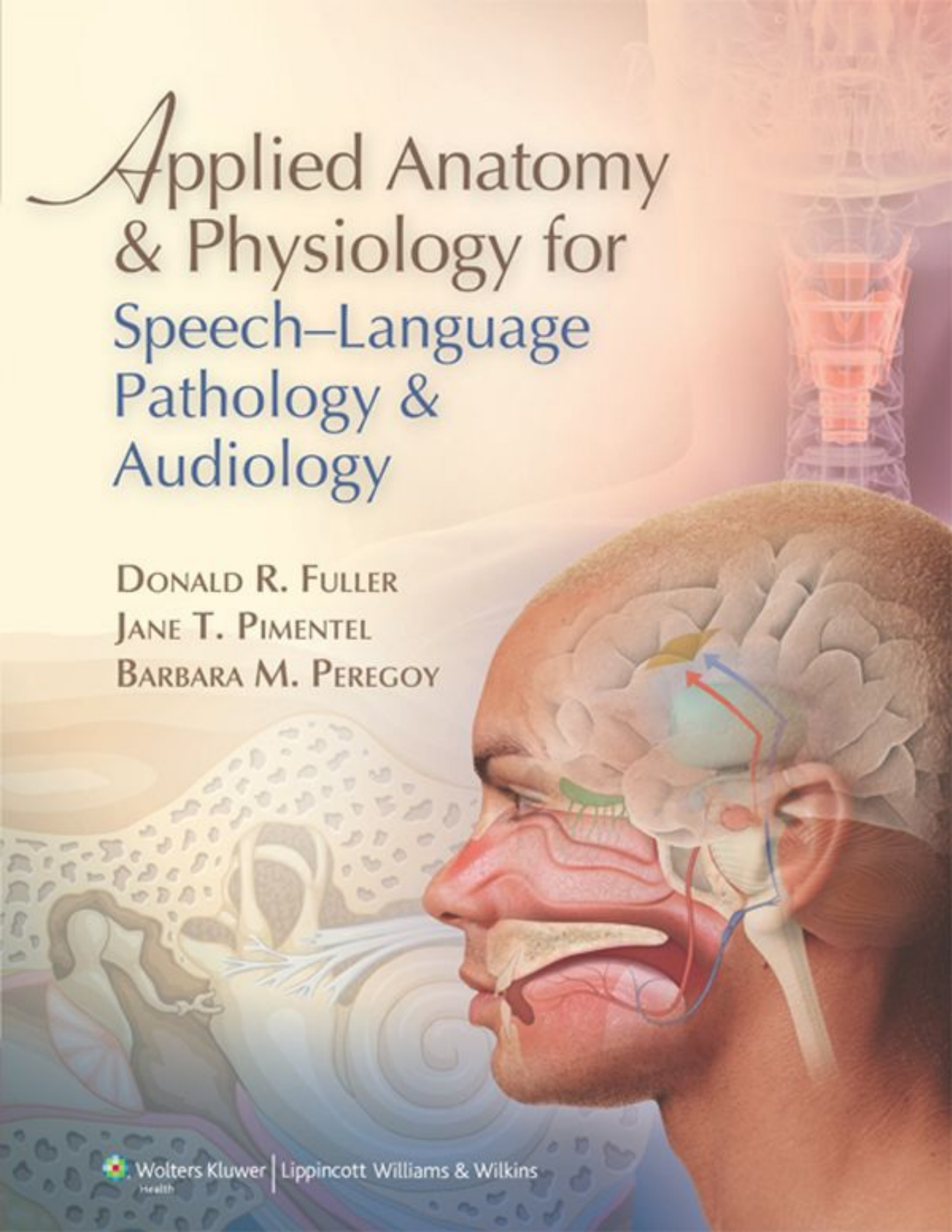

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Wolters Kluwer Health | Lippincott Williams & Wilkins
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Acquisitions Editor: Peter Sabatini
Product Manager: Paula C. Williams
Marketing Manager: Allison Powell
Designer: Teresa Mallon
Compositor: Aptara, Inc.

351 West Camden Street
Baltimore, MD 21201

Two Commerce Square
2001 Market Street
Philadelphia, PA 19103

Printed in China

9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Fuller, Donald (Donald R.), author.
Applied anatomy and physiology for speech-language pathology and audiology / Donald Fuller, Ph.D., CCC-SLP, Jane Pimentel, Ph.D., CCC-SLP, Barbara M. Peregoy, Au. D., CCC-A.
p. ; cm.
Includes bibliographical references and index. ISBN 978-0-7817-8837-3 (hardback : alkaline paper)
1. Communicative disorders—Pathophysiology. 2. Human anatomy. 3. Human physiology. I. Pimentel, Jane, author. II. Peregoy, Barbara M., author. III. Title.
[DNLM: 1. Language Disorders—physiopathology. 2. Hearing Disorders—physiopathology. 3. Nervous System—anatomy & histology. 4. Respiratory System—anatomy & histology. 5. Speech—physiology. 6. Speech-Language Pathology—methods. WL 340.2]
RC423.F824 2010
616.8†5[H11032]5—dc22

2010044328

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To my wife, Zhe Qu ("Joyce"), and our daughter, Ersi Nie ("Sisi"), two intellectually superior women who understand the importance of life-long learning; and to our younger children—Destiny, Richard, and Aidan—may the love of learning be just as important to them. Finally, to my mother, Hannah Louise Bridges, and father, Roy Fuller, Sr., both now deceased, who instilled within me the need to never stop learning.

Donald R. Fuller

To my husband, Paul, for his limitless patience and support and to my late mother, Ramona, for her incredible enthusiasm for my professional pursuits.

Jane T. Pimentel

To my husband, Bob, for his patience and for encouraging me to continue when I wanted to quit; to my sons, Stephen and William, for understanding when I told them, "I can't right now, I have a deadline"; and to my big brother, Steve, for teaching me by example that life's challenges are "do-able" even if you just pick your way down the mountain.

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PREFACE

“Why do we need to know all of this anatomy?”

It’s a question for the ages. Every instructor who has ever taught anatomy and physiology of the speech and hearing mechanism has heard that question at least once—if not several times—in his or her career. Too often, and for various reasons, anatomy and physiology is taught separately from the disorders in the typical communication disorders curriculum. For those of us who are “purists,” there is a belief that the foundational courses for the profession should be taught before the applied courses are introduced. This is reinforced by the classifi cation of anatomy and physiology as one of the “basic human communication processes.” The assumption for many is that applied coursework is not appropriate until the underlying basic processes are understood. For others, the logistical nightmare of trying to coordinate anatomy and physiology with the disorders within a 3-, 4-, or even 5-credit course has precluded the introduction of applied information with the information pertaining to anatomy and physiology. The problem is exacerbated by the fact that the most commonly used textbooks on anatomy and physiology of the speech and hearing mechanism provide very little, if any, applied information. Other than the occasional “clinical application” box or short paragraph, one would be hard pressed to fi nd any substantive information about how anatomy and physiology is used clinically to govern the decision-making process regarding diagnosis or potential intervention strategies.

The reality is that for whatever reason we choose not to integrate anatomy and physiology with their clinical relevance, students are not provided the “big picture.” At least while they are taking the course, most students do not fully comprehend how anatomy and physiology fi ts into this big picture. Most of us try to provide clinically relevant

examples while we are teaching the course, but too often, the few examples we provide are simply not enough. The industrious student may take the initiative and seek out that information independently. Most students, however, wait until they take the applied courses and hope that at that point they will begin to see the big picture. From these students who no doubt make up the majority, those often said words are uttered:

“Why do we need to know all of this anatomy?”

Throughout the many years we have taught anatomy and physiology of speech and hearing, we must have heard that question a thousand times. Even in light of our attempts to provide clinically relevant examples to illustrate the importance of understanding the anatomy and physiology, that question kept rearing its ugly head. We are happy to report that the vast majority of students who have taken an anatomy course under us went on to make the connection later in their studies. However, we have always had the nagging feeling that students needed to make that connection much sooner in their undergraduate careers.

We have never been overly enamored with the textbooks in anatomy and physiology that have been published over the years. Some of them were too technical or advanced for the typical undergraduate student, bogging the student down in detail after detail to the point that comprehension was minimal. Other textbooks were too simplistic, not providing enough detail to be meaningful to the student. With the exception of one or two, most textbooks provided very little in the way of ancillary materials. All of them provided too little information about the clinical relevance of anatomy and physiology. The more and more we taught anatomy and physiology over the years, the more we thought about what we would like to see in an anatomy textbook: a good balance in terms of the complexity of the information provided; ancillary materials to assist the student in further understanding the material; and most importantly, a good, healthy dose of applied clinical information to assist the student in making the critical connection between anatomy/physiology and its clinical application. Such a textbook, and a course built around it, would hopefully eliminate the need for students to ask:

“Why do we need to know all of this anatomy?”

Enter the American Speech-Language-Hearing Association (ASHA). When ASHA introduced its new standards for certification in January 2005, we saw it as an opportunity. With the new certification standards being knowledge- and skills-based as opposed to course-based, we realized that professional programs were freed from counting academic credits in various areas such as basic human communication processes, professional courses, etc. Instead, programs could concentrate on ensuring that students acquire certain knowledge and skills outcomes. Such a shift in focus allows professional programs to redesign their curricula to meet knowledge and skills outcomes instead of counting academic credits. Other than the general requirement that graduates have 75 semester hours credit of coursework in the profession (with 36 of those credits being earned at the graduate level), there are no longer specific academic credit requirements. An obvious benefit of this is that the need to separate the anatomy and physiology from the clinical application no longer exists. Both could be taught in parallel since professional programs are no longer required to "bean count" the academic credits.

This textbook represents the culmination of the ideas we have had for the last 20 years. First, a conscious attempt was made to present the anatomy and physiology of speech and hearing in a manner that is not too complex, but also not too simplistic. The critical information is here. The terminology is here. The detail is also here. The writing style is what possibly separates this textbook from the other texts available on the market. An attempt was made to write in a style that invites the reader on a tour of anatomy and physiology.

Second, ancillary materials are available to assist the student in understanding the anatomy and physiology and also to assist the instructor in presenting the material. In our opinion, the artwork (both drawings and photographs) in this textbook is superior by comparison with the artwork in other textbooks on the market. Case studies, clinical "tie-in" boxes, a large glossary, references to research, study questions, and terminology "hint" boxes are used liberally to assist the reader's comprehension. A companion Web site is also available; this includes a library of images and other pedagogical materials to further reinforce the concepts learned. This textbook is possibly the fi rst one in our profession to link the information contained within to the pertinent

knowledge outcomes of ASHA's certification standards (see the section Addressing Knowledge and Skills [KASA] Outcomes later).

Third, and most importantly, this textbook includes chapters on pathology and its relationship to anatomy and physiology. Each major part of this book (articulatory/resonance system, auditory/vestibular system, nervous system, phonatory system, and respiratory system) consists of two chapters. The first chapter in each unit provides the relevant information pertaining to anatomy and physiology. The second chapter in each unit provides an in-depth discussion of pathology and its relationship to the anatomy and physiology. Although these chapters do not provide an exhaustive list of all the possible pathologies, sufficient detail is provided about a large number of organic and nonorganic disorders to allow the student to see the big picture. This textbook is organized in such a manner that it can be used in a stand-alone anatomy and physiology course or as the primary text in a combined undergraduate anatomy/pathology course.

Speaking of the organization of this textbook, one may note that it differs from the other anatomy textbooks. After an introductory section on terminology and basic concepts, most other textbooks present the anatomy and physiology in the following order: respiratory system, phonatory system, articulatory/resonance system, nervous system, and auditory system. This textbook organizes the anatomy/physiology information in a slightly altered sequence: nervous system, respiratory system, phonatory system, articulatory/resonance system, and fi nally the auditory/vestibular system. The rationale for this sequence is that since the nervous system underlies all other processes in speech and hearing, it should be presented fi rst. It should be presented first also because information presented in later chapters (e.g., physiology of muscles) is dependent upon the student's understanding of the neurological bases. Once the student has been introduced to the nervous system, the traditional sequence of respiration, phonation, and articulation/resonance is presented. As a somewhat independent system, the auditory/vestibular system is presented last.

We have told our students over the years, "If you understand the anatomy and physiology, you're more than half-way to understanding the pathology." Many of these students have come back to us years later and affirmed that observation. These same former students have almost

invariably mentioned that it would have been more helpful had they made that connection earlier in their academic careers. Hopefully, this textbook represents a successful attempt to align the basic science of anatomy and physiology with the applied art and science of communication disorders. We will know that this attempt was successful if we no longer hear students ask:
"Why do we need to know all of this anatomy?"

Additional Resources

Applied Anatomy and Physiology for Speech–Language Pathology and Audiology includes additional resources for both instructors and students that are available on the book's companion Web site at http://thePoint.lww.com/Fuller.

INSTRUCTOR RESOURCES

Approved adopting instructors will be given access to the following additional resources:

- Test bank
- Answers to Part Questions that are within the textbook
- Image bank to assist in creating Powerpoint slides
- Acland Human Anatomy videos related to speech and hearing

STUDENT RESOURCES

- Interactive student quiz bank
- Animations on the workings of anatomical and physiological structures of the body as they relate to speech and hearing
- Acland Human Anatomy videos related to speech and hearing

In addition, purchasers of the textbook can access the searchable Full Text On-line by going to the *Applied Anatomy and Physiology for Speech–Language Pathology and Audiology* Web site at http://thePoint.lww.com/Fuller. See the inside front cover of this textbook for more details, including the passcode you will need to gain

access to the Web site.

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February 2011

ADDRESSING KNOWLEDGE AND SKILLS (KASA) OUTCOMES

This textbook may be the first of its kind to indicate which knowledge outcomes of the *Knowledge and Skills Acquisition* (*KASA*) form are addressed through the content found within its pages. On January 1, 2005, the American Speech-Language-Hearing Association (ASHA) revised its certifi cation standards. These are standards every student must meet to earn the Certifi cate of Clinical Competence (CCC). The old standards were based upon the student taking certain courses in specific domains. For example, the Basic Human Communication Sciences domain required that the student earn 15 semester credit hours in such courses as anatomy and physiology of speech and hearing; phonetics; speech and language development; and speech and hearing science. The new standards are no longer primarily based upon the student earning a set number of academic credits but instead are primarily competency-based. Now, the student must demonstrate competence in certain knowledge and skills.

Table P-1 indicates the *KASA* knowledge outcomes that are addressed in this textbook. Up to 25 knowledge outcomes may be addressed by this textbook, depending on how the textbook is used. It should be noted that the items in this table are numbered consecutively from 1 to 25; these numerals were arbitrarily assigned by the authors of this textbook solely for the purpose of organization and reference, and do not correspond to any numbering system developed by ASHA.

TABLE P-1

KASA KNOWLEDGE AND SKILLS OUTCOMES ADDRESSED BY THE CONTENT OF THIS TEXTBOOK

Knowledge Outcome	Addressed to What Extent?	Addressed in Chapter(s)
1. Biological basis of the basic human communication processes (III-B)	80%	2, 3, **6, 8, 10, 12**
2. Neurological basis of the basic human communication processes (III-B)	30%	2, 3, **4**, 6, 8, 10, 12
3. Acoustic basis of the basic human communication processes (III-B)	20%	**8, 10,** 12
4. Psychological basis of the basic human communication processes (III-B)	10%	**4**
5. Developmental and life span bases of the basic human communication processes (III-B)	20%	4, 8, 13
6. Linguistic basis of the basic human communication processes (III-B)	10%	**4**
7. Biological basis of swallowing processes (III-B)	80%	**8, 10**
8. Neurological basis of swallowing processes (III-B)	30%	**4**
9. Etiologies of articulation disorders (III-C)	10%	**11**
10. Characteristics of articulation disorders (III-C)	10%	**11**
11. Etiologies of fluency disorders (III-C)	10%	5, 9, 11
12. Characteristics of fluency disorders (III-C)	10%	5, 9, 11
13. Etiologies of voice and resonance disorders (III-C)	20%	**9**
14. Characteristics of voice and resonance disorders (III-C)	20%	**9**
15. Etiologies of receptive and expressive language disorders (III-C)	10%	**5,** 13
16. Characteristics of receptive and expressive language disorders (III-C)	10%	**5**
17. Etiologies of hearing disorders (III-C)	80% SLP/50% Aud.	**13**
18. Characteristics of hearing disorders (III-C)	60% SLP/30% Aud.	**13**
19. Etiologies of swallowing disorders (III-C)	10%	5, 9, 11
20. Characteristics of swallowing disorders (III-C)	10%	5, 9, 11
21. Etiologies of cognitive aspects of communication (III-C)	10%	**5**
22. Characteristics of cognitive aspects of communication (III-C)	10%	**5**
23. Prevention of voice and resonance disorders (III-D)	10%	9
24. Prevention of hearing disorders (III-D)	50% SLP/10% Aud.	13
25. Prevention related to the cognitive aspects of communication (III-D)	10%	5

The reader will note right away that a horizontal line separates the first eight knowledge outcomes from the remaining outcomes. If this textbook is used as the primary source of information for a stand-alone course in anatomy and physiology of the speech and hearing mechanism, then only knowledge outcomes 1 through 8 are applicable. However, if this textbook is used as the primary source of information in a course having greater content than simply anatomy and physiology (e.g., the anatomy and physiology are presented within a larger course on organic speech, language, and hearing disorders), all 25 knowledge outcomes are applicable.

Table P-1 also provides information as to the relative extent a particular knowledge outcome is being addressed. It should be emphasized that these are *relative* percentages based upon the expected amount of information that would be provided in an anatomy and physiology and/or an organic disorders course and the amount of

information that would be provided elsewhere in a typical communication disorders curriculum. To illustrate, the relative extent to which a stand-alone anatomy and physiology course would address the biological basis of the basic human communication processes (outcome 1) has been estimated at 80%. In other words, one would expect that approximately 80% of the information provided within a typical communication disorders curriculum related to outcome 1 would come from a basic, stand-alone course in anatomy and physiology of the speech and hearing mechanism. The remaining 20% is typically addressed in disorders courses, where a review of the anatomy and physiology may be provided as part of the course. For outcomes 17, 18, and 24, relative percentages are provided separately for speech–language pathology and audiology majors. For example, this textbook provides approximately 80% of the information in a typical communication disorders curriculum related to etiologies of hearing disorders for speech–language pathology majors, but only 50% of the same information for audiology majors because they'd more likely receive more extensive information in other courses within their major. Once again, it should be emphasized that these are *relative* percentages. The actual extent to which this textbook addresses the knowledge outcomes in Table P-1 will likely differ from academic program to academic program. It is up to the individual program to determine that extent.

Finally, Table P-1 indicates the chapter or chapters in which the individual knowledge outcomes are addressed. This column is provided as a means of cross-referencing the content of the textbook to the specifi c knowledge outcomes. The reader will note that in some instances the chapter number has been boldfaced in the table. Chapter numbers that are boldfaced provide the greatest amount of information relative to the knowledge outcome in question. When no chapter number is boldfaced for a corresponding KASA outcome, the information provided in this textbook for that outcome should be considered minimal. Relative percentages are provided in Table P-1 to guide academic programs as they determine how the KASA outcomes are to be addressed within their own unique curriculum.

CONTENTS

 **PART 5**

Anatomy, Physiology, and Pathology of the Articulatory/Resonance System

 **PART 6**

Anatomy, Physiology, and Pathology of the Auditory/Vestibular System

PART I

Terminology, Nomenclature, and Basic Concepts

CHAPTER 1

An Overview of this Textbook

"Why do we have to learn all of this anatomy and physiology?"

It is a question for the ages. Speech–language pathology and audiology students have asked this question practically since the beginning of the professions. Although many come to appreciate the relationship between speech perception and production and the concomitant anatomy and physiology, there oftentimes seems to be a disconnect between the two for most clinicians in training. It is not until much later in their education that the link is solidified in the minds of these future professionals.

The answer is simple, yet complex at the same time. To understand what may be pathological, one must first know what is "normal" or "typical." Many of the so-called organic disorders of speech, language, and hearing have an etiology that points toward aberrations in the anatomy and/or physiology of the speech or hearing mechanism. An anatomical or physiological etiology will likely provide the clinician with clues as to the expected signs and symptoms associated with a given disorder, and may also indicate what course of intervention to take.

The complexity of the answer lies in the complexity of the human body. There are literally hundreds of anatomical structures (e.g., bones, cartilages, muscles, organs, and nerves) involved in the speech perception and production processes. Likewise, many laws, principles, and theories of physical science are involved in the physiology of speech and hearing. The prospect of learning all of the terminology and concepts related to speech perception and production can be

overwhelming to many students. However, the learning process can seem more manageable (and for many students downright fun!) if one understands that there is actually a method to the madness. More information will be provided about this method in a later section of this chapter.

The authors of this textbook have a combined experience in anatomy and physiology reaching into decades. Hundreds of students have passed through our classes in anatomy and physiology of speech and hearing. Although we have used clinical examples to some degree in our classes, most of the class time involved the presentation of anatomical and physiological concepts and nomenclature. We suspect this is true for most academic programs in communication disorders.

Because of this, many students simply cannot see a clear relationship between anatomy and physiology and disorders of speech and hearing. The anticipation is that students will come to understand the relationship when coursework in the disorders is taken. The problem with this is that by the time most students take the disorders courses, they have forgotten the anatomy and physiology because a solid link was never established early on. This textbook attempts to alleviate this problem by offering not only the concepts and nomenclature associated with the anatomy and physiology of the speech and hearing mechanism but also in-depth information about a variety of disorders of speech and hearing so that you can understand the link between the two early in your educational experience.

A Quick Tour of this Textbook

Traditionally, speech perception and production have been described according to several components: articulatory/resonance, auditory/vestibular, neural, phonatory, and respiratory. This textbook will not deviate from organizing the anatomy and physiology of speech and hearing according to this well-established scheme. However, we refer to each of these components as a *system*. By definition, a system is a group of independent but interrelated elements comprising a unified whole. The processes of articulation/resonance, hearing, pho-nation, and respiration are indeed anatomically independent from each other, but

they are also composed of interrelated elements that come together for a specific purpose—that purpose being speech perception and production. Although the nervous system is not involved mechanically in speech perception and production in the way the other systems are, without the nervous system the processes of speech perception and production would not be possible. We view the nervous system as the overriding system that coordinates and controls all other systems.

Because we refer to these components of speech perception and production as *systems*, you should not confuse them with the systems that comprise the human body. Depending on the anatomist, the human body may be organized into as few as nine and as many as twelve body systems. Some of these body systems include the circulatory (or vascular) system, digestive system, muscular system, nervous system, reproductive system, respiratory system, and skeletal system. As Table 1-1 illustrates, the systems that are mechanically involved in speech perception and production (i.e., the articulatory/resonance, auditory/vestibular, phonatory, and respiratory systems) are in turn composed of structures from several body systems. Right away, you may note that the muscular, nervous, skeletal, and vascular body systems are all components of every system that is mechanically related to speech perception and production. Using the auditory/vestibular system to illustrate, the contribution of the muscular system comes in the form of several muscles such as the stapedius and tensor tympani muscles. The nervous system contributes by way of the vestibulocochlear nerve and the auditory pathway. The skeletal system is represented by bones (e.g., the ossicles: malleus, incus, and stapes) and cartilages (e.g., the ear canal and pinna). Finally, the vascular system contributes several arteries and veins to the auditory/vestibular system to provide nutrients and to take away waste products.

It is interesting to note that not only is respiration considered a body system but is also considered a system of speech production. Defined as a body system, the respiratory system typically includes only the trachea, bronchial tree, and lungs. When viewed as a system of speech production, respiration also draws upon the muscular, nervous, skeletal, and vascular systems. This points up the fact that when one refers to body systems, one is generally referring to an *anatomical* organization of the human body. It becomes apparent that when one

considers the *physiology* of the human body, the body systems overlap considerably. Therefore, although this textbook will describe the articulatory/resonance, auditory/vestibular, nervous, phonatory, and respiratory systems in terms of their anatomy, these systems of speech perception and production are organized primarily according to their *physiological function*.

TABLE 1-1

THE SYSTEMS OF COMMUNICATION AND THE HUMAN BODY SYSTEMS (WITH EXAMPLES IN ITALICS) THAT COMPRISE THEM

Communication System	Human Body Systems
Speech Perception	
Auditory system	Muscular system *Stapedius muscle; tensor tympani muscle* Nervous system *Facial nerve; vestibulocochlear nerve* Skeletal system *Temporal bone of the skull* Vascular system *Anterior inferior cerebellar artery*
Speech Production	
Respiratory system	Muscular system *Diaphragm; external intercostals* Nervous system *Phrenic nerve* Respiratory system *Lungs* Skeletal system *Cervical, thoracic, lumbar vertebrae; ribs* Vascular system *Pulmonary artery*
Phonatory system	Muscular system *Cricothyroid; posterior cricoarytenoid* Nervous system *Recurrent laryngeal nerve* Skeletal system *Hyoid bone* Vascular system *Inferior laryngeal artery*
Articulatory/resonance system	Digestive system *Oral cavity; pharynx* Muscular system *Levator veli palatini; palatoglossus* Nervous system *Mandibular branch of the trigeminal nerve* Skeletal system *Ethmoid; mandible; vomer* Vascular system *Lingual artery*

Although this textbook will not deviate from the established organizational scheme of articulatory/resonance, auditory/vestibular, nervous, phonatory, and respiratory systems, these systems of speech perception and production will be presented in a slightly different order than they typically appear in most anatomy textbooks. Traditionally, the nervous system tends to be presented after the three systems of speech production (respiration, phonation, and articulation/resonance). However, we feel that since the nervous system coordinates and controls all of the other systems of speech perception and production, it should be presented first. Therefore, the nervous system is presented in this textbook in Part II. Following the nervous system will be the three systems involved in speech production. Part III will present the respiratory system, Part IV will present the phonatory system, and Part V will present the articulatory and resonance systems. Finally, the auditory/vestibular system will be presented last, in Part VI. It should be noted that although the auditory system is of primary interest to speech perception, information about the vestibular system is also provided because the audiologist or speech–language pathologist is very likely to encounter patients who exhibit disturbances in balance and equilibrium.

Part I consists of three chapters. The purpose of the present chapter is to orient you to the general organization and intended use of this textbook. Chapter 2 provides basic information to orient you to the anatomical position; planes of reference; terminology describing spatial relationships between and among structures; and other nomenclature related to anatomy, physiology, and pathology. Chapter 3 provides you with basic information concerning the organization of the human organism: cells, tissues, organs, and systems. Upon completion of the first part, you will have the basic building blocks to assist in understanding the information presented in the remaining parts. For the remaining parts of this textbook, not only will anatomy and physiology be presented but information about the relationship between anatomy and physiology and many disorders of speech, language, and hearing will also be presented. For Parts II through VI, the anatomy and physiology of each of the five systems mentioned earlier will be presented first in a stand-alone chapter (Chapters 4, 6, 8, 10, and 12). Following each chapter on anatomy and physiology, a separate chapter

will include information relative to certain disorders affecting those systems (Chapters 5, 7, 9, 11, and 13). It is hoped that taken together, the two chapters within each part will provide you with that elusive link between anatomy and physiology and the disorders that may occur when abnormal structures or conditions exist.

A Quick Overview of Speech Perception and Production

As mentioned previously in this chapter, the processes of speech perception and production are quite complex, enlisting the participation of literally hundreds of anatomical structures such as bones, cartilages, muscles, organs, and nerves. In addition, the various anatomical parts are bound together by different types of connective tissue such as fascia, ligaments, membranes, and tendons. In general, the various systems involved in speech perception and production require that you know the entire human body except for the upper and lower extremities (i.e., arms, legs, hands, feet, fingers, and toes).

To illustrate, speech perception involves the auditory and nervous systems. Acoustic energy in the form of sound waves (whether speech or environmental sounds) are collected by the pinna and directed into the ear canal. At the terminus of the ear canal resides the tympanic membrane (eardrum), which converts the acoustic energy into mechanical energy. The mechanical energy is then transmitted through the middle ear cavity by way of the ossicular chain (the malleus, incus, and stapes). To protect the inner ear from being excessively driven, the acoustic reflex may enter the picture. This reflex is accomplished through the contraction of muscles. As mechanical energy is transmitted through the middle ear, the stapes acts upon the oval window of the cochlea, which is in the inner ear. Housed within a chamber of the cochlea is the essential organ of hearing (the organ of Corti) that contains fluid and is also surrounded by two other chambers filled with fluid. The rocking action of the stapes causes the fluid inside these chambers to vibrate. Vibration of the fluid within the cochlea sets up a receptor potential from the organ of Corti. Sensory nerve impulses then travel to fibers of the cochlear portion of cranial nerve VIII (the vestibulocochlear or auditory nerve), where the impulses are then

relayed through the auditory pathway. The auditory pathway includes portions of the lower brain stem, upper brainstem (i.e., the midbrain), and cerebral cortex. It is at the cerebral cortex where sound is finally perceived and interpreted. Separate from the acoustic and vestibular functions of the hearing mechanism, the Eustachian tube assists in regulating air pressure within the middle ear cavity. When air pressure within the middle ear cavity becomes negative in relation to atmospheric pressure, the Eustachian tube opens to equalize pressure. This is accomplished in part through muscle contraction. In total, a very large number of anatomical structures make up the auditory/vestibular system. These include bones, cartilages, ligaments, membranes, muscles, neurons, organs, and tendons.

By the same token, the process of speech production is equally complex. This process requires coordinated activity of the nervous, respiratory, phonatory, and articulatory/resonance systems. To an extent, the auditory system is also involved, as it is used by individuals who can hear as a means of acquiring speech and language. Further, once speech and language have been acquired, the auditory system is used by persons with normal hearing to monitor their own speech.

Proper timing of the events that make up speech production is essential. Neural impulses will regulate the various aspects of speech production such as respiration, phonation, and articulation/resonance, and will also provide the brain with sensory information related to tactile and kinesthetic feedback during the speech production process. Respiration will serve as the energy source for speech production. Expired air will be used to set the vocal folds into vibration to produce voicing. Neural impulses will cause certain muscles to contract, thereby resulting in respiration. The process of inhalation—whether for the purpose of speech production or not—is always active; that is, muscle contraction is always necessary to effect this process. On the other hand, normal exhalation is passive (i.e., no muscle contraction), while exhalation for vocal activity is typically active. Once the vocal folds are adducted (i.e., brought together or “closed”) by muscles of the larynx, the air trapped below the closed vocal folds must be pressurized by active muscle action in the abdomen and thorax. The vocal folds must also be abducted (i.e., separated or “opened”) for the production of voiceless speech sounds and to replenish air during vocal activity. The

abductor muscles of the larynx are needed for this action. In turn, neural impulses are needed to contract the abductor and adductor muscles of the larynx.

Upon adduction of the vocal folds, exhaled air coming up from the lungs gets trapped below the vocal folds, creating air pressure (referred to as subglottic pressure). Subglottic pressure will eventually force an opening between the vocal folds, setting them into vibration as the air passes through (a process referred to as phonation). During phonation, only a buzzing sound is produced. This buzzing sound is then shaped and molded (i.e., articulated and resonated) as it proceeds up through the pharynx and into the oral and/or nasal cavities. When oral speech sounds are produced, the soft palate will raise and seal off the nasal cavity from the oral cavity so that all of the resonating sound passes through the oral cavity and out through the lips. When the nasal speech sounds (i.e., /m/, /n/, and /ŋ/) are produced, the soft palate will lower, creating an opening between the oral and nasal cavities so that part of the vocal tone can resonate within the nasal cavity. Action of the soft palate is mediated through muscle activity. The tongue is the primary structure involved in articulation and resonance. All vowel sounds and most of the consonant sounds of English are created by placement and/ or movement of the tongue. The tongue consists of muscle tissue. For some speech sounds, there may be rounding of the lips (e.g., the /w/ sound). Shaping of the lips is accomplished by muscle action. Once again, muscle activity is accomplished via neural impulses from the nervous system.

The entire speech production mechanism is over-laid either upon or within the skeletal system. For example, the thoracic region is primarily associated with respiration and consists of the ribs, sternum, and thoracic vertebrae of the spinal column. In addition, the bones of the pectoral (i.e., shoulder) and pelvic (i.e., hip) girdles serve as a point of attachment for many of the muscles involved in respiration. The trachea (a structure made of cartilage) and the lungs (which are organs) are also involved in the respiratory process.

In terms of the phonatory system, the primary structure is the larynx, which is composed of a series of cartilages interconnected by membranes and ligaments. The hyoid bone serves as the superior attachment for the larynx as well as the skeletal base for many of the muscles of the tongue. The pharynx, soft palate, and tongue consist of

connective tissue, muscles, and mucous membrane. Many of the bones of the skull serve as points of attachment for muscles involved in articulation and resonance. The bones of the cranium house the brain.

In all, it should be apparent to you that a study of the anatomy and physiology of speech and hearing will require extensive knowledge of the human body and its components. In the parts that follow, each of the various systems (nervous, respiratory, phonatory, articulatory/resonance, and auditory/vestibular) will be provided in greater detail. You will learn the various components that make up each of the systems (e.g., bones, cartilages, muscles, organs, and nerves) and will also gain knowledge of the normal physiology of the various systems individually, as well as the physiology of the various systems collectively as they are used for the purpose of speech perception and production. However, before engaging in the study of the various systems involved in speech perception and production, you should have a solid understanding of the basic terminology and concepts that are used in the study of anatomy, physiology, and pathology. The remaining chapters of this part provide you with a basic foundation of terminology and concepts related to anatomy, physiology, and pathology so that learning of the various systems will be facilitated. We now turn our attention specifically to the nomenclature of anatomy, physiology, and pathology.

Knowledge Outcomes for ASHA Certification for Chapter 2

- Demonstrate knowledge of the biological basis of the basic human communication processes (III-B)
- Demonstrate knowledge of the neurological basis of the basic human communication processes (III-B)

Learning Objectives

- You will be able to recite the definitions of biology, anatomy, physiology, and pathology.
- You will describe the anatomical position, planes of reference, and spatial terminology used to denote the position and orientation of anatomical structures of interest to speech perception and production.
- You will determine the meaning of unfamiliar terminology by analyzing the meaning of the root and any affixes that may be attached.

Basic Concepts, Terminology, and Nomenclature

ANATOMY, PHYSIOLOGY, AND PATHOLOGY

Anatomy and physiology are both branches of **biology**. You may recall from a high school biological science course that biology is the scientific study of living organisms. A living organism is anything that exhibits the properties of life, including but not limited to:

- *Cell structure*—the cell is the basic unit of the organism, and in many organisms can create more complex structures like tissues and organs.
- *Metabolism*—the organism captures energy to be used to maintain itself.
- *Reproduction*—the production of offspring to perpetuate the species.
- *Mutation*—random changes in the structure or composition of the organism.
- *Death*— eventually, the organism will die.

Living organisms can range from single-celled creatures (e.g., bacteria) to more complex structures such as plants and animals. The human being, of course, is a complex animal, and therefore is a living organism.

Anatomy and physiology both fall under the umbrella of biology. Anatomy is the scientific study of the structure and organization of living organisms. The term comes from the Greek words “anatomia” and “anatemnein,” meaning to cut up or cut open. Years ago, in order to study the structure and organization of the human body it would have had to have been dissected. Since not too many human beings want to be cut up so that someone else can study them, anatomical studies were accomplished through the use of cadavers (an acronym of the Latin phrase “*ca*ro *da*ta *ver*mibus,” which translated means “ flesh given to worms”), deceased human bodies that have been donated to science for the purpose of study. Although cadavers are still used today to study the anatomical structure of the human body, modern technology such as positron emission tomography allows us to study these structures without dissecting the body. The advantage of imaging technology is that anatomy can be studied on living human beings.

Physiology is the study of the functions of living organisms and their parts. Physiology cannot be studied using a cadaver since a

deceased organism does not function. Instead, physiology must be studied by using a living human being, by using an animal that is similar in structure to a human being, or by using a model of the particular anatomical part of interest to the scientist. Taken together, anatomy and physiology are biological sciences that examine the living organism in terms of its parts and the functions of those parts and of the organism as a whole.

Pathology is the scientific study of the nature of diseases and of the structural and functional changes that are imposed upon the living organism as a result. In other words, pathology is concerned with conditions or processes that are outside the realm of typical or normal, whether the aberration is associated with anatomical structure or physiological function. One should note that a good understanding of pathology and its effect on the organism cannot be fully realized until the individual has an equally good understanding of the anatomy and physiology of the organism.

ORIENTATION TO THE HUMAN BODY

The Anatomical Position

To understand the human body and the spatial relationships among the various bones, cartilages, muscles, organs, nerves, and other structures, one must have a general point of reference. In the study of anatomy, this point of reference is known as the anatomical position. You should always remember that the anatomical position is in reference to the body being observed (whether a living human or a cadaver), not the observer. For illustrative purposes, a cadaver will be the body being observed. Thus, when one refers to the left side of the body, it is the left side of the *cadaver's* body. If the cadaver is facing the observer, its left side will be on the right side to the observer. If you always remember that spatial terminology is used in reference to the cadaver, you will have little difficulty in understanding the terminology associated with positioning and orientation.

The anatomical position is illustrated in Figure 2-1. Note that the body being observed is standing upright, facing the observer, with its

eyes straight ahead, arms at its side with the palms of the hands and toes of the feet facing forward. All of the terminology that will be used in this textbook, including terms associated with planes of reference and spatial orientation, will be in reference to the anatomical position.

Planes of Reference

The internal structures of the human body can be viewed from several different perspectives. For example, one can look at a particular organ from any angle, or the organ can be dissected in a horizontal, vertical, or other plane. When anatomical structures are photographed or drawn, it is important to note the plane of reference in which the structure is being presented. An anatomical structure may look quite different depending on its plane of reference. As you view the photographs and drawings in this textbook (and in other media as well), it is important that the figure caption be read and the plane of reference be noted.

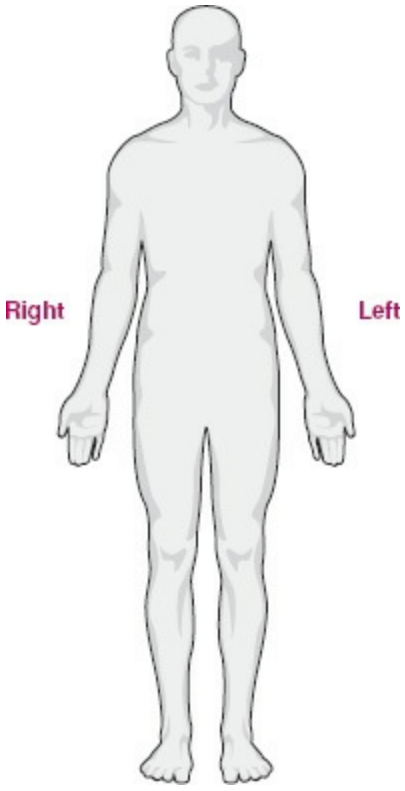

Figure 2-1 The anatomical position used as the general point of reference for describing the spatial orientation of the various parts

of the body. (Reprinted with permission from Cohen, B.J. (2008). *Memmler's the human body in health and disease* (11th ed.). Baltimore: Lippincott Williams & Wilkins.)

There are three planes of reference that will be used throughout this textbook; these are illustrated in Figure 2-2 and defined in Table 2-1. These planes of reference include *coronal*, *sagittal*, and *transverse*. The coronal plane of reference is a vertical plane that separates the body or body part into anterior (front) and posterior (back) sections. It is called the coronal plane in reference to the coronal suture, a suture of the skull immediately above the forehead, running from temple to temple and separating the frontal bone of the skull from the parietal bones. This plane of reference is also sometimes referred to as the frontal plane.

The sagittal plane is also a vertically oriented plane of reference, although the orientation is a bit different than the coronal plane. In the case of the sagittal plane, the body or body part is separated into a left and a right portion. This plane is named in reference to the sagittal suture that runs lengthwise down the center of the top of the skull, where the two parietal bones articulate with each other. If one were to divide the body or a body part right down the middle so that there is a left and right portion of relatively equal size, this is referred to as the *midsagittal* plane. The term *parasagittal* is often used in reference to any section that is parallel to the midsagittal plane.

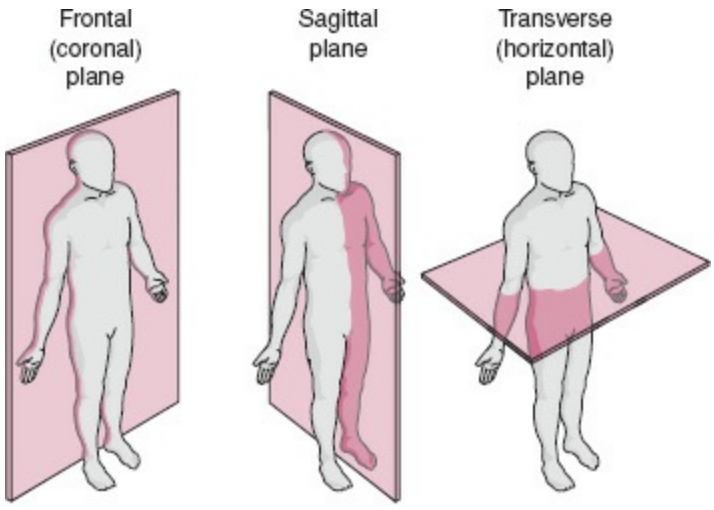

Figure 2-2 The planes of reference used to indicate the angle at

which the observer is viewing the anatomy. (Reprinted with permission from Cohen, B.J. (2008). *Memmler's the human body in health and disease* (11th ed.). Baltimore: Lippincott Williams & Wilkins.)

Finally, the transverse plane is a horizontal plane of reference that separates the body or body part into an upper and a lower portion. When a magician performs the trick where the assistant lies down in a box and is supposedly cut in half, essentially the assistant is being divided in a transverse plane. It should be noted that in neuroanatomy, the term *horizontal plane* is used more often than transverse plane.

Other Terminology Associated with Spatial Orientation

Now that the anatomical position and planes of reference have been established, your attention is directed toward more specific terminology that is associated with the spatial relationships that exist between and among the various structures of the body. Although not an exhaustive list, Table 2-1 provides a "survival list" of terms that will help you understand the relationships various body parts have to each other. Figure 2-3 also illustrates some of the more commonly used terms to describe spatial position and orientation. It is imperative that you become comfortable using these terms. Learning these terms is half the battle when it comes to understanding the relationships between and among the various anatomical structures of the human body.

The terms and affixes in Table 2-1 are presented in alphabetic order. However, one should note that many of the terms describing spatial position or orientation come in pairs, in which the two terms have opposite meanings. These include:

- Anterior/posterior (i.e., front/back)
- Caudal/cranial or rostral (i.e., closer to the tail/ closer to the head)
- Central/peripheral (i.e., located centrally/located in the periphery)
- Contra-/ipsi- (i.e., opposite side/same side)

- Deep/superficial (i.e., away from the body surface/toward the body surface)
- Distal/proximal (i.e., away from the point of origin/toward the point of origin)
- Dorsal/ventral (i.e., toward the back/toward the belly)
- Ecto-/endo- (i.e., outer/inner)
- External/internal (i.e., outside/inside)
- Extra-/intra- (i.e., outside/inside)
- Extrinsic/intrinsic (i.e., coming from the outside/ coming from within)
- Inferior/superior (i.e., below/above)
- Infra-/supra- (i.e., below/above)
- Lateral/medial (i.e., toward the side/toward the middle)
- Post-/pre- (i.e., after/before)
- Prone/supine (i.e., face down/face up)

It should also be noted that Table 2-1 contains several prefixes. These are placed at the beginning of root words to indicate direction, position, or spatial orientation. For example, take the prefixes “infra-” and “supra-.” When placed in front of the root word *hyoid*, they literally mean “below the hyoid” and “above the hyoid,” respectively. In Chapter 8, you will be presented the anatomy and physiology of the phonatory system. In that chapter, a discussion will center on the extrinsic muscles of the larynx (note the term *extrinsic* here, which is defined in Table 2-1 as “external or coming from the outside”). Muscles of the larynx are classified as either intrinsic or extrinsic. The extrinsic muscles are subdivided into *suprahyoid* and *infrahyoid* muscles. All of these muscles make an attachment to the hyoid bone (hence the root word *hyoid*). The suprahyoid muscles come from anatomical structures located above the hyoid bone, whereas infrahyoid muscles come from anatomical structures located below the hyoid.

As a second example, consider the prefixes “pre-” and “post-.” When used in conjunction with the term *central* and in reference to gyri (convolutions of the cerebrum), these terms denote two very important gyri of the brain. The *precentral gyrus* is the primary motor area and the *postcentral gyrus* is the primary somatosensory area. In this example, the root word *central* is in reference to the *central sulcus*, a narrow

trough that separates the frontal lobe from the parietal lobe. The precentral gyrus is located immediately anterior to the central sulcus, whereas the postcentral gyrus is located immediately posterior to the central sulcus.

TABLE 2-1

TERMS AND PREFIXES USED TO DESCRIBE PLANES OF REFERENCE AND SPATIAL RELATIONSHIPS

Term	Definition
Ante-	Situated before or in front of
Anterior	One structure is situated closer to the front of the body than another structure; sometimes the term *ventral* is used; opposite of *posterior*
Anteroposterior	Situated in an anterior-to-posterior (front-to-back) plane
Anti-	Situated against or on the opposite side
Bilateral	Pertaining to both sides of the body or an anatomical structure
Caudal	One structure is situated closer to the tail than another structure; opposite of *cranial* and *rostral*
Central	Pertaining to the center, or composing the primary part; opposite of *peripheral*
Contra-	Pertaining to the opposite side; opposite of *ipsi-*
Coronal	Vertical plane of reference that divides the body or a structure into an anterior and a posterior part; also known as the *frontal* plane
Cranial	One structure is situated closer to the head than another structure; used synonymously with *rostral*; opposite of *caudal*
Deep	One structure is situated further away from the body surface than another structure; opposite of *superficial*
Distal	Situated away from the center of the body or from the point of origin; opposite of *proximal*
Disto-	Pertaining to *distal*
Dorsal	Pertaining to the back; opposite of *ventral*
Dorsi-	Toward the *dorsal* (back) direction
Ecto-	Outer or on the outside; opposite of *endo-*
Endo-	Inner or on the inside; within; opposite of *ecto-*
Ento-	Inner or within
Epi-	Situated upon, following, or subsequent to
External	Situated on the outside; one structure is situated to the outside of another structure; opposite of *internal*
Extra-	Situated to the outside; opposite of *intra-*
Extrinsic	External or coming from the outside; opposite of *intrinsic*
Frontal	Situated in front of or relating to the anterior part of the body; also used synonymously with *coronal* as a plane of reference
Hypo-	Situated below; used sometimes instead of *sub-* or *infra-*
Inferior	Situated below or in a downward direction; opposite of *superior*
Infra-	Situated below; used sometimes instead of *sub-* or *hypo-*; opposite of *supra-*
Inter-	Situated between
Internal	Situated on the inside; one structure is situated to the inside of another structure; opposite of *external*
Intra-	Situated within or inside; opposite of *extra-*
Intrinsic	Internal or completely within; opposite of *extrinsic*
Ipsi-	Pertaining to the same side; opposite of *contra-*
Lateral	Situated to the side or farther from the *midsagittal* plane; opposite of *medial*
Longitudinal	Situated lengthwise or in the direction of the axis of the body or any of its parts
Medial	Situated toward the middle or center, or closer to the *midsagittal* plane; opposite of *lateral*
Mes-, Mesio-, Meso-	Situated in the middle; intermediate
Mesial	Toward the median or *midsagittal* plane
Met-, Meta-	After, behind, or hindmost; see also *post-*
Midsagittal	Vertical plane of reference through the midline of the body, dividing the body into left and right halves
Oblique	Situated in a slanting or diagonal direction
Palmar	Pertaining to the palm of the hand

Para-	Adjacent, alongside, or near
Peri-	Around, about, or near
Peripheral	Pertaining to the periphery, or composing the secondary part; opposite of *central*
Plantar	Pertaining to the sole of the foot
Post-	After, behind, or posterior to; see also *meta-*; opposite of *pre-*
Posterior	One structure is situated closer to the back of the body than another structure; sometimes the term *dorsal* is used; opposite of *anterior*
Pre-	Before, in front of, or anterior to; opposite of *post-*
Prone	Body lying face down; opposite of *supine*
Proximal	Situated toward the center of the body or close to the point of origin; opposite of *distal*
Rectus	Straight, usually in a longitudinal direction
Retro-	Situated behind or in a backward direction
Rostral	One structure is situated closer to the head than another structure; used synonymously with *cranial*; opposite of *caudal*
Sagittal	Vertical plane of reference that divides the body or a structure into a left and a right part
Sub-	Situated beneath
Superficial	One structure is situated closer to the body surface than another structure; opposite of *deep*
Superior	Situated above or in an upward direction; opposite of *inferior*
Supine	Body lying face up; opposite of *prone*
Supra-	Situated above; used sometimes instead of *epi-*; opposite of *infra-*
Transverse	Horizontal plane of reference that divides the body or a structure into upper and lower parts
Unilateral	Pertaining to one side of the body or an anatomical structure
Ventral	Pertaining to the front or belly; opposite of *dorsal*
Version	Deviation of a body part from its normal axis

In the chapters that follow, the position of a particular body part may be described in reference to its spatial relationship to another body part. As you read these chapters and attempt to make sense of the anatomy, it is important to note the spatial terminology that is being used. These are not trivial terms. To the contrary, these terms allow you to pinpoint the exact location or orientation of a body part. You cannot have a complete understanding of anatomy without knowing where the various parts are located, especially in reference to other body parts.

A METHOD TO THE MADNESS

At the beginning of this chapter, it was mentioned that although the prospect of learning all of the anatomy and physiology of speech and hearing may cause anxiety on your part, there is a method to the madness that can make the learning process much easier than it first appears. There is no getting around it; to become a competent clinician you must learn the anatomy and physiology of speech perception and production. In part, this will involve committing a huge body of terminology to memory. How can one be expected to remember the vast nomenclature associated with anatomy and physiology? If you take each individual term and attempt to commit it to memory without really thinking about what the term really *means*, then the process of memorizing the vast amount of terminology will indeed be nearly

impossible. However, if you analyze each term by considering the root and any affixes that may be attached, the learning process can be a lot less taxing.

In addition to the terminology presented in Table 2-1, you are referred to the appendix at the end of this book. The appendix contains seven tables that present terms and affixes that are used extensively in describing the anatomy, physiology, and pathology of the speech and hearing mechanisms. Although you would certainly be in a better position if you committed to memory the vocabulary and affixes found within these tables, the tables are provided primarily as a reference for you as you encounter the vast nomenclature of anatomy and physiology throughout the remainder of this textbook. Many of the terms and affixes presented in the appendix will also be included in the individual chapters that follow. It is hoped that by presenting the terminology numerous times throughout the book, you will be more likely to learn the nomenclature.

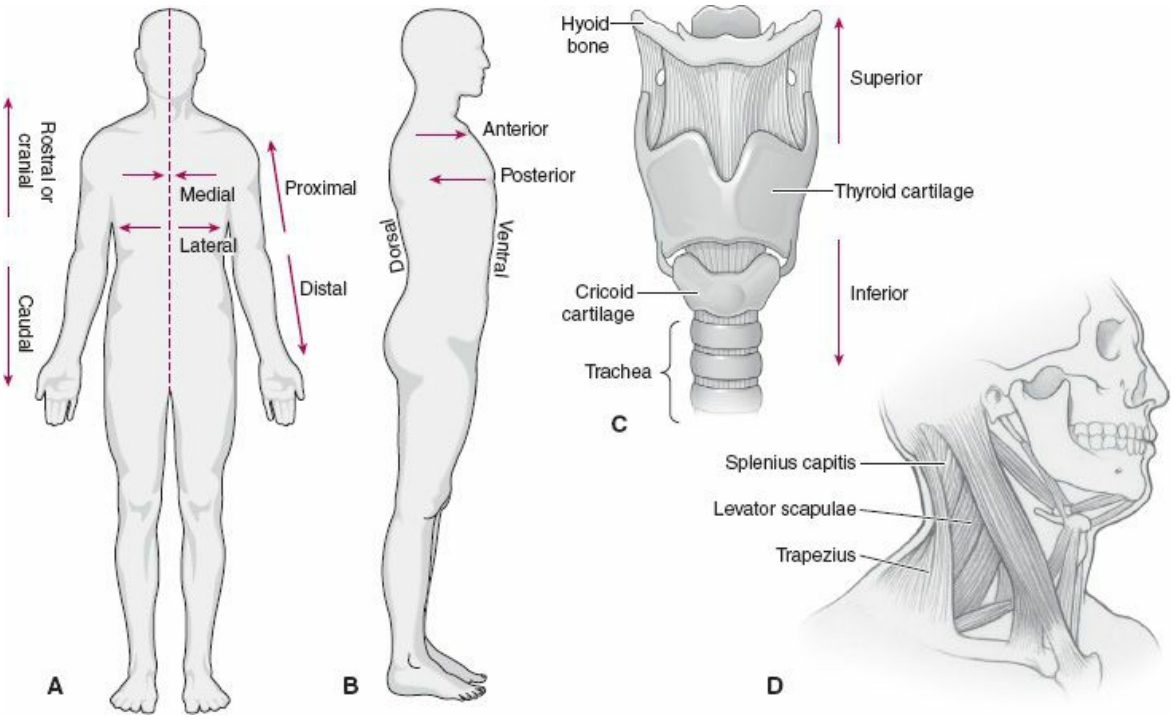

Figure 2-3 An illustration of the more commonly used terms for describing spatial position and orientation. **A**. Distal vs. proximal; lateral vs. medial; rostral (cranial) vs. caudal. **B**. Anterior vs. posterior; dorsal vs. ventral. **C**. Superior vs. inferior (note that the

hyoid bone and thyroid cartilage are superior to the cricoid cartilage, and the trachea is inferior to the cricoid). **D**. Deep vs. superficial (note that the levator scapulae and splenius capitis are deep to the trapezius). (**A** and **B**: Modified with permission from Cohen, B.J. (2008). *Memmler's the human body in health and disease* (11th ed.). Baltimore: Lippincott Williams & Wilkins. **C**: Reprinted with permission from Cohen, B.J. (2008). *Memmler's the human body in health and disease* (11th ed.). Baltimore: Lippincott Williams & Wilkins. **D**: Reprinted with permission from Scheuman, D.W. (2006). *The balanced body: A guide to deep tissue and neuromuscular therapy* (3rd ed.). Baltimore: Lippincott Williams & Wilkins.)

How to Use the Appendix

As mentioned above, the appendix is organized into seven tables. Each table presents vocabulary and affixes that are related in terms of what they describe. These include:

- Table A-1: Terms and affixes associated with movement
- Table A-2: Terms and affixes associated with anatomical structures or their parts
- Table A-3: Terms and affixes associated with color, form, general location, relative size, or shape
- Table A-4: Terms and affixes associated with bones, cartilages, cavities, membranes, or spaces
- Table A-5: Terms and affixes associated with the nervous system
- Table A-6: Terms and affixes associated with the auditory/vestibular system
- Table A-7: Miscellaneous terms and affixes used in anatomy, physiology, and pathology

With the exception of Table A-1 (which provides definitions only), the tables in the appendix provide definitions of the terms and affixes as well as an example of the use of each term or affix. The paragraphs that

follow also provide more detailed information as to how knowledge of these terms and affixes can assist you in developing a deeper understanding of the anatomy, physiology, and pathology of the speech and hearing mechanisms.

Table A-1 presents terms and prefixes that are used to describe movement. In terms of muscle activity, the terms *extension* and *flexion* are used to denote how muscle contraction affects the movement of the body part being acted upon. The terms *abduction* and *adduction* are also very important. Although a single anatomical structure can abduct or adduct, these terms are used most often to describe the movement of two structures. For example, humans have two vocal folds. When the vocal folds are abducted (moved away from midline), the glottis—a variablesized aperture between the vocal folds—opens so that air can flow in and out of the lungs. When the vocal folds are adducted (moved toward midline), they come together so that expired air can be used to vibrate them to produce voicing.

The terms *depressor*, *levator*, and *tensor* are also used to describe the action that occurs when muscles contract and act upon an anatomical structure. These terms are sometimes used as part of the name of a muscle, and therefore describe the action that particular muscle makes. For example, the *tensor tympani* muscle tenses the eardrum (tympanic membrane) by pulling inward on the malleus, to which the eardrum is attached. The *depressor anguli oris* is a muscle of the lips that pulls the corner of the mouth downward, as in frowning. Finally, the *levator veli palatini* muscle elevates or raises the soft palate (i.e., the velum, where according to Table A-2 the term *veli palatini* comes).

In reference to pathology, the prefixes “hyper-” and “hypo-” are often used to describe movement disorders. For example, a *hyperkinetic* movement disorder means that the patient exhibits involuntary, excessive, extraneous movements. By the same token, a patient with a *hypokinetic* movement disorder exhibits paucity of movement (i.e., the movements tend to be difficult to initiate and are very slow).

Table A-2 provides terms and affixes whose meanings are related to specific body parts. For example, upon first encountering the *omohyoid* muscle, you may scratch your head in wonder. However, if the term was analyzed into its components “omo-” and *hyoid*, one would be able to discern very quickly that the omohyoid muscle runs from the

shoulder area to the hyoid bone. Similarly, by understanding the root terms and affixes, one can readily understand that cranial nerve III, the *oculomotor* nerve, is responsible for movements of the eyeball ("oculo-" meaning eye, and *motor* referring to activity resulting in movement). What does *sternocleidomastoid* mean? By knowing the terminology in Table A-2, you can determine that it is a muscle that has three attachments. "Sterno-" refers to the sternum, "-cleido-" refers to the clavicle, and *mastoid* refers to the mastoid process, which is the rounded part of the base of the skull right behind the ear. Therefore, the sternocleidomastoid is a muscle that attaches to the sternum, clavicle, and mastoid process.

Table A-3 provides terms and prefixes associated with general location, size, shape, color, or general form. For example, the *serratus posterior superior* muscle can be found in the upper part (*superior*) of the back (*posterior*) and has a jagged or sawtooth (*serratus*) appearance. In Chapter 8, while learning about the cricoid cartilage (one of the cartilages of the larynx), you will encounter the term *posterior quadrate lamina*. From Table 2-1, you know that *posterior* refers to the back. Table A-3 defines *quadrate* as something that is somewhat square- or rectangular-shaped. Finally, according to Table A-4 *lamina* is a thin plate or flat layer of bone or cartilage. Taken together, you will correctly deduce that the posterior quadrate lamina is the back plate of the cricoid cartilage that is somewhat square-shaped.

Table A-4 includes terms and affixes that are used in reference to bones, cartilages, membranes, or cavities. For example, "cerato-" refers to a horn of some sort. The thyroid cartilage has two sets of cornua (horns) along its posterior margin. The superior cornua articulate with the greater cornua of the hyoid bone. The inferior cornua of the thyroid cartilage articulate with the cricoid cartilage, forming the cricothyroid joint. This joint is held in place by a series of ligaments known as the *ceratocricoid ligaments.* The term *ceratocricoid* refers to the two parts that make up the joint—the inferior cornua of the thyroid cartilage and the cricoid cartilage. Similarly, the *mental symphysis* refers to the fusion of the two halves of the mandible (jaw). During fetal development, the two halves of the mandible fuse to form a singular bone. The point where the two halves meet is the *mentum*, which is the protruding part of the chin. A *symphysis* is a union of two structures, in this case the two

halves of the mandible.

Table A-5 provides terms and affixes associated primarily with the nervous system, and Table A-6 provides terms and prefixes associated with the auditory/vestibular system. (It should be noted here that although the respiratory, phonatory, and articulatory/resonance systems have their own unique nomenclature, many of the terms and affixes provided in Table 2-1 in this chapter and Tables A-1 through A-4 in the appendix are also used to describe structures and functions pertaining to these systems.)

In reference to the nervous system, the terms *afferent* and *efferent* are often used to describe nerves and nerve pathways. Afferent nerves are also known as sensory nerves because the impulses originate in the periphery (where the sense organs are located) and then are sent toward the central nervous system for interpretation. On the other hand, the impulses of efferent (or motor) nerves originate in the central nervous system and then proceed to the various muscles and viscera located in the periphery. The purpose of these nerves is to effect movement.

Many of the structures of the brain have peculiar names: *caudate nucleus, corpus striatum*, *olives*, and *pyramids* to name a few. Once again, by analyzing these names you can remember something about each of them. *Caudate* means tail (see Table A-5 of the appendix). A nucleus is a collection of gray matter—nerve cell bodies. Therefore, the caudate nucleus is a mass of gray matter that has a head and a long slender tail. *Corpus* means body. *Striatum* refers to a striped appearance. The corpus striatum then is a series of bodies deep within the brain that has a striped appearance. Finally, the olives (technically, the olivary complex) and pyramids can be seen on the ventral surface of the medulla oblongata. They each get their name from their general shape. To carry this thought out a bit further, when one encounters the term *pyramidal motor tract*, one should not be alarmed. The astute observer will note that another term for motor is efferent. The pyramidal motor tract is a tract of efferent nerve fibers that passes through the pyramids on the way to the spinal cord, which is immediately below the medulla oblongata. In fact, the pyramidal motor tract is the primary motor tract, as opposed to the *extrapyramidal motor tract*, which is a secondary motor tract whose nerve fibers also pass down to the spinal cord, but do not make a stop at the pyramids along the way. Remember from Table

2-1, “extra-” means situated to the outside, so extrapyramidal means “situated to the outside of the pyramids.”

In regard to the auditory/vestibular system (see Table A-6), terms and prefixes can also be analyzed to provide meaning to the nomenclature. For example, *incudostapedial* refers to the incus and stapes, and in fact, the incudostapedial joint is formed by the articulation of the incus with the stapes. As another example, a pathological condition of the middle ear, *otitis media*, can easily be remembered if the term is analyzed into its individual parts: “ot-” means ear; “itis-” means inflammation; and *media* refers to the middle. Therefore, otitis media is an inflammation of the middle ear cavity.

The last table in the appendix (Table A-7) provides a list of miscellaneous terms and affixes that can also be used to assist you in retaining the nomenclature of anatomy, physiology, and pathology. Although many of the terms and affixes in this table are pertinent to anatomy and physiology, a large number of them are used in reference to pathology. Once again, the terms and affixes presented in this table can be considered a “survival set” of vocabulary for you. For example, a *tracheotomy* is a procedure in which an incision is made in the anterior wall of the trachea through the outer neck to assist the patient in breathing (usually due to some type of upper airway obstruction). You know from Table A-2 that “tracheo-” refers to the trachea or windpipe. Table A-7 shows that “-otomy” means an operation involving cutting. As a second example, Table A-7 provides the definition for *malacia* (a softening or loss of consistency of tissues or organs). From Table A-4, you can see that “chondro-” is a prefix meaning cartilage. Therefore, *chondromalacia* is a pathological condition in which a cartilage is too soft or underdeveloped.

As a final word, it should be noted that the terms presented in Table 2-1 of this chapter and Tables A-1 through A-7 in the appendix are not an exhaustive list but are presented as a starter set for you. You are encouraged to consult a dictionary when an unfamiliar term is encountered. Pay particular attention to the root and any affixes that may be attached. Clues often exist to assist you in learning the nomenclature. Also, it should be emphasized that many of the terms presented in this chapter were placed in a particular table because of the *primary* context in which the term is used. There are many terms and affixes in these

tables that could just as well be presented in another table. For example, the prefixes “ary-,” “crico-,” and “thyro-” were all placed in Table A-2 because they refer to specific parts of the human body (i.e., the arytenoid cartilages, cricoid cartilage, and thyroid cartilage, respectively). However, all of them could just as easily have been placed in Table A-4 because they are associated with cartilages. You are discouraged from relying too heavily on how these terms and affixes are organized in the tables. Instead, your focus should be simply on the terminology.

It should be readily apparent from all of these examples that the process of learning anatomy, physiology, and pathology is not as difficult as one may first imagine. Learning anatomy and physiology should not be an exercise in rote memorization of terms. Instead, by focusing more on the meanings of a relatively small, finite set of terms and affixes, you have nearly the entire world of anatomy, physiology, and pathology within grasp. As you proceed through the remaining chapters of this textbook and encounter terminology that is unfamiliar to you, the last thing you should do is panic. Step back, think of the meanings of the root and affixes, and the meaning of the unfamiliar term may very well present itself.

Now that you have an understanding of the basic nomenclature in terms of the anatomical position, planes of reference, spatial terminology, and more specific vocabulary related to anatomy, physiology, and pathology, it is time to turn your attention to the structural organization of human beings.

CHAPTER 3

The Structural Organization of Humans

Knowledge Outcomes for ASHA Certification for Chapter 3

- Demonstrate knowledge of the biological basis of the basic human communication processes (III-B)
- Demonstrate knowledge of the neurological basis of the basic human communication processes (III-B)
- Demonstrate knowledge of the biological basis of swallowing processes (III-B)

Learning Objectives

- You will define cell types and organelles.
- You will describe the four tissue types and subclassifications.
- You will discuss the organ systems most pertinent for speech and swallow function.

MEDICAL TERM PART BOX

TERM	MEANING	EXAMPLE
-arthrodial	joint	di**arthrodial**
bi-	two or double	**bi**polar
cellular	related to a cell	intra**cellular** movement
chondrium	related to cartilage	peri**chondrium**
cyto-	pertaining to a cell	**cyto**plasm
endo-	toward the interior	**endo**mysium
epi-	upon or above	**epi**mysium
extra-	outside of	**extra**cellular
inter-	between	**inter**cellular
intra-	within	**intra**cellular
meatus	an opening	external auditory **meatus**
meso-	middle or intermediate	**meso**thelial tissue
micro-	small size	**micro**tubule
-mysium	pertaining to muscle	peri**mysium**
os	bone	**os**sicles
-osteum	pertaining to bone	peri**osteum**
peri-	around	**peri**mysium
-plasm	cellular substance	cyto**plasm**
proto-	first	**proto**plasm
uni-	one or single	**uni**polar

The complexity of human communication is largely what sets human beings apart from other vertebrate species. Thought, language, and speech are all necessary for effective verbal communication. Speech, our primary mode of expressive communication, is the sequential production of sounds to represent our thoughts resulting in a comprehensible auditory signal for a listener to perceive. Furthermore, the ability to produce speech relies on the coordination of multiple speech processes: respiration, phonation, and articulation/resonance. In order to better understand these speech processes, they can be broken down by reducing them to their structural makeup. For example, the process of respiration relies on the thoracic skeletal framework of the ribcage and vertebral column upon which the muscles attach to enact the movement necessary to breathe for speech. In addition, each speech process includes organs, such as lungs, and each organ has a predominant tissue type. Tissues are defined by their cellular makeup. Thus, the cell is our