

a clinical approach to speech anatomy and physiology

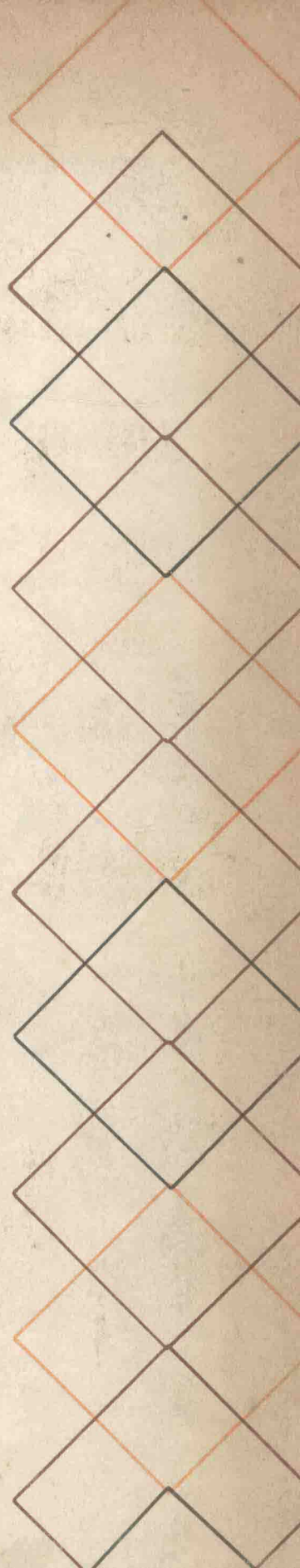
hugh e. bateman, ph.d.

*Professor of Communicative Disorders
Director of Communicative Disorders Center
Department of Communicative Disorders
and
Chairman, Premedical and Predental Advisory Program
University of Mississippi
University, Mississippi*

With a Foreword by
Robert M. Mason, Ph.D., D.M.D.

As an introductory text in anatomy and physiology — specifically speech and hearing functions — this book is heralded as a most complete and lucid presentation in the field. Of particular importance is the approach; the student is introduced gradually to complex mechanisms as principles, vocabulary and detail are unfolded but not oversimplified. Features which seem to motivate students are accented. In this useful text, even the experienced clinician will find many concepts uniquely presented and applicable to clinical evaluations and diagnoses.

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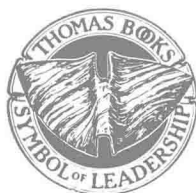
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FOREWORD

ONE OF THE MOST frequent complaints of speech clinicians is the lack of applicability of textbook information to clinical problems. No area of speech and hearing is more subject to this type criticism than the study of the anatomy and physiology of the speech and hearing mechanisms. While such complaints are valid in many instances, a welcomed exception is *A Clinical Approach to Speech Anatomy and Physiology*. This book is written primarily for the undergraduate student in speech and hearing who has no previous background in anatomy and physiology and who is also apprehensive about the study of the physical systems and processes of speech. For the graduate student or practicing clinician, mastery of the materials and clinical processes discussed in this book is a worthy aspiration. Clinicians with considerable experience will probably find much new information for sharpening clinical skills.

The neophyte student of anatomy and physiology of speech and hearing will be especially pleased by this clinical approach to the topic. Interest levels in reading and study should remain high as a result of the clarity of the text, the illustrations, and the rich embellishment of clinical insights, examination procedures, and clinical variations.

One of the noteworthy contributions that this book makes to the literature is filling the large gap between the presentation of academic materials and the clinical application of those materials. Doctor Bateman shares his extensive experience in speech pathology and his knowledge and interest in medicine and dentistry to enrich basic principles with an expanded view of clinical work in speech and hearing.

In addition to presenting the standard view of speech and hearing anatomy and physiology found in other texts, this book makes some unique contributions. One is the inclusion of perspectives and specific information about the many variations seen among normal anatomical specimens. Also, the section on superficial anatomy, not developed in most other texts, is a refreshing and beautifully written contribution to Doctor Bateman's text. I was especially pleased about the most competent and readable handling of information concerning the circulatory and endocrine systems and the histology and embryogenesis of the speech and hearing apparatus. These systems have been largely ignored in speech and hearing and are necessary inclusions in the training of the developing clinician. Most therapists have a number of patients with major vascular and metabolic insults to the body.

As one reads this book, he is impressed with Doctor Bateman's regard for students and his enthusiasm for the learning process. The aspiring clinician will appreciate the development of information, perspectives, and clinical skills related to speech and hearing anatomy that pervade the pages of this book.

The readability of the text is partially related to the fact that the text is not cluttered by reference sources and names. Instead, a list of references is provided at the end of each chapter for the interested scholar.

Altogether, *A Clinical Approach to Speech Anatomy and Physiology* represents

a most significant contribution to the literature in speech pathology and audiology. As our profession expands to include additional perspectives about the multidisciplinary nature of the clinical patient, information about the various processes of the body, and their clinical significance, becomes increasingly important. This text takes a bold step forward in bridging the gap between academic materials and the clinical setting. The foundations in this book are built with considerable care, affection, and attention to detail.

Robert M. Mason, Ph.D., D.M.D.

PREFACE

DESIGNED FOR THE beginning undergraduate student with an interest in speech and hearing, this book seeks to entice the student to look carefully at the subject of speech and hearing anatomy and physiology.

Speaking and listening are extremely complex processes. The premise for this book is that these processes can be explained and illustrated adequately without oversimplifying for the gifted student and without overwhelming the student whose best subject is not anatomy. This book was also prepared in recognition of the great variability among the instructors who teach this course to beginning students—some are anatomy scholars; others are just acquiring skill and confidence in handling the subject.

The initial parts of this book present a departure from traditional approaches to achieve the objectives mentioned above. The student is introduced gradually to complex mechanisms as principles, vocabulary, and detail are unfolded. Further, the arrangement of the material becomes systematic after the entire vocal tract is surveyed. After Chapter 6, for example, selective, detailed presentations of the muscular and skeletal systems involved in speech and hearing are grouped according to their respective systems rather than fragmented across numerous chapters. There is a notable exception to this arrangement in Part Six, which focuses on hearing.

Much information pertaining to functional anatomy as may be applied in the clinical setting is lacking or is poorly understood in this field. Hopefully, the student studying this book will develop an inquiring appreciation of the topic. If he or she does, the way will have been paved for expanding the wealth of present and future information from the progressive medical, biological, bio-communications, and other specialty areas. The ultimate benefit may be that the student will translate his or her learning from this study into meaningful and insightful management in clinical treatment of the communicatively handicapped. A number of references to clinical anatomy have been included in this book to encourage relating this treatment of the subject to concrete applications.

This book is the outgrowth of teaching an introductory course in fundamentals of speech and hearing science over a period of many years. It reflects those features which appear to motivate most students in such a course. The first chapter gives the rationale for such a course.

No book of this scope could be written without the benefit of the works of numerous anatomists and other professionals. While these are not referenced in the text itself, the key sources are listed at the close of the chapters. This is not to minimize their contributions; rather, documentation within the text was excluded in order to enhance the readability of the material for the beginning student. Further, clinical comments (and opinions on certain structural functions) are not always experimentally valid. These statements are based on observation of clinical cases and discussions with others involved in clinical work. The purpose of this type of information is to stimulate the beginning student to develop

discriminating, perceptive clinical skills and to foster interest in ascertaining a sound position on clinical and research data that appear questionable.

The author's good teachers, Doctor Robert W. Peters and Doctor Robert B. Mahaffey (both presently at the University of North Carolina), Doctor Julia M. Davis (presently at the University of Iowa), and Doctor James E. Harris (private practice, ENT, Hattiesburg, Mississippi), and those who reviewed the manuscript are absolved from any fault for any errors that may be present in the text. The author accepts full responsibility for the content.

For reading the manuscript and making helpful suggestions, the author is appreciative to Mr. L. Judson Farmer of the University of Mississippi Medical Center. Doctor Robert M. Mason reviewed an early draft of the manuscript and made many valuable critical comments. Doctor Mason's expertise as a speech pathologist, researcher, and dentist permitted him to offer many valuable suggestions which, in the author's opinion, greatly improved the interest factor of the material. For his contributions to this text, including the Foreword, the author is profoundly grateful.

Mrs. Patsy M. Bateman labored many hours typing the various copies of the manuscript, without compensation. Her skill in attending to detail and perseverance gave the author the impetus to complete this involved project. She really deserves coauthorship recognition.

In reality, it was the feedback from my students that encouraged this book to be planned and written. Their eagerness to learn and dislike of being frustrated and bored in the classroom set the bounds for this book.

H.E.B.

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A CLINICAL APPROACH TO SPEECH
ANATOMY AND PHYSIOLOGY

PART ONE: ORIENTATION

Chapter 1. INTRODUCTION

Overview

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Justification for the Study of Speech and Hearing Anatomy

Chapter 2. SUPERFICIAL ANATOMY

Anatomical Position and Direction

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CHAPTER 1

INTRODUCTION

OVERVIEW

WHEN A DISORDER of communication arises which is caused by an obvious malfunction of the anatomic system producing speech, much interest is generated, especially for the student of speech and hearing. To explain the *why* of such a hearing or speaking pathology necessitates a fundamental investigation and comprehension of the structure and function of the speech, language, and hearing mechanisms. Most students are unprepared to attempt any such investigation independently. The temptation is great for the student to look for a very superficial and general explanation of the makeup and operation of the communicative system.

It is true that one can quickly and easily become overwhelmed by the amassed anatomic and physiologic publications, their minutiae, and the varied approaches and objectives employed in presenting a treatise on the topic. Hence, it is likely that the unversed or unforewarned student will shun all anatomy books, as fine as they may be, for the purposes for which they were written.

At some point, the aspiring speech pathologist and audiologist must take the plunge into the subject, for some understanding of the structure and function of the speech and hearing mechanisms is essential in the field of speech and hearing (also known as communicative disorders and communicology). Management procedures for the communicatively handicapped can only be studied effectively with proper perspective and practiced with proper clinical follow-through if the student has considerable knowledge of

the normal, intact speech and hearing mechanisms. Working with the communicatively handicapped without this prerequisite can easily lead the clinician to develop strange concepts of the cause and remediation of speech and hearing problems. A graphic example of this may be found during the tragic period when surgery on the tongue was considered a cure for stuttering. Although this occurred in the 1840s, a number of therapy devices and procedures are advertised in current literature which are based on false assumptions of the processes involved in speech and hearing behavior. Systematic study of anatomy, designed in approach for speech and hearing students, will, hopefully, equip students to develop sound assumptions underlying communicative disorders. Such an approach should also encourage a technically accurate exchange of patient treatment information with other professionals.

A basic purpose of this text concerns the usefulness of anatomy and physiology to the student of speech and hearing as s/he relates with the communicatively impaired. Its design may prevent incorrect interpretations, false theories, and unfounded courses of action pertaining to the physical makeup and operation of the speaking and listening machinery by leading the student into sound comprehension of the structural and functional dimensions of normality and abnormality. This should permit the clinician to formulate proper therapeutic responses for communicative handicaps, engendering clinic ability and confidence.

INTRODUCING THE COMMUNICATIVE PROCESS

Communication may be thought of as an active and complex social process. It is ex-

tremely difficult to separate the parts of such a highly integrated process. Nonetheless, a

study of the processes contributing to communication may best be understood if introduced as sequential steps and sometimes as separate components. The plan chosen here is to present components of the communicative process in a discrete arrangement. Inasmuch as possible, an attempt will be made periodically to remind the student of the integrative nature of the total act and to foster an appreciation for the unity of the systems.

Communication

Communication may be thought of as a process involving the sorting, selecting, and sending of symbols in such a way as to help a listener recreate in his own mind the meaning contained in the mind of the speaker. A typical model of the communication process may be described by listing the sequence of events transpiring.

Before one person can communicate with another, according to this description, the speaker must arrange his thoughts, decide what he wants to say, and transform what

he wants to say into linguistic form. This is accomplished by selecting the correct words and phrases to express the intensive message. In addition, grammatical rules must be applied to place the words in correct order. After this encoding activity has been completed by the brain, appropriate impulses from the motor centers of the brain are sent to activate the muscles of speech sound production. The activity of the vocal process produces waves of pressure in the surrounding air. Hence, the "message" is sent by sound waves, which strike the sensitive receptive mechanisms of the listener. These pressure changes on the eardrum cause the inner ear to transform the pressure waves into nerve impulses, which are carried to the brain along the acoustic nerve. The brain interprets the pattern of the impulses, correlates the pattern with previous experiences, and brings about recognition of the speaker's message. Figure 1 is a schematic presentation of this definition of communication.



Figure 1. Communication model.

Speech

Speech may be thought of as a subdivision of communication. Defined, *speech* is the communication of thought and emotion by means of an oral linguistic code designed to influence the behavior of others. The vocal process used in the production of speech involves organs of the body whose functions include a number of biological roles. The above definition does not imply a speaking apparatus apart from the basic structures of air and food intake.

Muscles and bones involved in speech production have as their first responsibility those processes involved with the maintenance of life and normal homeostasis. These include

respiration, mastication (chewing), and swallowing. Aspects of speech production include an *energy source*: expiratory air; a *vibrator*: the vocal folds; *resonators*: oral, nasal, and pharyngeal cavities; and the *modifiers*: the articulators (Fig. 2). Although speech in each phase is produced by organs whose basic functional duty is not communication, special design features of these organs make speech a first-class citizen in the biological activities of man.

Brass musical instruments are somewhat analogous to the speech mechanism. Both utilize expiration of air as an energy source. For a vibrator, the lips are pressed against a mouthpiece and are made to vibrate as air

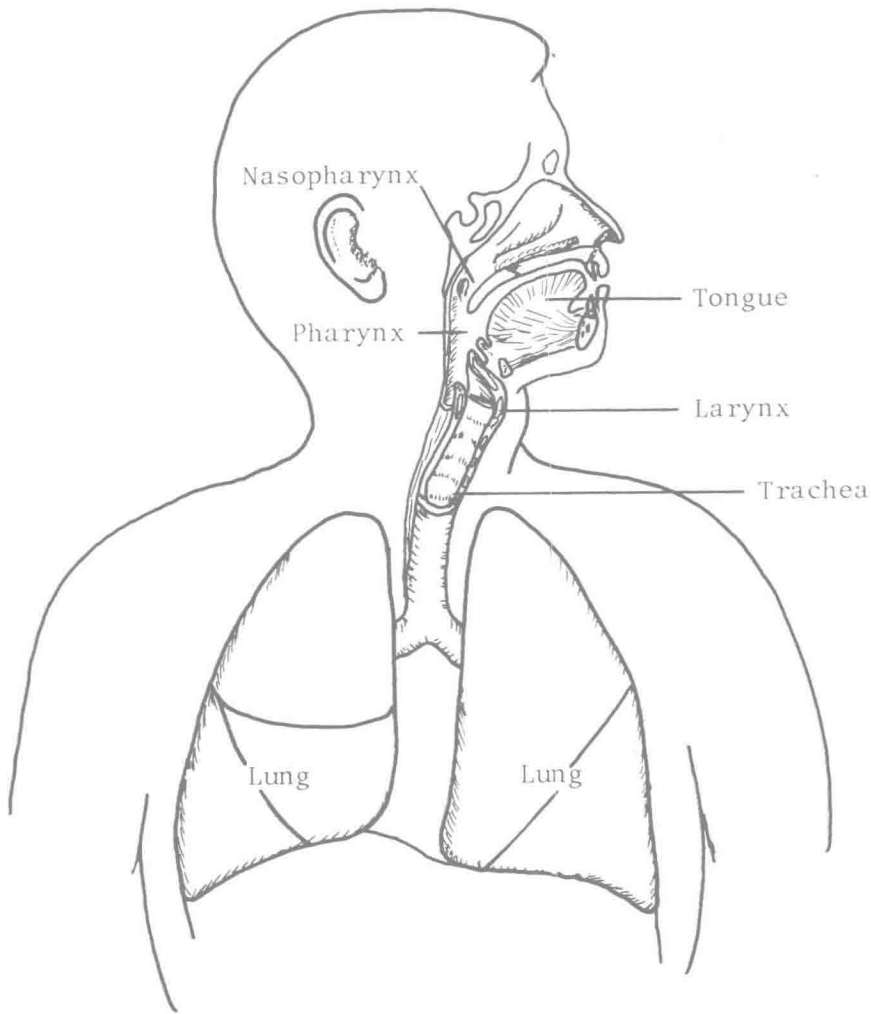


Figure 2. The vocal tract. From *Dorland's Illustrated Medical Dictionary*, 24th ed., 1965. Courtesy of W. B. Saunders Co., Philadelphia.

is forced through them. Resonation, which acts to alter sound, is achieved by the release of the vibrating lip sound into the coiled tubes of the instrument. The length of the column of air vibrating in the instrument is changed by means of valves or a sliding tube, which in turn causes the pitch to vary for musical articulation.

Speech Monitoring

The speed by which the vocal mechanism produces speech immediately suggests a very

complex and integrated behavior with the benefit of automatic neural control. By way of the ear, by tactile sensations created by contacts of the articulators, and by muscle position and sense receptors, the speaker's brain is given feedback during speech production. Adjustments in the speech musculature can be made in midstream to correct or alter patterns of articulation, voice quality, pitch, loudness, rhythm, or melody aspects (the *prosodic* features) of ongoing speech. The speaker monitors his speech for at least

two basic requirements, (1) correct content of words that convey the meaning intended and (2) correct speech sound pattern.

From the above, it is clear that speech automation truly involves elaborate neural control. This regulatory apparatus brings into focus a basis for explaining speech pathologies and their underlying etiologies. Faulty monitoring by the neural systems can yield faulty parameters in the speech product to the extent that if adequate feedback controls are not established, correction of a deficit may be beyond reach.

Coupled with one another, each aspect of the speech mechanism presents a complex anatomic and physiologic apparatus. It works intricately with the same type of bewilderment as the operation of a mammoth pipe organ with thousands of pipes, energized by multiple blowers and operated by miles of wires, relays, and valves, and controlled from a single console where an organist may command the music equivalent to an entire symphony orchestra (Fig. 3). Mediated by master nerves from the brain, the expiratory muscles compel the lungs to send their inhaled quantities of air under pressure up the windpipe to operate the vocal folds in a vibratory pattern for sound production. The sound stream (or air stream for whisper-like sounds) leaves the larynx and resonates in the cavities of the throat, oral, and nasal chambers. At the same time, the articulators of the oral cavity begin to halt, constrict, and redirect the sound stream so as to form meaningful chunks of sound interpreted as words. All the while, the entire operation is watched

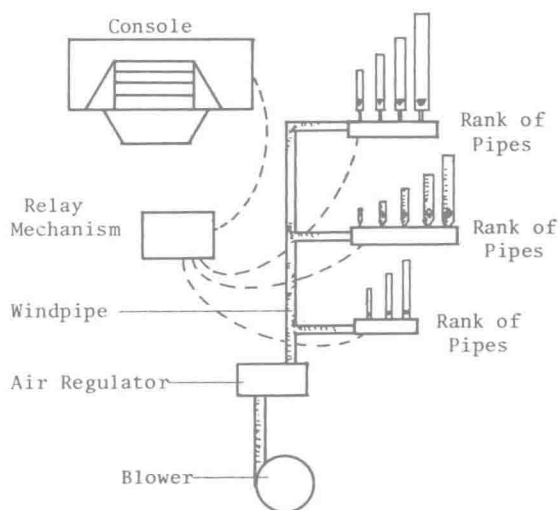


Figure 3. Schematic of pipe organ.

over by the brain's neural sensory and speech perception units, checking for adequacy according to learned standards.

There are actually two cardinal components in speech production. These were presented in the foregoing paragraph as (1) a concept of neurophysiologic timing interactions and (2) a concept of pressure variations. While neural activity is the initiator of speech as well as a monitoring system, each speech sound involves an intricate distribution of pressures along the vocal tract. Further, each speech sound requires an adjustment of pressures along the vocal tract, in part because of the nature of the individual sound but also because of the influence of neighboring sounds.

THE JUSTIFICATION FOR THE STUDY OF SPEECH ANATOMY

Understanding the general anatomic and physiologic components of the communicative process provides meaningful insight into the problems of the hearing-, language-, and speech-handicapped. The aspiring communicologist who views the speech and hearing mechanisms as a "black box," elusive to all but a few erudite individuals, is relegated to guessing tactics when dealing with underlying communicative problems. Management

procedures may then be based on faulty assumptions because of improper understanding of the communicative process.

Without a doubt, many erroneous concepts have been perpetrated upon the unwary because of deficient anatomic knowledge. Thorough patient treatment has sometimes been thwarted simply due to an inability of the speech and hearing specialist to communicate effectively with medical professionals con-