



*the* **Voice**

*A Medical Guide for  
Achieving and Maintaining  
a Healthy Voice*

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SCIENCE &  
MEDICINE

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## **the Voice: A Medical Guide for Achieving and Maintaining a Healthy Voice**

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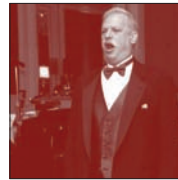
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## ▲ Introduction

This book is meant to be an informational source for professional voice users on how to care for and maintain the longevity of the voice from a purely medical perspective. This is not a book on vocal pedagogy, but rather a guide to common medical problems that can affect the voice and to common vocal difficulties that can develop from ineffective voice use. This book also serves as a resource guide for finding and recognizing appropriate voice care.

This book is purposely designed to be easy to read and is intended for non-medical voice professionals. Singing teachers, those studying vocal performance and acting, acting voice teachers, and voice coaches may find this material particularly useful. However, the material within this book applies to all voice professionals, including singers, actors, lawyers, public speakers, politicians, teachers, phone operators, stock brokers, salesmen, corporate executives, and others who use their voice in their profession.

To our knowledge, this is the first book on the medical aspects of the voice and vocal health written by physicians for voice professionals.

*YDH*  
*RTS*  
*MJH*

## ▲ Anatomy: Where is the Voice Produced?

The human voice is remarkable, complex, and delicate. It is capable of conveying not only sophisticated intellectual concepts, but also subtle emotional nuances. Although the uniqueness and beauty of the human voice have been appreciated for centuries, medical scientists have begun to really understand the workings and care of the voice only since the late 1970s and early 1980s. The larynx is the primary organ involved in voice production. However, phonation requires complex interactions between many bodily systems to achieve the sound that we associate with the voice. To fully understand how the voice is produced, it is necessary to understand both the anatomy of the larynx and its neural (nerve) connections, as well as the biomechanics of sound production.

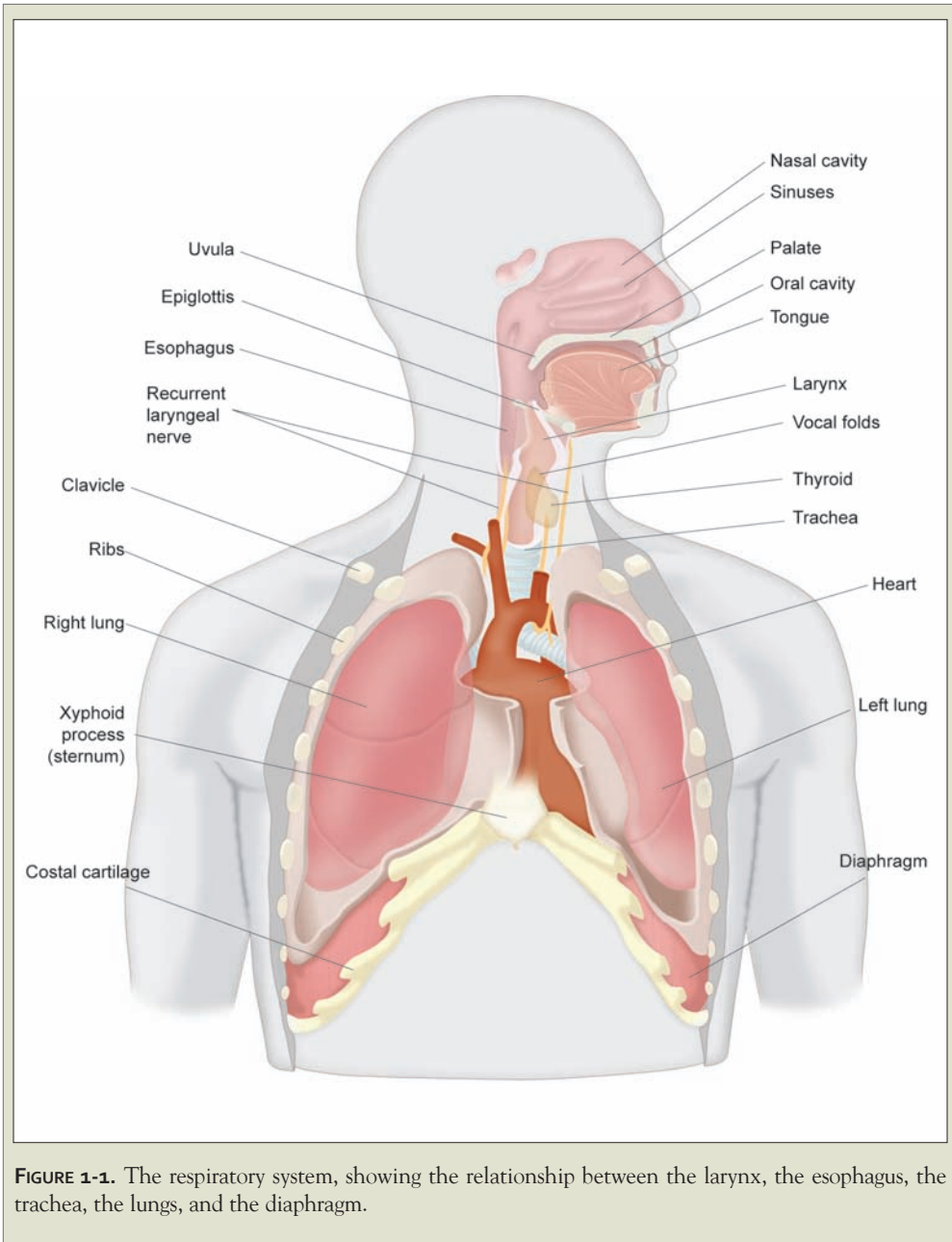
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### Laryngeal Anatomy

The larynx is the primary source of sound in humans and is commonly referred to as the “voice box.” It sits in the neck, just beneath the tongue base and in front of the esophagus, where it serves as the opening to the trachea and lungs (Figure 1-1). In humans, the larynx has four main functions:

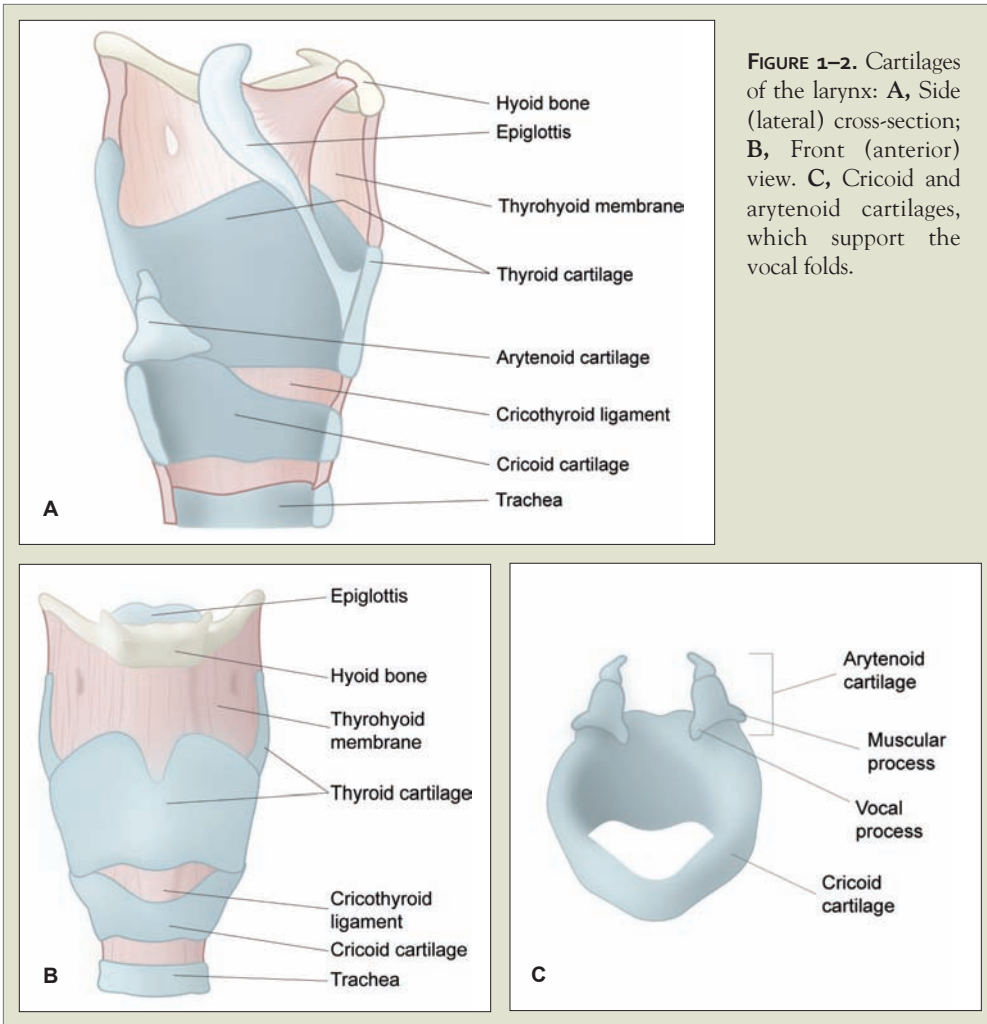
- to protect the lungs from foreign materials such as food and liquid,
- to serve as a conduit for the passage of air into the lungs during breathing,
- to produce the voice, and
- to help in stabilizing the pressure within the chest during activities such as lifting and straining.

The larynx is composed of cartilages, muscles, nerves, and the vocal folds. The movements of the vocal folds are coordinated by the actions of the muscles of the larynx, the cartilages of the larynx, and the nerves that supply the muscles of the larynx.<sup>1</sup>



**FIGURE 1-1.** The respiratory system, showing the relationship between the larynx, the esophagus, the trachea, the lungs, and the diaphragm.

The space between the vocal folds is referred to as the *glottis*, which is the reference point for the vocal tract. Structures within the vocal tract are described as *glottic* (at the level of the vocal folds), *supraglottic* (above the vocal folds), *subglottic* (just below the vocal folds), or *infraglottic* (well below the vocal folds).



### LARYNGEAL FRAMEWORK

The laryngeal cartilages provide the structural support for the laryngeal muscles, the vocal folds, and the mucous membranes in a manner similar to the way in which the framework of a house provides support for the walls and floors.

The main cartilages of the larynx are the thyroid, cricoid, arytenoid, and epiglottic cartilages (Figure 1-2A and 2B). At the top of the larynx is the epiglottis, an elastic flap that guards the entrance to the larynx and glottis; it sits upward (open) during breathing and is forced downward (closed) by the tongue during swallowing. The thyroid cartilage below it forms a shield around the upper part of the larynx, providing support and attachment for the laryngeal muscles; it is the familiar “Adam’s apple” on the neck.

The cartilages below are important for voice production. The cricoid cartilage forms a ring that provides support for the trachea (Figure 1-2C). The arytenoid car-



# 2

## ▲ How is the Voice Produced?

### *The Mechanics of Voice Production*

**P**roduction of the voice involves the same physics as the mechanism of sound production from any source, such as a musical instrument. In general, the production of sound requires four main components:

- airflow
- an oscillator (an instrument that puts the airflow into a wave-like motion, thus creating sound waves)
- a resonator (which helps to maintain a uniform frequency of vibration), and
- an amplifier (which increases the magnitude of the sound waves to make them louder).

In the case of the trumpet, power is generated by the chest, abdomen, and back musculature, and a high-pressure air stream is produced. The trumpeter's lips open and close against the mouthpiece, producing a “buzz” similar to the sound produced by vocal fold vibration. This sound then passes through the trumpet, whose twisted shape creates a resonance chamber that shapes the sound and gives it its “signature.” This “signature” helps us identify the sound as coming from a trumpet and not a flute or clarinet, for example. The resonance chamber of the trumpet is analogous to the vocal tract, which acts as a biological resonance chamber.

In voice production, the source of airflow is the lungs. The abdominal, diaphragm, chest, and back musculatures contribute to airflow in voice production. The oscillator is the vocal folds, which vibrate and place the airflow into a wave-like motion. The remainder of the vocal tract, the supraglottic larynx, the pharynx (throat), the oral cavity (mouth) including the lips, tongue and palate, the nasal cavity, the sinuses, and the head together form the resonance chamber and amplifier for voice production in humans (Figure 2-1).

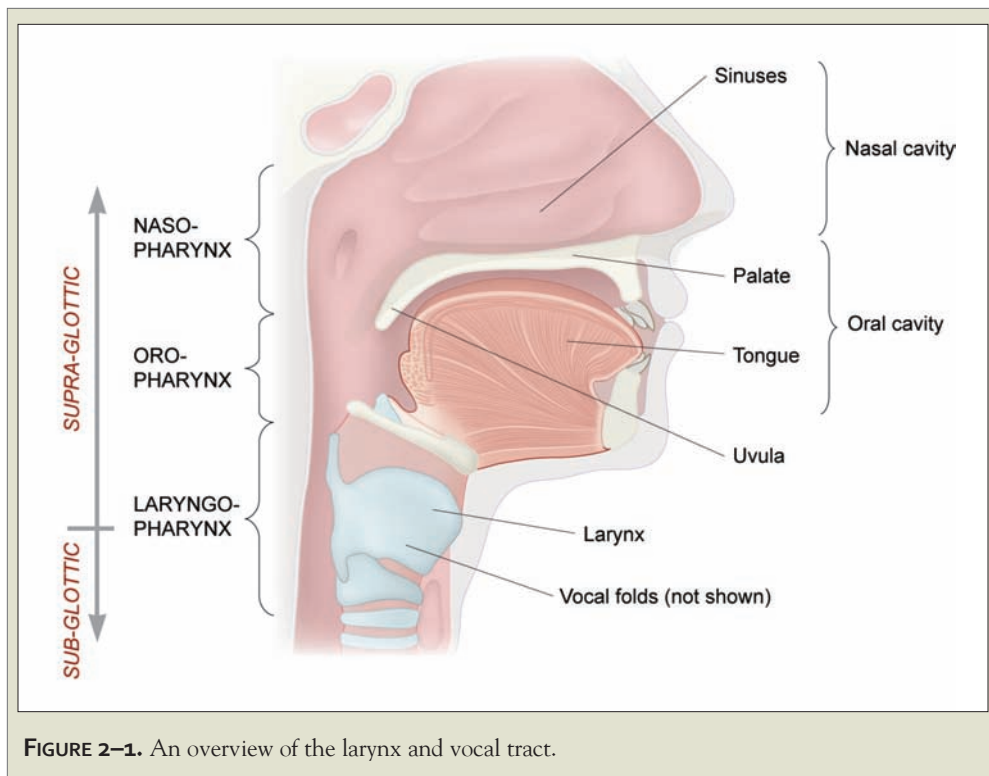


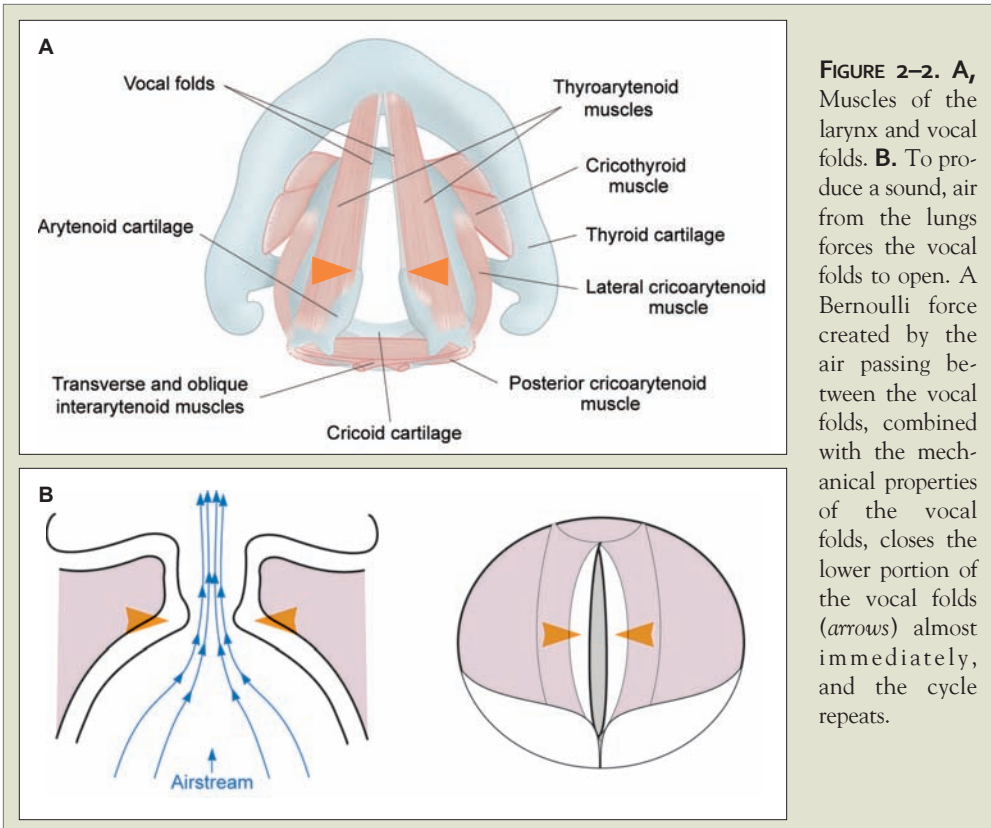
FIGURE 2–1. An overview of the larynx and vocal tract.

## Sound Source

The sound source for voice production is the larynx and the vibrating vocal folds. The vocal folds themselves are made of five layers of tissue, as explained in Chapter 1.

The outer mucosa (epithelium) forms the thin, lubricated surface of the vocal folds, which makes contact when the two vocal folds are closed. It looks like the mucosa lining the inside of the mouth. Mechanically, however, the vocal fold structures act more like three layers, consisting of the mucosal cover layer (epithelium and superficial layer of the lamina propria), the transition layer (intermediate and deep layers of the lamina propria), and the body (the vocalis muscle).

When one makes the decision to talk, the vocal folds come together in the midline (Figure 2-2A). Air is forced from the lungs past the closed vocal folds. The epithelium of the vocal folds glides open, over the superficial layer of lamina propria. As the mucosal cover opens, air travels past the vocal folds and into the upper parts of the larynx and pharynx. A Bernoulli force, similar to a “suction effect,” is created by the air that passes between the vocal folds (Figure 2-2B). This Bernoulli force combines with the mechanical properties of the vocal folds to begin closing the lower portion of the vocal folds almost immediately, even while the upper edges are still separating.



**FIGURE 2–2. A,** Muscles of the larynx and vocal folds. **B.** To produce a sound, air from the lungs forces the vocal folds to open. A Bernoulli force created by the air passing between the vocal folds, combined with the mechanical properties of the vocal folds, closes the lower portion of the vocal folds (arrows) almost immediately, and the cycle repeats.

The upper portion of the vocal folds has strong elastic properties that tend to make the vocal folds snap back to the midline. The upper portions of the vocal folds are then returned to the closed position, completing the glottic cycle. When the vocal folds snap shut, sound (i.e., a sound wave) is produced.<sup>1</sup> Subglottal pressure then builds again, and the events repeat.

The frequency of opening and closing of the vocal folds (the vibratory cycle) determines the frequency of the sound waves and, thus, the pitch of the voice. The frequency of the vibratory cycle is dependent on the strength of the airflow from the lungs and on mechanical properties of the vocal folds, which are regulated in part by the laryngeal muscles. Under most circumstances, as the vocal folds are thinned and stretched and airflow is increased, the frequency of air pulse emission increases, and pitch goes up.

The frequency of vibration of the vocal folds is termed the *fundamental frequency*, and the character of the sound that is produced from the vocal folds is very similar to the sound that is produced from buzzing lips.<sup>2</sup> This is a complex sound containing a fundamental frequency and many overtones, or higher harmonic partials. The amplitude (which determines volume) of the harmonic partials decreases uniformly at approximately 12 decibels (dB) per octave. This complex sound is modified by the resonance chamber of the supraglottic vocal tract and produces the voice that gives each person his or her own characteristic and distinguishing vocal signature.<sup>3</sup>

# 3

## ▲ How Do I Maintain Longevity of My Voice?

Those who use their voice professionally for singing, acting, teaching, counseling, public speaking, telecommunications, oration, or other venues need to maintain good vocal hygiene to sustain reliable, lifelong professional voice use. Like dental hygiene, vocal hygiene is a set of preventative measures that are actively and consciously undertaken by the voice user to maintain the health, reliability, and consistency of the voice. Proper training, strengthening, and conditioning are as important to the professional voice user as they are to a professional athlete.<sup>1</sup> Attention to these practices will help prevent vocal injury and maintain the voice through rigorous vocal performance and speaking schedules.

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### How Can The Voice Be Kept Healthy?

Preventative medicine is always the best medicine. The more one understands his or her voice, the more one will appreciate its importance and delicacy. Education helps us understand how to protect the voice, train and develop it to handle our individual vocal demands, and keep it healthy. A little bit of expert voice training can make a big difference.

Avoidance of abuses, especially smoke, is paramount. If voice problems occur, expert medical care with a laryngologist (an ear, nose, and throat doctor who specializes in voice care) should be sought promptly. Interdisciplinary collaboration among laryngologists, speech-language pathologists, singing teachers, acting teachers, many other professionals, and especially voice users themselves has revolutionized voice care since the early 1980s.<sup>1</sup> Technological advances, scientific revelations, and new medical techniques inspired by interest in professional opera singers have brought a new level of expertise and concern to the medical profession and improved dramatically the level of care available for any patient with voice dysfunction.

## How Can A “Normal” Voice Be Made Better?

Voice building is possible, productive, and extremely gratifying. Speaking and singing are athletic. They involve muscle strength, endurance, and coordination. Like any other athletic endeavor, voice use is enhanced by training that includes exercises designed to build strength and coordination throughout the vocal tract. Speaking is so natural that the importance of training is not always obvious. However, running is just as natural. Yet, most people recognize that, no matter how well a person runs, he or she will run better and faster under the tutelage of a good track coach. The coach will also provide instruction on strengthening and warm-up and cool-down exercises that prevent injury. Voice training works similarly.

Voice building starts with physical development. Once vocal health has been assured by medical examination, training is usually guided by a voice trainer (with schooling in theater and acting voice techniques), singing teacher, or a speech-language pathologist. In the authors’ setting, all three specialists are involved under the guidance of a laryngologist (the voice doctor), and additional voice team members are utilized, as well, including a psychologist or psychiatrist (for stress-management), pulmonologist, neurologist, and others.

Initially, training focuses on the development of physical strength, endurance, and coordination. This is accomplished not only through vocal exercises but also through medically supervised bodily exercise that improve aerobic conditioning and strength in the support system. Singing skills are developed (even in people with virtually no singing talent at all) and used to enhance speech quality, variability, projection, and stamina. For most people, marked voice improvement occurs quickly. For those with particularly challenging vocal needs, voice building also includes training and coordinating body language with vocal messages, organizing presentations, managing adversarial situations (interviews, court appearances, etc.), television performance techniques, and other skills that make the difference between a good professional voice user and a great one.

The process of voice building is valuable not just for premier professional voice users. Virtually all of us depend upon our voices to convey our personalities and ideas. The right subliminal vocal messages can be as important in selling a product or getting a job as they are in convincing a jury or winning a presidential election. The initial stages of voice building are no more complex than the initial stages of learning to play tennis or golf, and their potential value is unlimited. A strong, confident, well-modulated voice quietly commands attention, convinces, and conveys a message of health, strength, youth and credibility.

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## Care of the Conversational Voice

The source of many voice problems in both professional speakers and professional singers lies in unrecognized abuse or misuse of the everyday speaking voice. Such misuse and abuse can take the form of chronic throat clearing, yelling or shouting

## ▲ What Is Reflux and How Does It Contribute to Voice Problems?

Reflux laryngitis occurs as a result of a backward flow of stomach acid and other stomach contents into the esophagus, up to the level of the larynx, where contact results in a chemical burn of the tissue lining of the larynx. This backward flow, or reflux, of stomach contents into the larynx and pharynx is referred to as *laryngopharyngeal reflux* (LPR), which in turn can cause reflux laryngitis as well as reflux pharyngitis (sore throat or tonsil inflammation), rhinitis (nasal congestion), sinusitis, and/or otitis media (middle ear inflammation or infection).

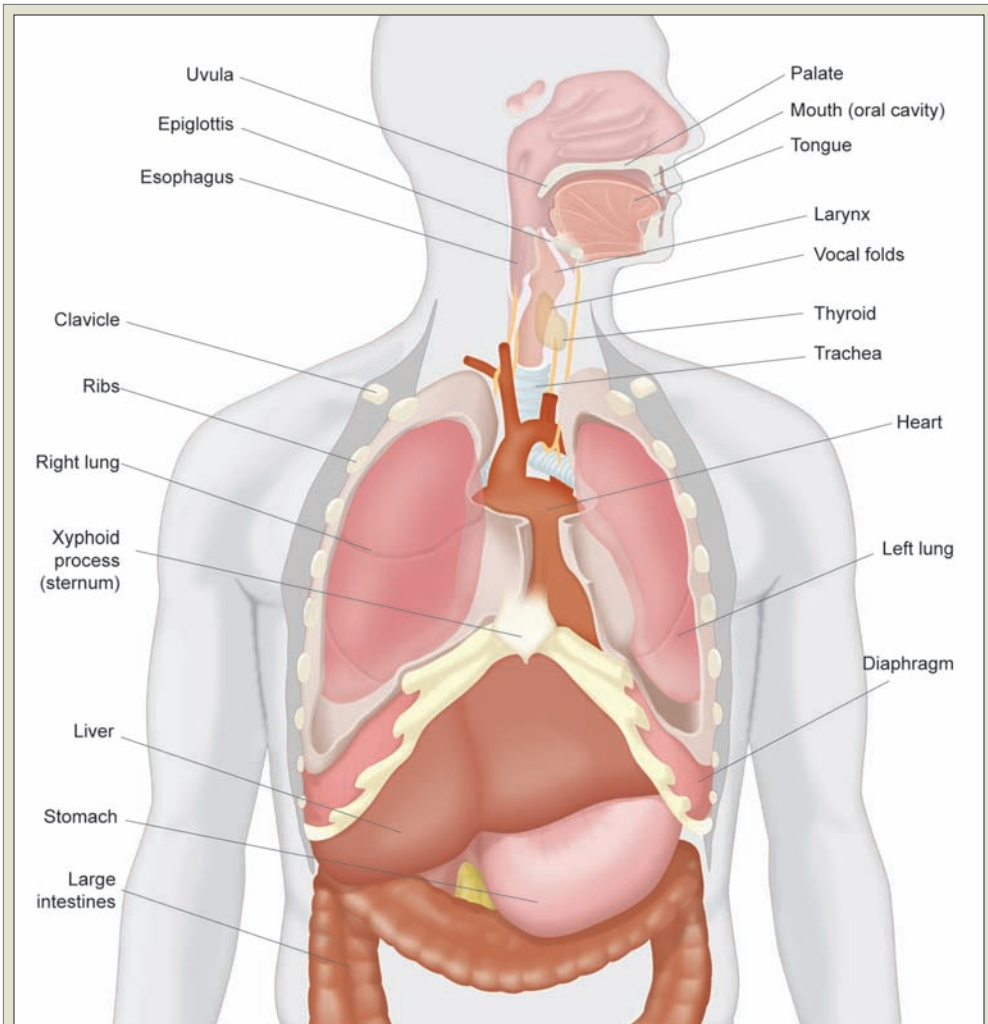
Laryngopharyngeal reflux and reflux laryngitis are different entities from gastroesophageal reflux disease (GERD) and esophagitis, although they are related. In order to fully understand this distinction, it is first necessary to understand the normal mechanisms of swallowing and emptying of the stomach, as both laryngopharyngeal reflux and GERD are disorders of these mechanisms.

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### Normal Swallowing and Gastric Emptying

The esophagus is the “swallowing tube” that connects the back of the throat (pharynx) to the stomach. The opening to the esophagus sits behind the larynx (Figure 8-1). At the top of the esophagus, behind the larynx, there is a ring-like muscle, the cricopharyngeal muscle (also referred to as the cricopharyngeus or *upper esophageal sphincter*), which normally is contracted or closed. This closed state allows air that is inhaled during normal breathing to go into the larynx, trachea, and lungs instead of into the esophagus and stomach.

When swallowing is initiated, the cricopharyngeus relaxes, opening the entrance to the esophagus and allowing food to pass into it. The muscles in the wall of the esophagus contract in a coordinated fashion to push the food down into



**FIGURE 8–1.** The respiratory system, showing the relationship between the larynx, the esophagus, the trachea, the lungs, and the diaphragm.

the stomach. At the junction of the stomach and esophagus is a sling-shaped ring of muscles in the diaphragm, called the *lower esophageal sphincter*, that is normally contracted to help keep the stomach contents in the stomach. When food in the esophagus reaches the lower esophageal sphincter (LES), it relaxes, allowing food to enter the stomach. After the swallow is complete, both the upper and lower esophageal sphincters return to their normal contracted and closed states.

When food reaches the stomach, it stimulates the stomach to release acid. The acid lowers the pH in the stomach. Enzymes from the stomach and pancreas and bile salts from the gallbladder are released into the stomach, as well. These enzymes and bile salts help in the digestion of proteins, fats, and carbohydrates. The enzymes that digest proteins are activated in the presence of an acidic environment, which

is the reason that the stomach makes acid when food enters. Regardless of what kind of food is eaten, the stomach releases some acid, although certain foods stimulate the release of more acid than do others. In addition to the surge of acid secretion that occurs with eating, the stomach also has a “basal” secretion of acids; that is, there is always a baseline secretion of acid by the stomach, even when empty. The amount of acid secreted increases with meals.

In addition to the secretion of acid and the influx of enzymes and bile salts, the stomach begins to churn when food enters. The churning helps with the digestion of food, and it helps to move the food from the stomach into the intestines for further digestion and absorption of nutrients. The stomach is a sac with two openings, the gastroesophageal junction (the region of the lower esophageal sphincter) and the gastroduodenal junction (the entrance into the intestines). As stomach pressure increases, either with churning or with an increase in abdominal pressure, the contents of the stomach will flow through the opening with the least amount of resistance. As long as the lower esophageal sphincter has normal tone, this flow is directed into the intestines.

---

### What Happens During GERD?

If the lower esophageal sphincter tone is decreased, it is less effective in blocking the flow of stomach contents into the esophagus. In such cases, when pressure in the stomach increases, the stomach contents (gastric juice) will flow through the opening of least resistance, which can be back through the lower esophageal sphincter and into the esophagus. If the sphincter has only a slight decrease in its tone, the amount of gastric juices that is allowed into the esophagus is small, as is the distance it travels up the esophagus usually. With decreasing levels of tone, more of the gastric juice can flow through the sphincter, and greater increases in stomach pressure tend to cause reflux across greater distances in the esophagus.

The esophagus is lined with “stratified epithelium,” which means that the lining of the esophagus is several cell layers thick and serves as a good protective covering for the esophagus against acid injury, similar to the way in which the multiple layers of cells on the skin of the hand protect the hand from injury. Thus, small amounts of acid in the esophagus may injure the first few layers of lining cells, but will leave many layers beneath unharmed.

If the amount of acid exposure is more severe, more cell layers are injured, and injury deep to the lining tissue may occur, resulting in inflammation or esophagitis, a diagnostic hallmark of GERD. This type of injury usually produces symptoms of heartburn. GERD that is severe or that goes untreated for prolonged periods of time may result in a change in the lining tissue of the esophagus to a different cell type, a process called metaplasia, creating a condition called Barrett’s esophagus, which can eventually become cancer if left untreated. Thus, everyone with symptoms of heartburn should be evaluated and treated—so should many people with other evidence of reflux (such as laryngopharyngeal reflux), even in the absence of heartburn.



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