

How the Larynx (Voice Box) Works

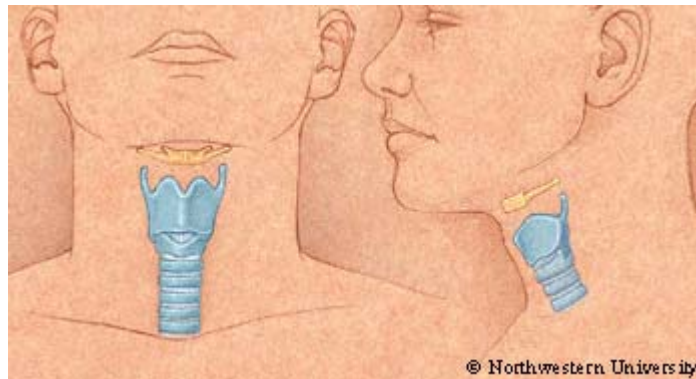
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If you love opera, or if you admire the voices of pop singers such as Celine Dion or Barbra Streisand, you may have wondered how it is these marvelous singers are able to create such beautiful music with this instrument we call the human voice. You may also know of someone who has a bad voice or has had to have their voice box, or larynx, removed because of illness or injury.

The larynx is a critical organ of human speech and singing, and it serves important biological functions as well. Let's have a look at the larynx to understand its functions, what it looks like and how it works.

It is thought that the same factors that favored the evolution of air-breathing animals on earth led to the evolution of the larynx. Lungs are comprised of very delicate tissues that must be maintained within strict biological limits, that is, temperature, humidity and freedom from foreign particles. Thus, along with the first air-breathing animals, there appeared a primitive sort of larynx, whose one and only function was protection of the lung. This function remains the most important of those the larynx has assumed in subsequent evolutionary developments. Now, of course we recognize that the larynx is critical for human speech and singing. But we also should realize that the larynx is important for swallowing, coughing, vomiting and eliminating contents of the abdomen.

If you have ever felt your 'Adam's Apple', then you know where the larynx is. The Adam's Apple is a protuberance on the front of the larynx. This protuberance is part of one of the main skeletal parts of the larynx, the thyroid cartilage. The larynx is comprised of several other cartilages as well as a single bone, the hyoid. Altogether, the cartilages and bone provide a somewhat flexible and rigid framework for support of softer tissues and muscles.



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This figure illustrates the location of the larynx within the neck. A: Hyoid bone, B: Thyroid cartilage, C: Cricoid cartilage, D: Trachea. Click on the image for a larger view.

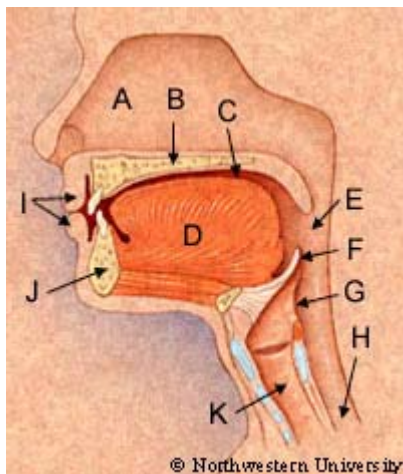


Figure 2: This figure depicts a

The larynx is attached below to the trachea, or windpipe, which goes down to the lungs in the chest and carries the air we breathe. Immediately behind the larynx is the pharynx. The pharynx is a tube-like structure that extends from the upper border of the esophagus, which is at the level of the bottom of the larynx, all the way up and in back of the oral and nasal cavities. The upper border of the larynx opens up into the pharynx. Thus, the air we breathe travels through the upper part of the pharynx and then into the larynx. One unfortunate consequence of human evolution is the fact that the food we eat and the air we breathe share part of the pharynx, and if a person tries to speak while swallowing food, the food can enter the larynx and cause the person to choke. This choking actually serves an important function, keeping food out of or removing it from the larynx and trachea for protection of the lungs. Another key protective

section through the center of the head and neck along the midline. In the top, one can see the inside of the nasal cavity(A), oral cavity(C), tongue(D), palate (B), jaw(J) and lips(I). Posterior to the nasal and oral cavities lies the pharynx(E). In the neck, the inside of the larynx(K) is shown anterior to the pharynx and esophagus(H). Note the position of the epiglottis(F) extending into the pharynx over the top of the entry into the larynx from the pharynx (G). Click on the image for a larger view.

Now let's examine what's inside the larynx and learn about the structures that are involved in choking, holding one's breath or the creation of the sounds of singing or speech, which we call vocalization or phonation. The inside of the bottom of the larynx is round and shaped like a cylinder. As air ascends through the larynx, it encounters two folds of tissue that extend out from the left and right sides of the larynx. These are known as the vocal folds. The vocal folds are also called the 'true vocal folds' because immediately above the ventricle, there is a second set of folds called the 'false vocal folds', or ventricular folds. These are called 'false' because the early doctors upon looking down into a patient's throat with the aid of a bent mirror, often mistook the 'false' folds for the 'true' folds. However, the function of the false vocal folds is thought not to be nearly so critical for airway protection or vocalization as are the true vocal folds.



Figure 3: This figure illustrates how doctors visualize the larynx. A small mirror attached to a bent rod is used to look down into the larynx from the open mouth. Click on the image for a larger view.

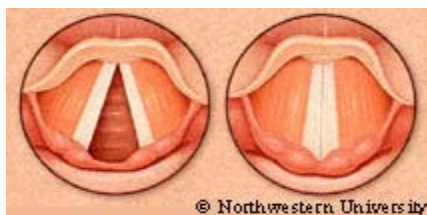


Figure 4: This figure illustrates two views of the vocal folds observed from the laryngeal mirror (Figure

The true vocal folds are attached to the inside of the thyroid cartilage at about the level of the Adam's Apple. Posteriorly, the vocal folds are attached to a set of cartilages known as the arytenoid cartilages. There are several sets of muscles that attach to the arytenoid cartilages, and by their contraction, can move the arytenoids and along with them the posterior part of the vocal folds. Because of these anatomical relationships, the space in the middle of the larynx between the vocal folds - the glottis - is triangular in shape, with the narrow part of the 'V' pointing towards the front.

3). On the left, the vocal folds are pulled laterally by the posterior cricoarytenoid muscle to open the glottis, such as when a person inhales, or takes a breath of air. On the right, the vocal folds are pulled towards the midline by 'adductor' muscles (see text), to close the glottis, as when a person vocalizes or holds their breath. Click on the image for a larger view.

When the posterior cricoarytenoid muscles contract, the arytenoid cartilages and vocal folds are pulled laterally to open the glottis (abduction). Every time we take a breath of air, we open the glottis in this way.

Most of the other muscles pull on the arytenoids to either close the glottis or stiffen the vocal folds. The lateral cricoarytenoid and interarytenoid muscles pull the muscular processes of the arytenoids and the vocal folds to the center of the glottis, thus closing it (adduction). A similar muscle, the thyroarytenoid, assists in closing the glottis and in addition makes the vocal folds become very stiff. When all three of these muscles contract, the glottis tightly closes. This is a configuration important for swallowing, holding one's breath, or generating high abdominal pressures associated with defecation, vomiting and child birth. The last of the muscles to be considered here, the cricothyroid, is on the front of the larynx and causes a rotational movement between the thyroid and cricoid cartilages. Because the arytenoid cartilages are attached to the back of the cricoid cartilage, and the vocal folds are attached to the thyroid and arytenoid cartilages, this rotational movement causes longitudinal stretching of the vocal folds. This stretching is the primary means by which we change the pitch of our voice.

The muscular and cartilaginous actions mentioned above are similar to those we use when we vocalize for speech or singing. In order to vocalize, the edges of the vocal folds that face the midline of the glottis are brought towards the midline, but they are not pressed together tightly as they are when we choke, swallow or hold our breath. Instead, the edges of the folds are positioned so that they are lightly touching each other or are close to each other. The process of vocalization then results from blowing air up from the lungs past the edges of the vocal folds. The flow of air initiates a repetitive cycle of vibratory movements of the vocal folds. High air pressure from below (subglottal pressure) blows the vocal folds apart, and then elasticity of the vocal folds causes them to return to the midline. Each time the folds are blown apart, a small puff of air bursts up through the space between the folds and 'excites' the air within the upper part of the larynx and pharynx. Excitation is the term used to refer to the generation of sound by the explosive quality of the burst of air. This vibrational sequence of events repeats itself on average about 110 times per second for an adult male and about 200 times for an adult female. The sequence of these air bursts takes on a tonal quality when repeated at high frequency, and that is why our voices sound like a tone rather than a series of mini explosions. When we sing, or raise the pitch of our voices for other reasons, we contract the cricothyroid muscles to stretch the vocal folds, and the stiffer the folds become, the higher the frequency at which they vibrate.

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