LessonTwo ; The phonatory and auditory systems

Learning Objectives

By the end of this chapter, students should be able to:

1. Identify the anatomical location of the larynx and hyoid bone.
2. Describe the skeletal framework of the larynx, including unpaired and paired cartilages.
3. Explain the function and attachment of intrinsic and extrinsic laryngeal membranes.
4. Identify and classify laryngeal muscles and their role in phonation.
5. Describe the structure and divisions of the internal cavity of the larynx.
6. Relate laryngeal anatomy to phonatory function, vocal fold motion, and speech production.
7. Identify the key auditory structures involved in hearing and their role in speech perception.
8. Correlate structural and functional abnormalities with common voice and hearing disorders.
9. Apply clinical reasoning to case scenarios involving phonatory and auditory dysfunction.

1. Introduction to the Larynx

The **larynx** is an unpaired musculo-cartilaginous–membranous structure located in the anterior neck, suspended between the hyoid bone above and the trachea below (Figures 4-1, 4-2). It is responsible for **phonation**, the production of voicing that underlies all vowels, diphthongs, and voiced consonants.

Phonation involves the smooth, rhythmic pulsation of air from the lungs, creating a **quasiperiodic acoustic signal**, which is perceived as speech.

2. Skeletal Framework of the Larynx

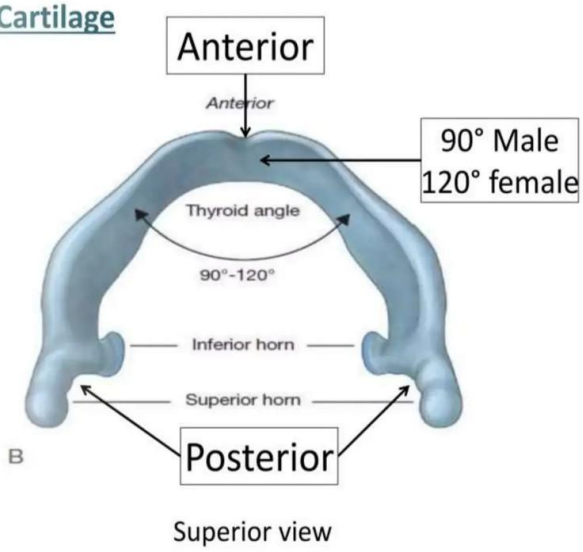
2.1 Unpaired Cartilages

The laryngeal skeleton consists of **three unpaired cartilages**:

- **Thyroid cartilage**: Largest cartilage, composed of two laminae fused anteriorly forming the thyroid angle (Adam’s apple) and superior/inferior cornua (Figure 1). Protects the vocal folds.

- formed by 2 laminae which fuse ventrally in the midline of the neck, forming a protuberance, the laryngeal prominence or "Adams apple,
- The 2 laminae meet at an angle of 90° in the male and 120° in the female.
- The upper limit of fusion of the two laminae forms the superior thyroid notch

Thyroid Cartilage

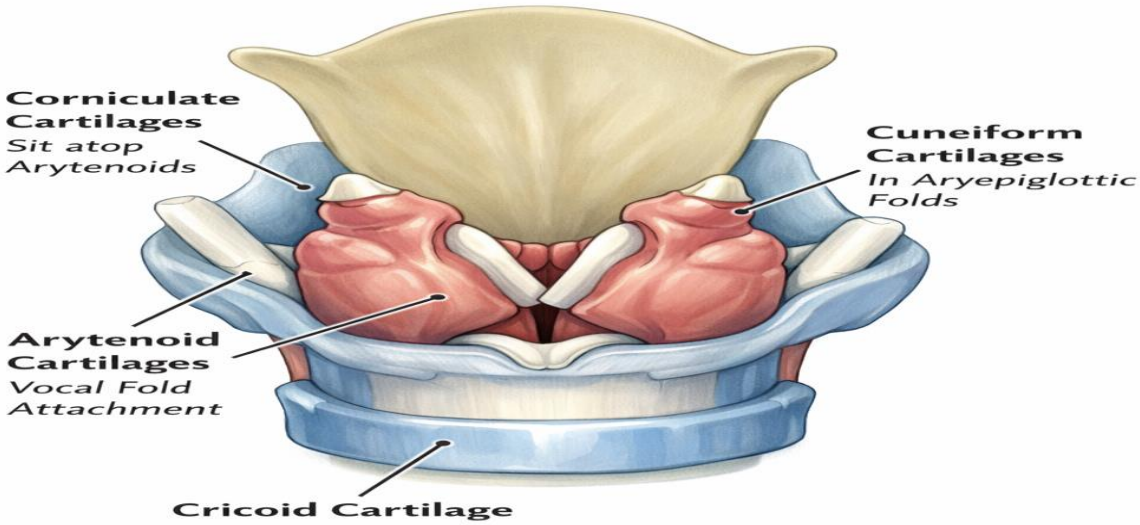


- **Cricoid cartilage**: Ring-shaped structure at the larynx base above the trachea; provides attachment points for arytenoids and articulation with thyroid cartilage.
- **Epiglottis**: Leaf-shaped cartilage posterior to the hyoid bone; protects airway during swallowing.

2.2 Paired Cartilages

- **Arytenoids**: Pyramid-shaped, located on the posterior cricoid; vocal folds attach here (Figure 2).
- **Corniculates**: Sit atop arytenoids, assist with fold movement.
- **Cuneiforms**: Embedded in aryepiglottic folds, provide structural support.

Figure 2: Laryngeal Cartilages



-

3. Laryngeal Membranes

3.1 Extrinsic Membranes

Connect laryngeal cartilages to external structures (Figure 3):

- **Hyothyroid (thyrohyoid) membrane**: Thyroid to hyoid.
- **Lateral hyothyroid ligaments**: Superior cornua to hyoid.
- **Hyoepiglottic ligament**: Epiglottis to hyoid.
- **Cricotracheal membrane**: Cricoid to first tracheal ring.

3.2 Intrinsic Membranes

Connect cartilages internally:

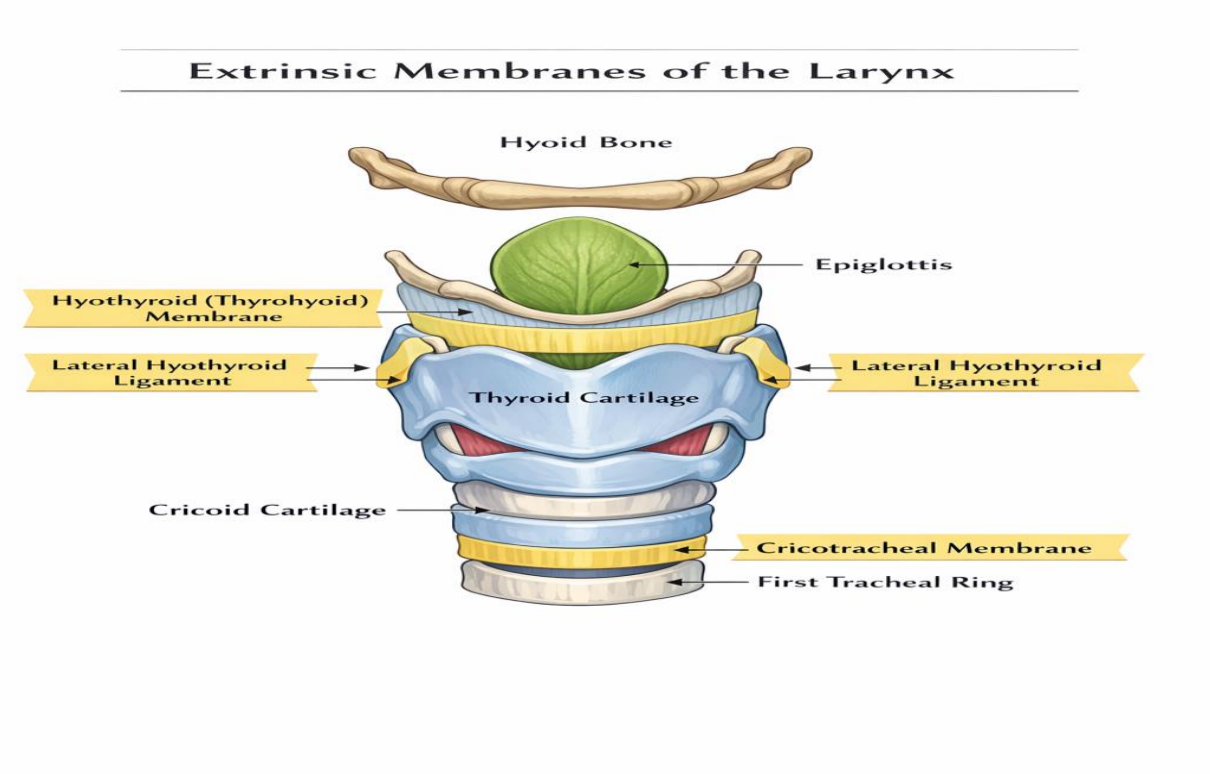
- **Conus elasticus**: Connects thyroid, cricoid, arytenoid cartilages.
- **Quadrangular membrane**: Connects epiglottis, thyroid, corniculate, arytenoid.
- **Aryepiglottic folds**: Epiglottis to arytenoids.
- **Ceratocricoid ligaments**: Reinforce crico-thyroid articulation.
- **Thyroepiglottic ligament**: Thyroid to epiglottis.
- **Posterior cricoarytenoid ligament**: Cricoid to arytenoids.

4. Laryngeal Muscles

4.1 Extrinsic Muscles

Connect the larynx to external structures; classified by function:

- **Suprahyoid (elevators)**: Digastricus, mylohyoid, geniohyoid, stylohyoid.
- **Infrahyoid (depressors)**: Sternohyoid, sternothyroid, omohyoid.
- **Supplementary elevators**: Tongue muscles—hyoglossus and genioglossus (Figure 4).

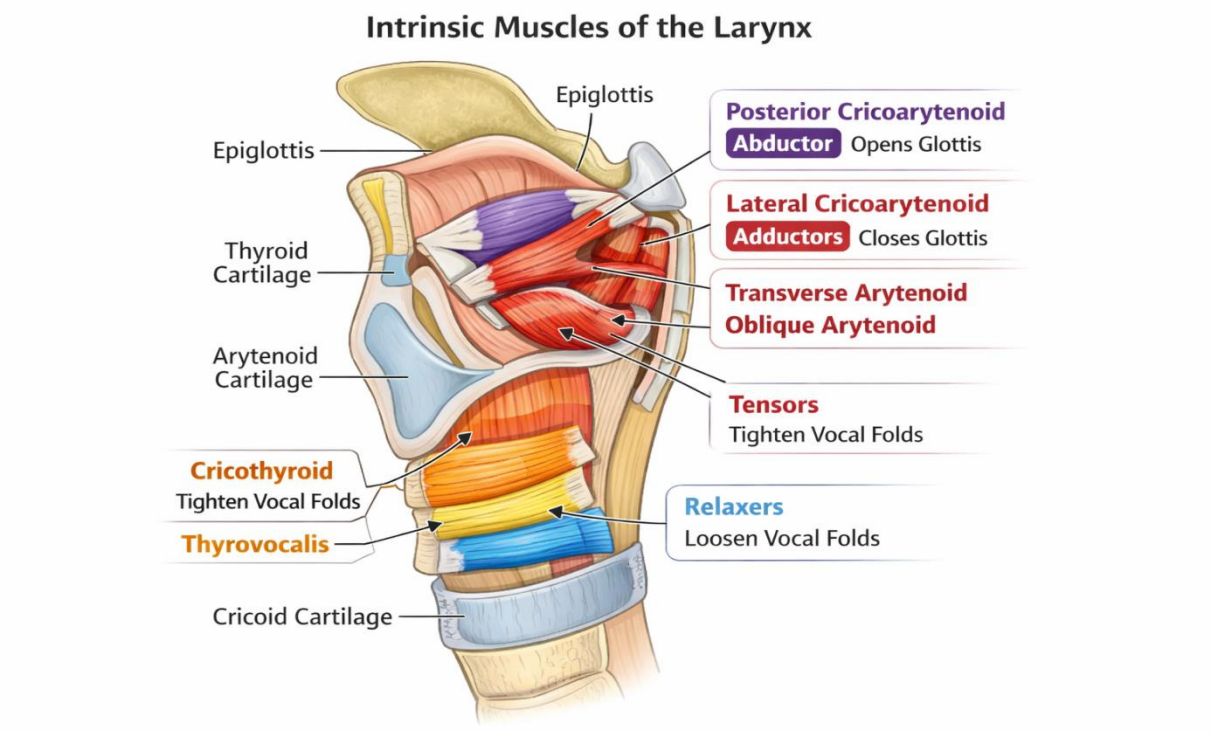


4.2 Intrinsic Muscles

Connect laryngeal cartilages to each other; control **vocal fold position**:

- **Abductor**: Posterior cricoarytenoid (opens glottis).
- **Adductors**: Lateral cricoarytenoid, transverse arytenoid, oblique arytenoid (close glottis).
- **Tensors**: Cricothyroid, thyrovocalis (tighten vocal folds).
- **Relaxers**: Thyromuscularis (relaxes folds) (Figure 5).

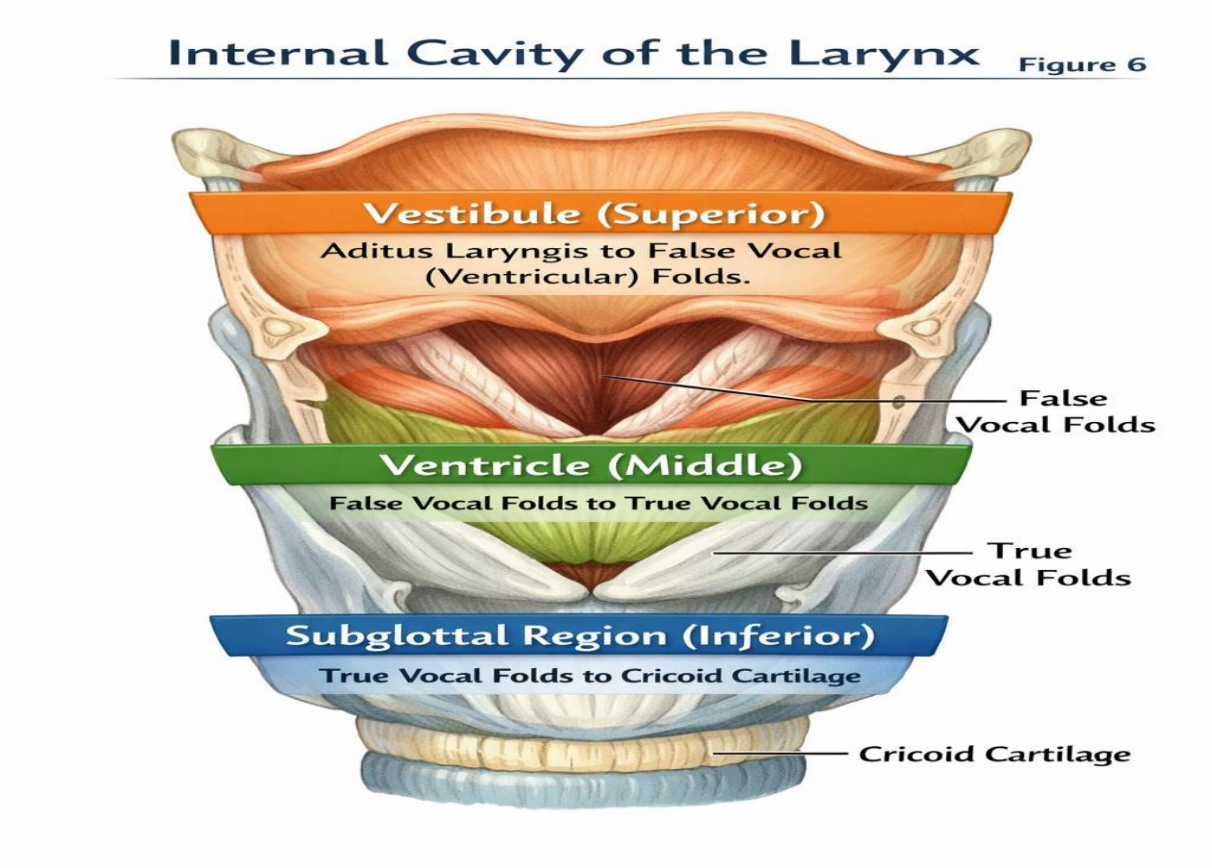
Glottis: Space between vocal folds; narrowest during phonation, widest during inhalation.



5. Internal Cavity of the Larynx

Divided into three regions (Figure 6):

1. **Vestibule (superior)**: Aditus laryngis to false (ventricular) folds.
2. **Ventricle (middle)**: False folds to true vocal folds.
3. **Subglottal region (inferior)**: True vocal folds to cricoid cartilage base.



6. Clinical Correlation and Phonation

Understanding the larynx is essential for:

- **Voice assessment**: Jitter, shimmer, fundamental frequency.
- **Speech disorders**: Dysphonia, vocal fold paralysis, aging-related changes.
- **Therapeutic intervention**: Targeting intrinsic/extrinsic muscle function, glottal closure, and vocal fold tension.

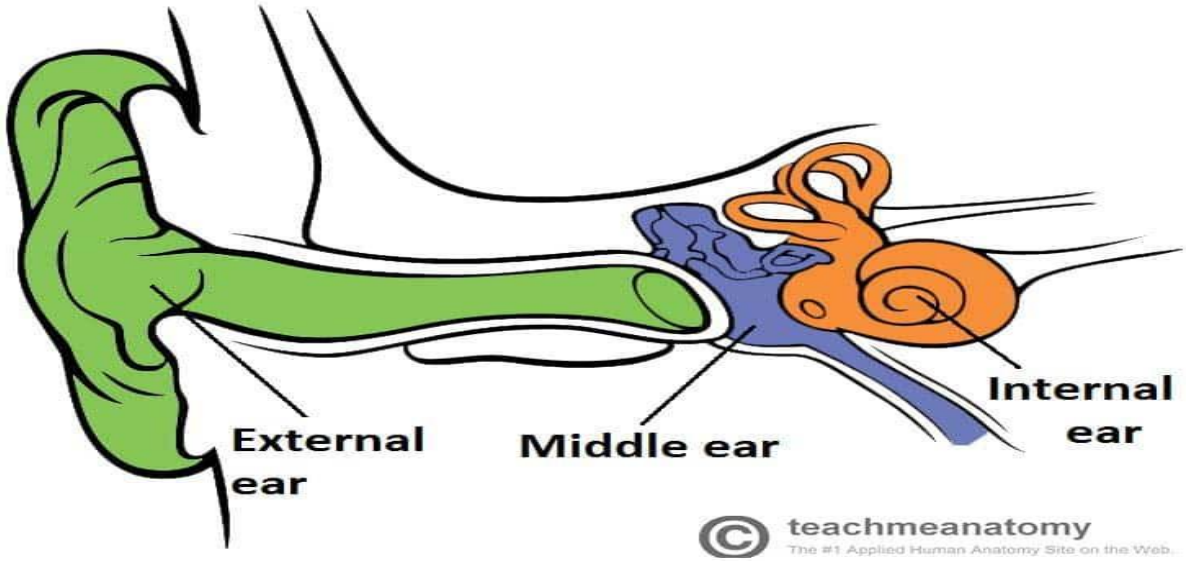
2. The Auditory System

2.1 Anatomy

The auditory system consists of **outer, middle, and inner ear structures**:

- **Outer ear**: pinna, ear canal (funnels sound)
- **Middle ear**: tympanic membrane, ossicles (malleus, incus, stapes – amplify sound)
- **Inner ear**: cochlea (transduces sound to neural signals), vestibular apparatus (balance)

Figure 2: *Diagram of the auditory system showing outer, middle, and inner ear.*



2.2 Physiology of Hearing

Sound waves travel through the ear, causing **tympanic membrane vibration**, ossicular movement, and **fluid waves in the cochlea**, which stimulate hair cells. This mechanical energy is converted to **electrical signals** in the auditory nerve and transmitted to the **auditory cortex**.

Clinical correlation: Disorders such as **sensorineural hearing loss, conductive hearing loss, and auditory processing disorder** can impair speech perception.

2.3 Clinical Cases

Case 1: A 7-year-old child with chronic otitis media exhibits delayed speech. Audiological testing shows mild conductive hearing loss. Management includes **medical treatment and auditory-verbal therapy**.

Case 2: A 50-year-old adult experiences gradual hearing loss and tinnitus. Audiogram indicates sensorineural hearing loss. Intervention involves **hearing aids and communication strategies**.

3. Integration of Phonatory and Auditory Systems

Effective communication depends on the **interaction between phonation and auditory feedback**. The auditory system monitors vocal output, allowing **pitch, loudness, and quality adjustments**. Damage to either system affects speech intelligibility and voice quality.

4. Summary

- The **larynx** is central to voice production; its cartilages, muscles, and ligaments work together for phonation.
- The **auditory system** enables sound detection and speech perception.
- Clinical understanding of both systems is essential for **SLP assessment and intervention**.

5. Review Questions

Multiple Choice Questions (MCQs):

1. Which cartilage of the larynx is unpaired and forms the anterior prominence ("Adam's apple")?
   a) Arytenoid
   b) Thyroid
2. c) Cricoid
   d) Corniculate
3. The vocal folds vibrate due to:
   a) Subglottic pressure
   b) Pharyngeal resonance
   c) Nasal airflow
   d) Epiglottic closure
4. Conductive hearing loss is caused by:
   a) Cochlear hair cell damage
   b) Ossicular chain disruption
   c) Auditory nerve lesion
   d) Auditory cortex lesion

Case Study Question:
A patient presents with hoarseness, reduced pitch range, and vocal fatigue. Laryngoscopy shows thickening along the mid-membranous portion of the vocal folds.

- Identify the likely pathology.
- Suggest at least two SLP intervention strategies.

Anatomy Identification

1. Label larynx, hyoid bone, trachea.
2. Identify thyroid, cricoid, epiglottis, arytenoid, corniculate, cuneiform cartilages.
3. Identify suprahyoid and infrahyoid muscles.
4. Identify intrinsic muscles (abductor, adductors, tensors, relaxers).
5. Label glottis, vestibule, ventricle, subglottal region.

True/False & Fill-in-the-Blank

- Phonation involves all vowels, diphthongs, and voiced consonants. (T/F)
- The cricoid cartilage is ring-shaped and forms the inferior larynx. (FILL IN)
- The glottis is widest during _____. (FILL IN: inhalation)

References

- Titze, I. R. (2021). *Principles of voice production* (2nd ed.). National Center for Voice and Speech.
- Kent, R. D., & Read, C. (2018). *The acoustic analysis of speech* (3rd ed.). Plural Publishing.
- Stach, B. A. (2019). *Clinical audiology: An introduction* (5th ed.). Plural Publishing.
- Behrman, A., & Sulica, L. (2018). *Voice disorders* (3rd ed.). Thieme.