

**Objective 1)**

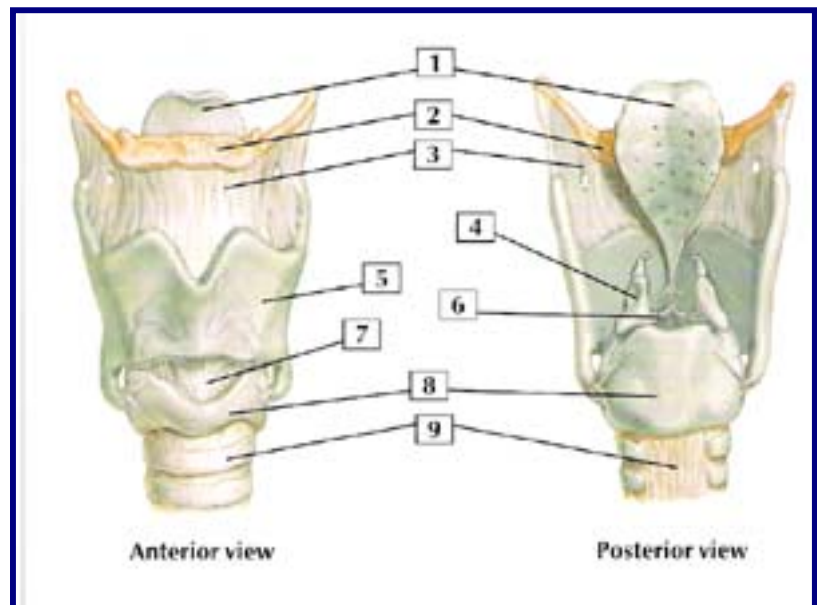
**Identify the major cartilages of the larynx, their articulations with one another, the folds of mucous membrane covering them, and the true and false vocal cords.**

A). Thyroid cartilage:

- i. Largest; inferior 2/3 of its plate-like laminae are fused to form laryngeal prominence with V-shaped superior thyroid notch in it; have superior and inferior horns

ii. Articulations:

- 1. The inferior horns articulate with the lateral surfaces of cricoid cartilage, which allows rotation and gliding of the thyroid cartilage, thereby changing length of vocal cords.
- 2. Thyrohyoid membrane attaches the superior border and superior horns of the laminae to the hyoid bone



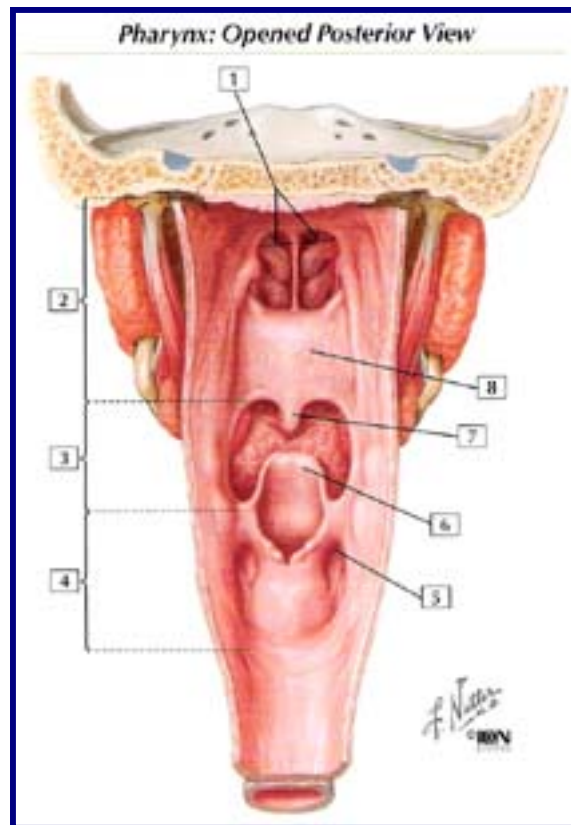
B). Cricoid cartilage:

- i. Forms complete ring around airway; posterior part is lamina and anterior part is the arch; smaller, thicker, stronger than thyroid cartilage
- ii. Articulations:
  - 1. The inferior horns of thyroid cartilage via median cricothyroid ligament and bases of arytenoid cartilages via cricoarytenoid joints.
  - 2. Cricotracheal ligament attaches cricoid cartilage to the first tracheal ring.

C). Epiglottic cartilage: gives flexibility to epiglottis; posterior to root of tongue and hyoid bone and anterior to laryngeal inlet;

- i. Thyroepiglottic ligament attaches inferior border of epiglottic cartilage to the superior thyroid notch formed by thyroid laminae
- ii. Quadrangular membrane extends between lateral aspects of arytenoid and epiglottic cartilages; free, superior margin of this membrane forms the core of the aryepiglottic fold; inferior margin of this membrane forms the vestibular ligament, which is covered by vestibular fold

- iii. Vestibular folds: false vocal cords, no role in voice production; protect the vestibular ligaments; located superior to vocal folds and extend from the thyroid to arytenoid cartilages.
- D). Arytenoid cartilages (2): articulate with lateral part of superior border of cricoid cartilage; consists of an apex superiorly, a vocal process extending anteriorly, and muscular process projecting laterally
- i. Vocal process: posterior attachment of vocal ligament; vocal ligament attaches anteriorly to junction of the thyroid laminae
  - ii. Vocal ligament: thickened, free superior border of the lateral cricothyroid ligament
  - iii. Vocal folds are the true vocal cords and they control sound production/tone. Each vocal fold consists of a vocal ligament and a vocalis muscle. Besides phonation, they also serve as the main sphincter of the respiratory tract when they are tightly closed (e.g. completely adducted).
  - iv. Muscular process: lever for the posterior and lateral cricoarytenoid muscles
  - v. Cricoarytenoid joint: between bases of arytenoid cartilages and superolateral surfaces of cricoid cartilage; allows arytenoid cartilages to slide toward or away from each other, tilt anteriorly or posteriorly, and rotate; these movements approximate, tense, and relax the vocal folds
- E). Corniculate cartilages (2):
- i. Small nodules in posterior part of aryepiglottic fold
  - ii. Articulations: attaches to apices of arytenoid cartilages
- F). Cuneiform cartilages (2):
- i. Small nodules in posterior part of aryepiglottic fold; located adjacent and superior to the corniculate cartilages along the aryepiglottic folds
  - ii. Articulations: does not attach to other cartilages
- G). Mucous membrane coverings
- H). Vocal cords
- i. Vocal folds (true vocal cords): Produce audible sounds when free margins are closely (not tightly) opposed during phonation. Can be totally adducted and close off airway. In glottis and attaches to vocal processes of arytenoid cartilages. The rima glottidis is the aperture b/ the vocal folds. Change in tension, length, and intensity of respiration can change voice.
  - ii. Vestibular folds (false vocal cords): Extend b/ the thyroid and arytenoid cartilages. They have little function in voice production; instead, they are more protective because they

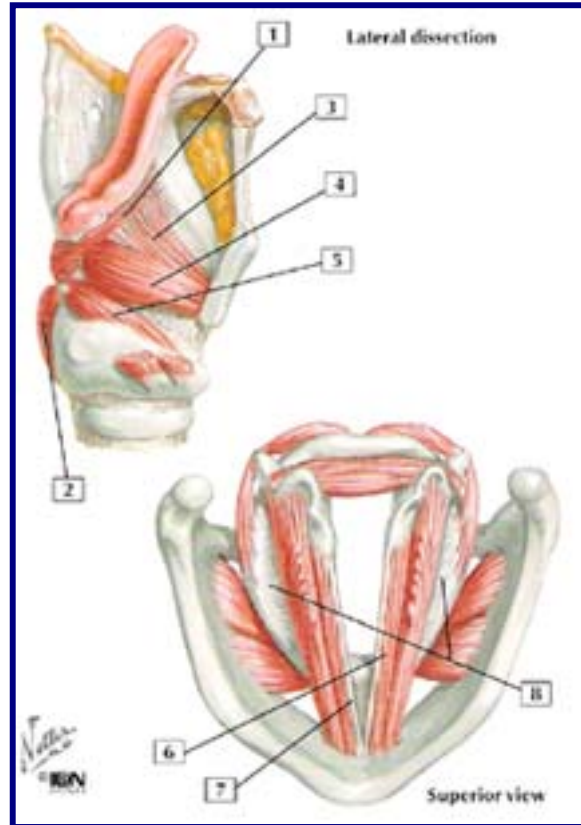


consist of two thick mucous membranes covering the vestibular ligaments.

**Objective 2)**

**Identify the muscles, which bring about the movement of the laryngeal cartilages. Identify the role played by each of these muscles in the control of vocal pitch and/or the control of the size of the rima glottidis.**

- I). Extrinsic laryngeal muscles
  - i. Infrahyoid muscles: depress larynx and hyoid
  - ii. Suprahyoid and stylopharyngeus muscles: elevate hyoid and larynx
  - iii. Infrahyoid and Suprahyoid muscles affect length and tension of the vocal folds; longer vocal folds produces lower pitch and shorter vocal folds produces higher pitch
- J). Intrinsic muscles:
  - i. Cricothyroid muscle:
    - 1. From anterolateral part of cricoid cartilage to inferior margin and horn of thyroid cartilage
    - 2. Innervated by external laryngeal nerve
    - 3. Stretches and tenses vocal fold → lengthens them to deepen voice
  - ii. Posterior cricoarytenoid muscle:
    - 1. From posterior surface of laminae of cricoid cartilage to muscular process of arytenoid cartilage
    - 2. Innervated by recurrent laryngeal nerve
    - 3. Abducts vocal fold (interligamentous part) → widens rima during forced respiration
  - iii. Lateral cricoarytenoid muscle:
    - 1. From arch of cricoid cartilage to muscular process of arytenoid cartilage
    - 2. Innervated by recurrent laryngeal nerve
    - 3. Adducts vocal fold → narrows rima during phonation
  - iv. Thyroarytenoid muscle:
    - 1. From posterior surface thyroid cartilage to muscular process of arytenoid cartilage
    - 2. Innervated by recurrent laryngeal nerve



3. Relaxes vocal fold → produce higher pitch
- v. Transverse arytenoid muscles:
  1. From one arytenoid cartilage to other arytenoid cartilage
  2. Innervated by recurrent laryngeal nerve
  3. Closes interligamentous part of rima glottis
- vi. Oblique arytenoid muscles:
  1. From one arytenoid cartilage to other arytenoid cartilage
  2. Innervated by recurrent laryngeal nerve
  3. Closes interligamentous part of rima glottis
- vii. Vocalis:
  1. From depression b/ laminae of thyroid cartilage to parts of vocal ligament and vocal process of arytenoid cartilage
  2. Innervated by recurrent laryngeal nerve
  3. Relaxes posterior vocal ligament while maintaining (or increasing) tension of anterior part → produces a higher pitch

### Objective 3)

**Identify the three pharyngeal constrictor muscles and their anterior attachments to bony/cartilaginous structures. Identify the three small longitudinal muscles of the pharynx.**

K). Pharyngeal constrictor muscles:

i. Superior-constrictor:

1. **From pterygoid hamulus, pterygomandibular raphe, posterior end of mylohyoid line of mandible, and side of tongue** to median raphe of pharynx and pharyngeal tubercle on basilar part of occipital bone
2. Constricts wall of pharynx during swallowing

ii. Middle-constrictor:

1. **From stylohyoid ligament and superior and inferior horns of hyoid bone** to median raphe of pharynx
2. Constricts wall of pharynx during swallowing

iii. Inferior-constrictor:

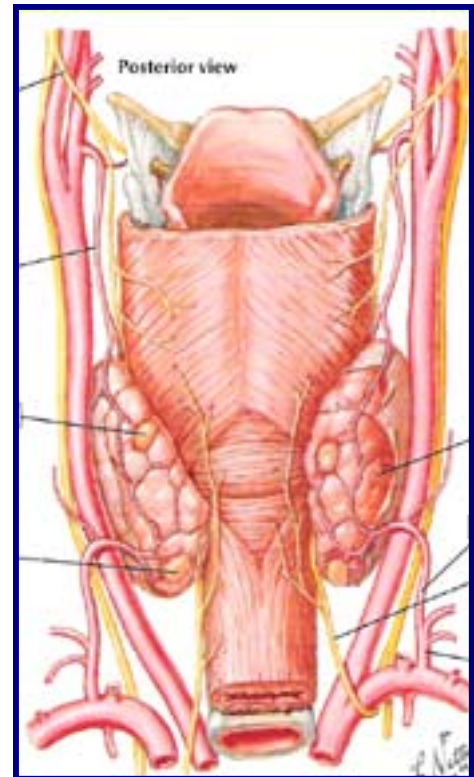
1. **From oblique line of thyroid cartilage and side of cricoid cartilage** to median raphe of pharynx
2. Constricts wall of pharynx during swallowing

B). Longitudinal internal muscle layer:

i. Palatopharyngeus:

1. From hard palate and palatine aponeurosis to posterior border of lamina of thyroid cartilage and side of pharynx and esophagus
2. Elevates (shortens and widens) pharynx and larynx during swallowing and speaking

ii. Salpingopharyngeus:



1. From cartilaginous part of pharyngotympanic tube to blend with palatopharyngeus
  2. Elevates (shortens and widens) pharynx and larynx during swallowing and speaking
- iii. Stylopharyngeus:
1. From styloid process to posterior and superior borders of thyroid cartilage with palatopharyngeus
  2. Elevates (shortens and widens) pharynx and larynx during swallowing and speaking

#### Objective 4)

**Follow the course of sensory and motor innervation of the larynx. Predict the functional consequences of damage to these nerves.**

- A). Vagus nerve (CN X): Laryngeal nerves are superior and inferior branches of the vagus nerve.
- i. Superior laryngeal nerve: Arises at the level of the inferior vagal ganglion and courses down the neck next to the pharynx and larynx to divide into two terminal branches:
    1. Internal laryngeal nerve (sensory and autonomic): Pierces the thyrohyoid membrane with superior laryngeal artery and supplies sensory fibers to the laryngeal mucous membrane superior to vocal folds, including superior surface of these folds.
    2. External laryngeal nerve (motor): Descends posterior to the sternohyoid muscle in company with the superior thyroid artery. At first the nerve lies on the inferior constrictor muscle and then pierces it to supply it and the cricothyroid muscle.
  - ii. Recurrent laryngeal nerve: Comes off of the vagus nerve and loops around the right subclavian artery on the right or aortic arch on the left. It comes up to supply all of the intrinsic laryngeal muscles, except the cricothyroid muscle. It also supplies sensory fibers to the laryngeal mucous membranes inferior to the vocal folds.
    1. Inferior laryngeal nerve: This continuation of the recurrent laryngeal nerve enters the larynx by passing deep to the inferior border of the inferior constrictor muscle of the pharynx and divides into anterior and posterior branches that accompany the inferior laryngeal artery into the larynx.
  - iii. Pharyngeal branch
  - iv. Carotid branch

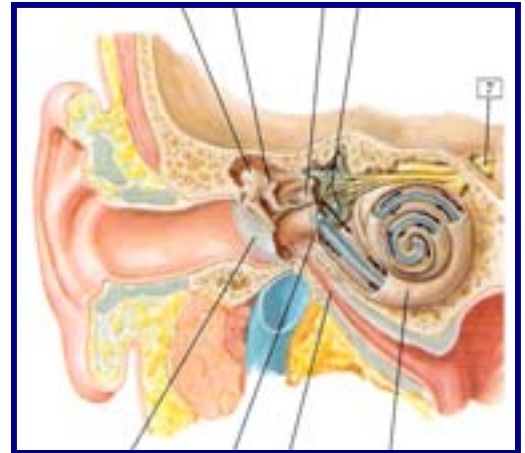
- B). Functional consequences due to damage:
- i. The recurrent laryngeal nerves are easily damaged during anterior triangle of the neck surgery and this impairs the inferior laryngeal nerves, which innervates muscles moving the vocal fold, so a paralysis of the vocal fold occurs and leads to a poor (“hoarse”) voice.
  - ii. If nerves to both vocal folds damaged, voice almost absent because vocal folds cannot be adducted enough to produce phonation.
  - iii. Dyspnea (difficult breathing) due to abduction of vocal folds damaged and difficult opening the vocal folds to allow for increased breathing during exertion. May lead to stridor (high-pitched, noisy respiration) and panic.
  - iv. Hoarse voice most common symptom of serious laryngeal problem.

### Objective 5)

**Identify the components of the external, middle and inner ear and indicate the relationship of each to the internal carotid artery, internal jugular vein, facial nerve, and chorda tympani.**

A). External ear:

- i. Auricle (pinna): Outer ear for collection of sound made up of the helix (outer curve), concha (large hollow floor), tragus, tubercle, and lobule.
- ii. External acoustic meatus: Conducts sound to the tympanic membrane. Leads inward from the concha through the tympanic part of the temporal bone to the tympanic membrane. The lateral 1/3 is cartilaginous and covered with skin continuous with the auricle, and the medial 2/3 is bony covered with skin continuous with the tympanic membrane.
- iii. Tympanic membrane: Thin, oval, semitransparent membrane at the medial end of external acoustic meatus. Forms the partition b/ the meatus and tympanic cavity of the middle ear. It is covered with thin skin on meatus side and mucous membrane on middle ear side. The umbo is the central cone-like depression.



B). Middle Ear (tympanic cavity):

- i. Walls of middle ear:
  1. Tegmental wall (roof): Formed by thin tegmen tympani bone to separate middle ear from middle cranial fossa and dura mater.
  2. Jugular wall (floor): Bone layer separating tympanic cavity from superior bulb of the IJV.
  3. Membranous wall (lateral wall): Formed mostly by tympanic membrane and somewhat by epitympanic recess. Handle of malleus in tympanic membrane and head extends into epitympanic recess.
  4. Labyrinthine wall (medial wall): Separates tympanic cavity from internal ear. Has prominence from cochlea in it.
  5. Carotid wall (anterior wall): Separates tympanic cavity from carotid canal, which contains the internal carotid artery. Has opening into pharyngotympanic tube and canal for tensor tympani muscle.

6. Mastoid wall (posterior wall): Has aditus to the mastoid antrum, tendon of the stapedius muscle, and pyramidal eminence. The canal for the facial nerve descends b/ the mastoid wall and the aditus.
- ii. Auditory ossicles: Take sound from tympanic membrane to oval window
    1. Malleus: Has three parts: 1.) Head – lies in epitympanic recess and articulates with the incus, 2.) Neck – lies against flaccid part of tympanic membrane and is crossed by the chorda tympani nerve and has tensor tympani muscle attached to it that pulls the handle medially, thereby tensing the tympanic membrane and reducing the amplitude of oscillations in order to prevent damage to internal ear when exposed to loud sounds, and 3.) Handle that imbeds in the tympanic membrane with its tip at the umbo.
    2. Incus: Has four parts: 1.) Body – lies in epitympanic recess and articulates with the malleus, 2.) Long limb – lies parallel with the handle of the malleus, 3.) Lenticular process – end of long limb that articulates with the stapes, and 4.) Short limb – connected to posterior wall by a short ligament.
    3. Stapes: The head articulates with the lenticular process of the incus, the base attaches to the oval window, and it has an anterior and posterior crus b/ the head and base.
  - iii. Chorda tympani nerve: Branch coming of the facial nerve containing preganglionic parasympathetic fibers that are destined to go to the submandibular ganglion, from which postganglionic fibers will go to submandibular and sublingual glands. Also contains afferent sensory fibers from the lingual nerve, which carries taste information from the anterior 2/3 of tongue. Chorda tympani nerve crosses through the middle ear lateral to long limb of incus and medial to handle of malleus. Chorda tympani joins with the lingual nerve in the infratemporal fossa.
  - iv. Tympanic plexus, which is formed by fibers of the facial and glossopharyngeal nerves, located at the promontory on the medial wall of tympanic cavity.
- C). Inner ear: Imbedded in petrous part of temporal bone
- i. Bony labyrinth:
    1. Series of fluid filled (perilymph) cavities composed of cochlea, vestibule, and semicircular canals surrounded by bony otic capsule.
    2. Cochlea is the shell-shaped part that contains the cochlear duct (part of membranous labyrinth that is the organ of hearing. Spiral canal of cochlea begins at vestibule and turns 2.5 times around bony core and is a prominence in the tympanic cavity.
    3. Vestibule is the small oval chamber that features the oval window and had the utricle and saccule in it (balancing apparatus). Continuous with the bony cochlea anteriorly and semicircular canal posteriorly. Has vestibular canaliculus to the internal acoustic meatus.
    4. Semicircular canals (anterior, posterior, and lateral) communicate with the vestibule. Occupy three planes and make 2/3 of circle and enlarge into an ampulla. Have 5 openings into vestibule because anterior and posterior canals share one opening. Contain semicircular ducts.
  - ii. Membranous labyrinth:
    1. Series of communicating sacs and ducts suspended in bony labyrinth and endolymph filled.

2. Semicircular ducts, through five openings, connect to the utricle. The utricle connects to the saccule via the utriculosaccular duct from which the endolymphatic duct arises and goes to the endolymphatic sac to store endolymph. The saccule connects to the cochlear duct via the ductus reuniens.
3. The saccule and utricle have maculae with hair cells that are specialized sensory epithelium for balance. Send messages via vestibular nerve of the vestibulocochlear nerve (CN VIII).
4. The semicircular ducts have ampullas with an ampullary crest each that senses movement of endolymph to give sense position of head. The crests have hair cells. Send messages via vestibular nerve of the vestibulocochlear nerve (CN VIII).
5. Cochlear duct has spiral organ (of Corti) that receives auditory stimuli and has hair cells imbedded in a tectorial membrane that overlays it. The hair cells respond deformations in the tectorial membrane via hydraulic pressure in the perilymph caused by sound waves, and this information is picked up by the cochlear nerve of the vestibulocochlear nerve (CN VIII).
6. Cochlear duct suspended in the cochlear canal and it divides the canal into two channels, scala tympani and scala vestibuli that communicate with each other at the apex of the cochlea, the helicotrema. Waves created in vestibule travel through the perilymph in scala vestibuli, pass through helicotrema, and return toward the round window of the vestibule via the scala tympani. This causes dissipation of the sound energy into the air of the tympanic cavity.

### Objective 6)

**Follow the flow of air from the nasopharynx to the mastoid air cells. Identify structures associated with the control of this flow.**

- A). Pharyngotympanic tube: Connects tympanic cavity with the nasopharynx. The posterolateral third is bony; the rest is cartilaginous, and the whole thing is lined in mucous membrane continuous with the tympanic cavity and nasopharynx. Function is to equalize tympanic cavity pressure with atmospheric pressure to allow free movement of the tympanic membrane. Tube kept open by the contracted belly of the levator veli palatini pushing against one wall and the tensor veli palatini pulling on the other wall. These are muscles of the soft palate, and yawning and swallowing can help to equalize pressure between the nasopharynx and the tympanic cavity by opening the tube. The salpingopharyngeus also helps to open the pharyngotympanic tube. The nerves of the pharyngotympanic tube come from the tympanic plexus, which is formed by fibers of the facial and glossopharyngeal nerves.
- B). Once air is in the tympanic cavity (middle ear), it can pass through the aditus to the mastoid antrum, which is an opening in the posterior wall. The mastoid antrum is a cavity in the mastoid process of the temporal bone and is separated from the middle cranial fossa by the tegmen tympani. The floor of the antrum has several apertures through which it communicates with the mastoid air cells.
- C). When flying in an airplane, atmospheric pressure drops and volume of air in middle ear increases. When the pharyngotympanic tube is occluded, residual air in the tympanic cavity is absorbed into the mucosal blood vessels, which lowers the pressure in the

tympanic cavity, causes retraction of the tympanic membrane and interferes with free movement of tympanic membrane. Thus, hearing is reduced.