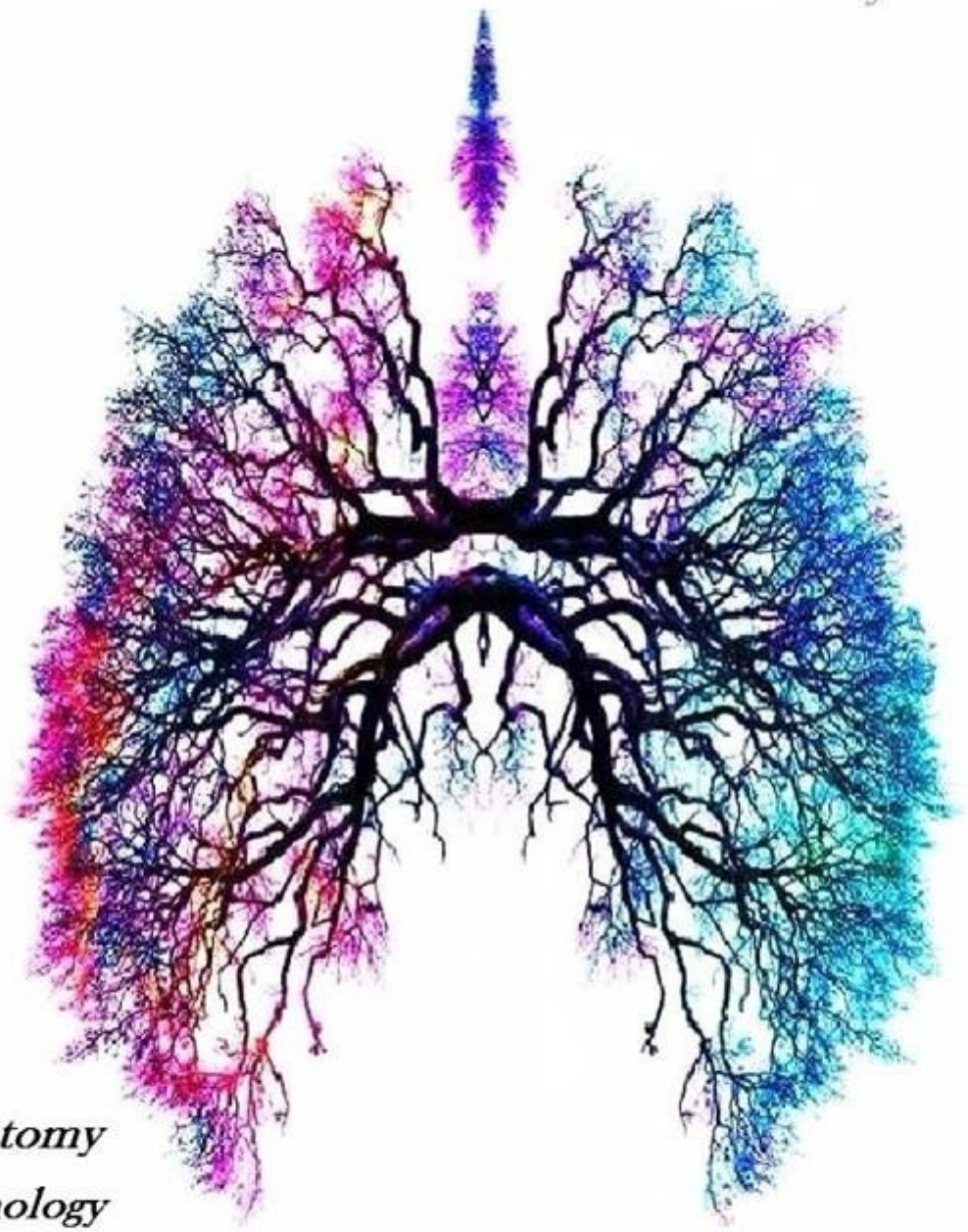
RESPIRATORY SYSTEM

Cover by: Aseil Khatib



- ● *Anatomy*
- ○ *Pathology*
- ○ *Physiology*
- ○ *Pharmacology*
- ○ *Microbiology*
- ○ *PBL*

Dr Name: **Dr. Al-Muhtaseb**

SLIDE # 3

Sheet ☐

Slide ■

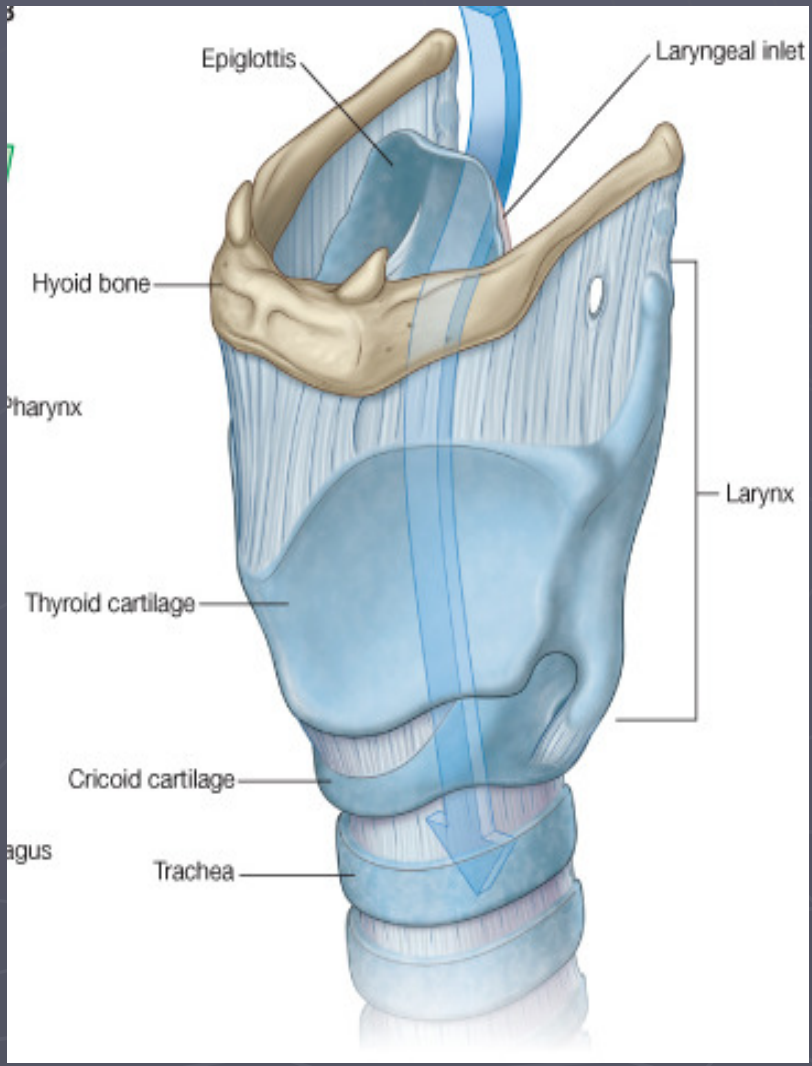
Other ☐

The Larynx

Prof. Dr.Mohammed Hisham Al-Muhtaseb

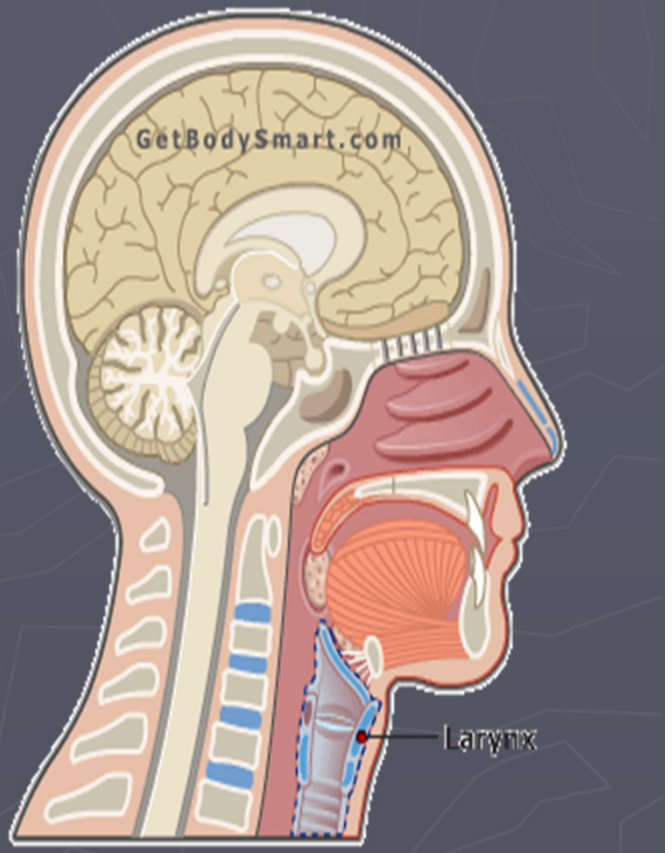
The Larynx

- Extends from the middle of C3 vertebra till the level of the lower border of C6
- Continue as Trachea
- Above it opens into the **laryngo-pharynx**
- Suspended from the hyoid bone above and attached to the trachea below by membranes and ligaments



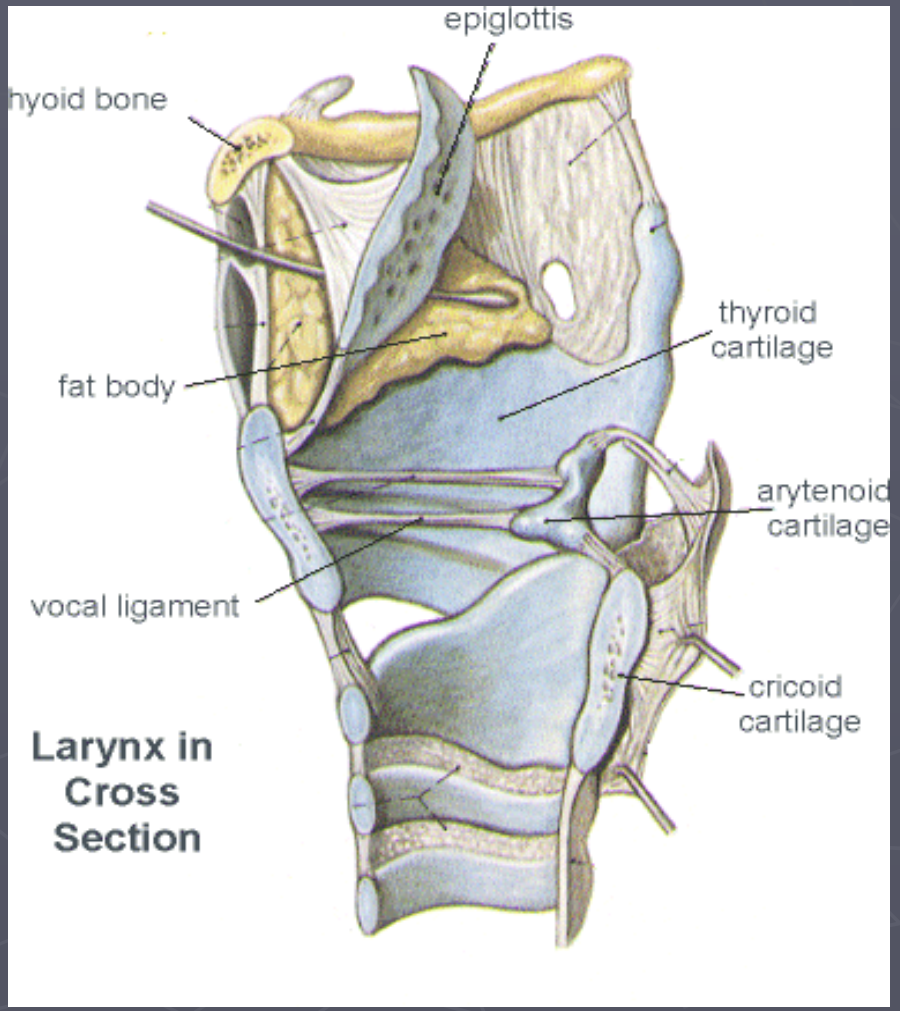
Functions

- 1. acts as an **open valve in respiration**
- 2. Acts as a **closed valve in deglutition**
- 3. Acts as a **partially closed valve in the production of voice**
- 4. During cough it is first closed and then open suddenly to release compressed air



Parts

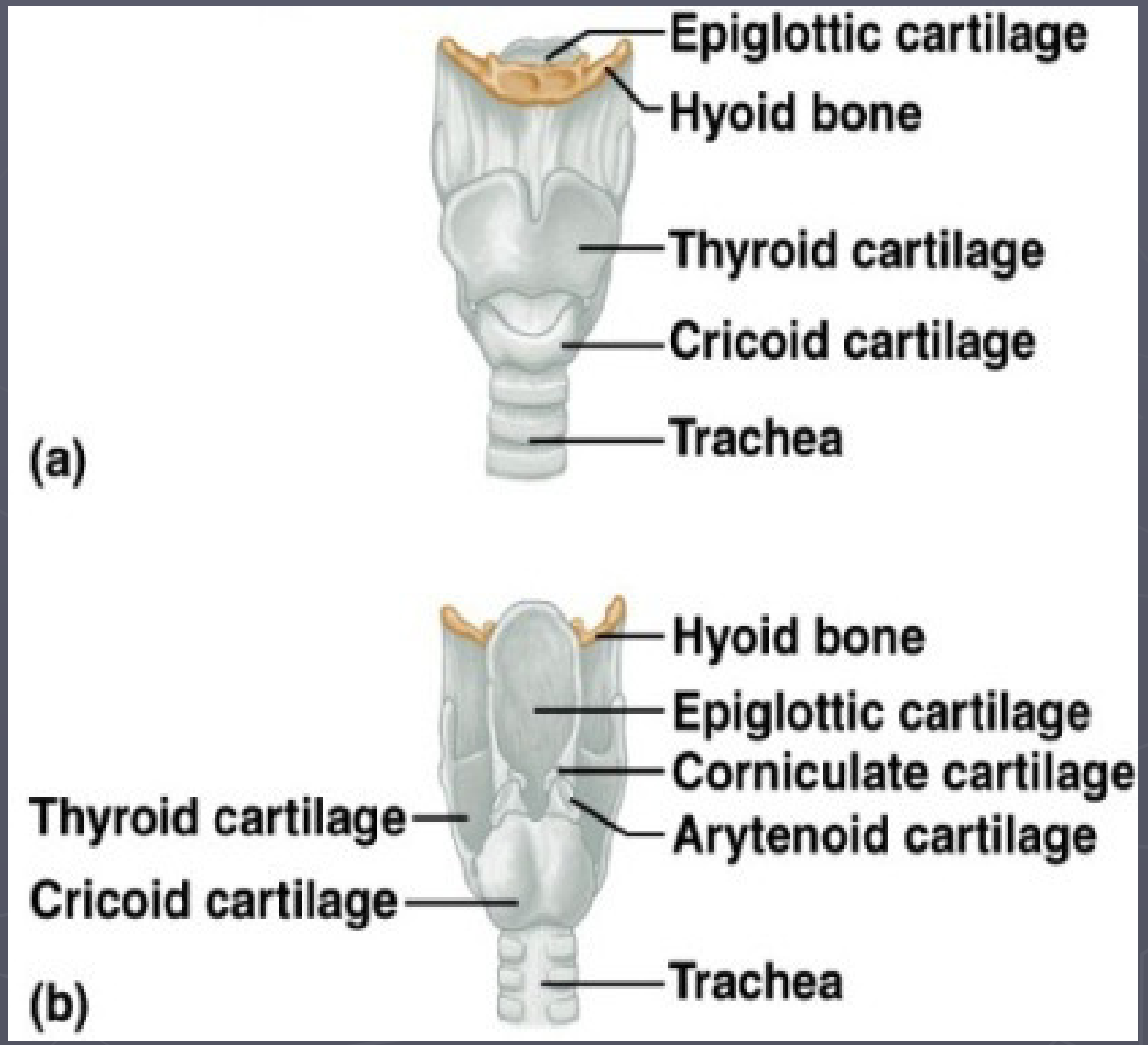
- 1. Cartilage
- 2. Mucosa
- 3. Ligaments
- 4. Muscles



Cartilage

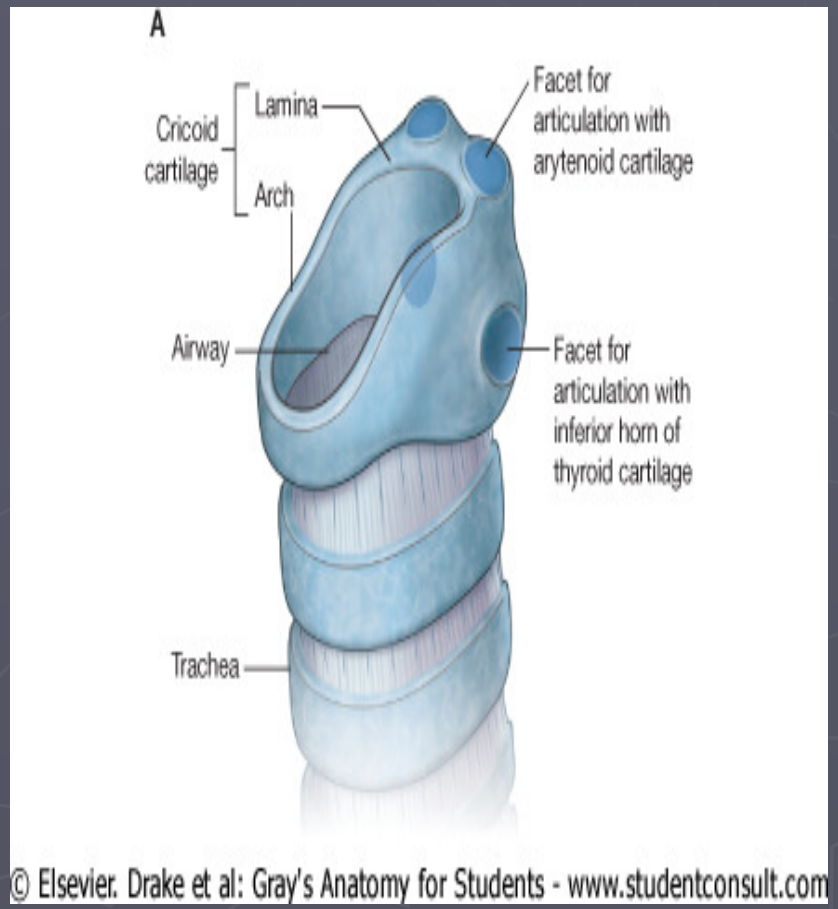
- A. Single :
  Epiglottis
  Cricoid
  Thyroid

B. Pairs:
Arytenoid
Cuneiform
Corniculate



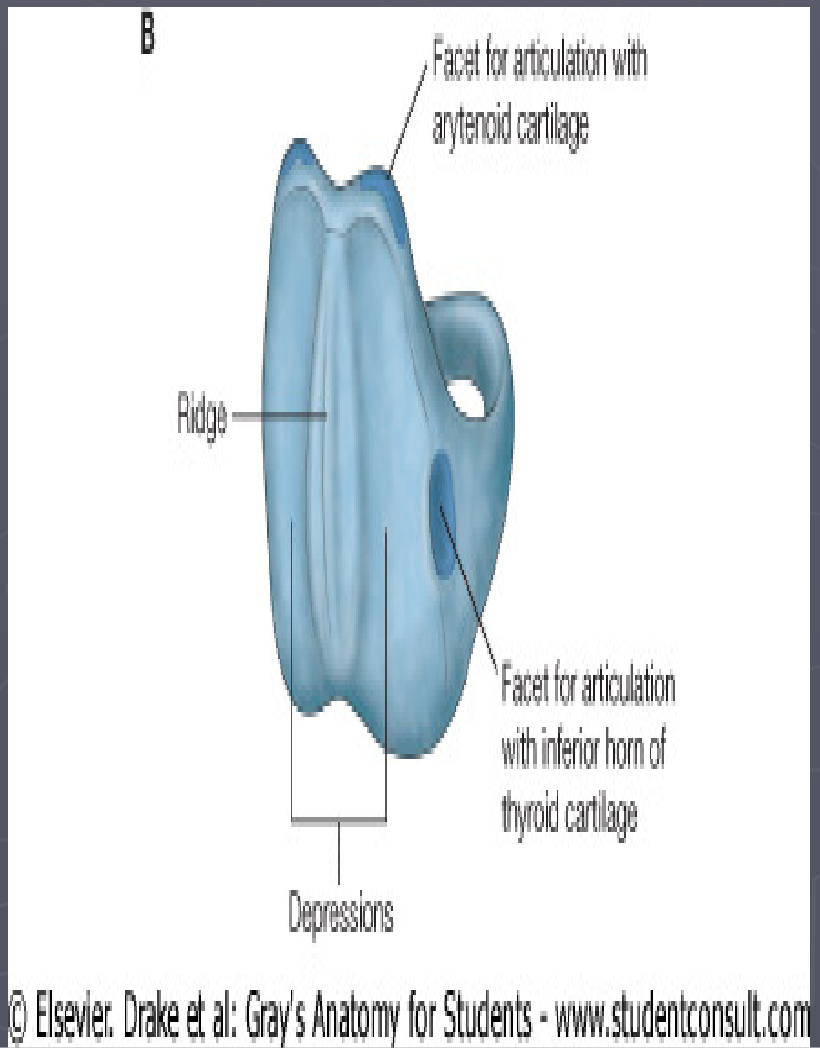
Cricoid cartilage

- The most inferior of the laryngeal cartilages
- Completely encircles the airway
- Shaped like a 'signet ring'
- Broad **lamina of cricoid cartilage** posterior
- Much narrower **arch of cricoid cartilage** circling anteriorly.



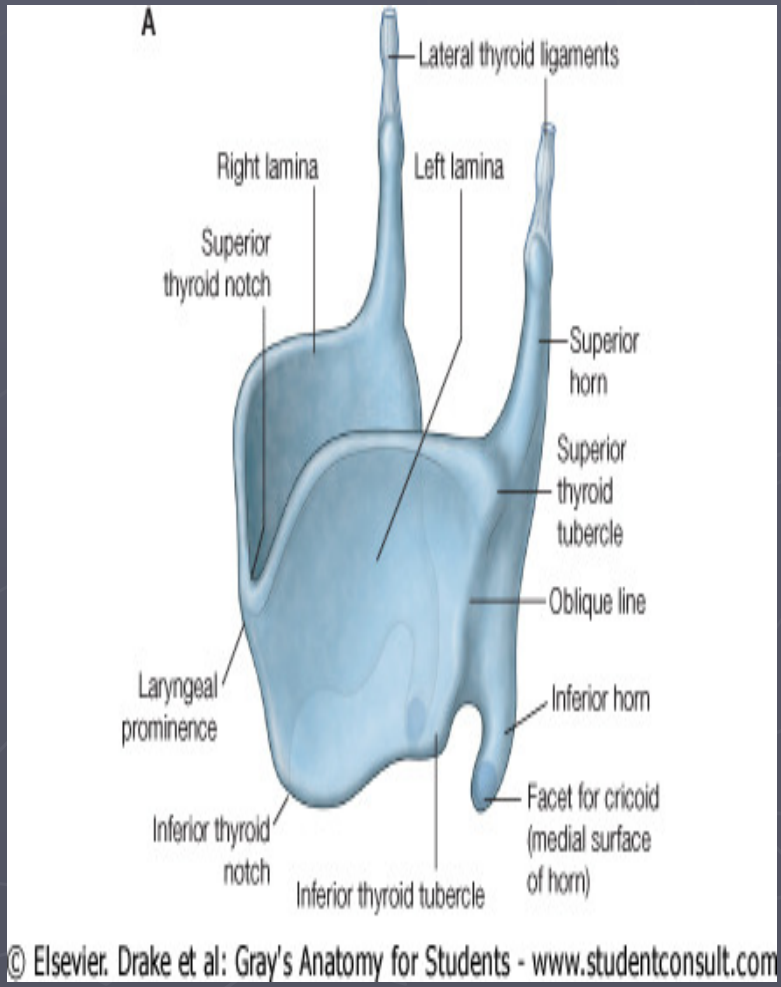
Cricoid cartilage

- Posterior surface of the lamina has two oval depressions separated by a ridge
- The **esophagus** is attached to the ridge
- Depressions are for attachment of the **posterior crico-arytenoid muscles**.
- Has two **articular facets** on each side
- One facet is on the sloping superolateral surface and articulates with the **base of an arytenoid cartilage;**
- The other facet is on the lateral surface near its base and is for articulation with the **inferior horn of the thyroid cartilage**



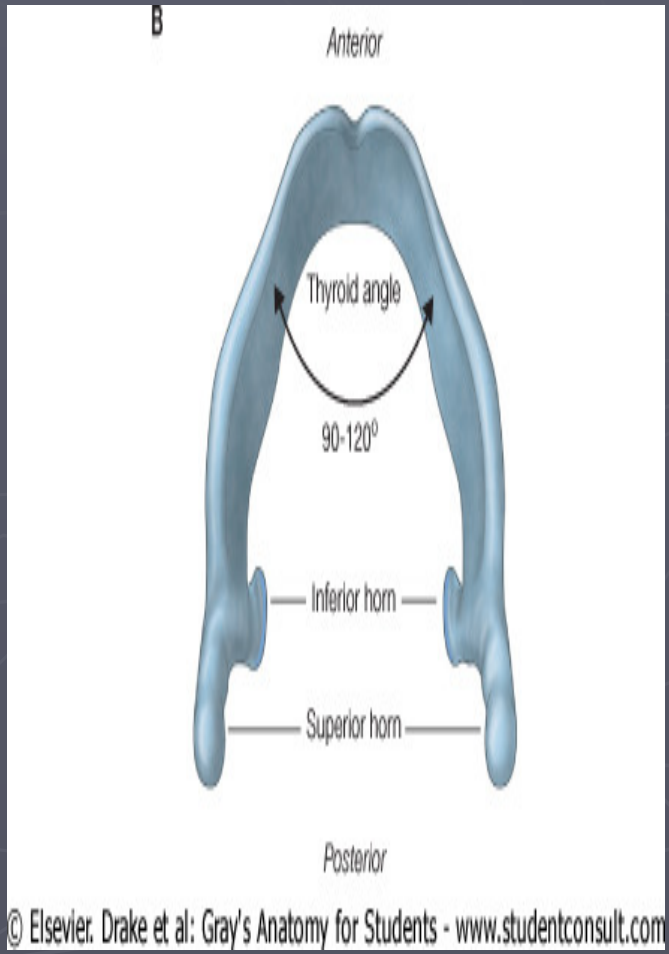
Thyroid cartilage

- The largest of the laryngeal cartilages
- It is formed by a right and a left lamina
- Widely separated **posteriorly**, but converge and join **anteriorly**
- Posterior margin of each lamina is elongated to form a **superior horn** and an **inferior horn**



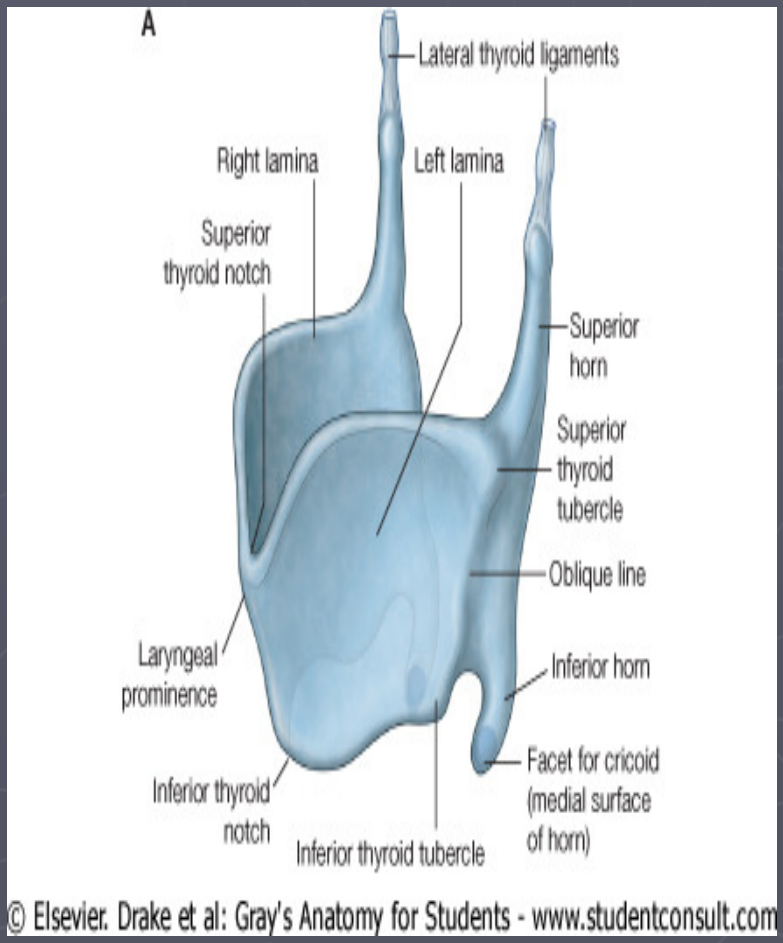
Thyroid cartilage

- Most superior point of the site of fusion between the two laminae is the **laryngeal prominence** (**'Adam's apple**')
- Angle between the two laminae is more acute in men (90°) than in women (120°)
- Superior to the laryngeal prominence, the **superior thyroid notch** separates the two laminae
- Superior thyroid notch and the laryngeal prominence are **palpable** landmarks in the neck
- Less distinct **inferior thyroid notch** in the midline along the base of the thyroid cartilage.



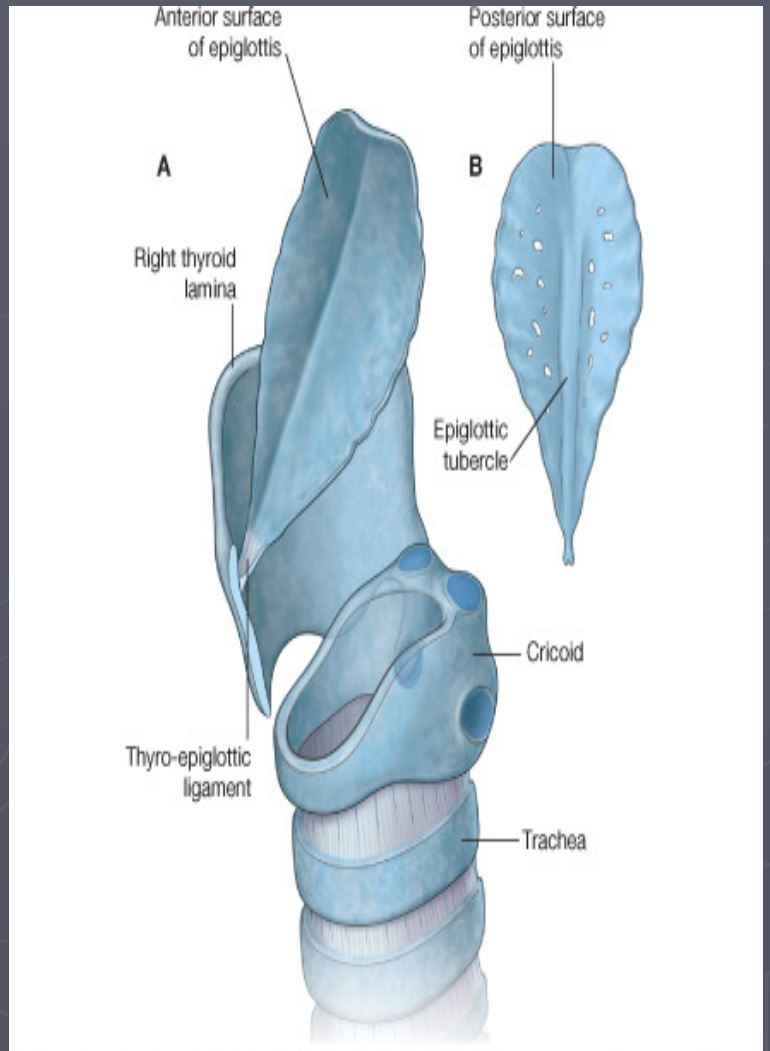
Thyroid cartilage

- The medial surface of the inferior horn has a **facet** for articulation with the **cricoid cartilage;**
- The superior horn is connected by a **ligament** to the posterior end of the greater horn of the **hyoid bone**.
- Lateral surface of lamina is marked by a ridge (the **oblique line**), which curves anteriorly from the base of the superior horn to the inferior margin of the lamina.
- Ends of the oblique line are expanded to form **superior** and **inferior thyroid tubercles**
- The oblique line is a site of attachment for the **extrinsic muscles** of the larynx (sternothyroid, thyrohyoid, and inferior constrictor).



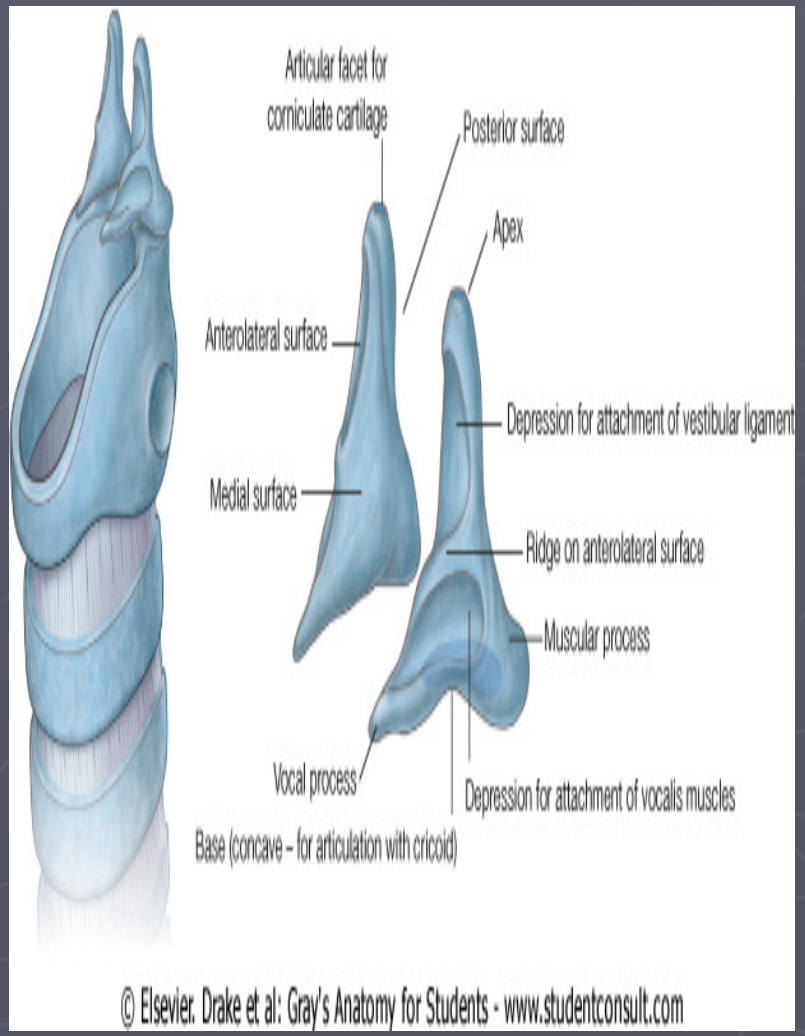
Epiglottis

- Is a 'leaf-shaped' cartilage attached by its stem to the angle of the thyroid cartilage
- Projects posterosuperiorly from its attachment to the thyroid cartilage.
- The attachment is via the **thyro-epiglottic ligament** in the midline between the laryngeal prominence and the inferior thyroid notch
- The upper margin of the epiglottis is behind the pharyngeal part of the tongue.
- The inferior half of the posterior surface of the epiglottis is raised slightly to form an **epiglottic tubercle.**



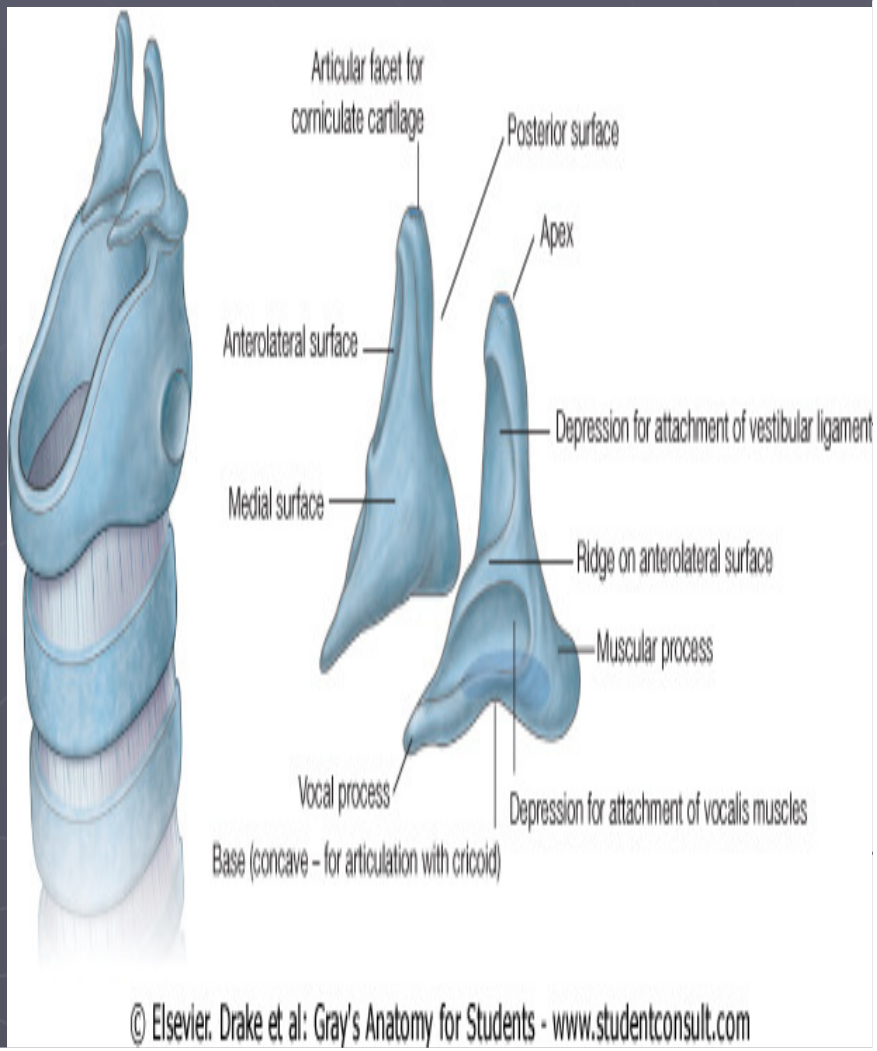
Arytenoid cartilages

- Two arytenoid cartilages are pyramid-shaped cartilages with three surfaces
- **Base of arytenoid cartilage** and an **Apex of arytenoid cartilage**
- The **base** of arytenoid cartilage is concave and articulates with the facet on the superolateral surface of the **cricoid cartilage**;
- The **apex** of arytenoid cartilage articulates with a **corniculate cartilage**;
- The **medial surface** of each cartilage faces the other;



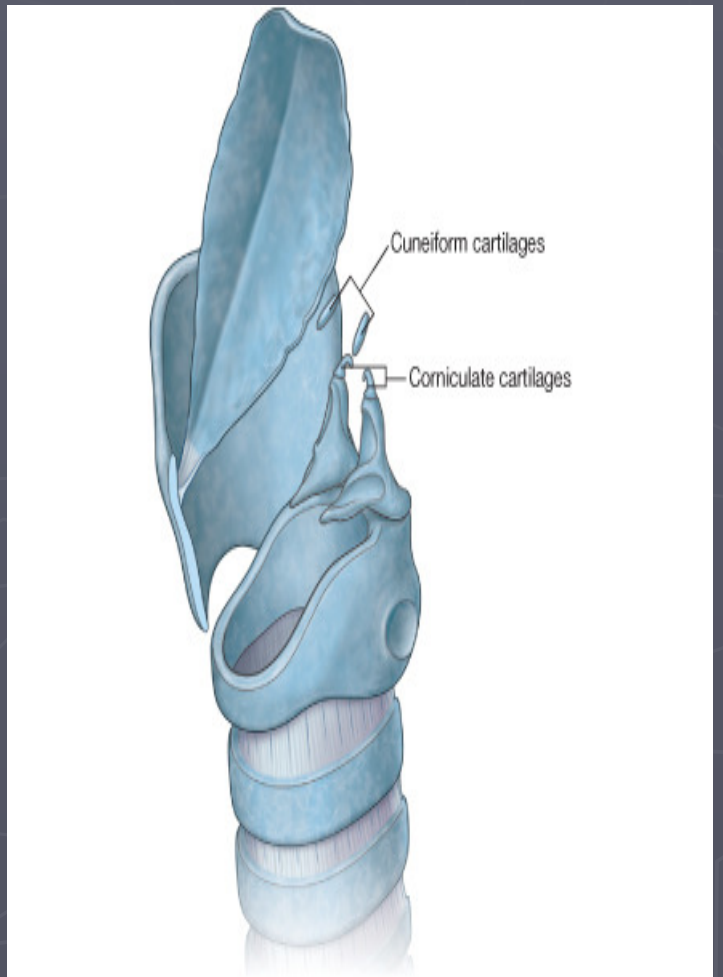
Arytenoid cartilages

- The **anterolateral surface** has two depressions, separated by a ridge, for **muscle (vocalis)** and **ligament (vestibular ligament)** attachment.
- The anterior angle of the base of arytenoid cartilage is elongated into a **vocal process** to which the **vocal ligament** is attached
- The lateral angle is similarly elongated into a **muscular process** for attachment of the posterior and lateral crico-arytenoid muscles.



Corniculate and Cuneiform

- The **corniculate** cartilages are two small conical cartilages
- Bases articulate with the apices of the arytenoid cartilages
- Their apices project posteromedially towards each other.
- The **Cuneiform** are two small club-shaped cartilages
- Lie anterior to the corniculate cartilages
- Suspended in the part of the fibroelastic membrane that attaches the arytenoid the epiglottis.



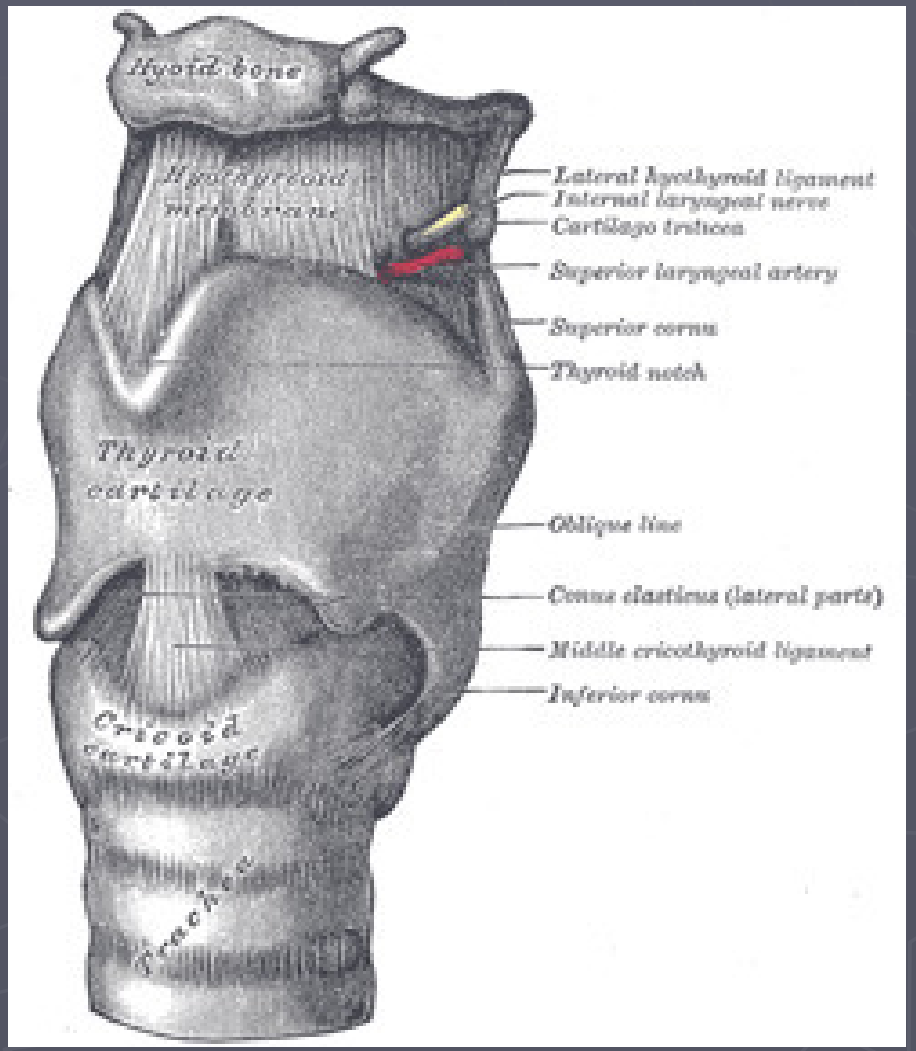
Ligaments

Extrinsic ligaments

- **Thyrohyoid membrane**
- **Hyo-epiglottic ligament**
- **Cricotracheal ligament**

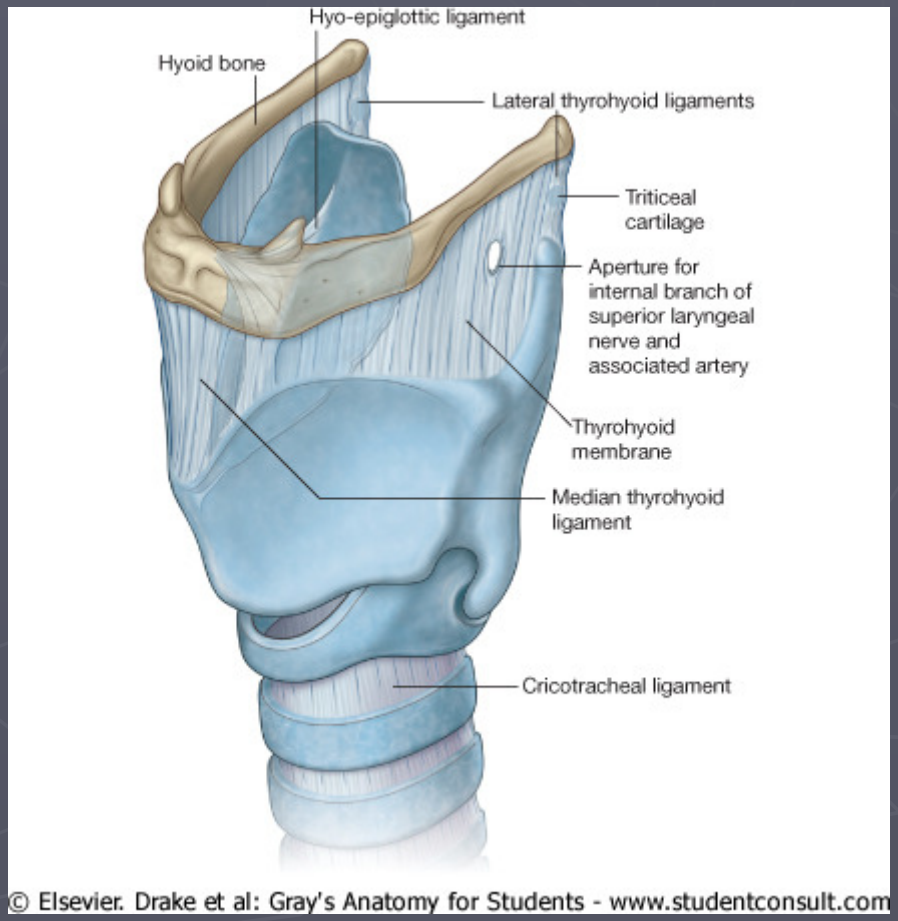
Thyrohyoid membrane

- Tough fibroelastic ligament that spans between the superior margin of the thyroid cartilage below and the hyoid bone
- Attached to the thyroid laminae and adjacent anterior margins of the superior horns
- Ascends medial to the greater horns and posterior to the body of the hyoid bone to attach to the superior margins of these structures.
- An **aperture** in the lateral part of the thyrohyoid membrane on each side is for the **superior laryngeal arteries, nerves, and lymphatics**



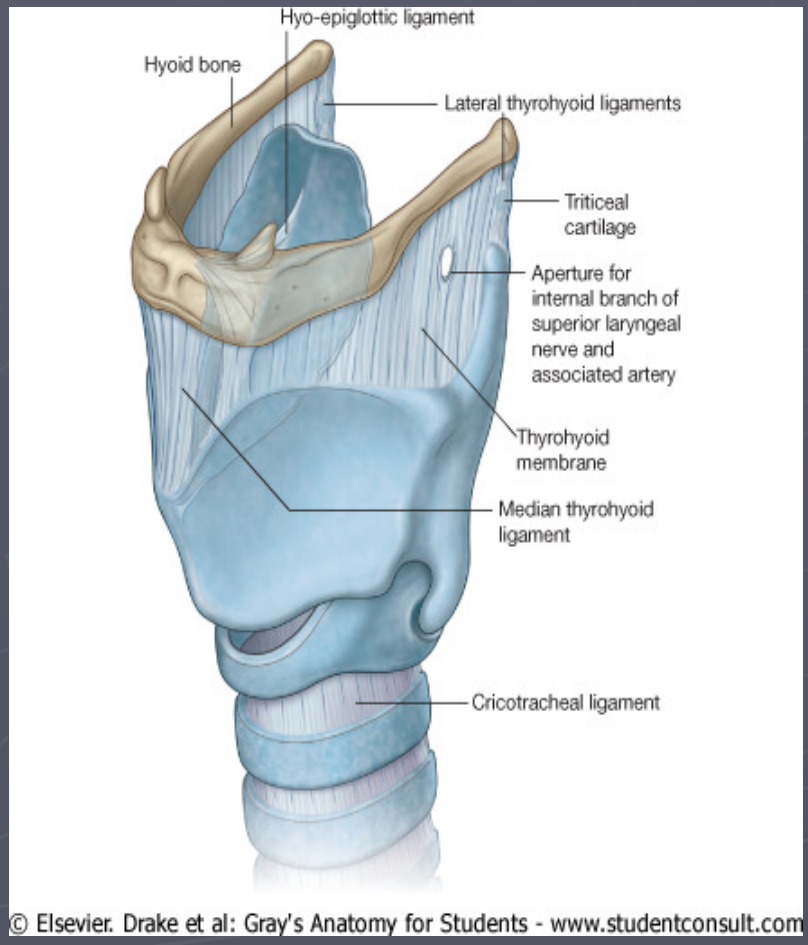
Thyrohyoid membrane

- The posterior borders of the thyrohyoid membrane are thickened to form the **lateral thyrohyoid ligaments**.
- Also thickened anteriorly in the midline to form the **median thyrohyoid ligament**.
- Occasionally, there is a small cartilage (**triticeal cartilage**) in each lateral thyrohyoid ligament.



Extrinsic ligaments

- **Cricotracheal ligament** runs from the lower border of the cricoid cartilage to the adjacent upper border of the first tracheal cartilage.
- **The hyo-epiglottic ligament** extends from the midline of the epiglottis, anterosuperiorly to the body of the hyoid bone.



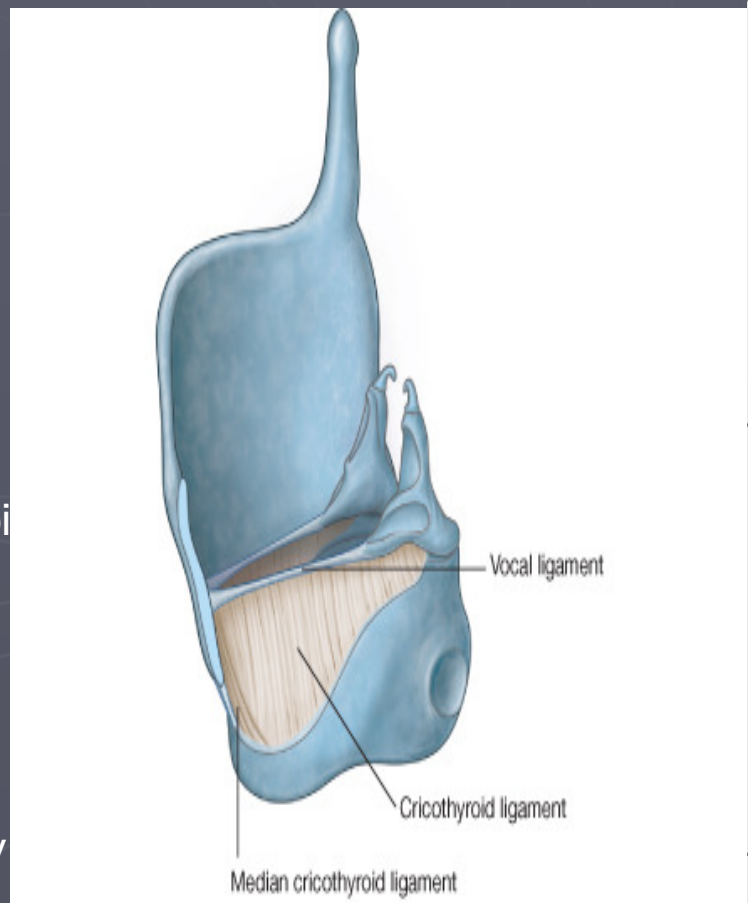
Intrinsic ligaments

- The fibro-elastic membrane of larynx links together the cartilages and completes the architectural framework of the laryngeal cavity

- It is composed of two parts-a lower **cricothyroid ligament** and an upper **quadrangular membrane.**

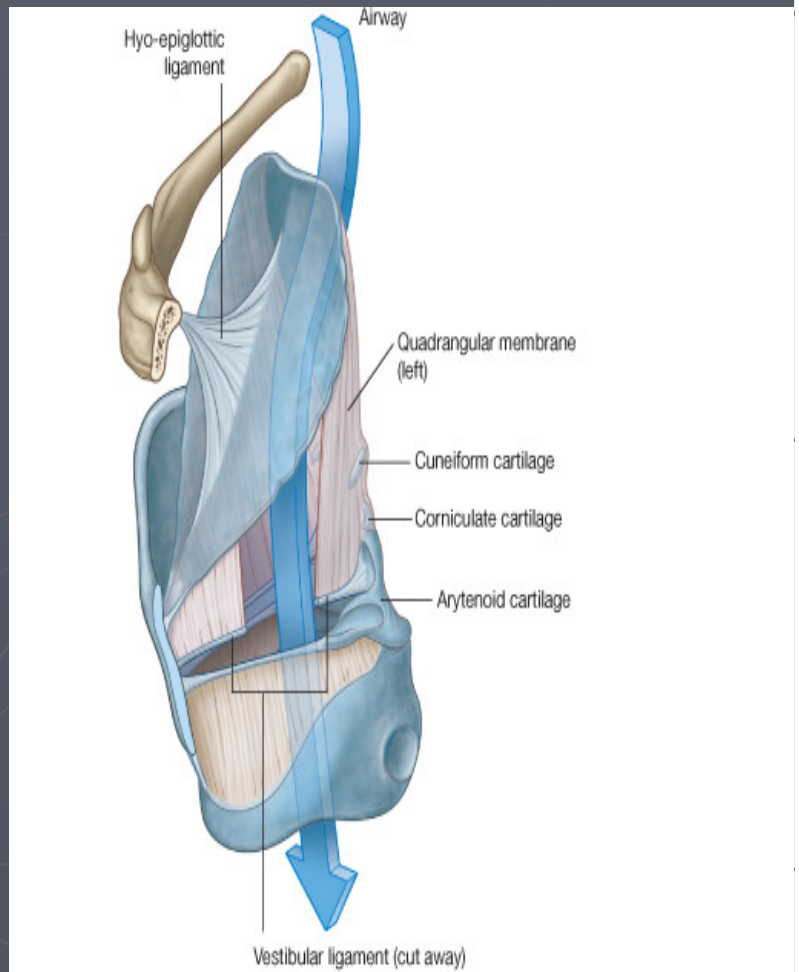
Cricothyroid ligament

- **Cricovocal membrane or cricothyroid membrane**
- Attached to the arch of cricoid cartilage and extends superiorly
- End in a **free upper margin** within the space enclosed by the thyroid cartilage
- Upper free margin attaches:
- **Anteriorly** to the **thyroid cartilage;**
- **Posteriorly** to the **vocal processes** of the arytenoi cartilages.
- The free margin is thickened to form the **vocal ligament**, which is under the **vocal fold** (**true** '**vocal cord**') of the larynx.
- The cricothyroid ligament is also thickened anteriorly to form a **median cricothyroid ligament**
- *In emergency situations, the median cricothyroid ligament can be perforated to establish an airway*



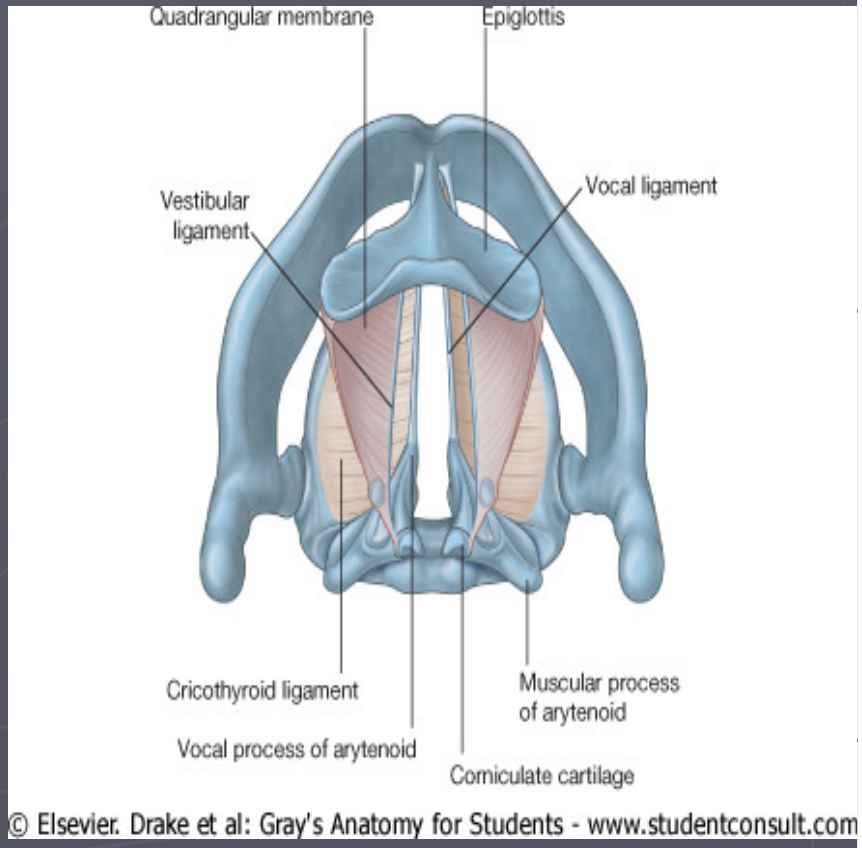
Quadrangular membrane

- Runs between the lateral margin of the epiglottis and the anterolateral surface of the arytenoid cartilage
- Attached to the corniculate cartilage
- Free upper margin and a free lower margin
- **Free lower margin** is thickened to form the **vestibular ligament** under the **vestibular fold** (**false 'vocal cord'**)

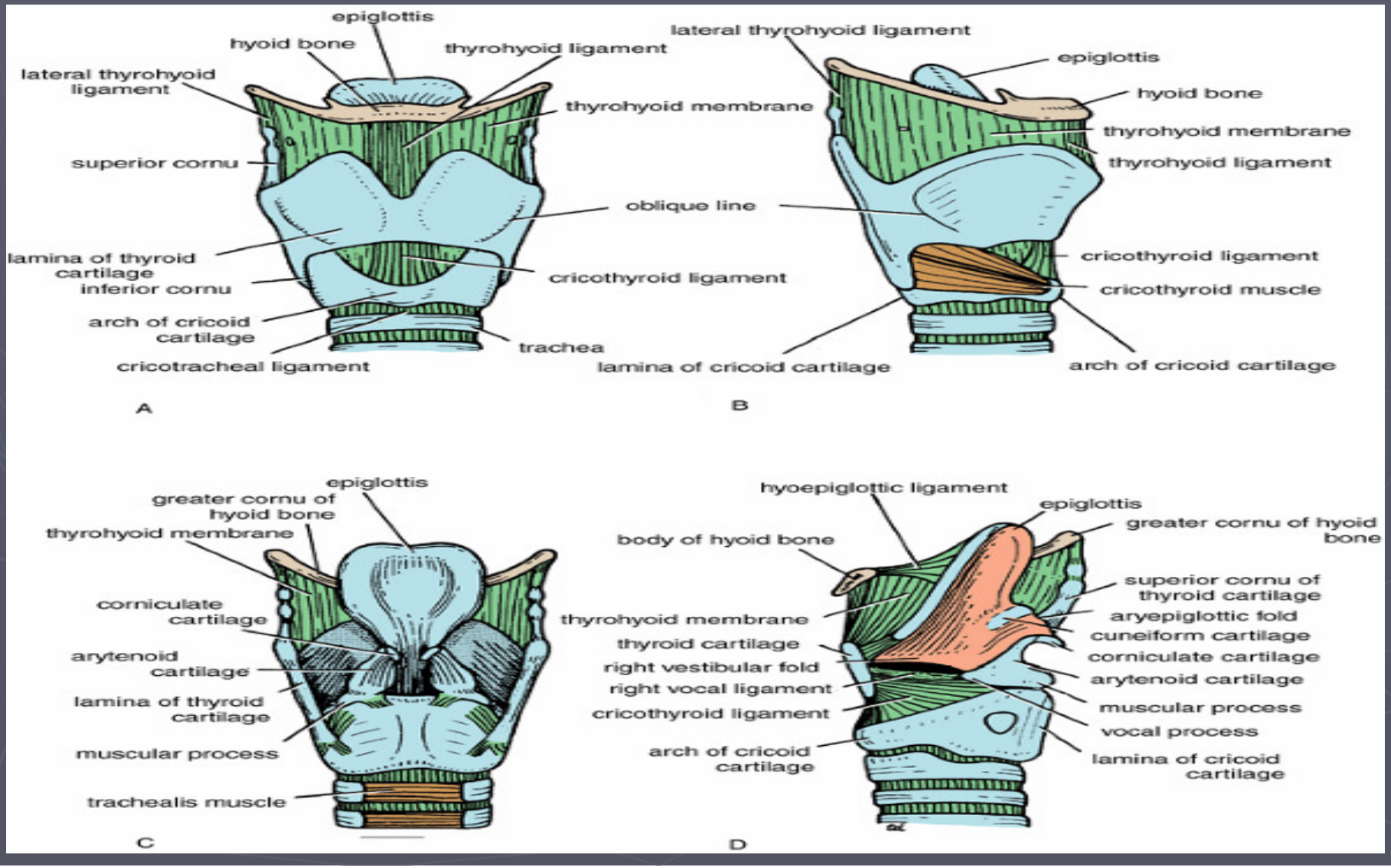


Quadrangular membrane

- Vestibular ligament is separated from the vocal ligament below by a gap
- When viewed from above the vestibular ligament is **lateral** to the vocal ligament



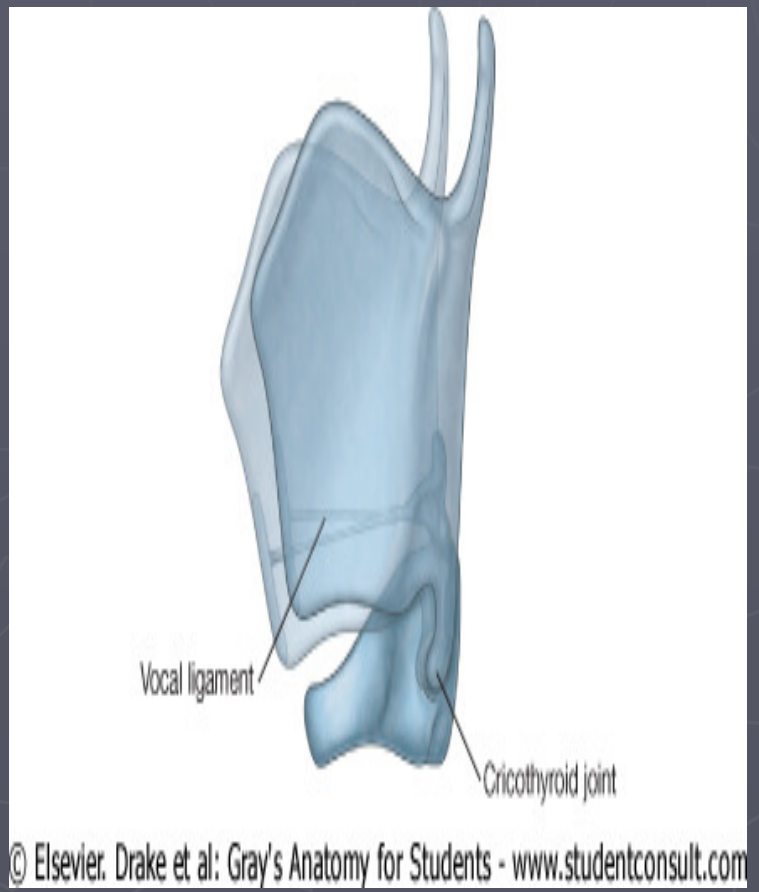
Cartilage and Ligaments



Laryngeal joints

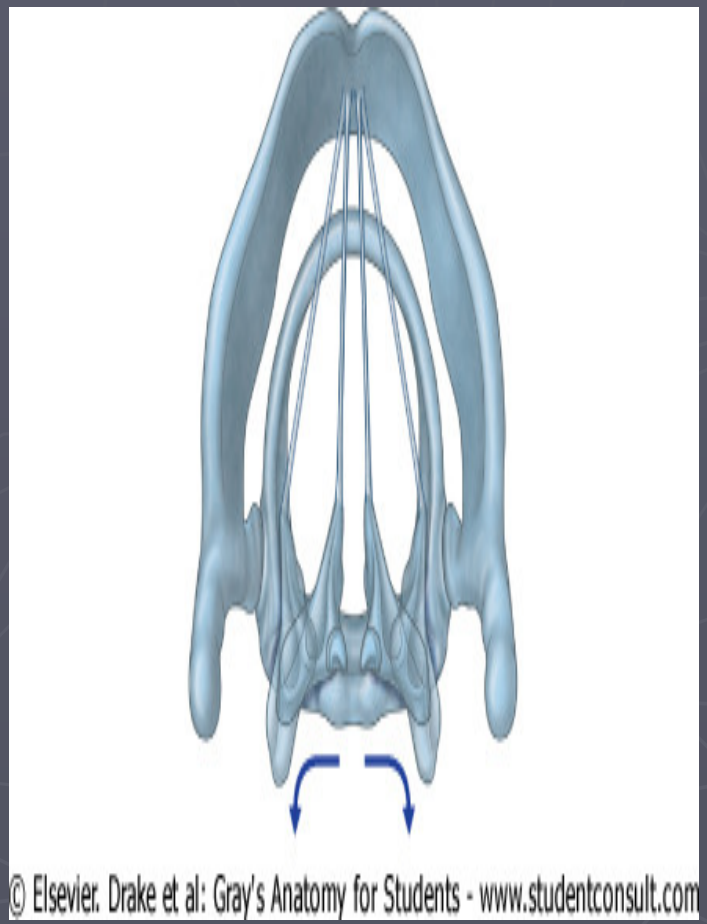
Cricothyroid joints

- Between the inferior horns of the thyroid cartilage and the cricoid cartilage, are **synovial**
- Surrounded by a capsule and is reinforced by associated ligaments
- Enable the thyroid cartilage to move **forward and tilt downwards** on the cricoid cartilage
- Forward movement and downward rotation of the thyroid cartilage effectively **lengthens and puts tension on the vocal ligaments**



Crico-arytenoid joints

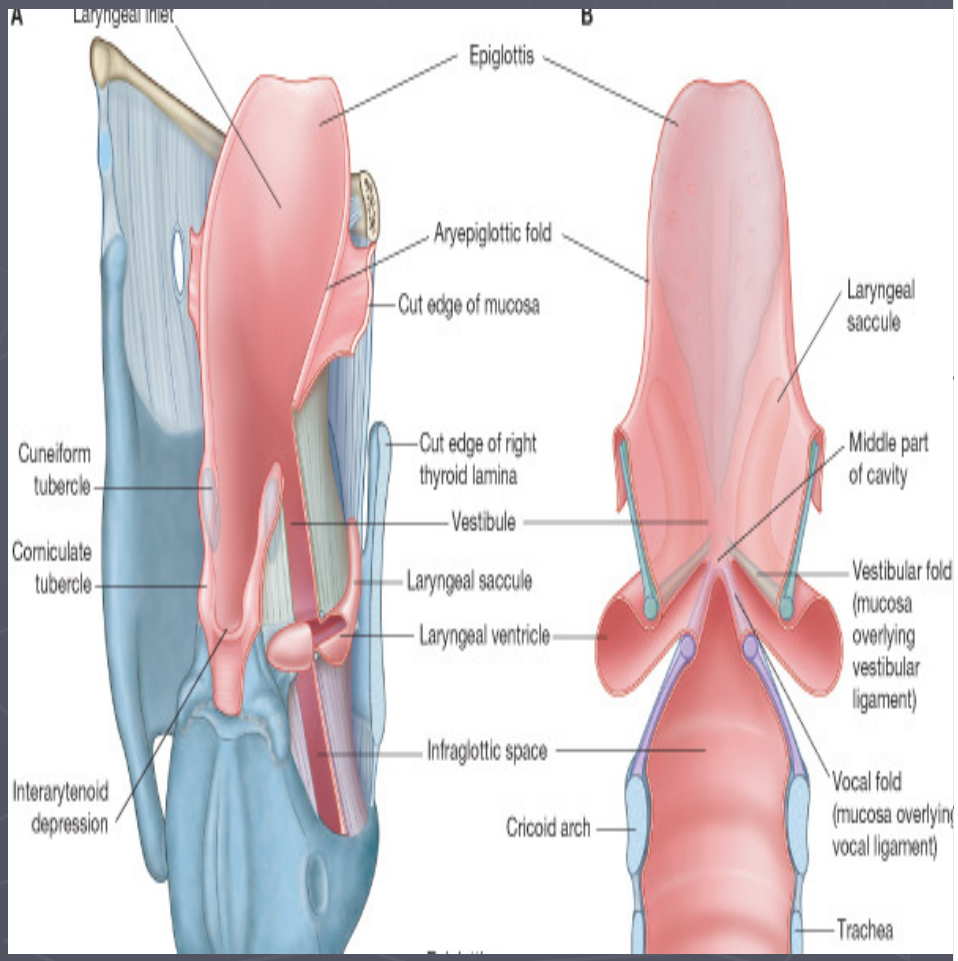
- Between articular facets on the superolateral surfaces of the cricoid cartilage and the bases of the arytenoid cartilages
- Enable the arytenoid cartilages to **slide away or towards each other and to rotate**
- The vocal processes **pivot either towards or away from the midline.**
- These movements **abduct and adduct the vocal ligaments**



Cavity of the larynx

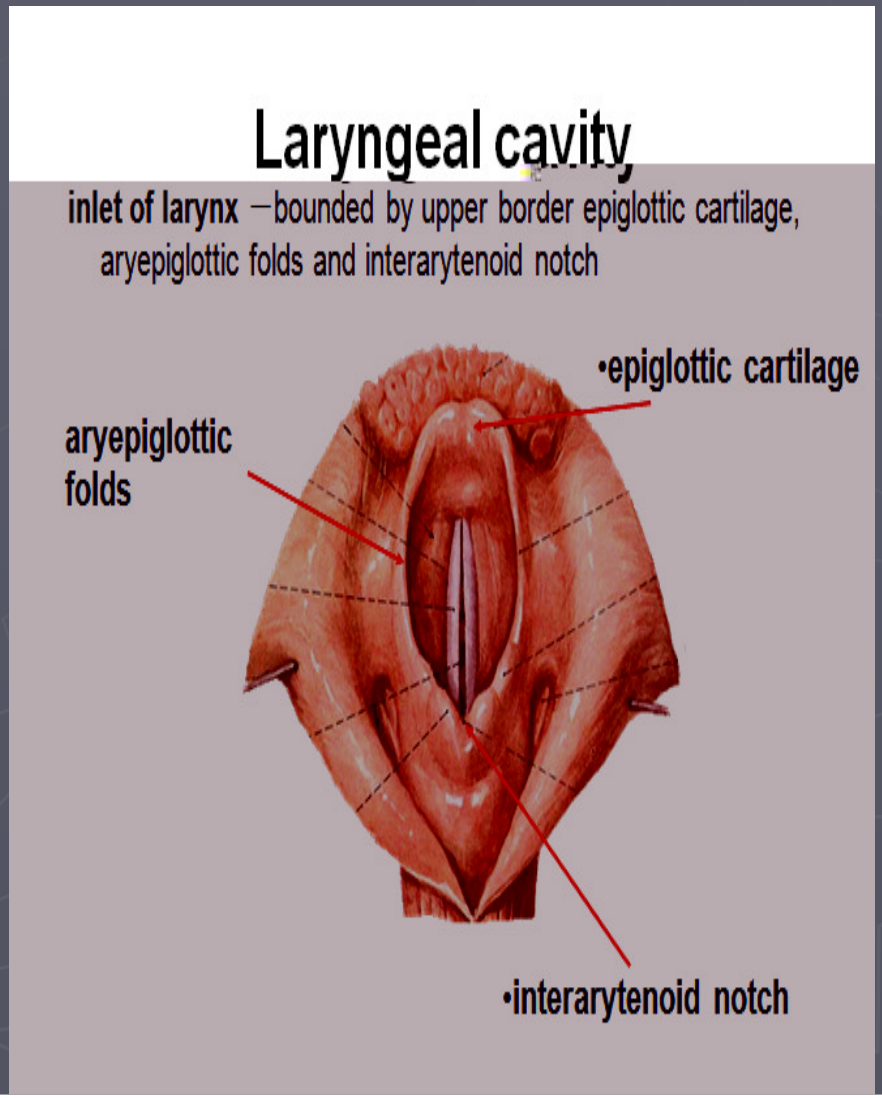
Laryngeal cavity

- The central cavity of the larynx is tubular in shape and is lined by mucosa
- Support is provided by the fibro-elastic membrane of larynx and by the cartilages to which it is attached.
- The superior aperture of the cavity **(laryngeal inlet)** opens into the anterior aspect of the pharynx just below and posterior to the tongue
- laryngeal inlet is **oblique** and points posterosuperiorly

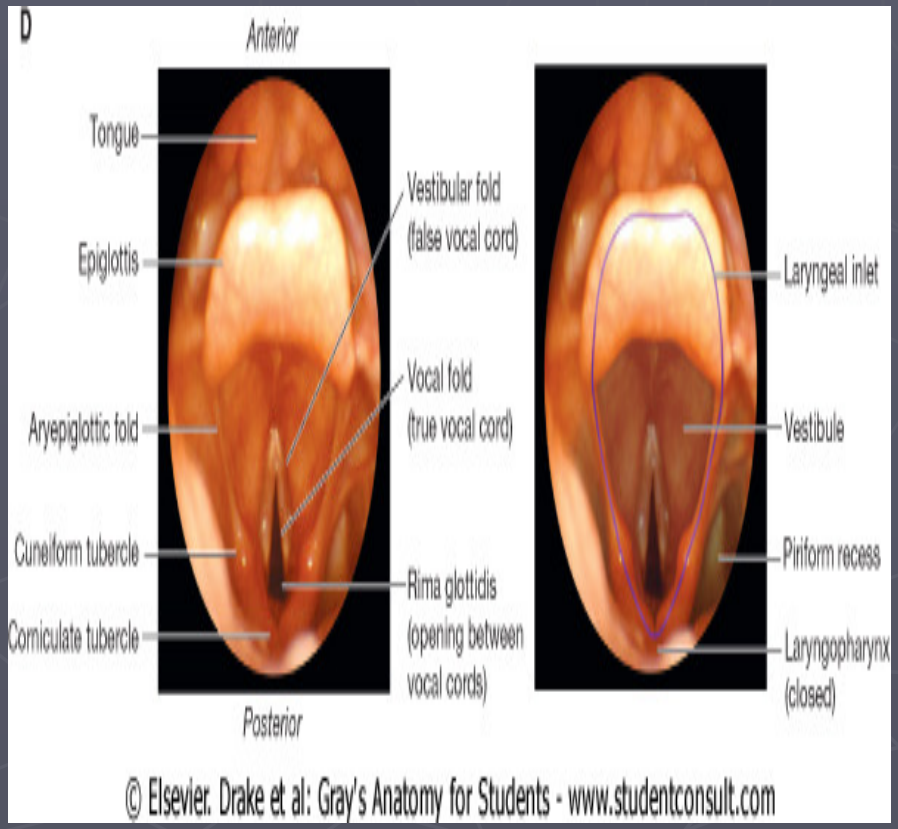


laryngeal inlet

- Anterior border is formed by mucosa covering the superior margin of the **epiglottis**
- Lateral borders are formed by mucosal folds (**aryepiglottic folds**),
- Posterior border in the midline is formed by a mucosal fold that forms a depression (**interarytenoid notch**) between the two corniculate tubercles

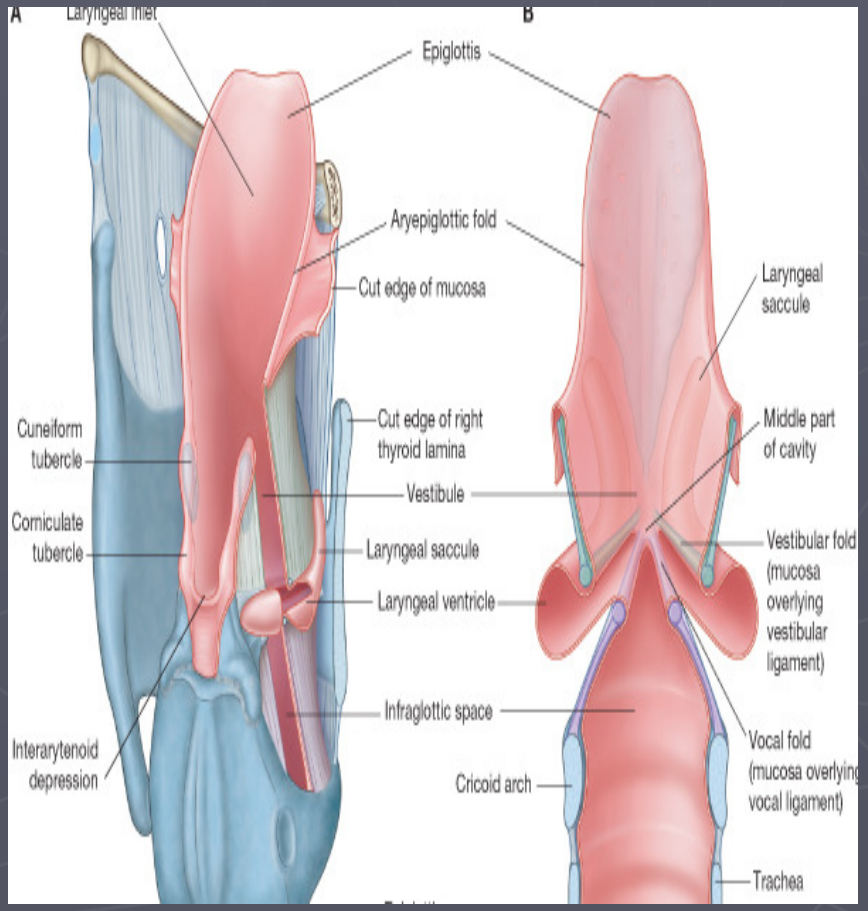


- **Aryepiglottic folds**
- Enclose the superior margins of the quadrangular membranes and adjacent soft tissues
- Two tubercles on the more posterolateral margin side mark the positions of the underlying **cuneiform and corniculate** cartilages;



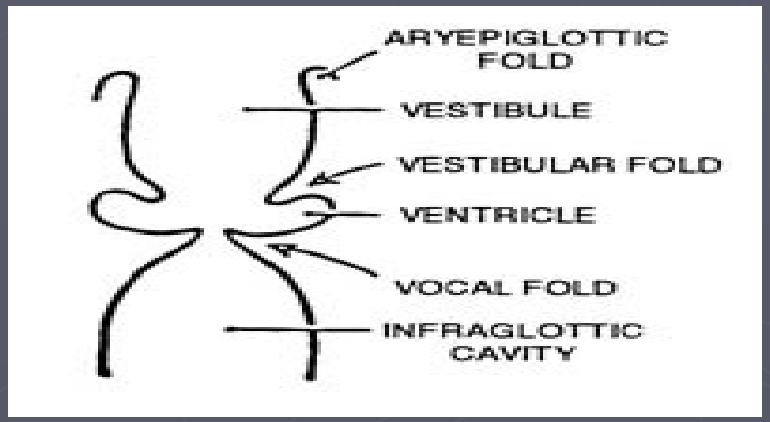
Inferior opening

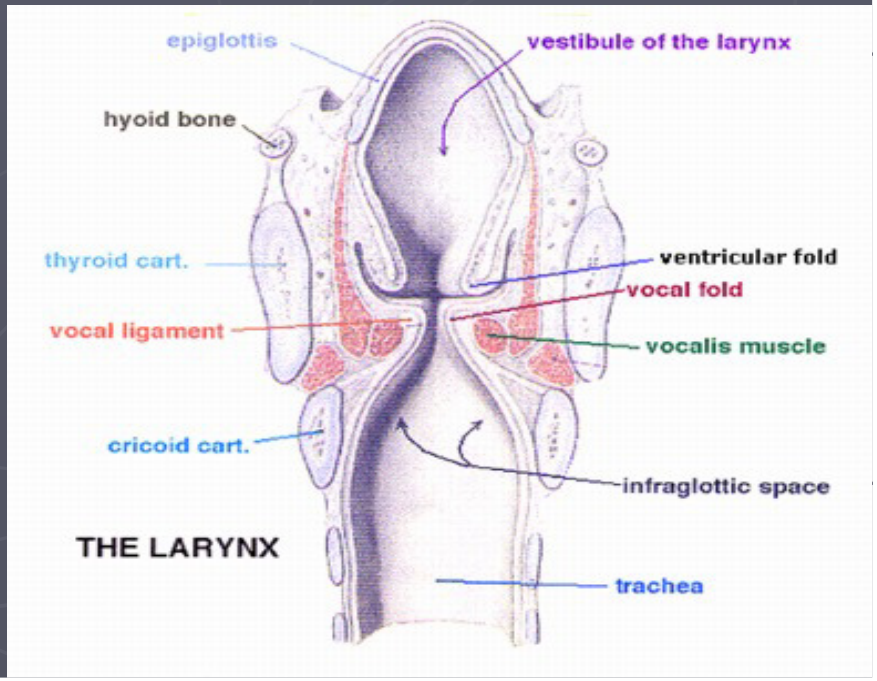
- Inferior opening of the laryngeal cavity is continuous with the lumen of the trachea
- Completely encircled by the cricoid cartilage
- Horizontal in position unlike the laryngeal inlet
- The inferior opening is continuously open whereas the laryngeal inlet can be closed by downward movement of the epiglottis



Division into three major regions

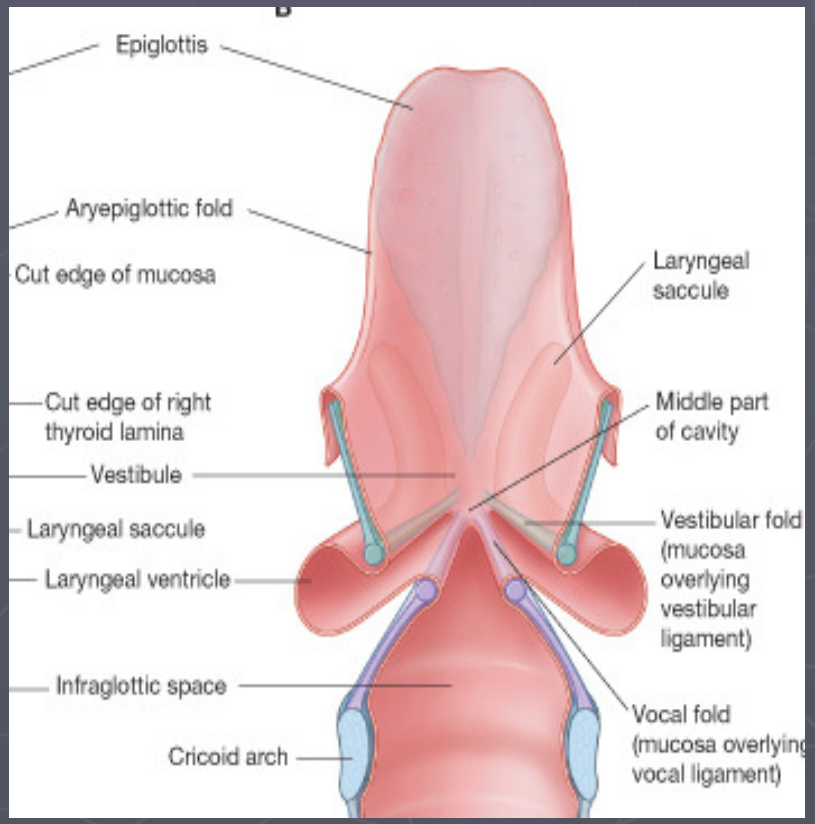
- The **vestibular and vocal folds**, divide it into three major regions**-the vestibule,** a **middle chamber,** and the **infraglottic cavity**
- The **vestibule** is the upper chamber of the laryngeal cavity between the laryngeal inlet and the vestibular folds
- *Vestibular folds enclose the vestibular ligaments and associated soft tissues;*





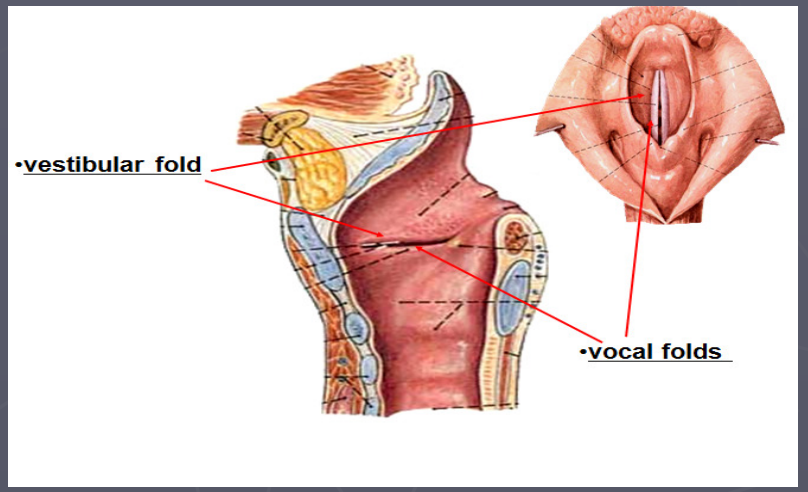
Division into three major regions

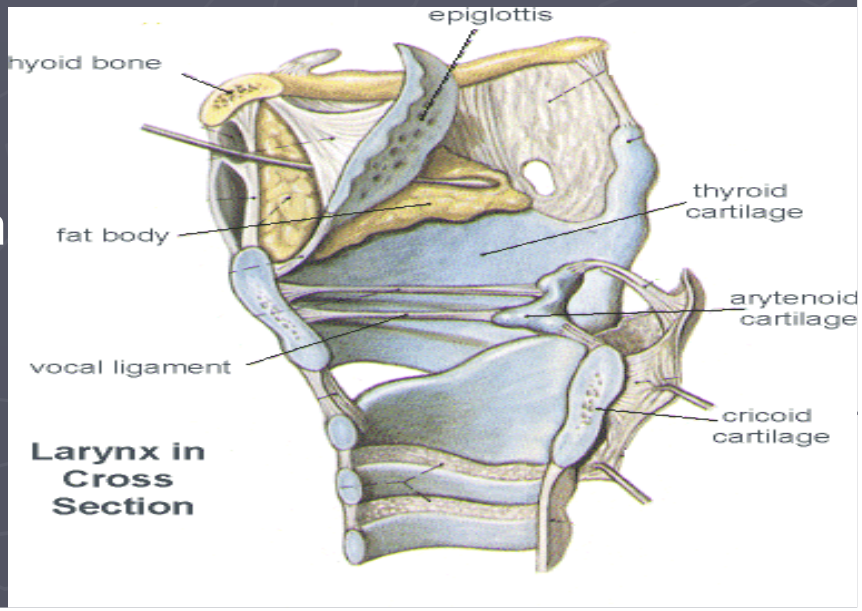
- The **middle part** of the laryngeal cavity is very thin and is between the vestibular folds above and the vocal folds below
- *Vocal folds enclose the vocal ligaments and related soft tissues below.*
- The **infraglottic space** is the most inferior chamber and is between the vocal folds and the inferior opening of the larynx;



Vocal Folds

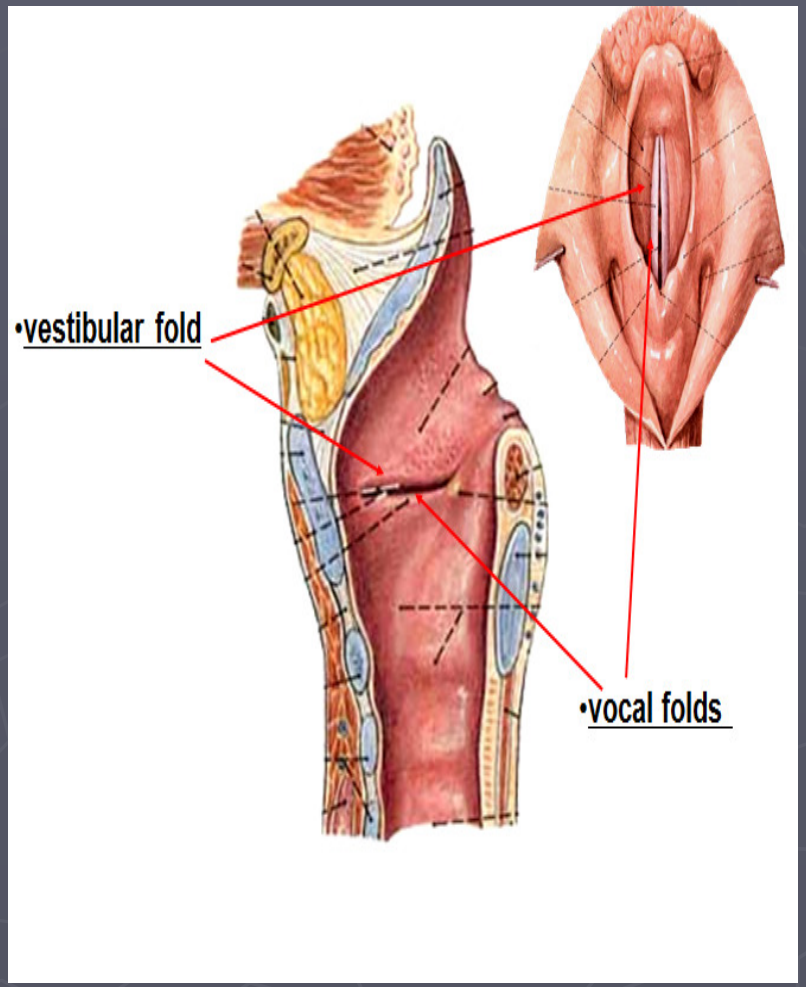
- Consist of :
- Vocal ligament
- Mucous membrane (stratified squamous)
- Vocalis muscle
- No submucosa
- No blood vessels (white in color)
- On each side extend between the voca process of the arytenoid and the back of the anterior lamina of thyroid.
- Longer in male which cause the difference of the pitch of the voice between genders





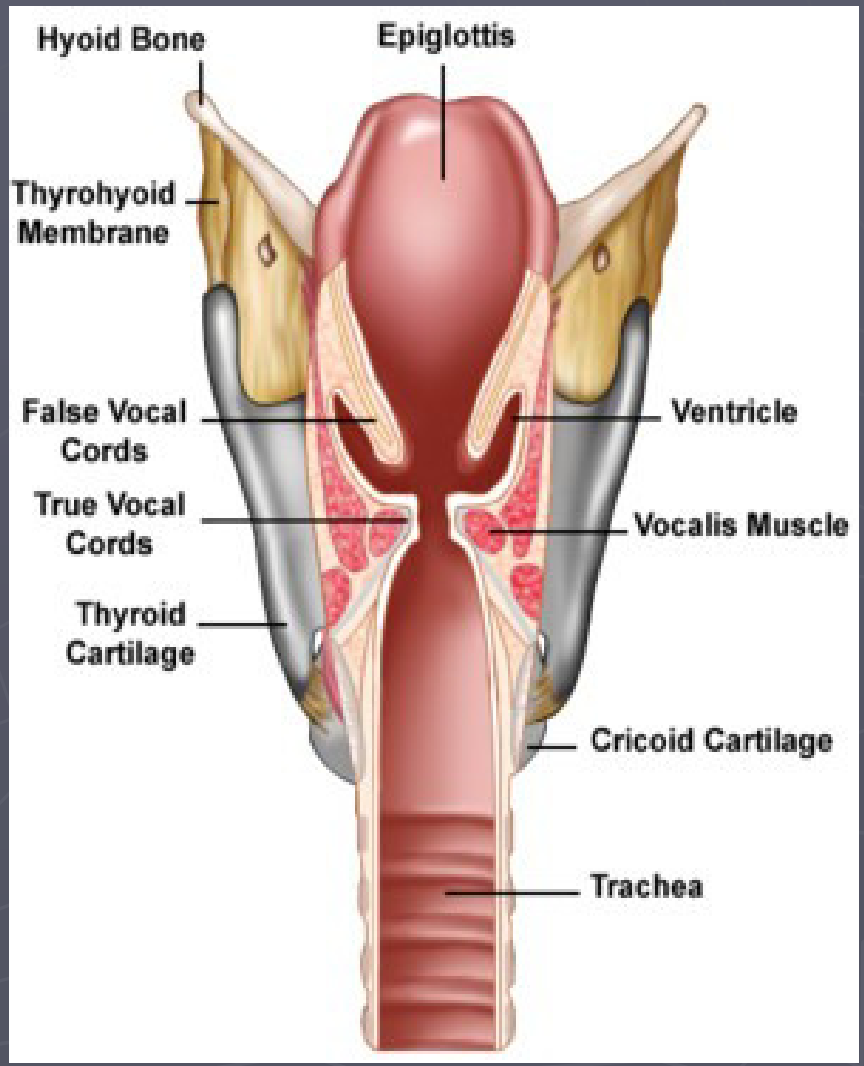
Vestibular folds

- False vocal cords
- *Vestibular folds enclose the vestibular ligaments and associated soft tissues*
- *Vascularised (red in color)*
- *Fixed and not movable unlike the vocal cord*
- *Superior to the vocal cord*



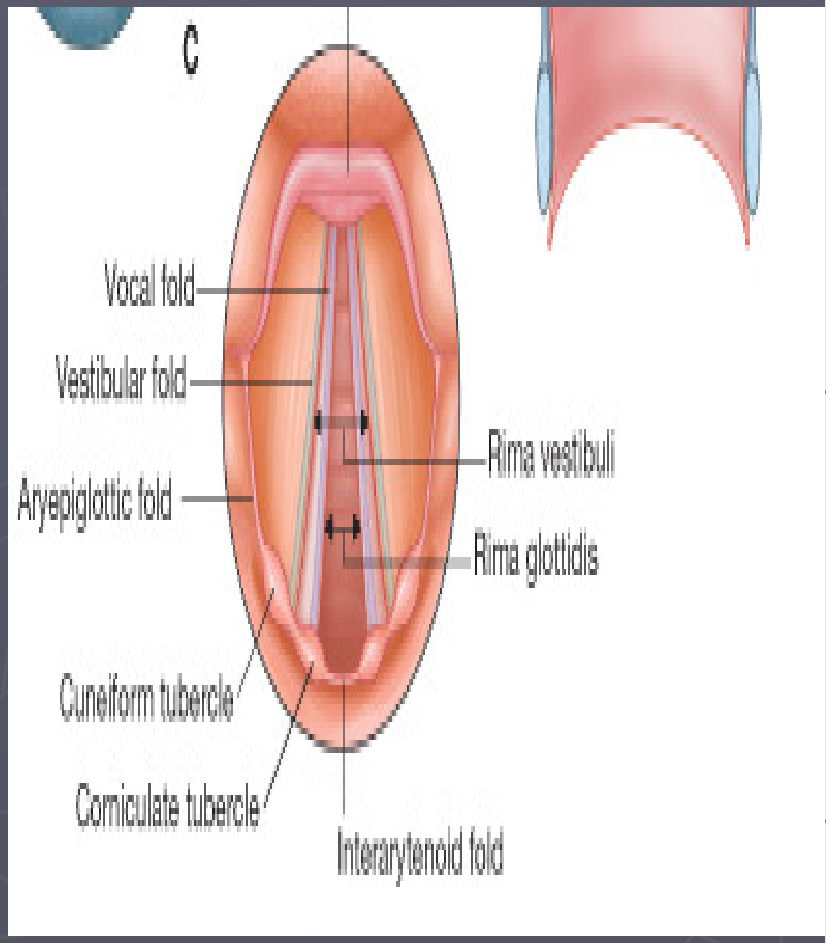
Laryngeal ventricles and saccules

- On each side, the mucosa of the middle cavity bulges laterally through the gap between the vestibular and vocal ligaments to produce a **laryngeal ventricle**
- Tubular extension of each ventricle (laryngeal saccule) projects anterosuperiorly between the vestibular fold and thyroid cartilage
- Within the walls of these laryngeal saccules are numerous mucous glands.
- **Mucus** secreted into the saccules **lubricates the vocal folds**.



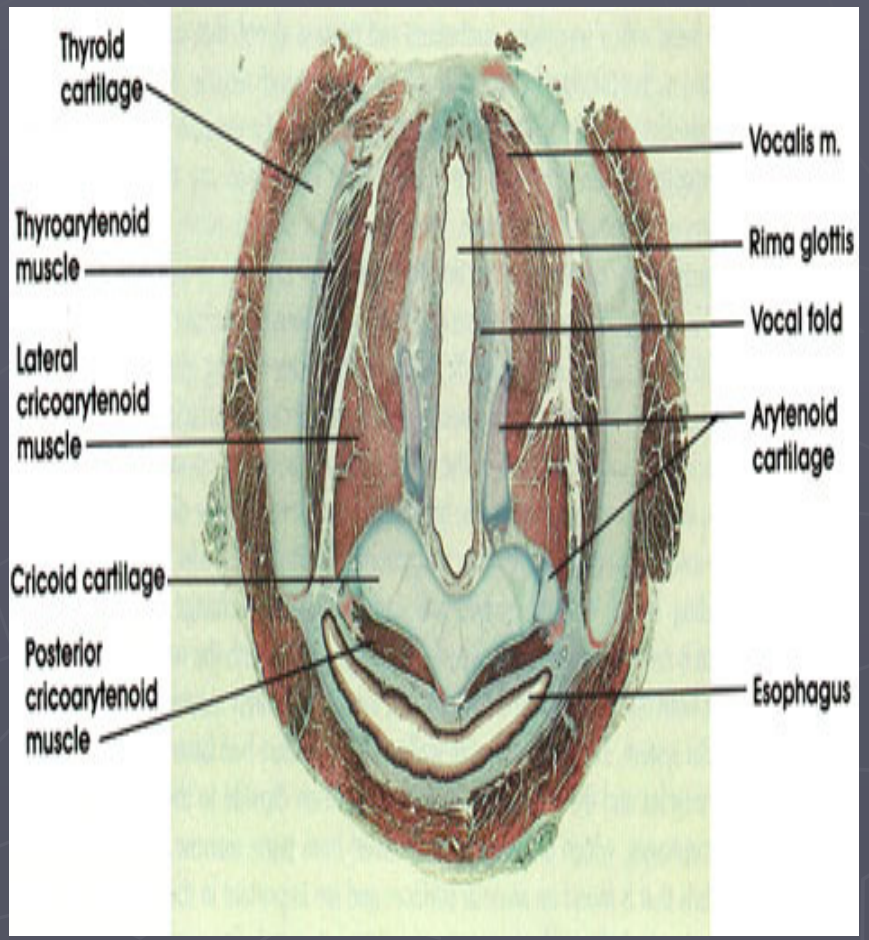
Rima vestibuli and rima glottidis

- **Rima vestibuli** is a triangular-shaped opening between the two adjacent **vestibular folds** at the entrance to the middle chamber
- Apex of the opening is anterior and its base is posterior
- The **Rima glottidis** is formed by the **vocal folds (true vocal cords)** and adjacent mucosa-covered parts of the arytenoid cartilages



Rima vestibuli and rima glottidis

- **Rima glottidis** opening separates the middle chamber above from the infraglottic cavity
- The base of it is formed by the fold of mucosa (interarytenoid fold) at the bottom of the interarytenoid notch
- Rima glottis is the narrowest part of the laryngeal cavity
- Both the rima glottidis and the rima vestibuli can be opened and closed by movement of the arytenoid cartilages and associated membranes.



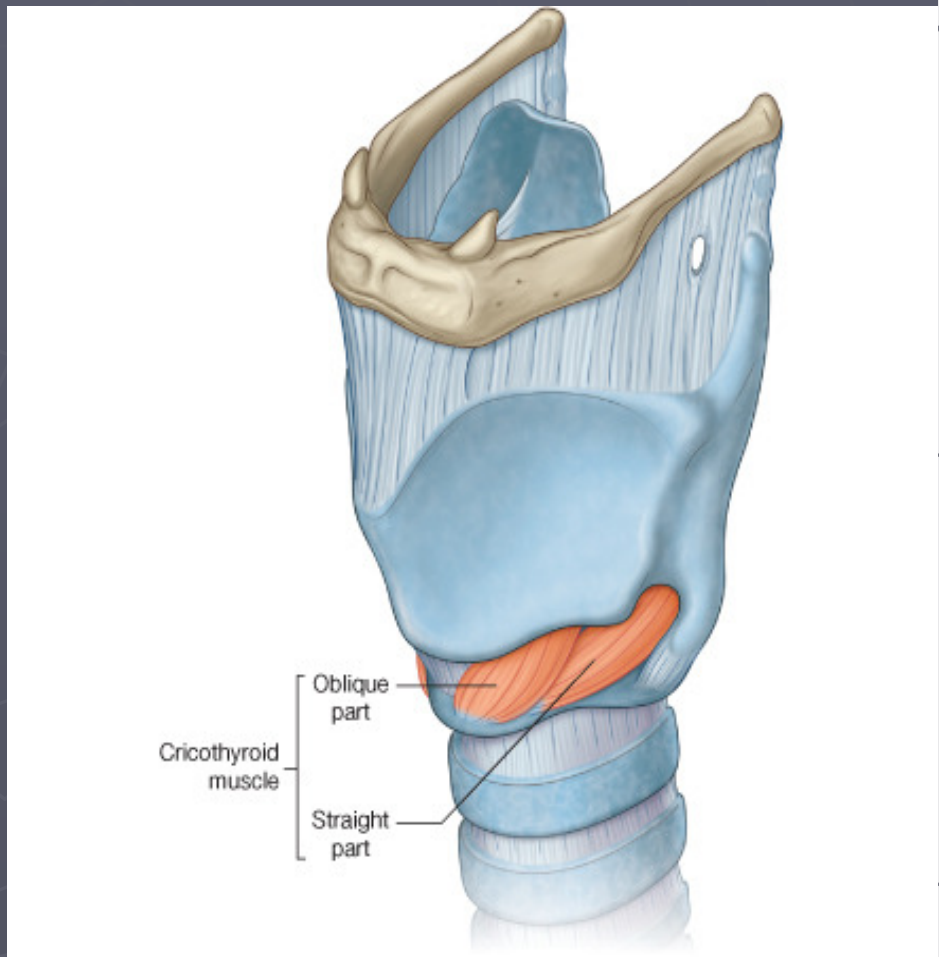
Muscles

Intrinsic muscles

- Adjust tension in the vocal ligaments,
- Open and close the rima glottidis,
- Control the inner dimensions of the vestibule,
- Close the rima vestibuli

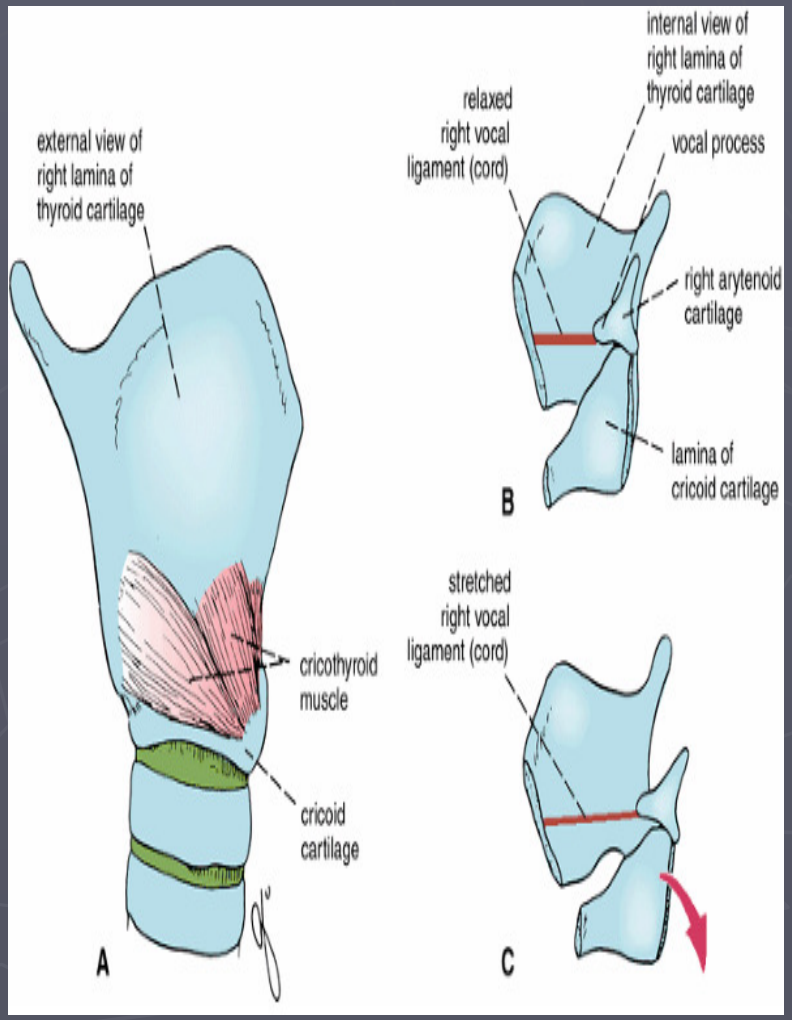
Cricothyroid muscles

- Fan-shaped muscles
- Attached to the anterolateral surfaces of the cricoid cartilage and expand superiorly and posteriorly to attach to the thyroid cartilage
- Each muscle has an oblique part and a straight part:
- The **oblique part** runs in a posterior direction from the arch of the cricoid to the inferior horn of the thyroid cartilage
- The **straight part** runs more vertically from the arch of the cricoid to the posteroinferior margin of the thyroid lamina



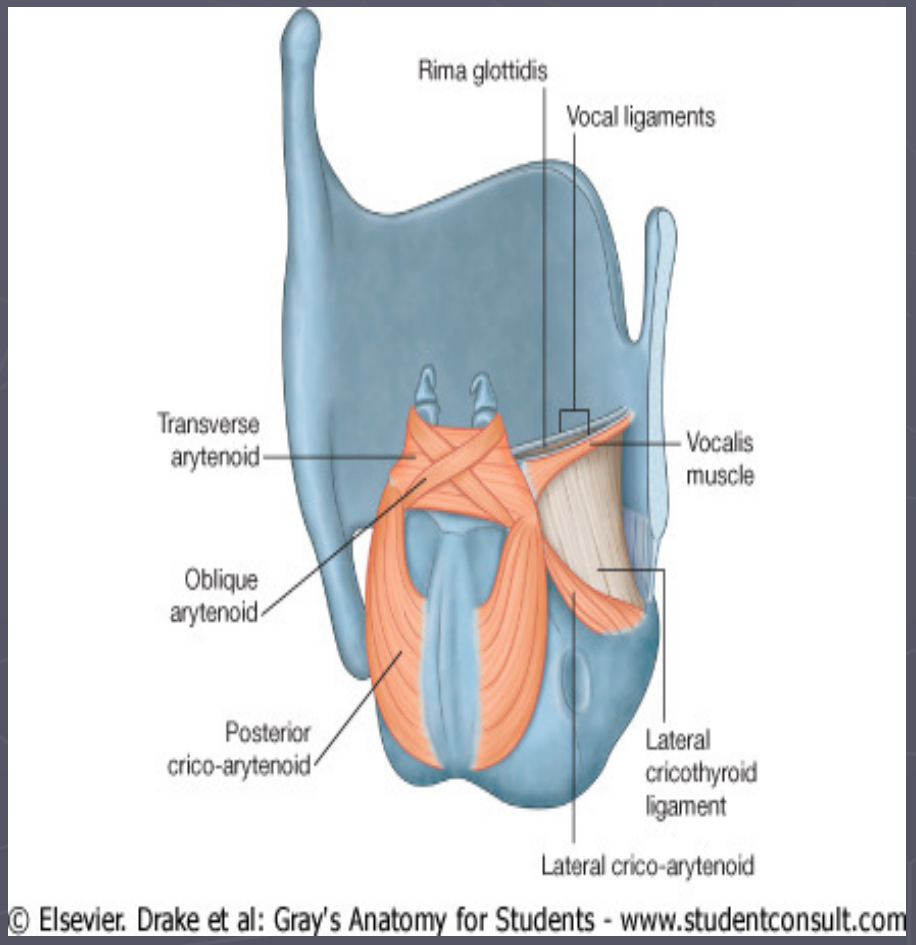
Cricothyroid muscles

- Pull the thyroid cartilage **forward** and **rotate** it down relative to the cricoid cartilage
- These actions **Tenses vocal cords**
- Are the only intrinsic muscles innervated by the **superior laryngeal branches** of the vagus nerves
- All other intrinsic muscles are innervated by the **recurrent laryngeal branches** of the vagus nerves



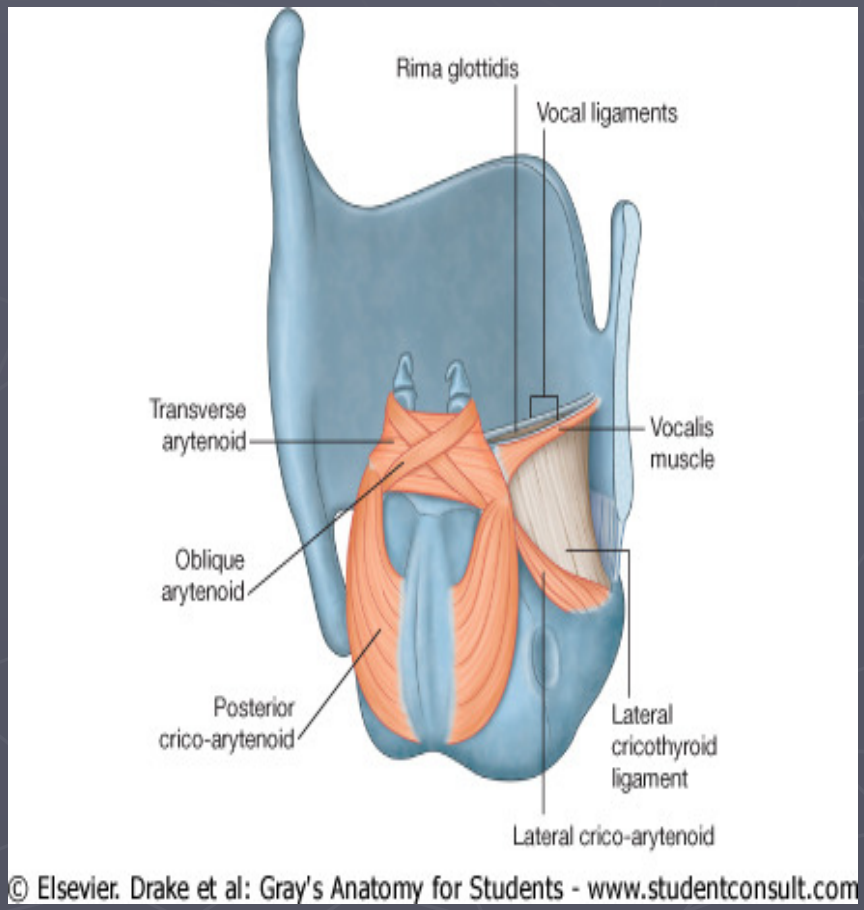
Posterior crico-arytenoid muscles

- There is a right and a left **posterior crico-arytenoid**
- The fibers of each muscle originate from the Back of cricoid cartilage , and run superiorly and laterally to the muscular processes of the arytenoid cartilage
- **Abducts the vocal cords** by rotating arytenoid cartilage
- Innervated by the recurrent laryngeal branches of the vagus nerves



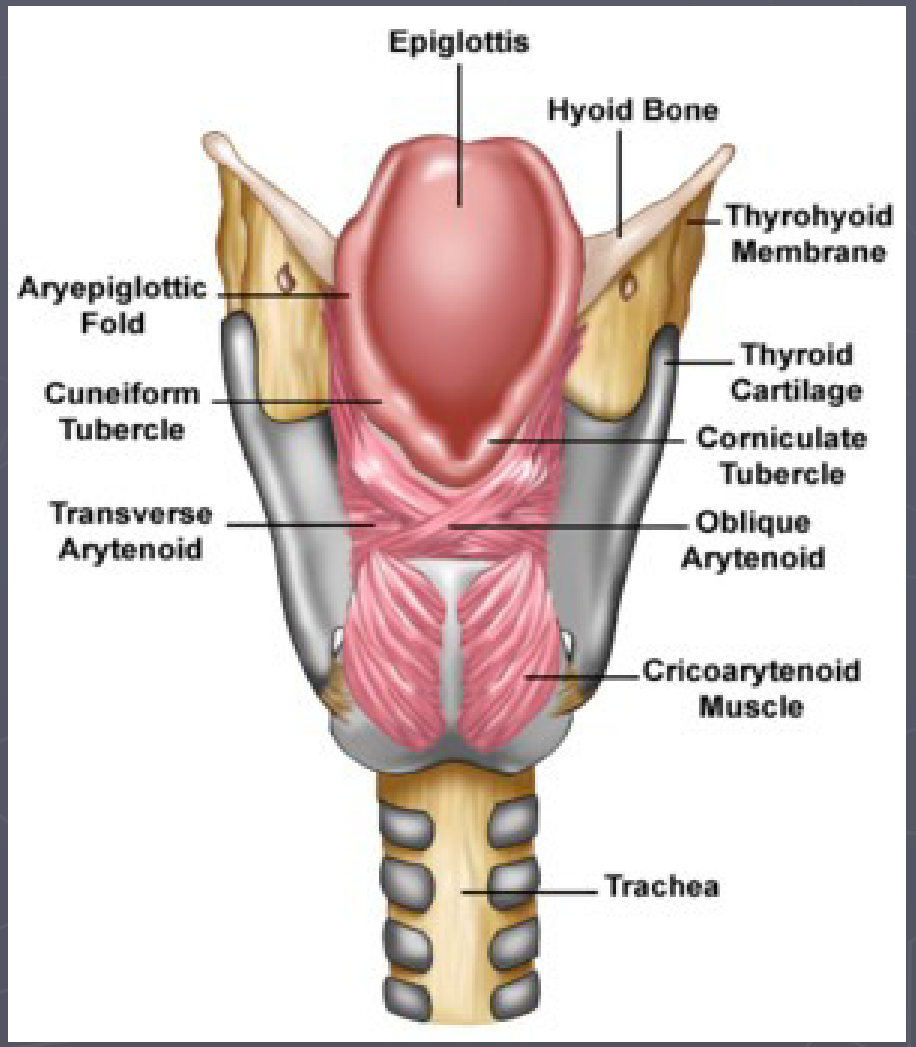
Lateral crico-arytenoid muscles

- Muscle on each side originates from the Upper border of cricoid cartilage , and runs posteriorly and superiorly to insert on the muscular process of the arytenoid
- **Adducts the vocal cords** by internally rotating arytenoid cartilage
- Innervated by the recurrent laryngeal



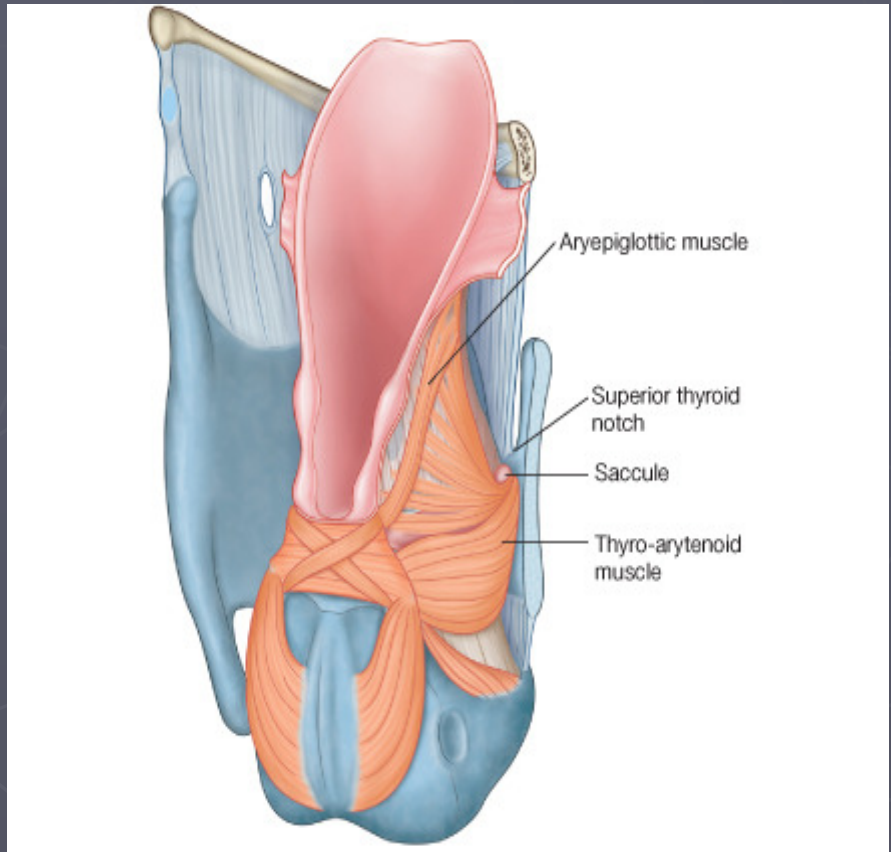
Transverse arytenoid

- Originates from Back and medial surface of arytenoid cartilage and insert in the Back and medial surface of opposite arytenoid cartilage
- **Closes posterior part of rima glottidis** by approximating arytenoid cartilages
- Recurrent laryngeal nerve



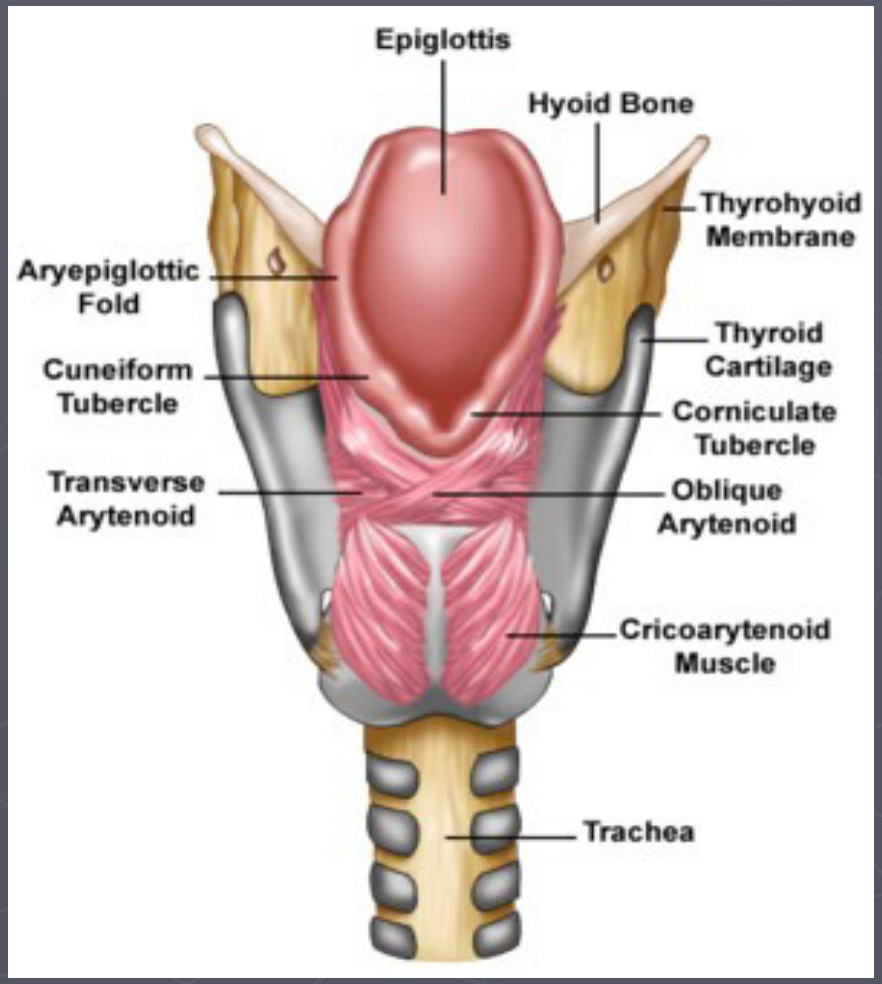
Thyroarytenoid (vocalis)

- From the Inner surface of thyroid cartilage to the Arytenoid cartilage
- **Relaxes vocal cords**
- Recurrent laryngeal nerve



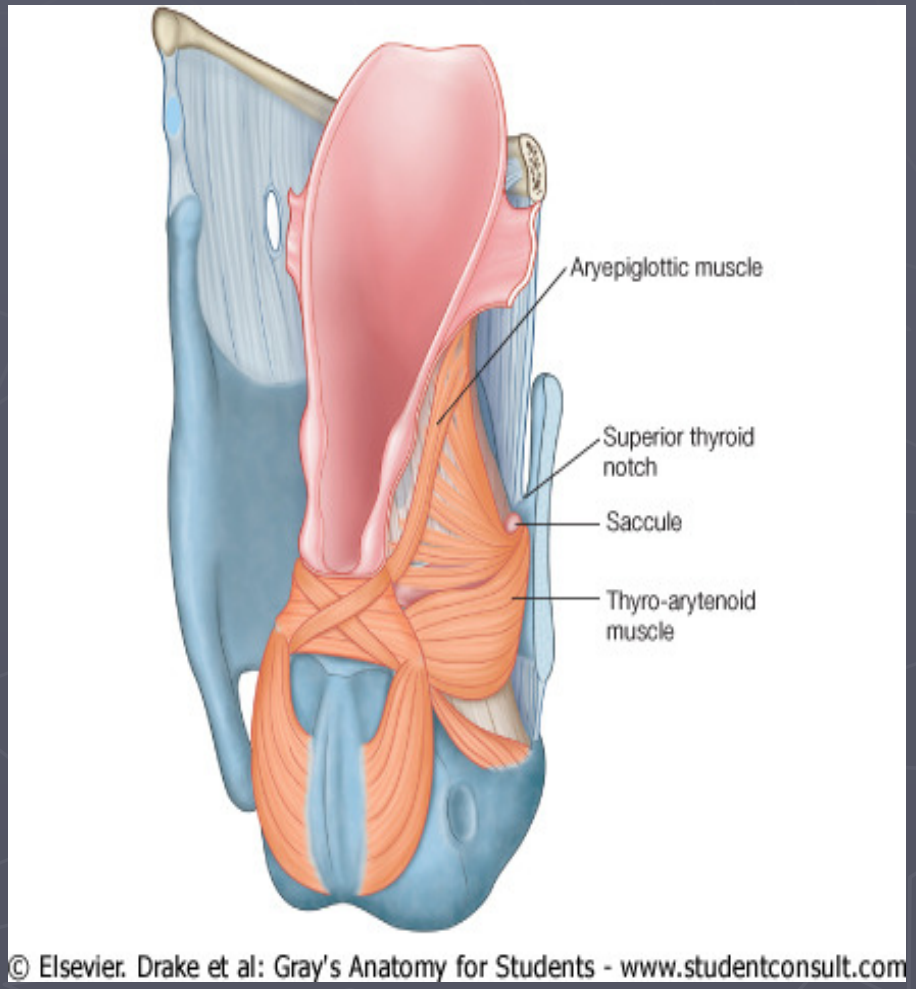
Oblique arytenoid

- From the Muscular process of arytenoid cartilage to the Apex of opposite arytenoid cartilage
- **Narrows the inlet** by bringing the aryepiglottic folds together
- Recurrent laryngeal nerve



Thyroepiglottic (aryepiglottic muscles)

- From the Medial surface of thyroid cartilage to the Lateral margin of epiglottis and aryepiglottic fold
- **Widens the inlet** by pulling the aryepiglottic folds apart
- Recurrent laryngeal nerve



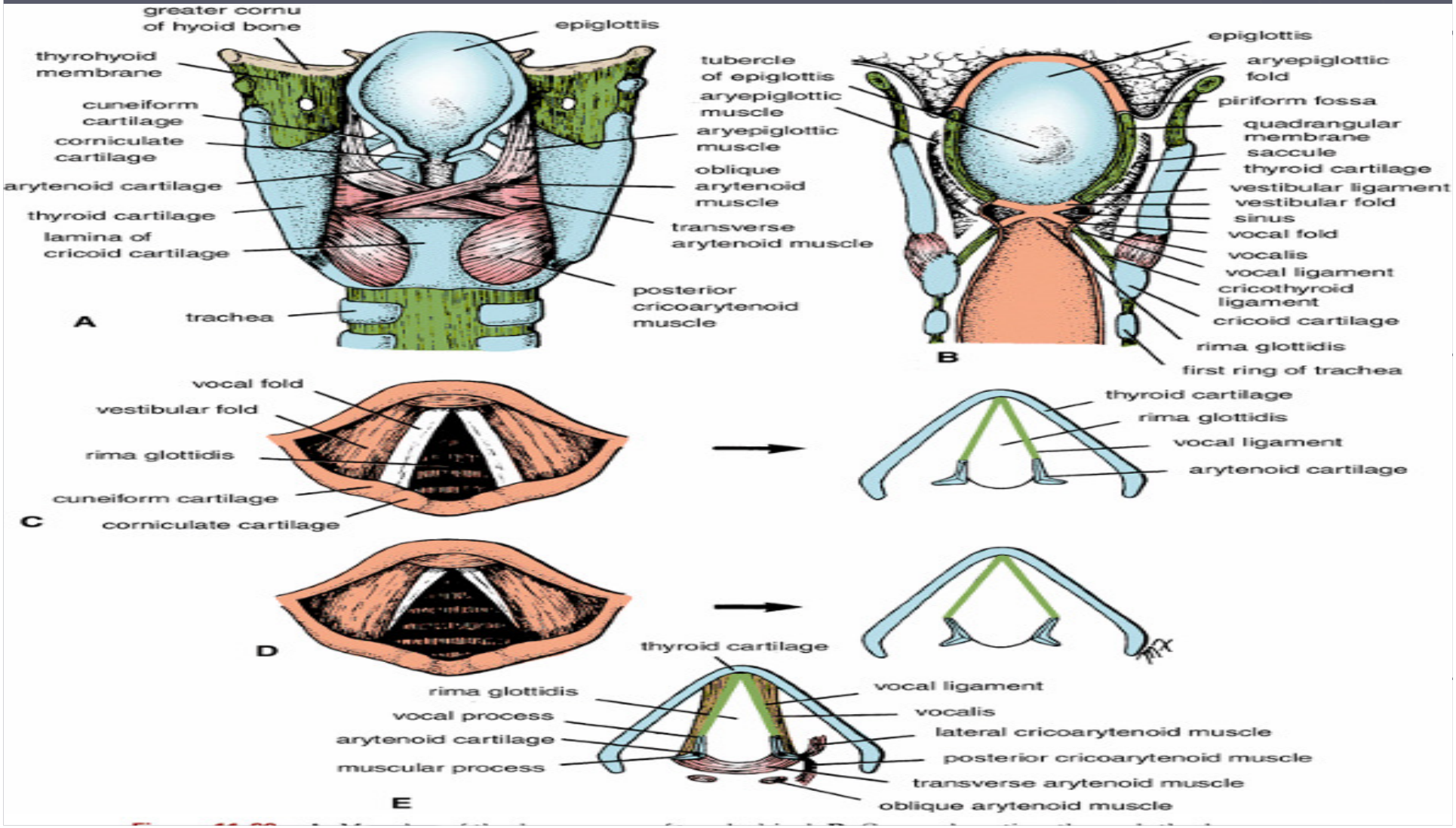
Extrinsic muscles

- Elevators of the larynx:
- 1. Digastric muscle
- 2. Stylohyoid
- 3. Myelohyoid
- 4. Geniohyoid

- The larynx moves up in swallowing by these muscles assisted by :
- Stylopharngeus, Salpingo-pharngeus, And Palatopharngeus.

- Depressors of the larynx :
- 1. Sternothyroid
- 2. Sternohyoid
- 3. Omohyoid

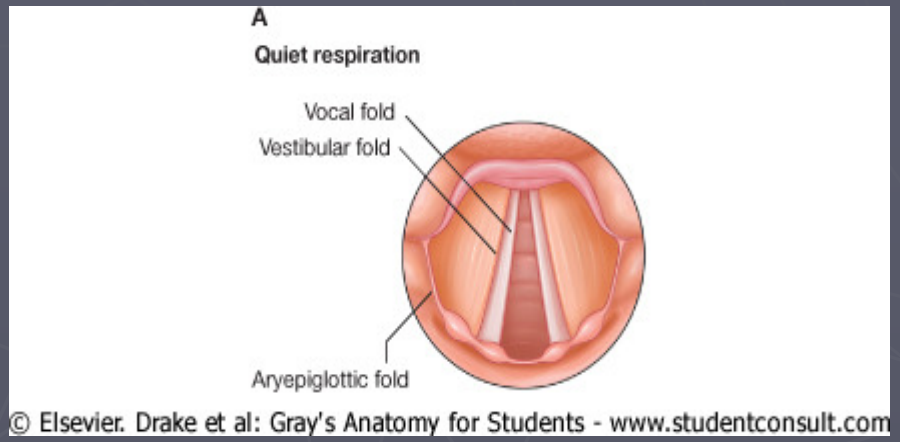
Muscles and Cavity

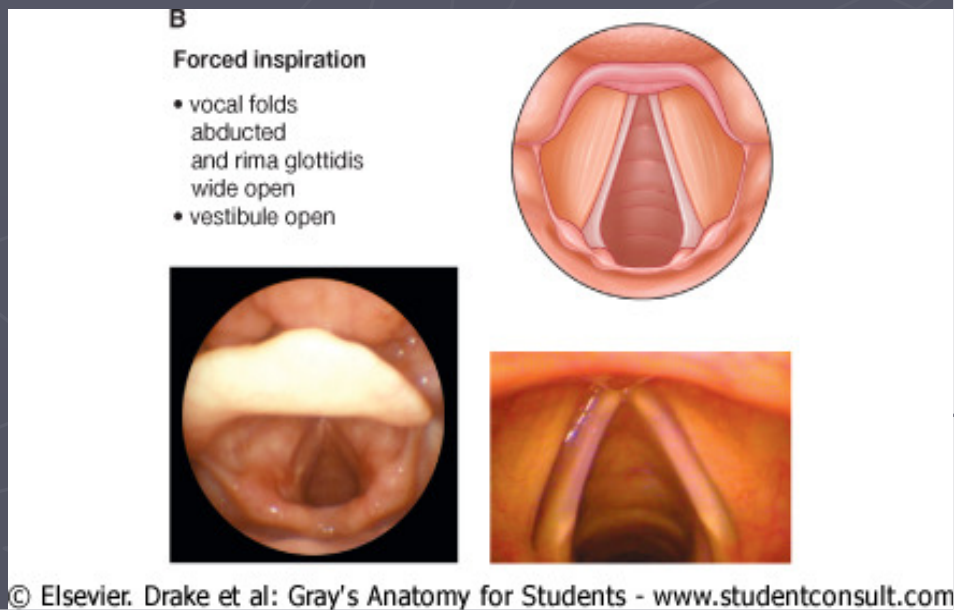


Function of the larynx

Respiration

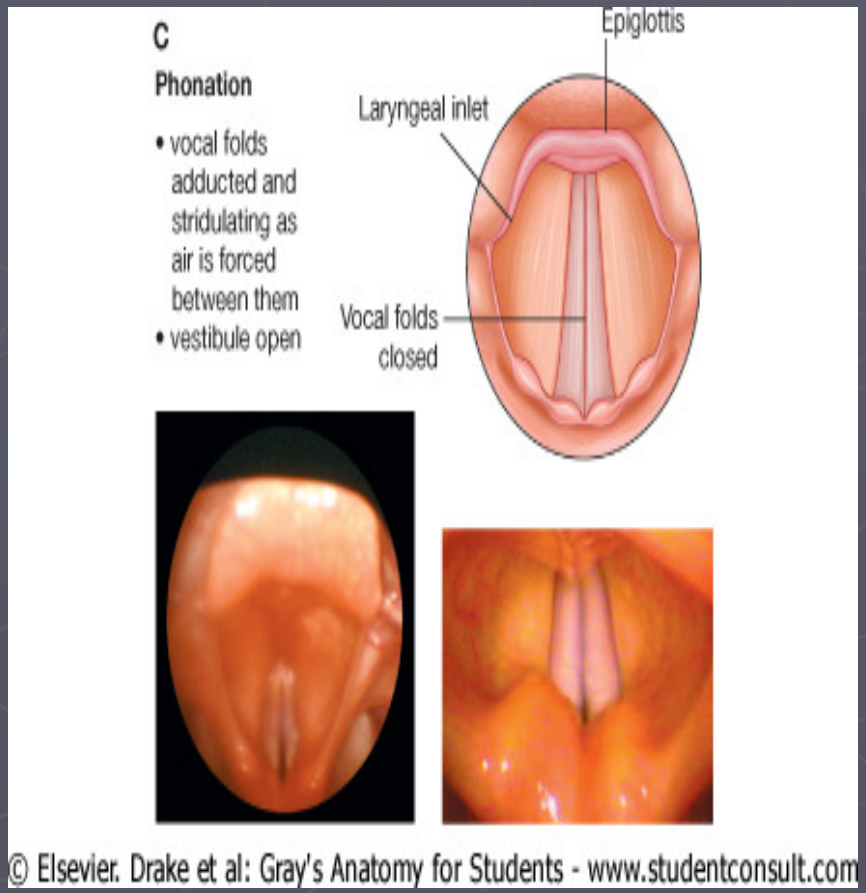
- During quiet respiration, the laryngeal inlet, vestibule, rima vestibuli, and rima glottidis are **open**
- During forced inspiration the arytenoid cartilages are **rotated laterally**, mainly by the action of the **posterior crico-arytenoid muscles.**
- As a result, the vocal folds are **abducted**, and the **rima glottidis widens** into a rhomboid shape, effectively **increases the diameter of the laryngeal airway.**





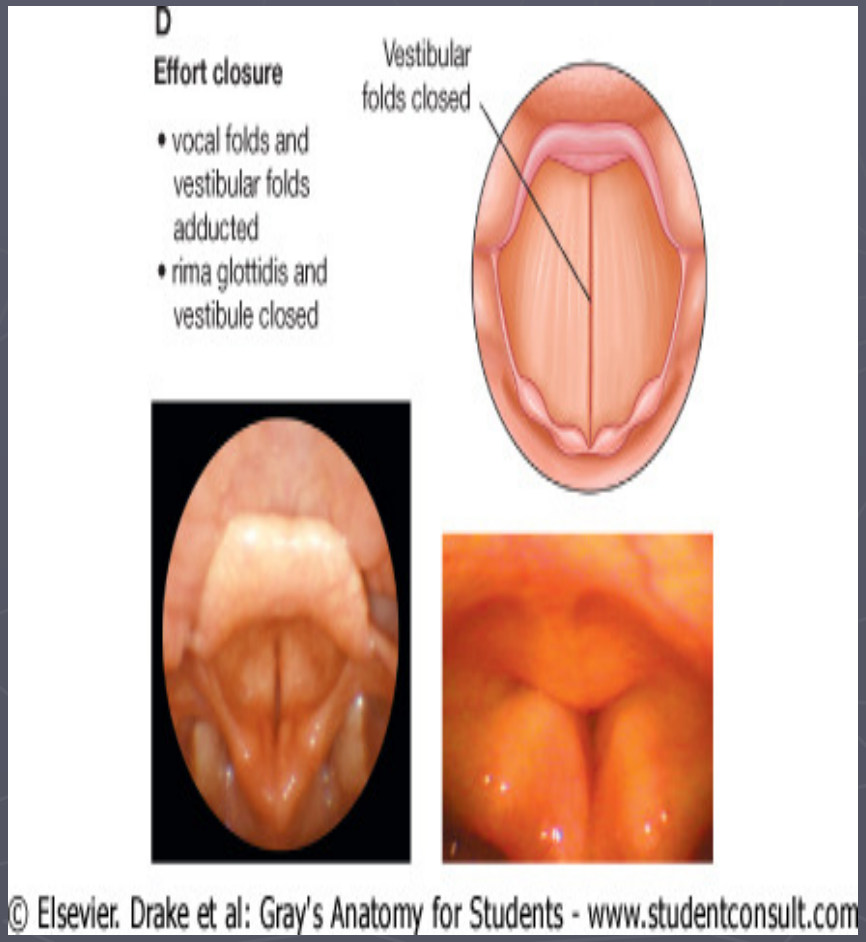
Phonation

- When phonating, the arytenoid cartilages and vocal folds are **adducted** and air is forced through the **closed rima glottidis**
- This action causes the vocal folds to **vibrate** against each other and produce sounds
- Can then be modified by the upper parts of the airway and oral cavity
- **Tension** in the vocal folds can be adjusted by the **vocalis and cricothyroid muscles.**



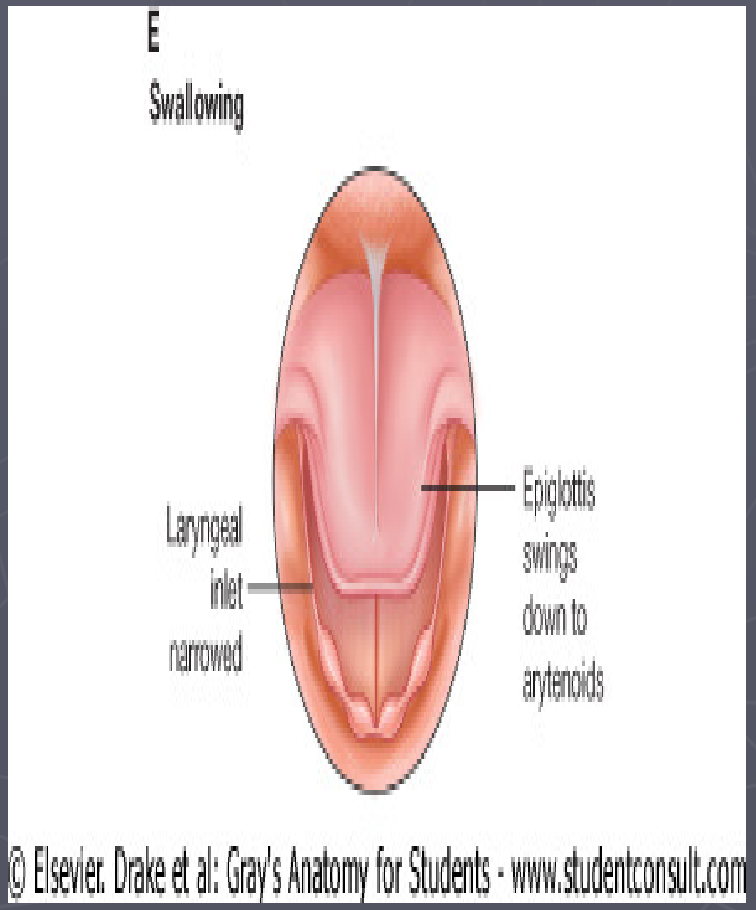
Effort closure

- Effort closure of the larynx occurs when air is retained in the thoracic cavity to **stabilize the trunk**
- For example during heavy lifting, or as part of the mechanism for increasing intra-abdominal pressure
- The rima glottidis is **completely closed**, as is the rima vestibuli and lower parts of the vestibule
- The result is to completely and **forcefully shut the airway**.



Swallowing

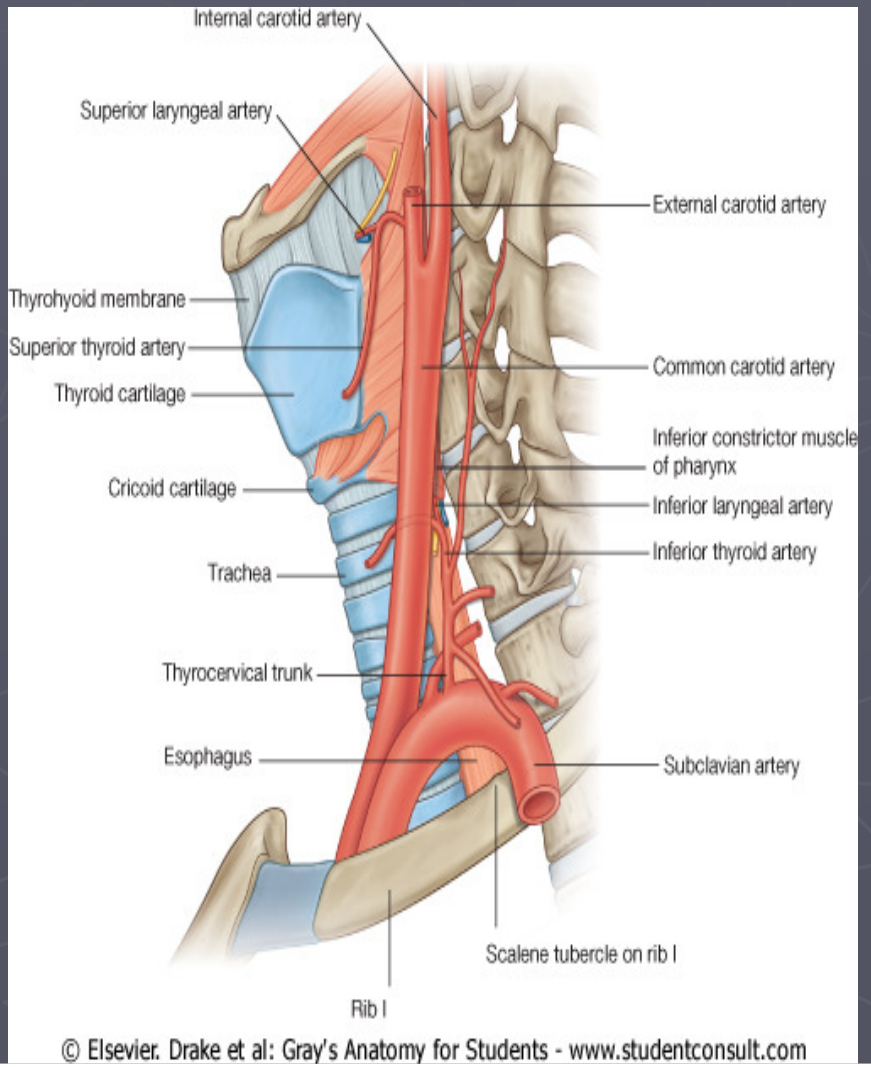
- During swallowing, the rima glottidis, the rima vestibuli, and vestibule are **closed** and the **laryngeal inlet is narrowed**
- The larynx moves **up and forward**
- This action causes the **epiglottis** to swing **downward** to effectively **narrow or close the laryngeal inlet**
- The up and forward movement of the larynx also **opens the esophagus**
- All these actions together **prevent solids and liquids from entry into the airway**



Blood Supply

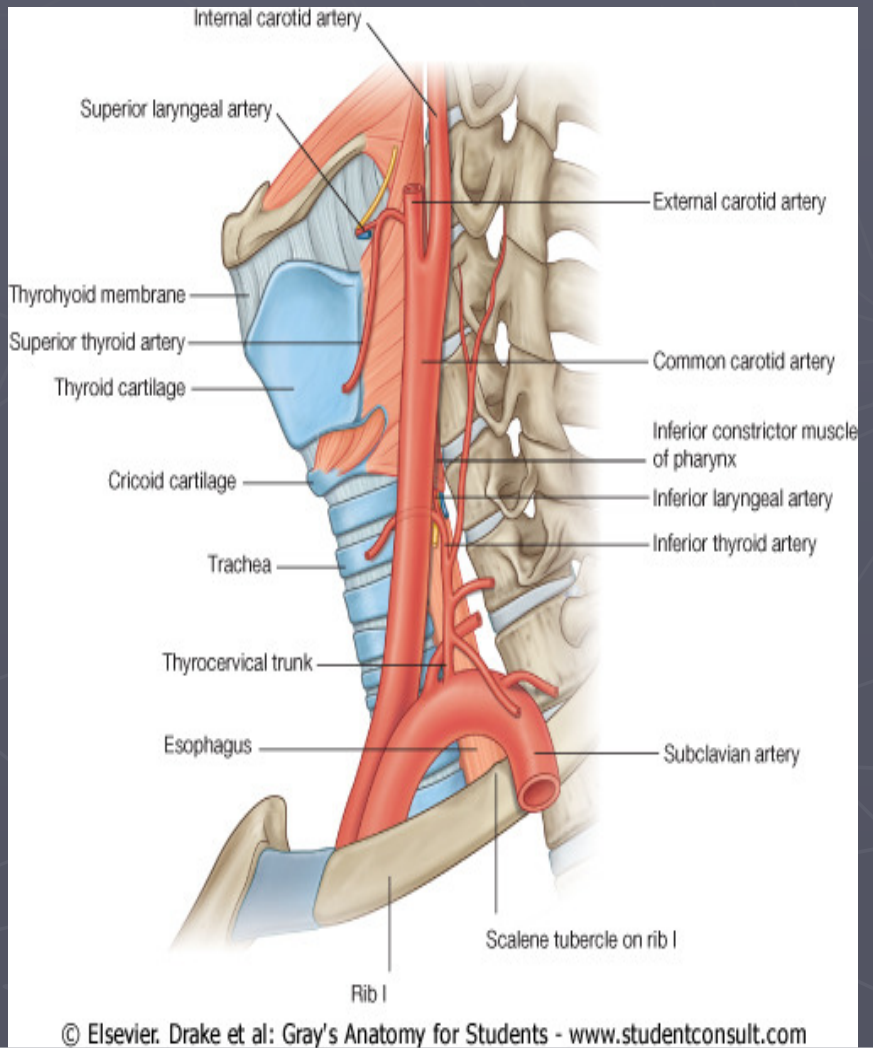
Arteries

- The major blood supply to the larynx is by the superior and inferior laryngeal arteries
- The **superior laryngeal artery** originates from the superior thyroid branch of the external carotid artery,
- Accompanies the internal branch of the superior laryngeal nerve through the thyrohyoid membrane to reach the larynx.



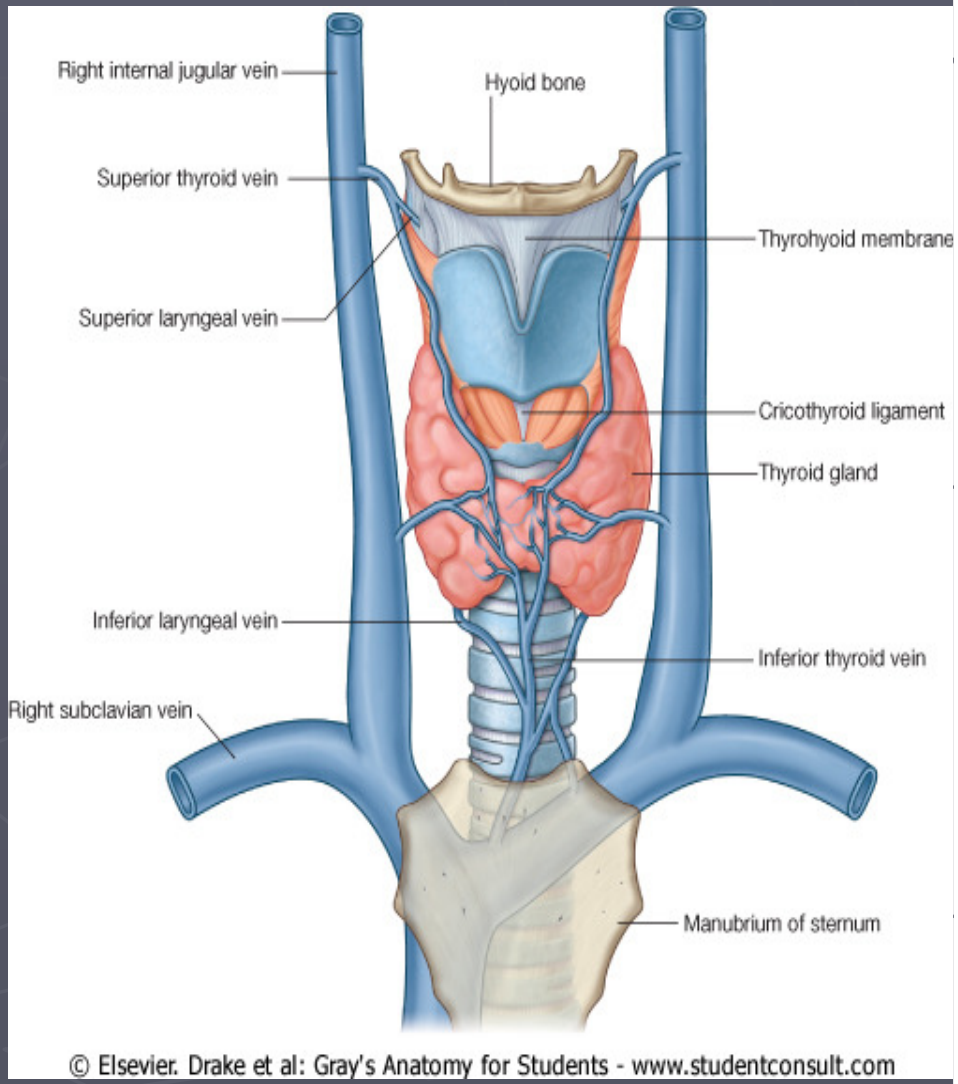
Arteries

- The **inferior laryngeal artery** originates from the inferior thyroid branch of the thyrocervical trunk of the subclavian artery
- Together with the recurrent laryngeal nerve, ascends in the groove between the esophagus and trachea
- It enters the larynx by passing deep to the margin of the inferior constrictor muscle of the pharynx;



Veins

- Veins draining the larynx accompany the arteries:
- **Superior laryngeal veins** drain into superior thyroid veins, which in turn drain into the internal jugular veins
- **Inferior laryngeal veins** drain into inferior thyroid veins, which drain into the left brachiocephalic veins.



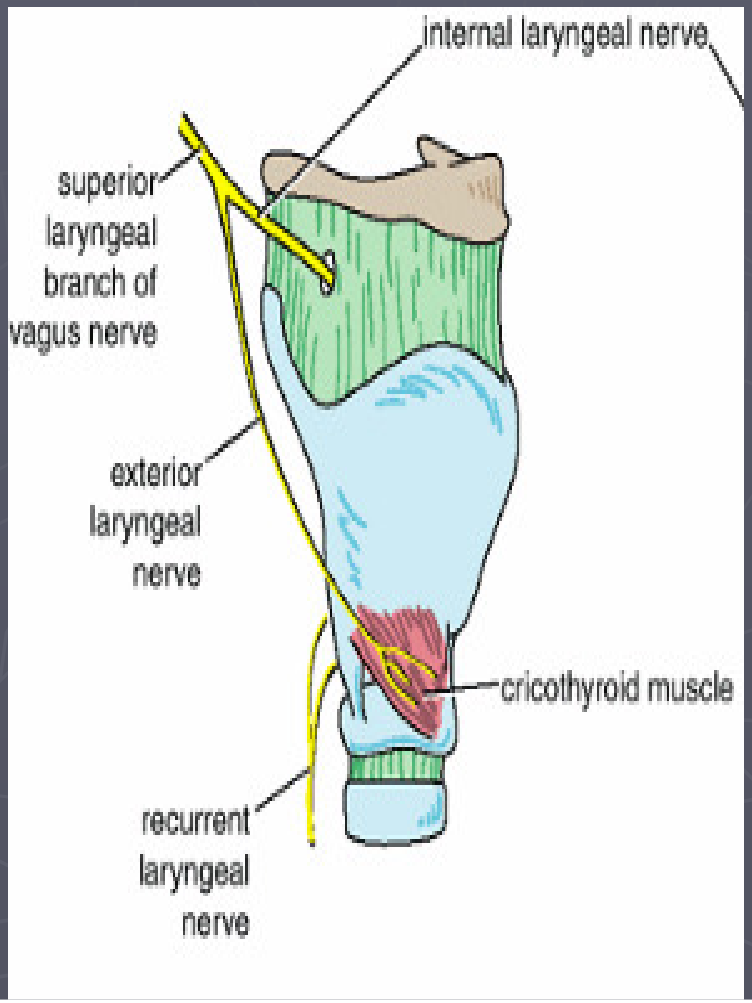
Lymphatics

- Lymphatics drain regions above and below the vocal folds:
- Those above the vocal folds follow the superior laryngeal artery and terminate in deep cervical nodes
- Those below the vocal folds drain into deep nodes associated with the inferior thyroid artery
- Or with nodes associated with the front of the cricothyroid ligament or upper trachea.

Innervations

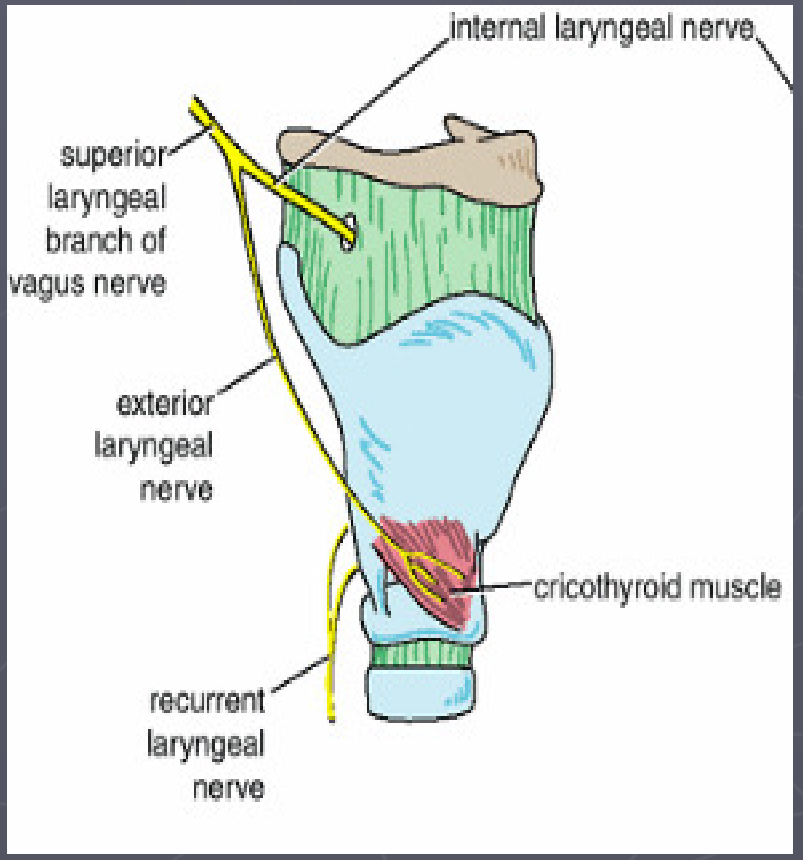
Superior laryngeal nerves

- The **superior laryngeal nerves** originate from the inferior vagal ganglia high in the neck
- They descend medial to the internal carotid artery and divide into **internal** and **external branches** above the hyoid bone
- The external branch (**external laryngeal nerve**) descends along the lateral wall of the pharynx to supply the inferior constrictor of the pharynx and ends by supplying the **cricothyroid muscle;**



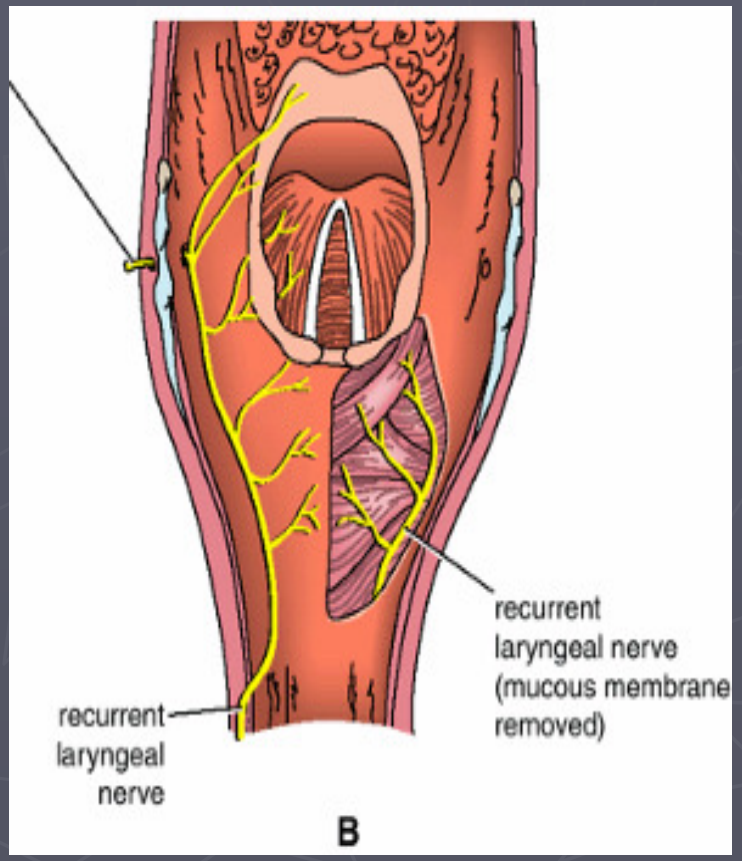
Superior laryngeal nerves

- The **internal laryngeal nerve** passes anteroinferiorly to penetrate the thyrohyoid membrane
- Internal nerve is mainly **sensory** and supplies the laryngeal cavity down to **the level of the vocal folds.**



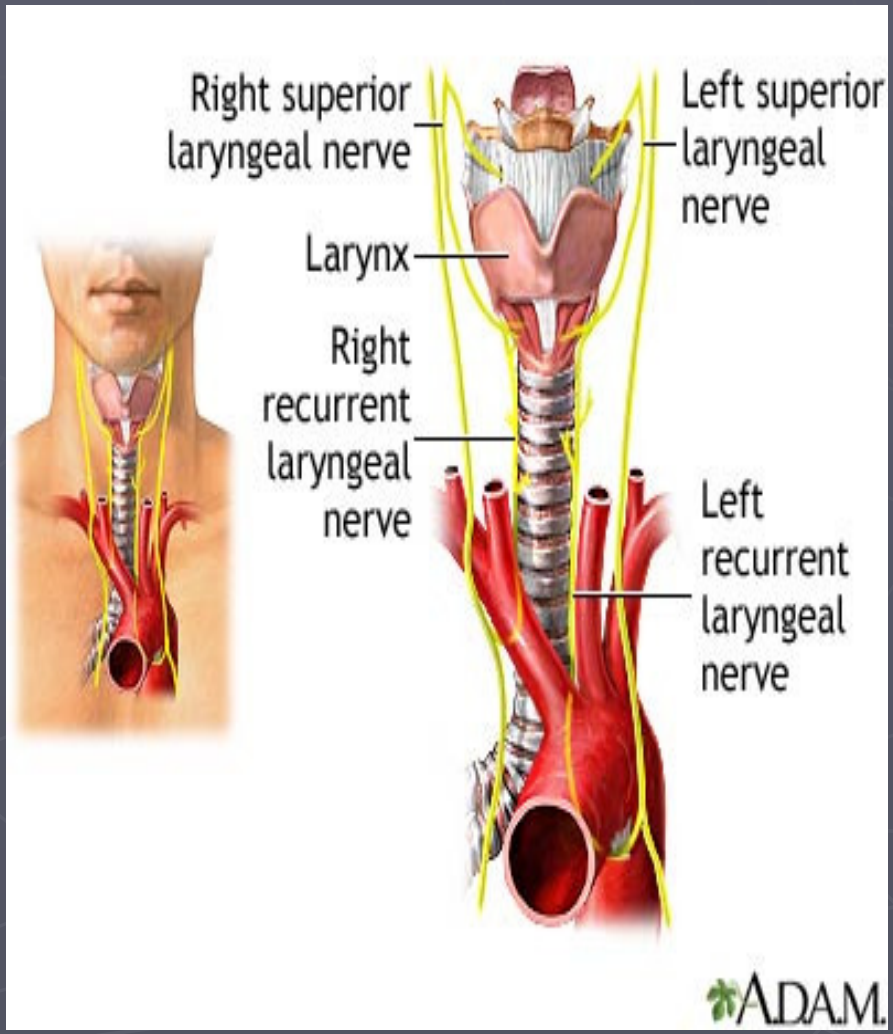
Recurrent laryngeal nerves

- The recurrent laryngeal nerves are:
- Sensory to the laryngeal cavity **below the level of the vocal folds**;
- Motor to all intrinsic muscles of the larynx **except for the cricothyroid**.



Recurrent laryngeal nerves

- The **left** recurrent laryngeal nerve originates in the **thorax** whereas the **right** recurrent laryngeal nerve originates in the **root of the neck**
- Both nerves generally ascend in the neck in the groove between the esophagus and trachea
- Enter the larynx deep to the margin of the inferior constrictor

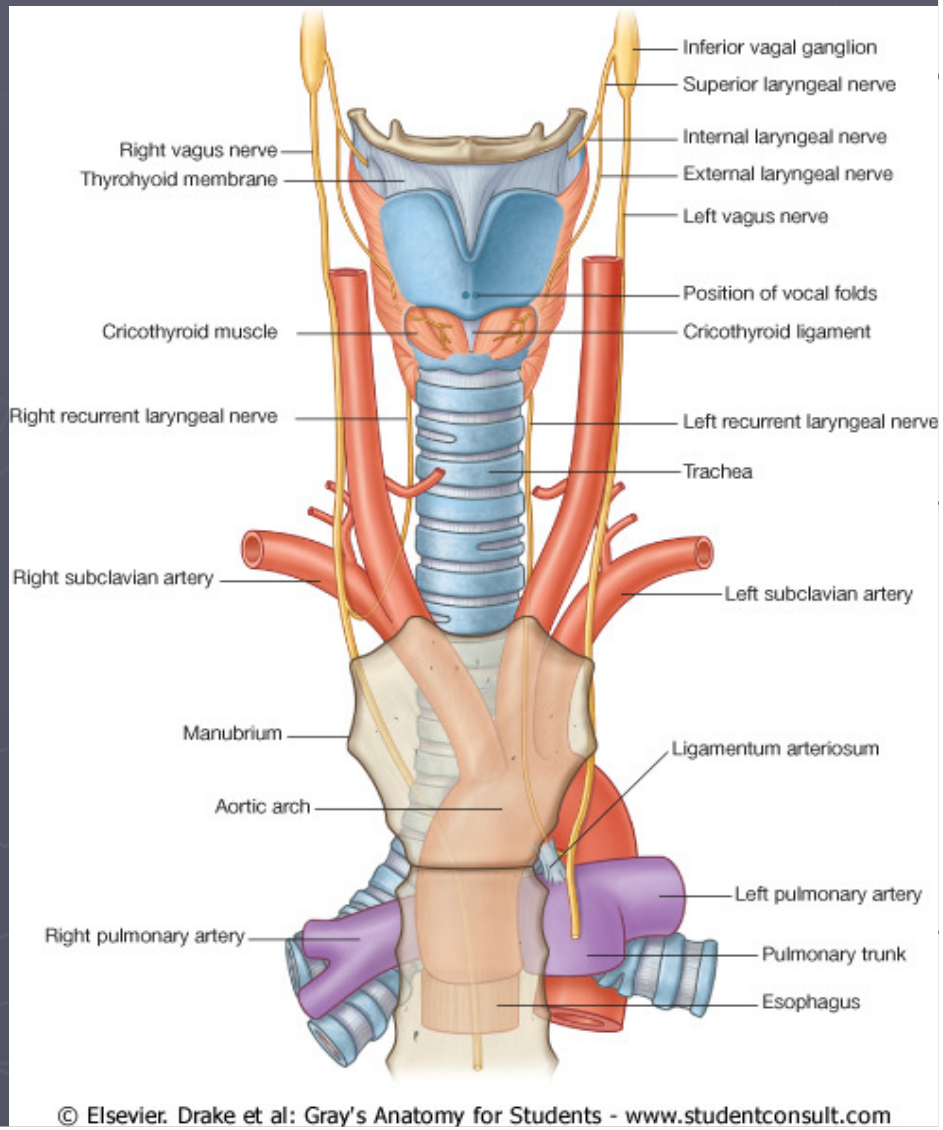


Relations of the larynx

- On each side :
- **Carotid sheath (contents), and lateral lobe of the thyroid gland**

- Posterior:
- **Pharynx and the right recurrent laryngeal nerve**

- Anterior:
- **Skin, fascia and its contents, 4 infra-hyoid muscles**



Clinical notes

Thyroidoctomy

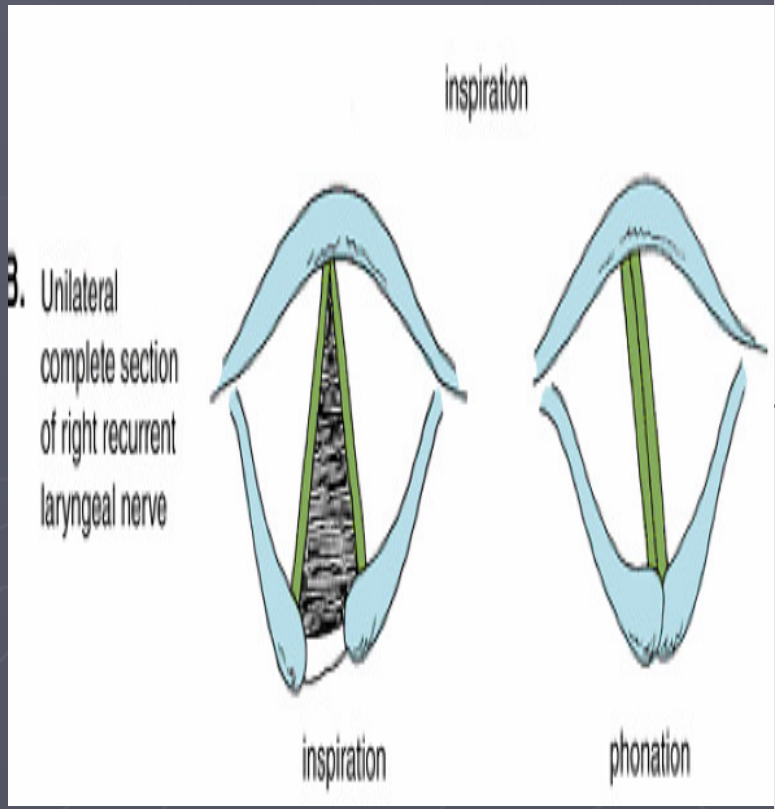
- Sectioning of the **external laryngeal** nerve might happen in thyroidoctomy
- Due to the close relationship between the external laryngeal nerve and the superior thyroid artery.
- Produces **weakness in voice** since the vocal cords cannot be tensed (criciothyroid M.).

Section of the Recurrent laryngeal nerve

- **1. Unilateral complete section:**

- One vocal fold (on the affected side) in the position midway between abducted and adducted

- Speech not greatly affected as the other vocal cord compensate for the action.

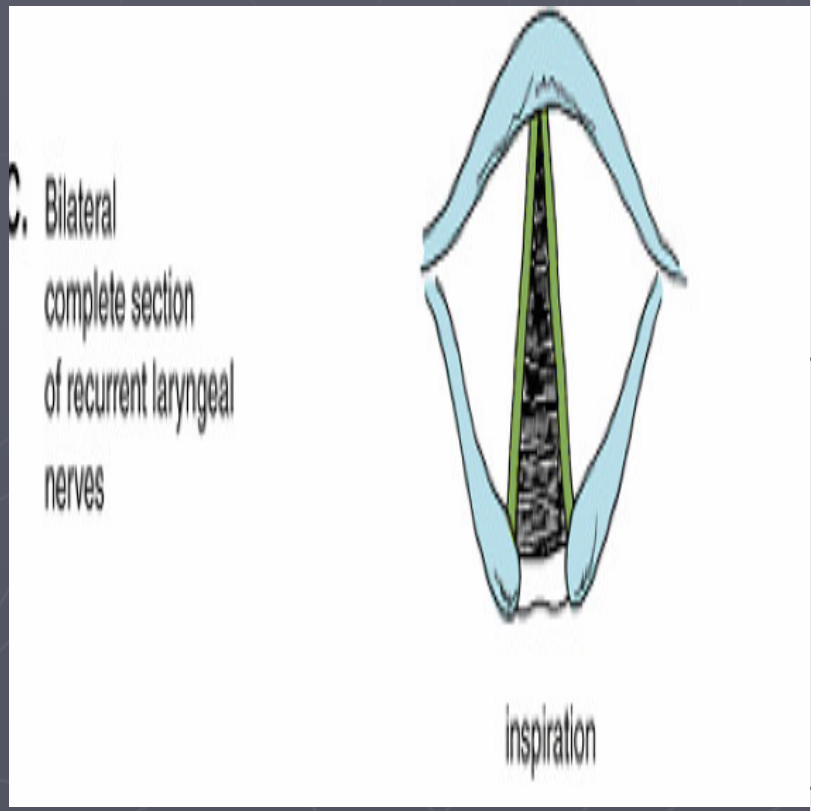


Section of the Recurrent laryngeal nerve

- **2. Bilateral complete section:**

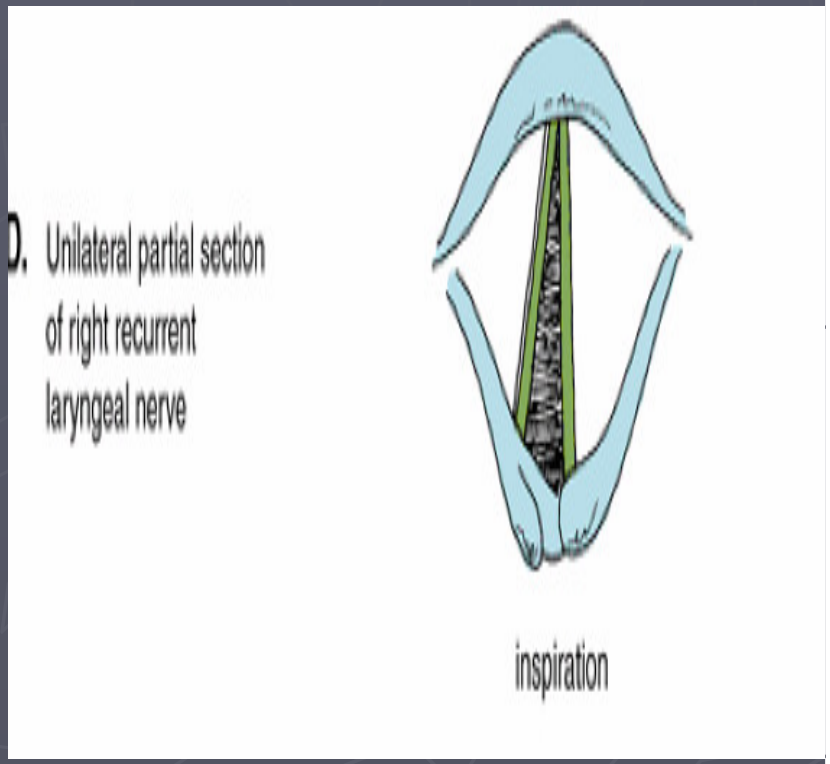
- Both vocal folds in position midway between abducted and adducted

- Breathing is impaired since the rima glottis is partially close and speech is lost



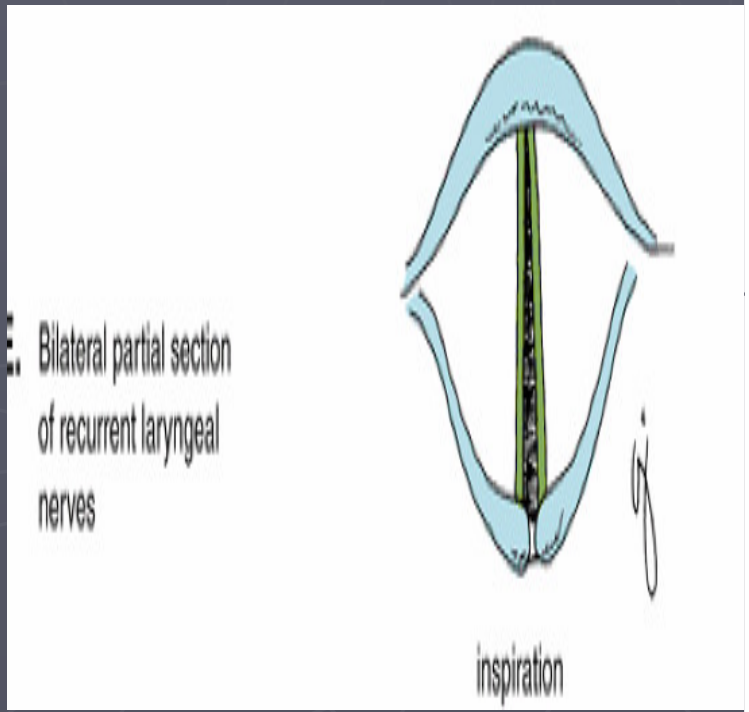
Section of the Recurrent laryngeal nerve

- **3. Unilateral partial section :**
- This results in a greater degree of paralysis of the abductor muscles than of the adductor .
- Therefore the affected cord is in the adducted midline position
- Hoarseness of the voice (the other vocal fold compensates the action)



Section of the Recurrent laryngeal nerve

- **4. Bilateral partial section:**
- This results in bilateral paralysis of the abductor muscles
- Therefore the vocal folds are adducted together in the midline
- Acute breathlessness (Dyspnea) and stridor follow
- Lead to suffocation so tracheostmy is necessary



Thank you