

Anatomy of the Respiratory System

Objectives

By the end of this presentation, further private study and completion of the formative assessment you will:

1. Know the structure and function of each component of the Respiratory System;
2. Know the important (clinically or surgically relevant) relationships of each component of the Respiratory System;
3. Be aware of any important (clinically or surgically relevant) aspects of the blood (arterial, venous, lymph) and nerve supplies of each component of the Respiratory System;
4. Be aware of common clinical conditions that may affect the Respiratory System.

Components of the Respiratory System

Nose, nasal cavity and sinuses

Nasopharynx and soft palate

Larynx

Trachea

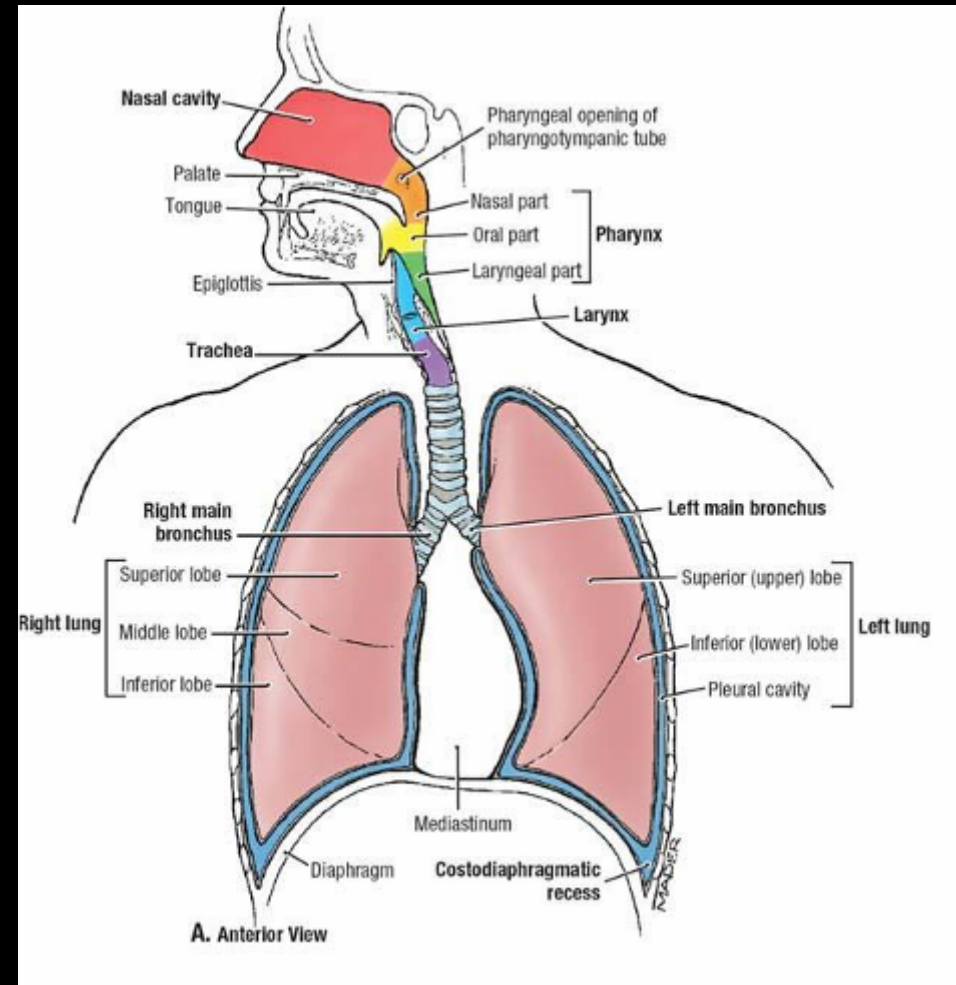
Lungs and pleura

Bronchi and bronchial tree

Thoracic wall

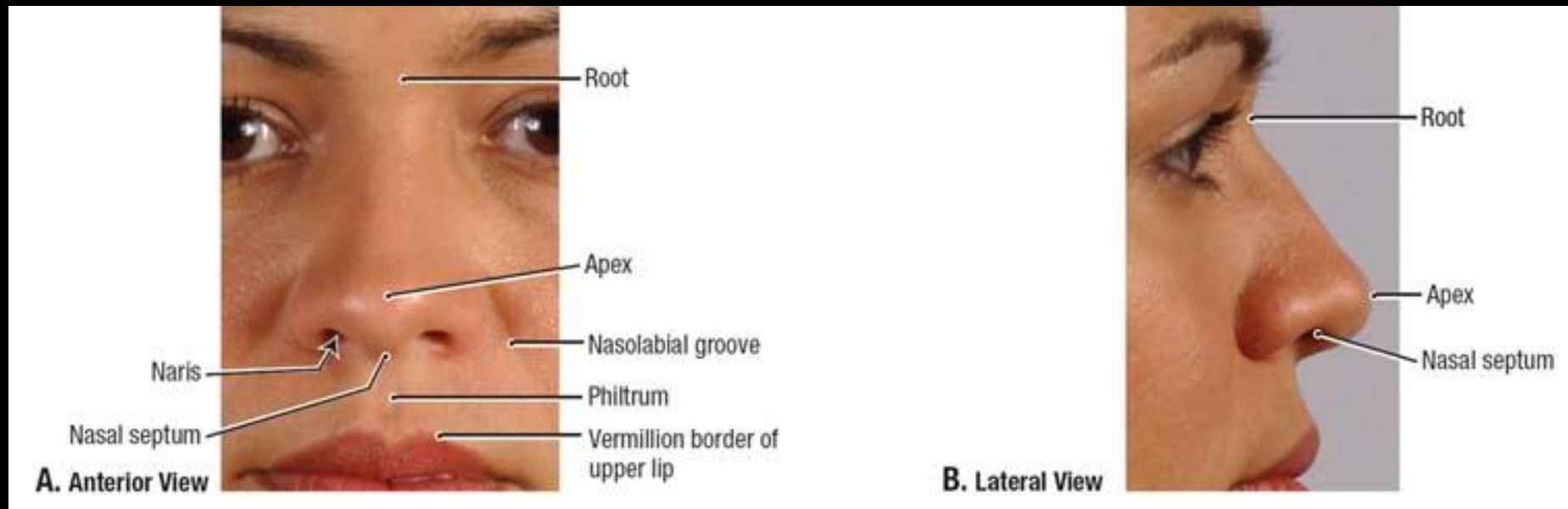
Diaphragm

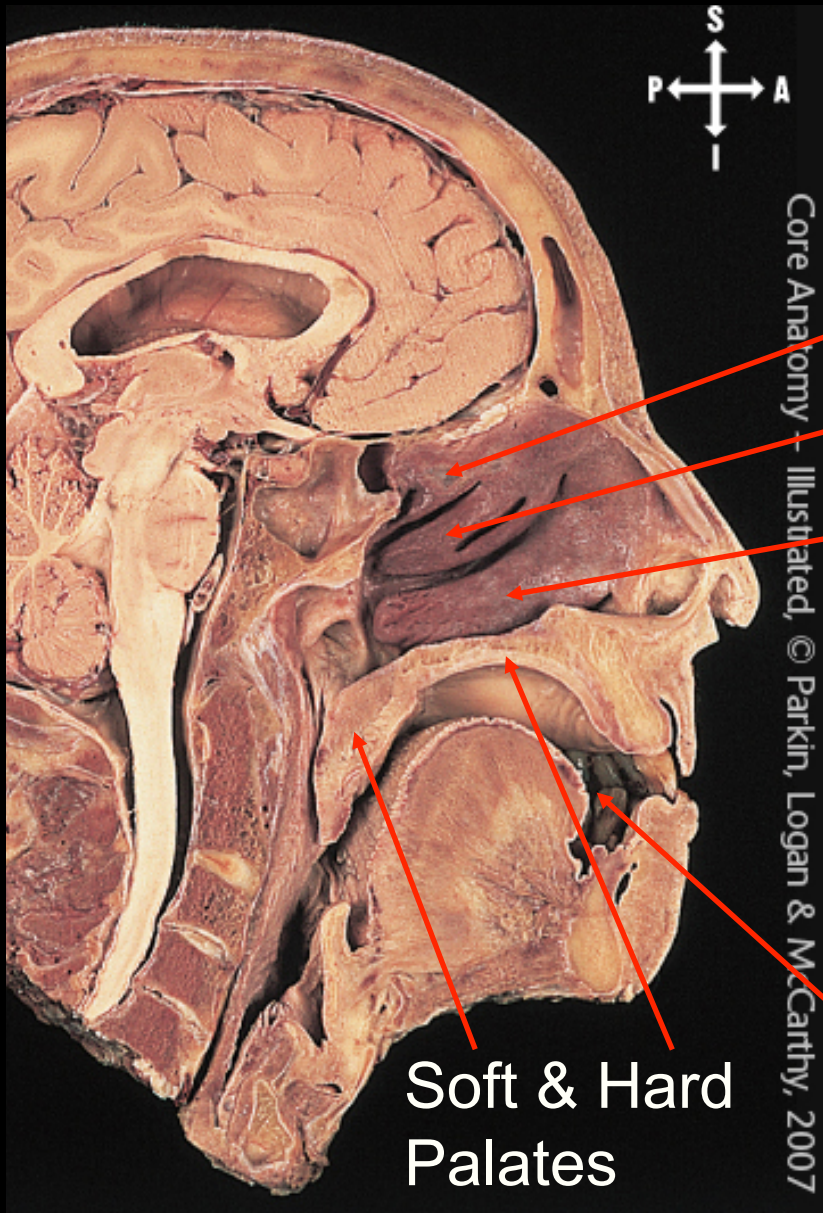
Mechanisms of respiration



Nose, Nasal Cavity and Sinuses

Here is the nose as we see it, but the **nasal cavity** is a “box” of bone and cartilage (which hold the cavity open against inspiratory pressure) posterior to the nose, above the oral cavity and between the orbits.





Lateral wall of Nasal Cavity with

Superior

Middle

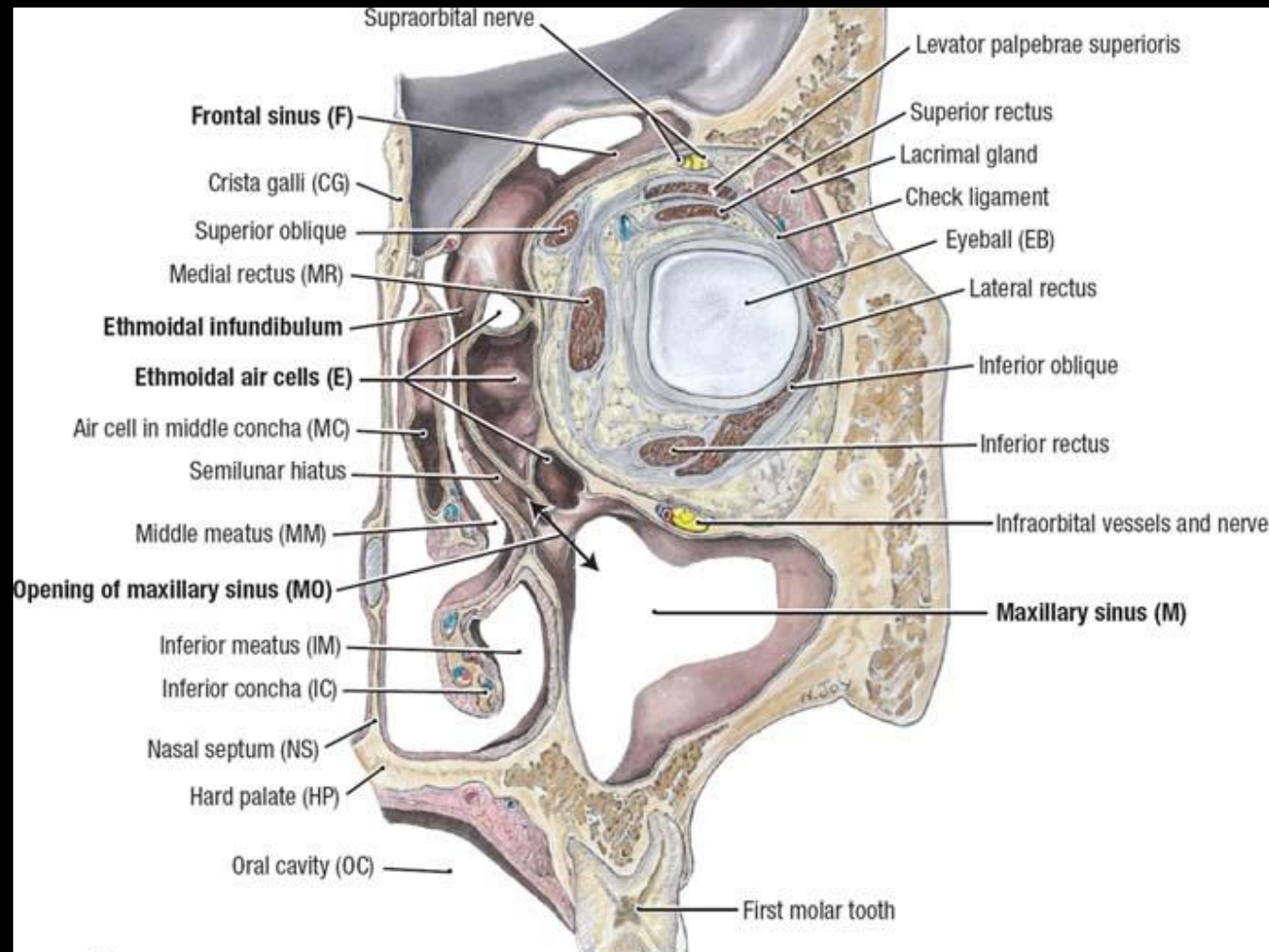
Inferior

Turbinates (Conchae)

Soft & Hard Palates

Oral Cavity with Tongue and Teeth



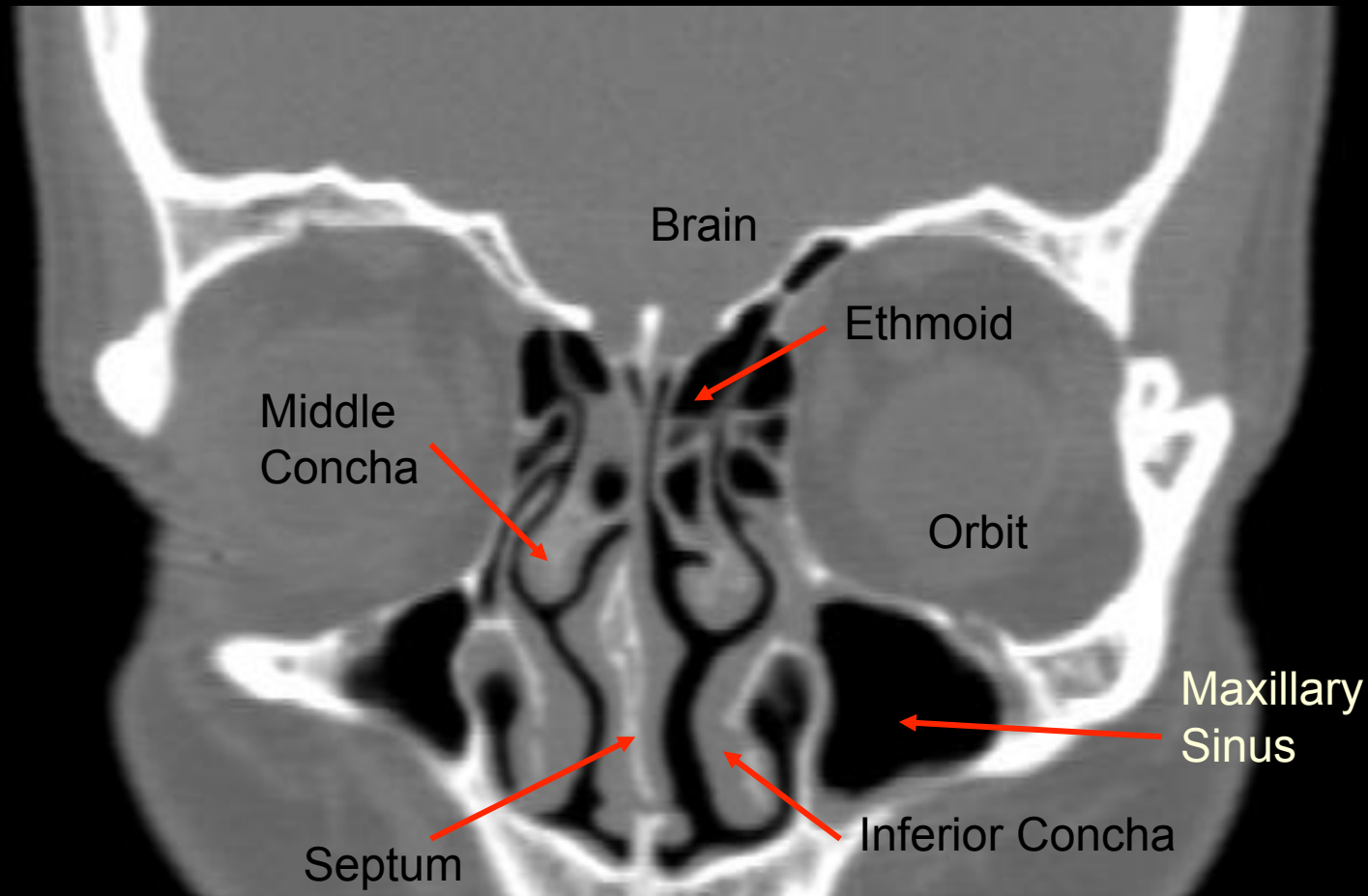


The nasal cavity is divided by the midline septum, the turbinates (conchae) project from the lateral wall and overhang the meati, into which the sinuses open.

Coronal Section of Head

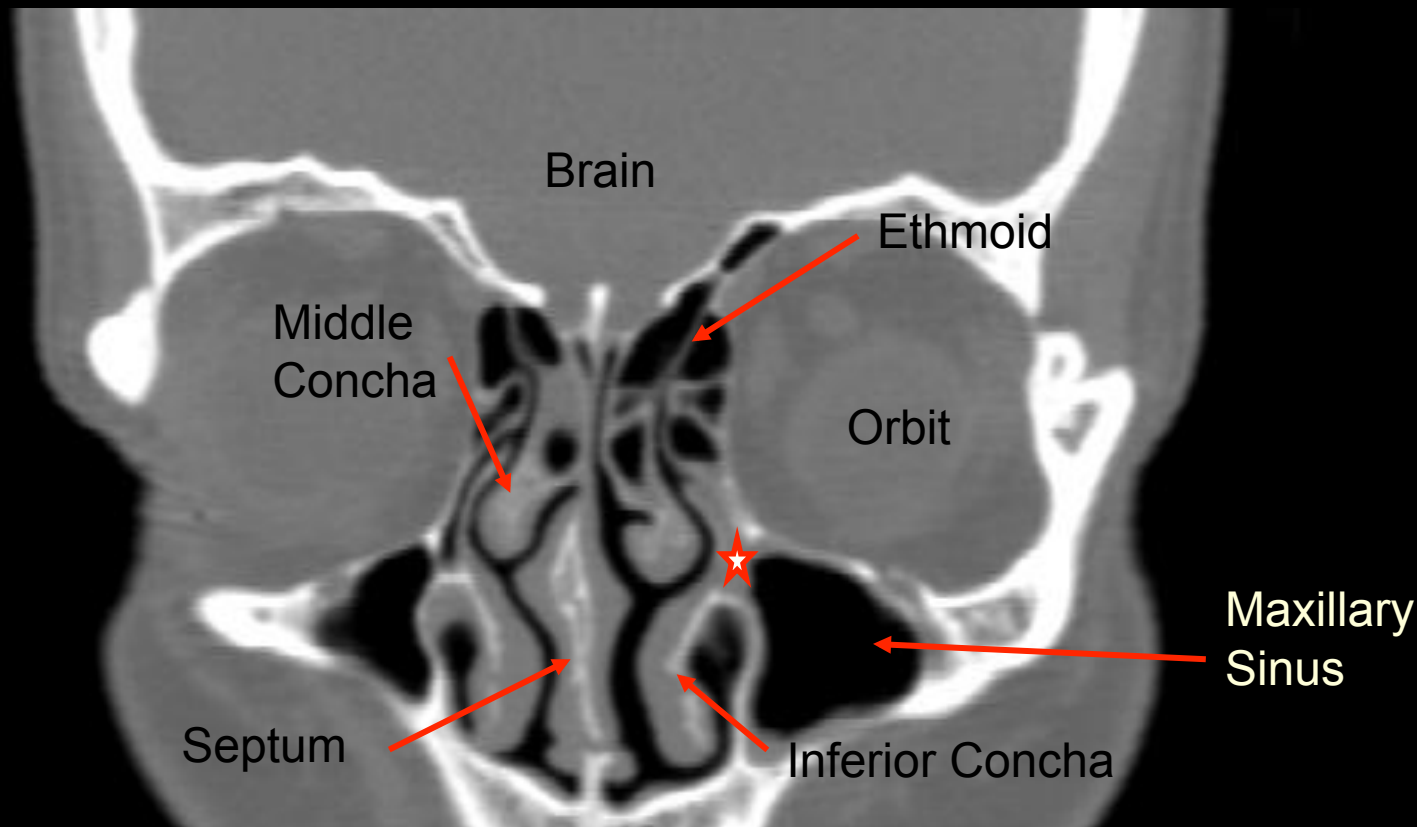
- The nasal cavity and sinuses warm, filter and humidify the inhaled air (vascular mucosa, cilia and mucus)
- The turbinates (conchae) increase the surface area and create turbulence.
- The mucous membrane is highly vascular and lined with Respiratory Epithelium i.e. pseudostratified, ciliated, columnar, interspersed with goblet cells (that also secrete mucus).
- Olfactory epithelium (sense of smell) is restricted to the cavity roof and the adjacent lateral wall and septum.
- The surrounding bones (maxilla, ethmoid, frontal and sphenoid) are excavated by air sinuses into which the nasal mucous membrane extends.
- The mucus from the sinuses and the tears from the eye (via the nasolacrimal duct) empty into the meati.

Note the close proximity of the orbits, and the brain in the cranial cavity, to the nasal cavity.

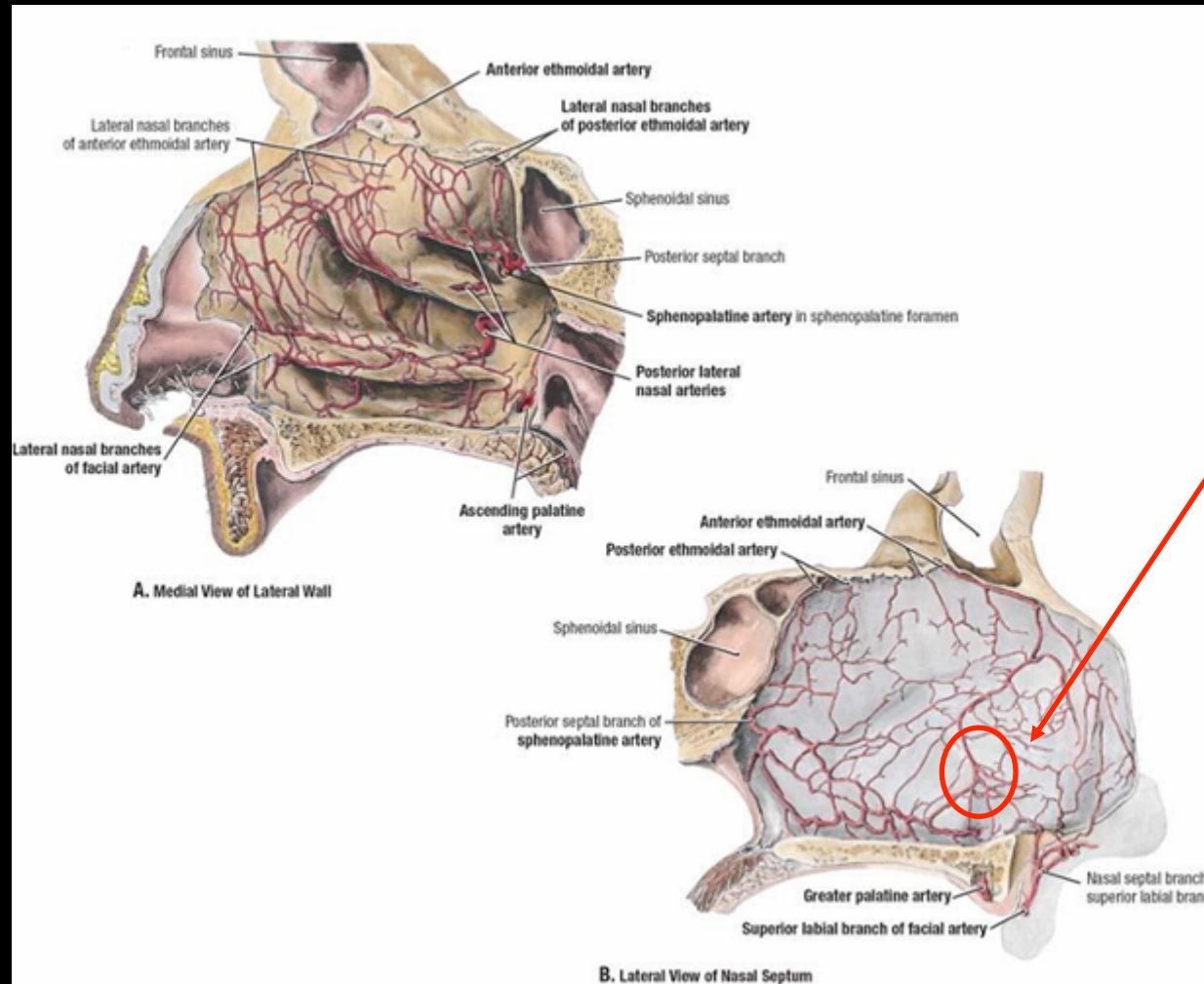


- ★ The maxillary sinus opening is high in its medial wall and clearance of mucous is dependent upon ciliary action, which may be compromised by infection, possibly leading to sinusitis.

A deviated septum may also predispose to sinusitis.



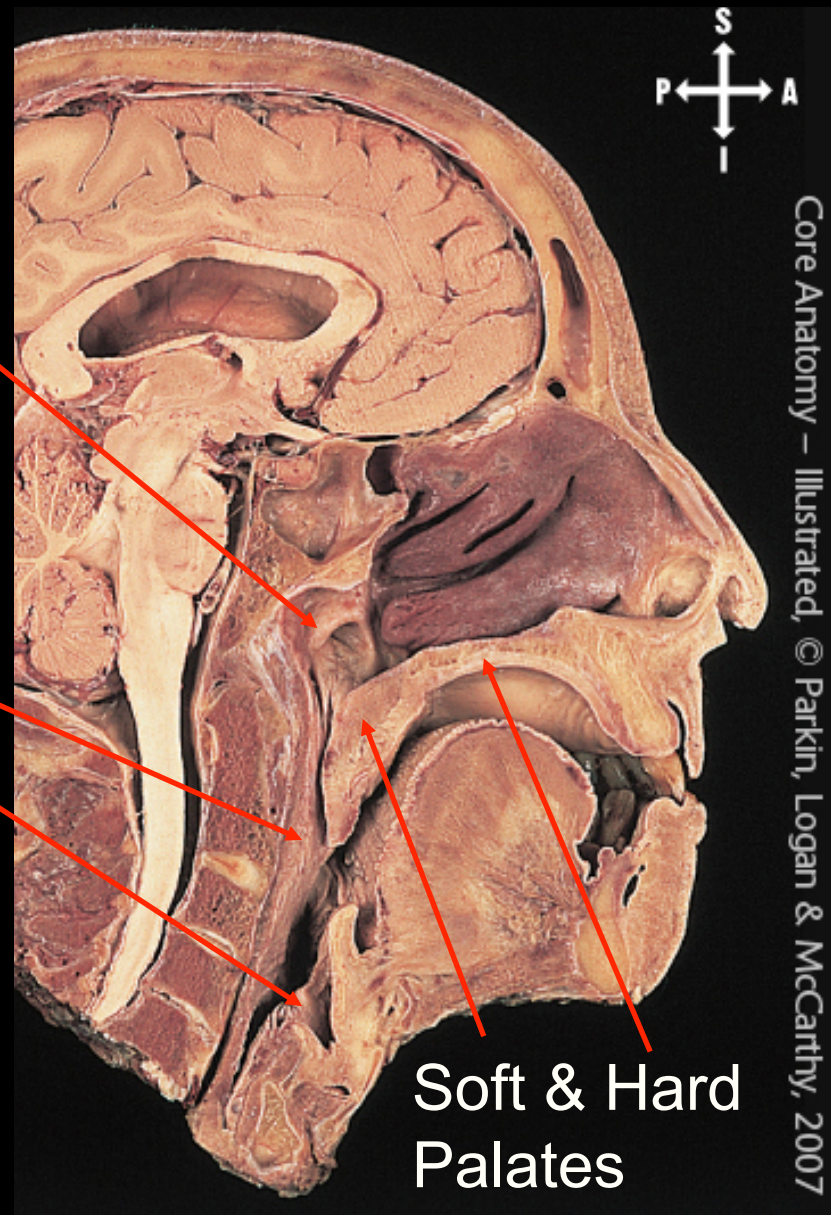
These two views show the high vascularity of the nasal mucous membrane. The vessels also form an anastomosis between the left, right, internal, and external carotids.

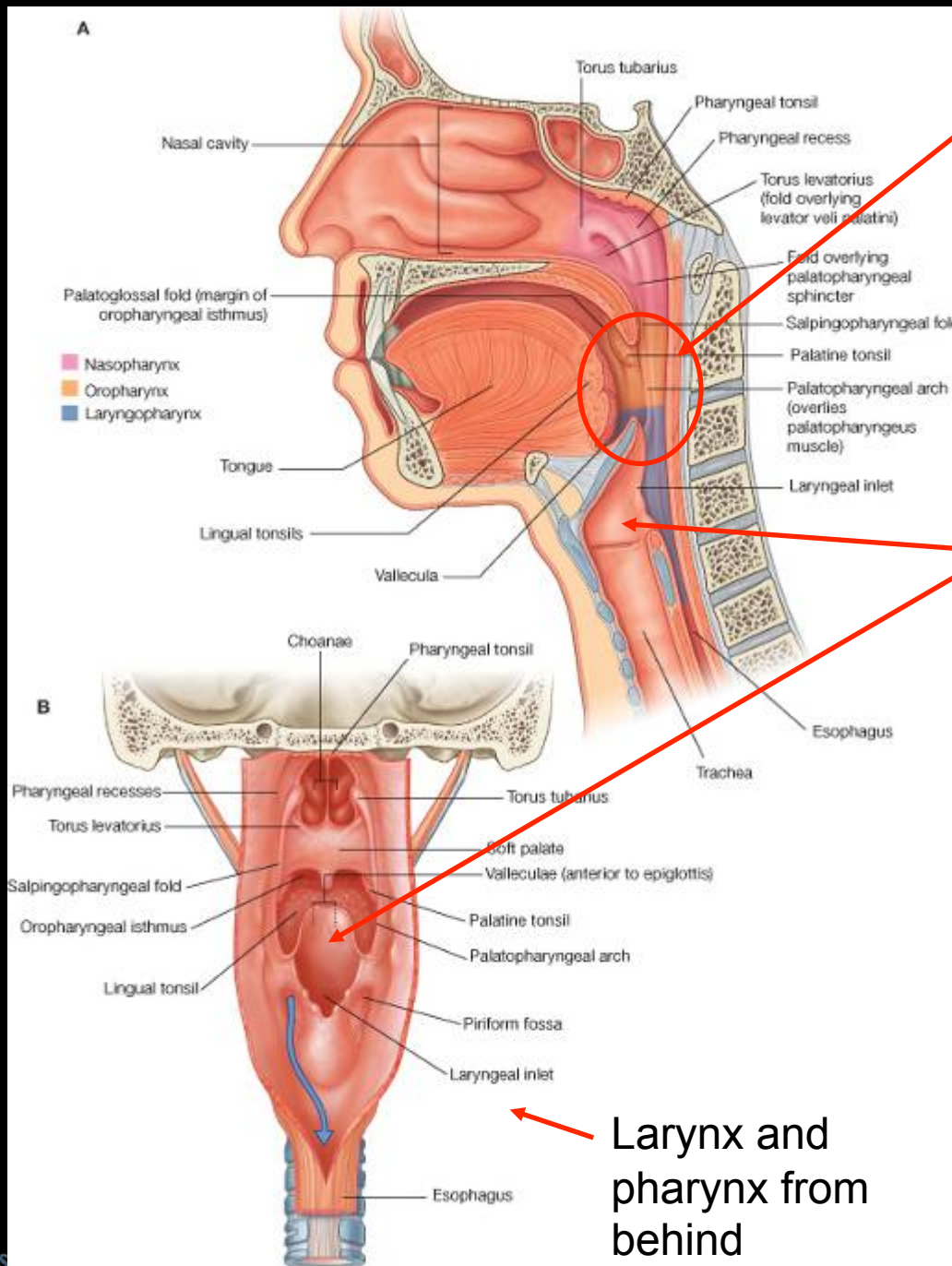


“Little’s Area” on the septum is a common site for epistaxis (nosebleed)

Inhaled air passes from the nasal cavity to the nasopharynx, which has protective, tonsillar tissue on its posterior wall (adenoid), then past the soft palate to the oropharynx before entering the larynx

The **Larynx** is a protective sphincter that prevents foreign bodies entering the airway.

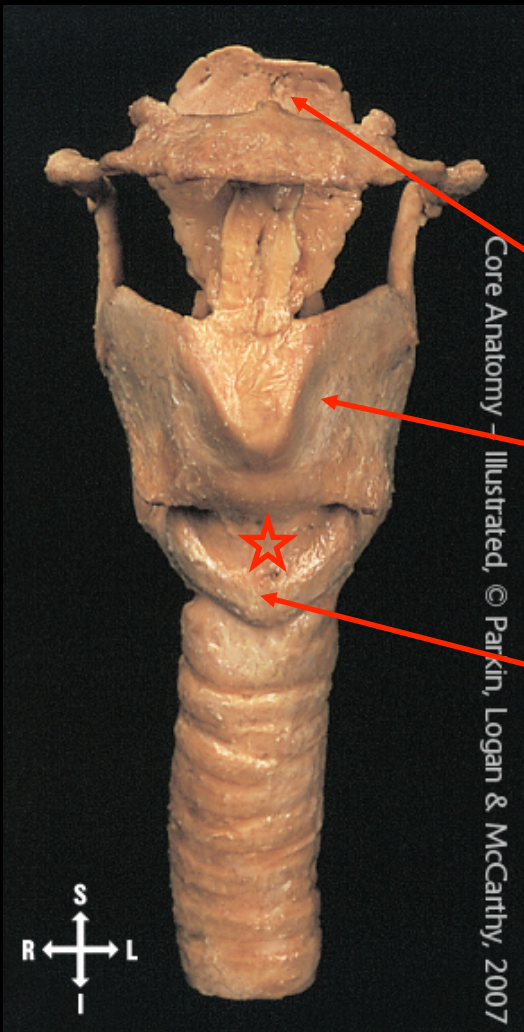




The oropharynx is a common pathway for air, food and fluid.

The Larynx amounts to a membranous tube suspended between cartilages, the positions of which are controlled by muscles, so that laryngeal diameters may be altered to allow the passage of air only, and also control airflow for speech.

Larynx and pharynx from behind



Larynx from front

Laryngeal Cartilages

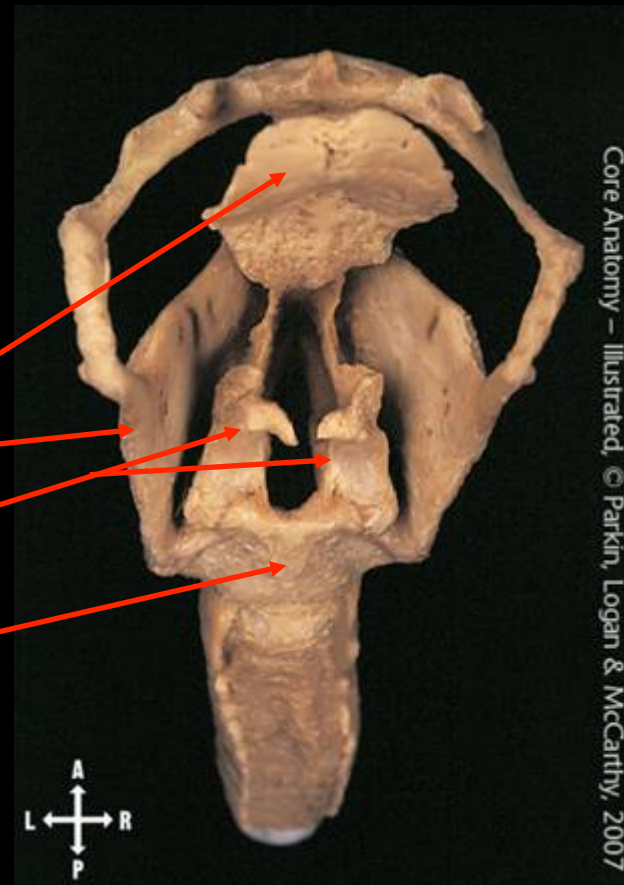
Epiglottic (elastic)

Thyroid

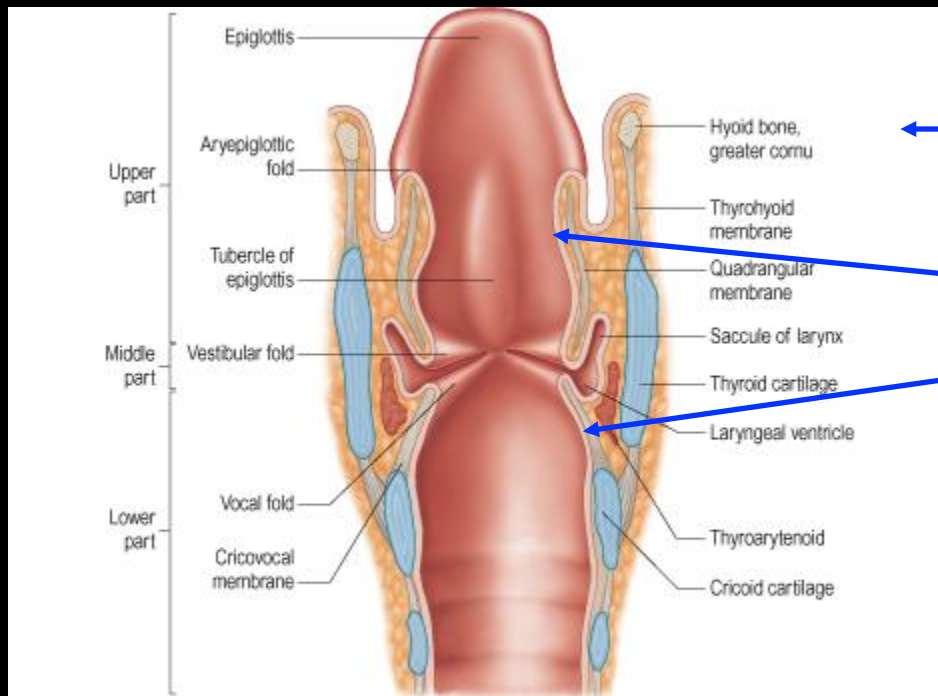
Arytenoid

Cricoid

★ Cricothyroid membrane, site of emergency access to the airway



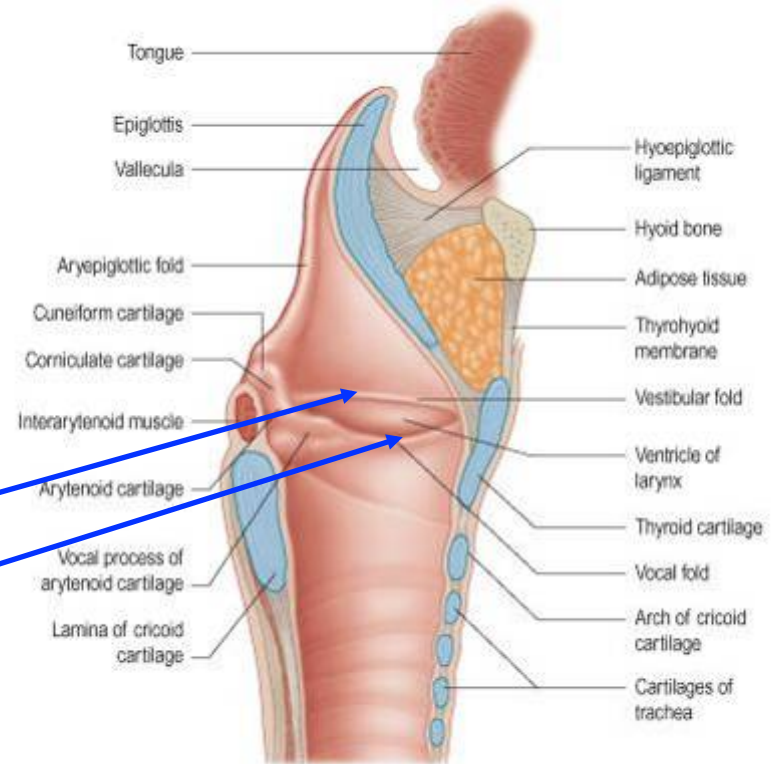
Larynx from behind



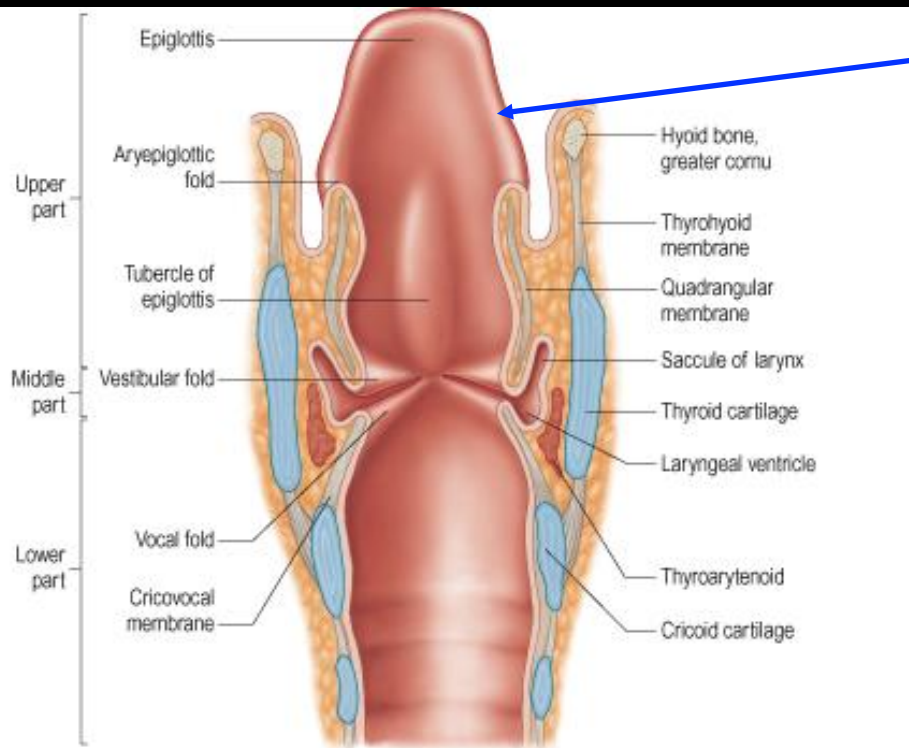
Coronal larynx to show arrangement of supportive cartilages, and membranes
Quadrangular Cricothyroid (vocal)

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Sagittal larynx to show vestibular fold and vocal fold



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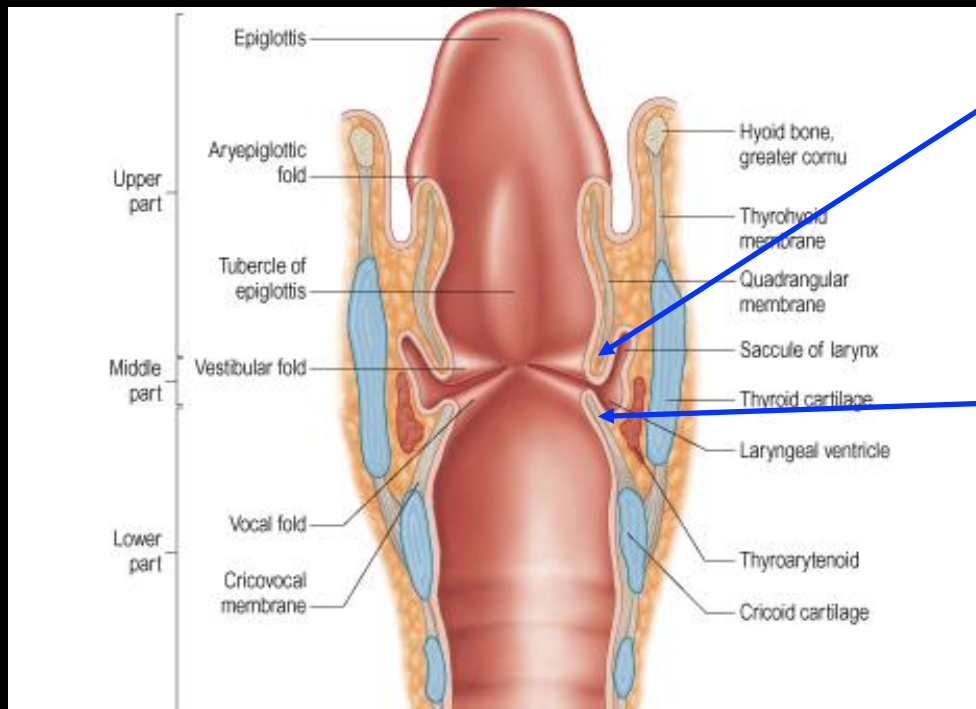
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Aryepiglottic folds on each side are the upper edge of the quadrangular membrane and they form the laryngeal inlet, which is the protective sphincter.

Closure of the inlet is by elevation of the larynx, which is lifted up and forward during swallowing.

Gently hold your own larynx (Adam's apple) between finger and thumb, then feel it rise when you swallow.

There are also muscles within the aryepiglottic folds that aid both closure and widening of the laryngeal inlet.



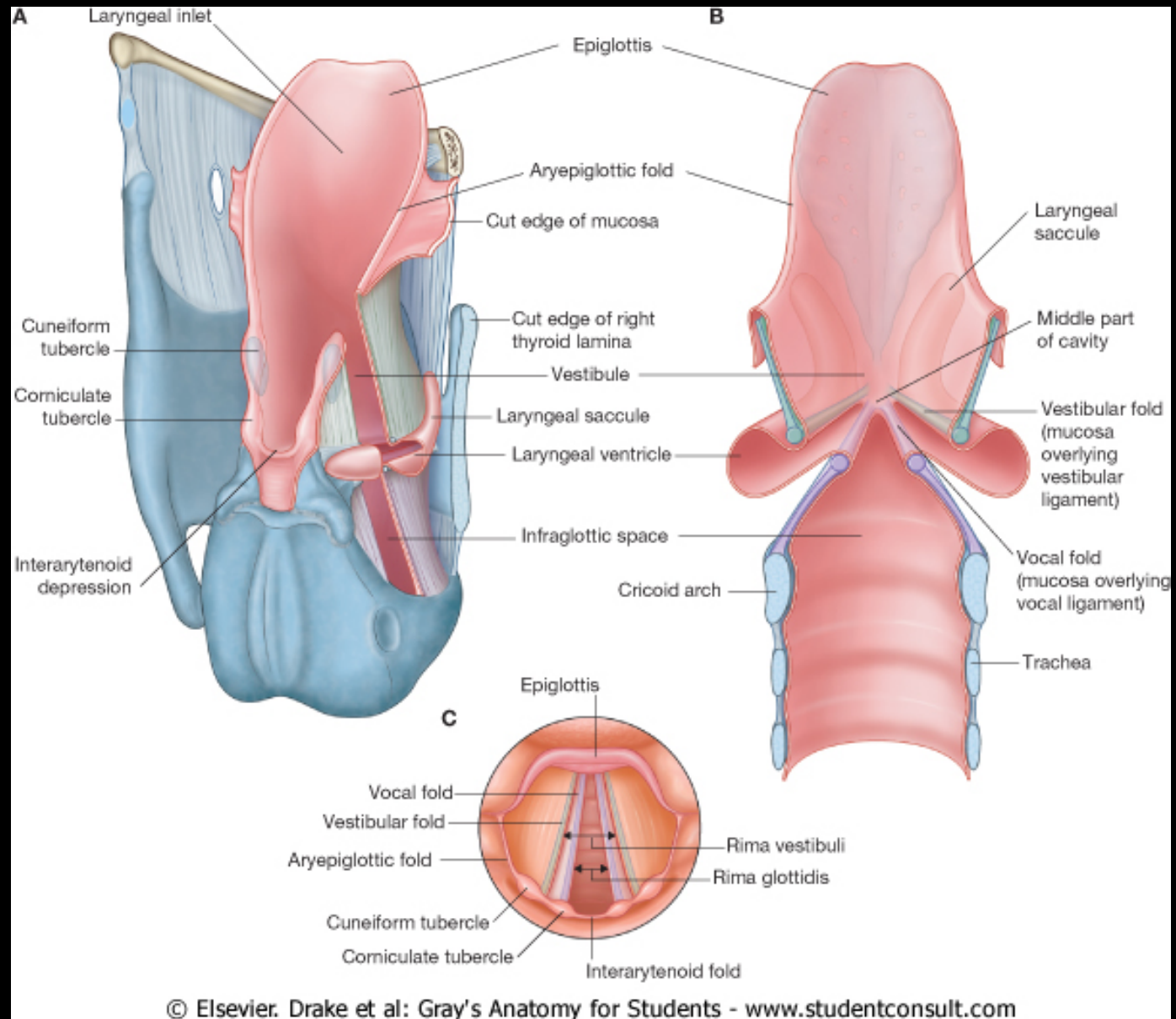
Vestibular or false vocal folds on each side are the lower edge of the quadrangular membrane.

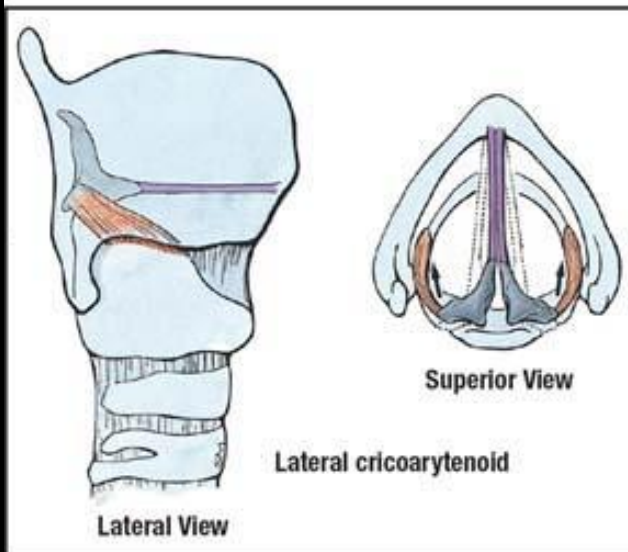
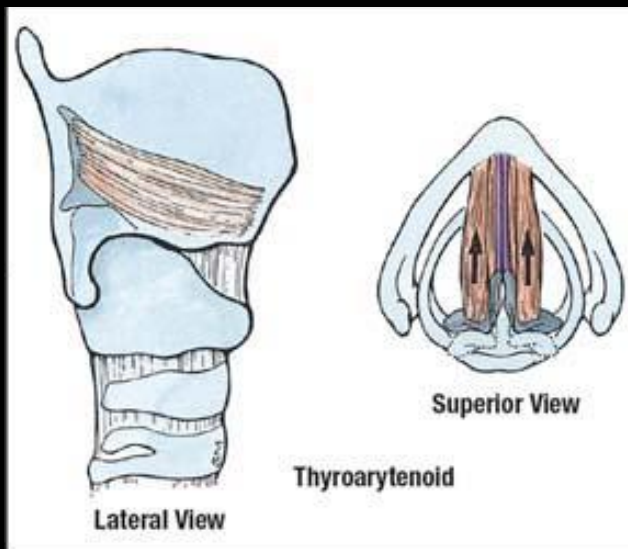
Vocal folds (cords) on each side are the upper edge of the cricothyroid or cricovocal membrane.

The vocal folds control laryngeal diameter for: speech, coughing, sneezing and raising the intra-abdominal pressure, which is vital in parturition, micturition, defecation and lifting heavy objects.

Muscles within and adjacent to the vocal folds narrow or widen the opening between them (rima glottidis), or alter their tension.

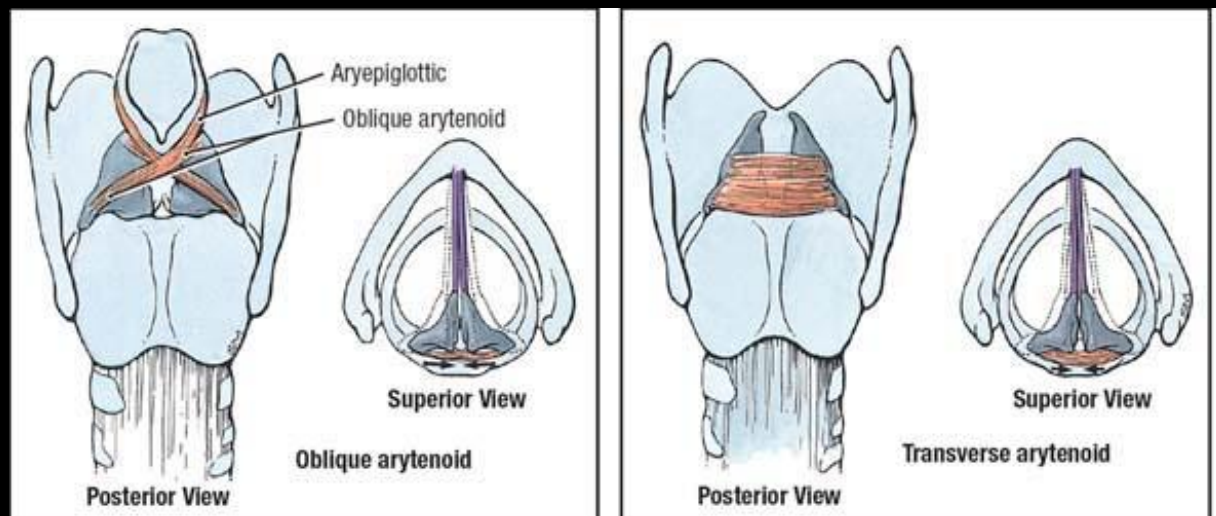
The ventricle of the larynx is between the vestibular and vocal folds and leads to the saccule, which is to provide lubricating mucus for the vocal folds.

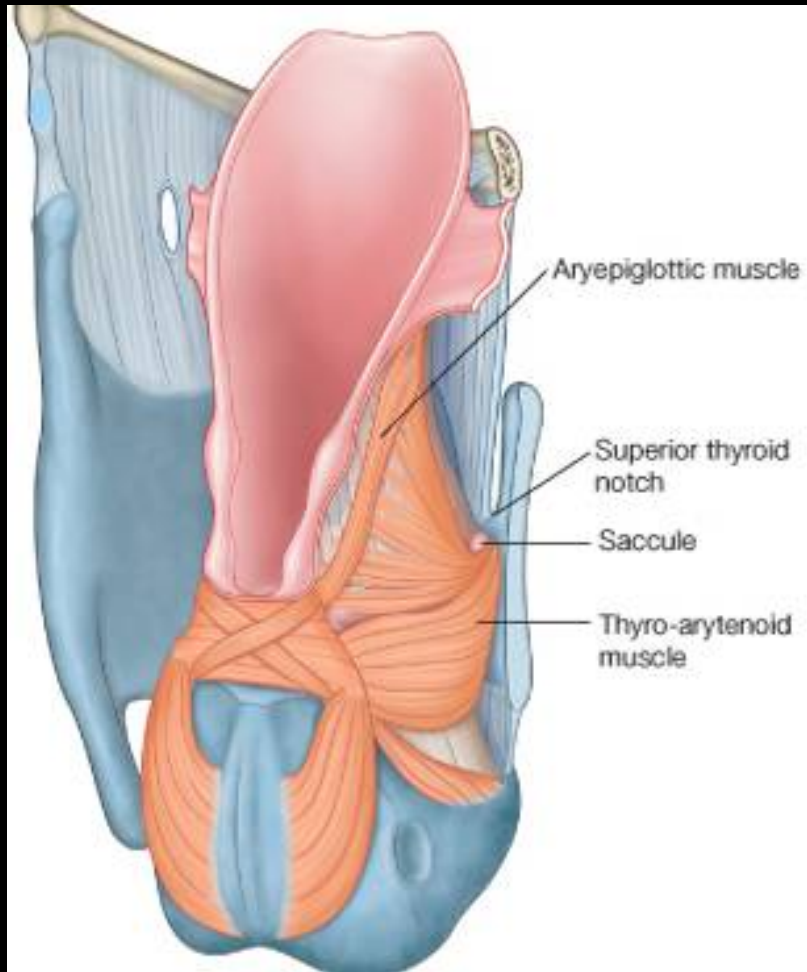




Consider muscles to:

1. Close/open the inlet (aryepiglottic folds)
2. Close/open the rima glottidis (arytenoid gliding and rotation)
3. Shorten/lengthen the vocal folds (“rocking” at cricothyroid joints)





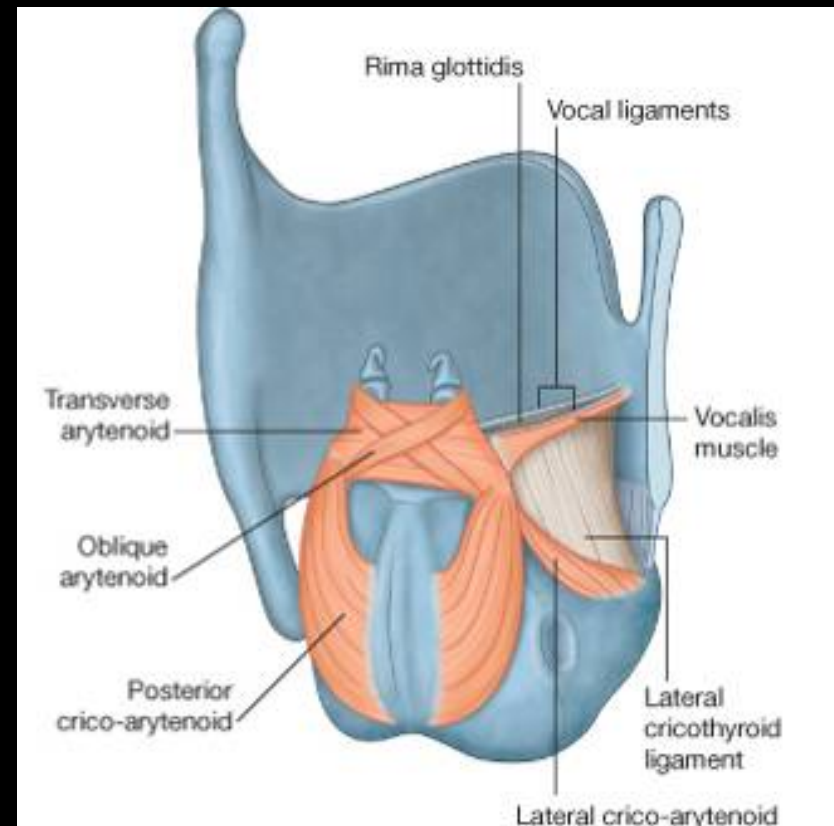
Close inlet: **elevation** and aryepiglotticus

Open rima: posterior crico-arytenoid (glide/rotate)

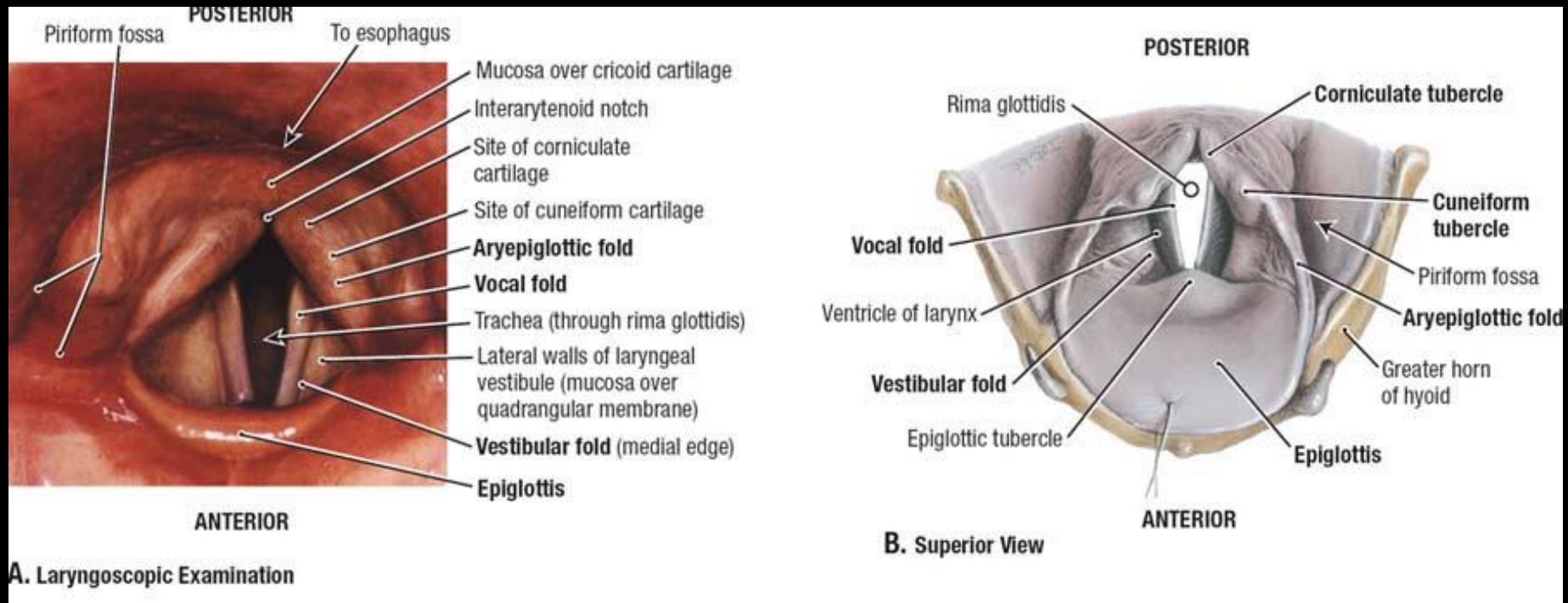
Close rima: trans arytenoid and lat. crico-arytenoid.

Lengthen folds: cricothyroid

Shorten folds: thyro-arytenoid



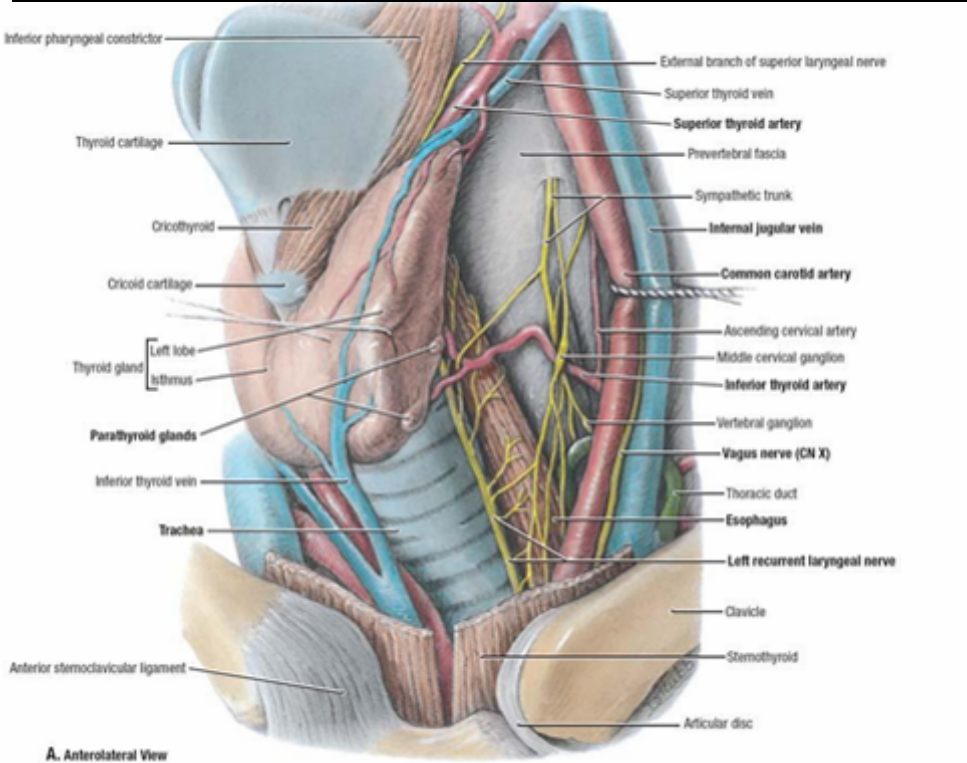
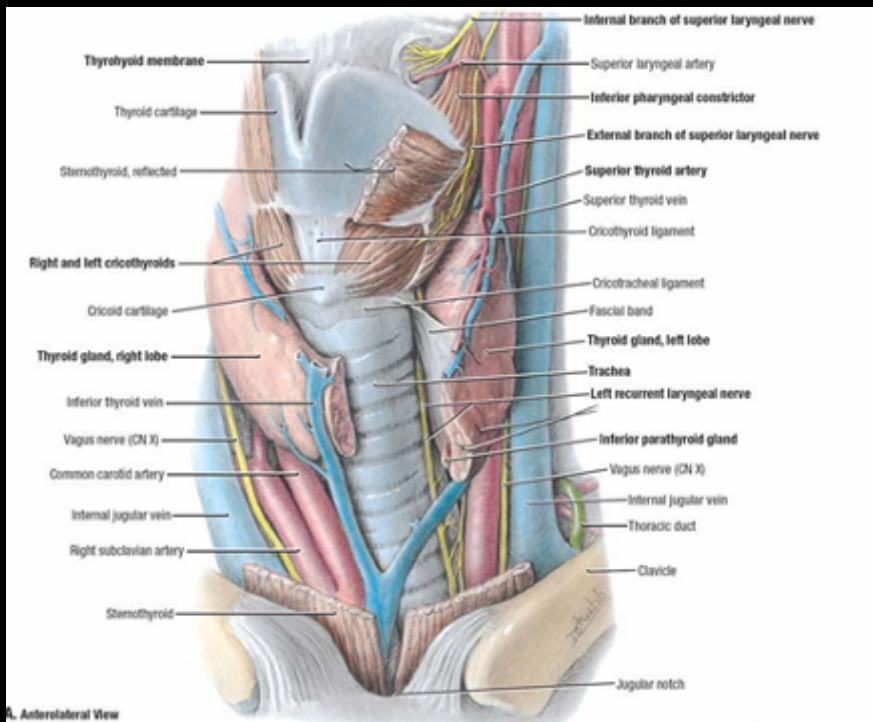
Laryngoscopic and superior views of the larynx to show the inlet (aryepiglottic folds, **SPHINCTER**) and vocal folds (raising intra-abdominal pressure, speech, coughing, sneezing).



Laryngeal Innervation

Sup. Lar: Cricothyroid (ext.)
and sensation above cords

Rec. Lar: All other muscles,
sensation of cords and below



Sup. laryngeal nerve and
sup. thyroid artery

Recurrent laryngeal nerve
and inf. thyroid artery

Laryngeal nerves may be at risk during thyroid surgery



Core Anatomy – Illustrated, © Parkin, Logan & McCarthy, 2007

Trachea

C-shaped rings of hyaline cartilage supporting a fibro-elastic and muscular air-transport tube

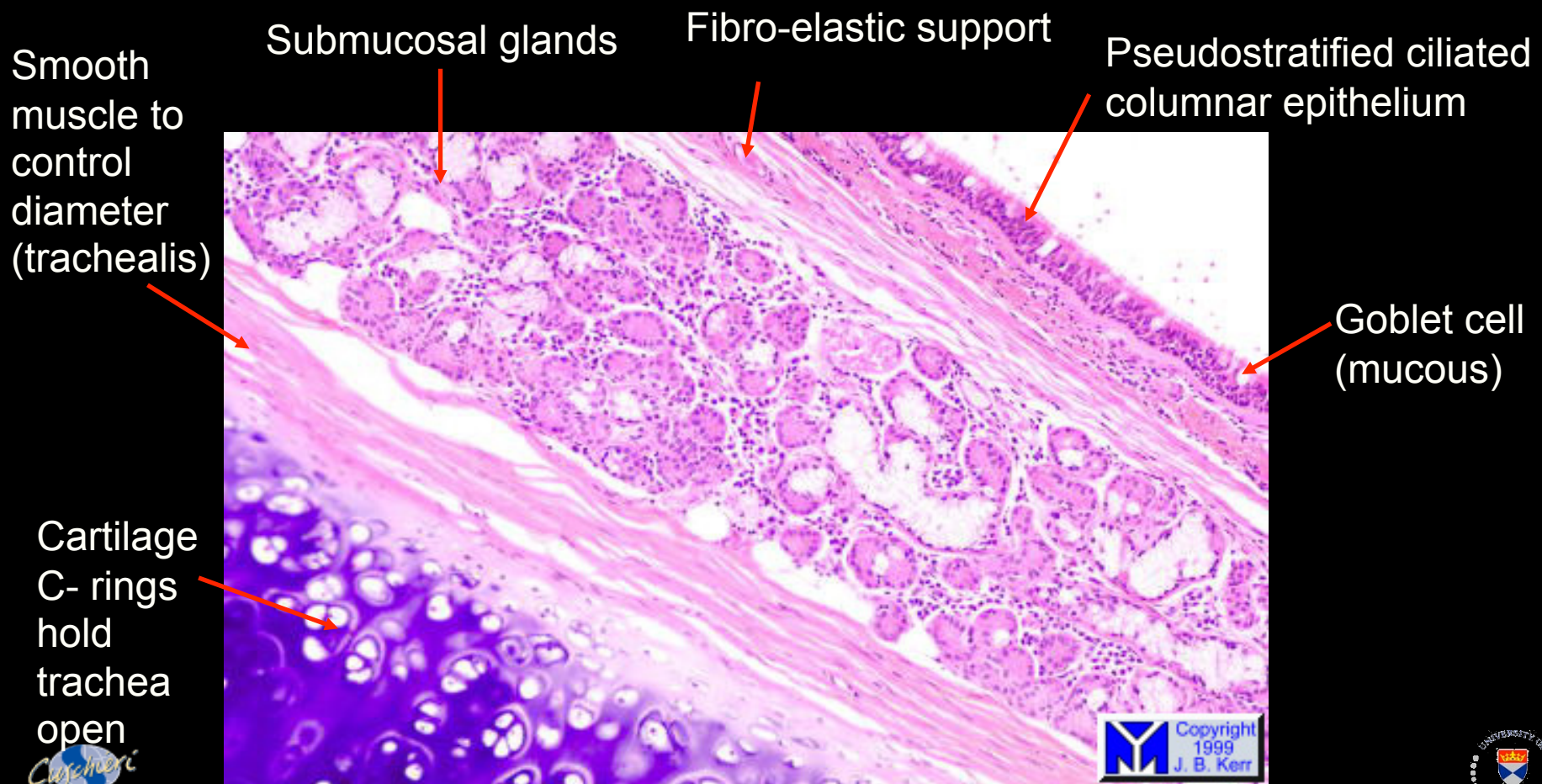
Starts at C6, ends at T 4/5 at carina

Right main bronchus shorter, wider, more vertical than left

Trachealis alters tracheal diameter

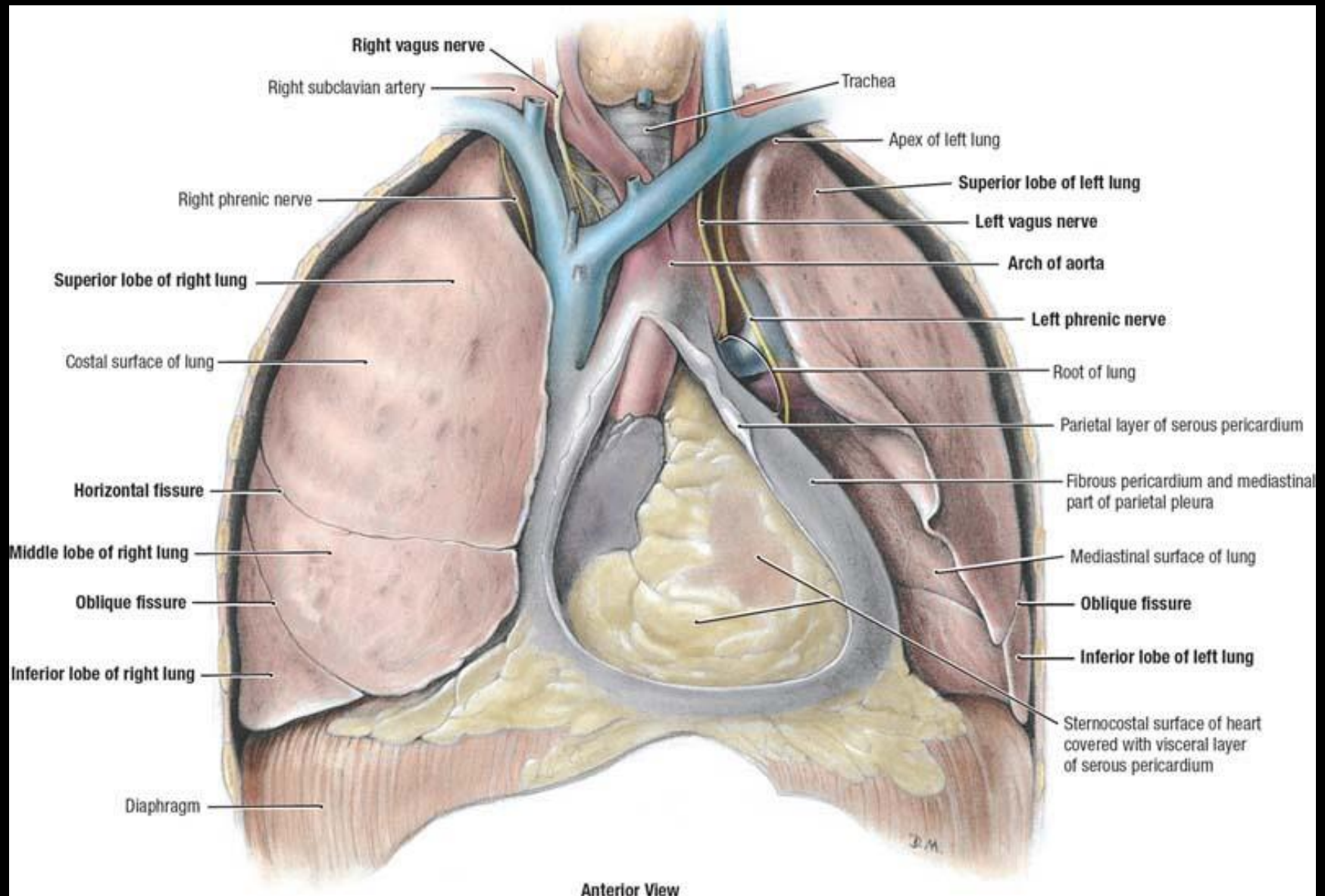
Palpable anteriorly in midline of neck

The trachea typifies the conducting system. The cilia are paralysed by cigarette smoke. At rest, smooth muscle contraction decreases tracheal (and bronchial) diameter to decrease respiratory dead space.

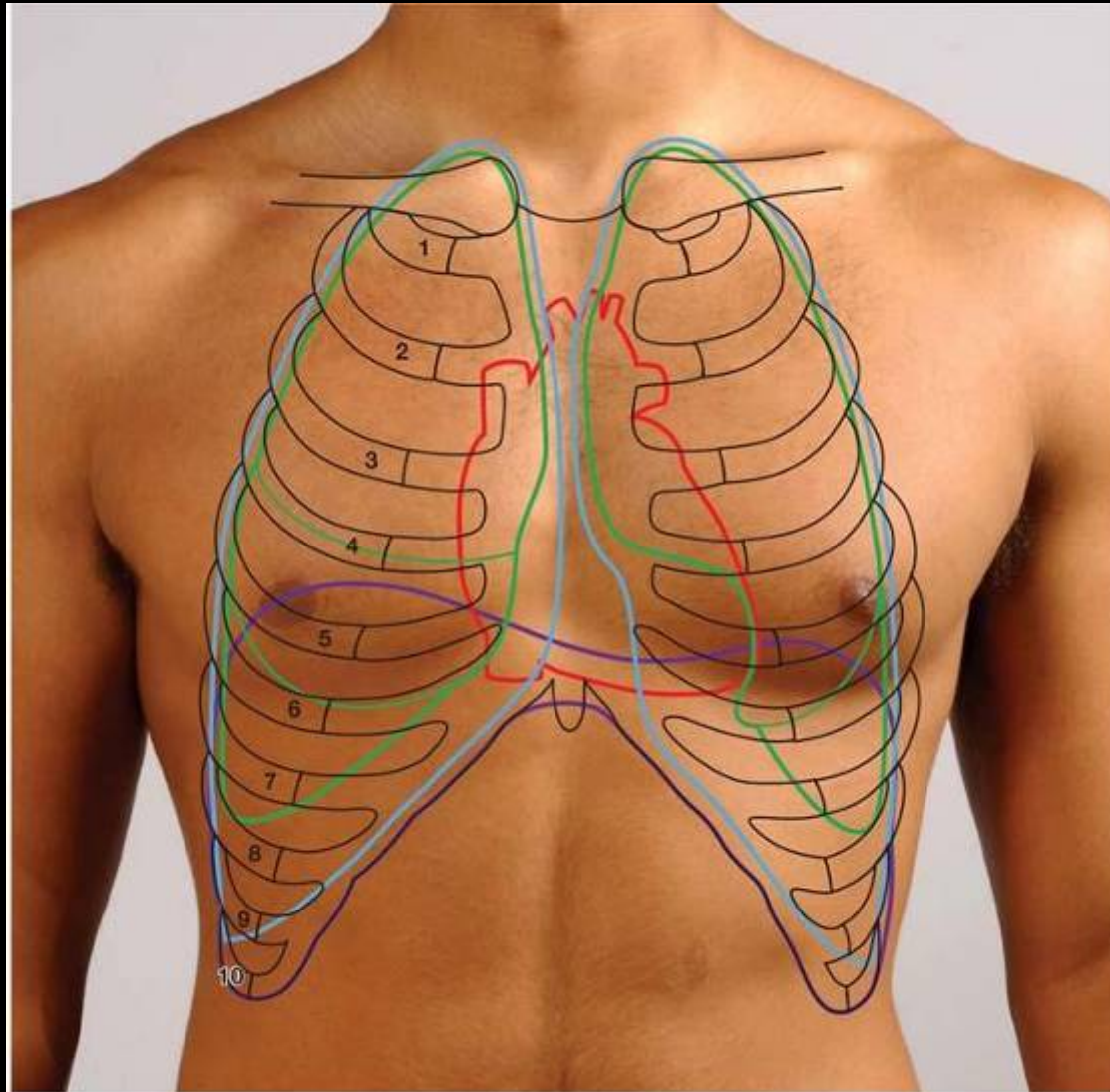


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Lungs and Pleural Cavities



Anterior View

Surface anatomy of heart and lungs:

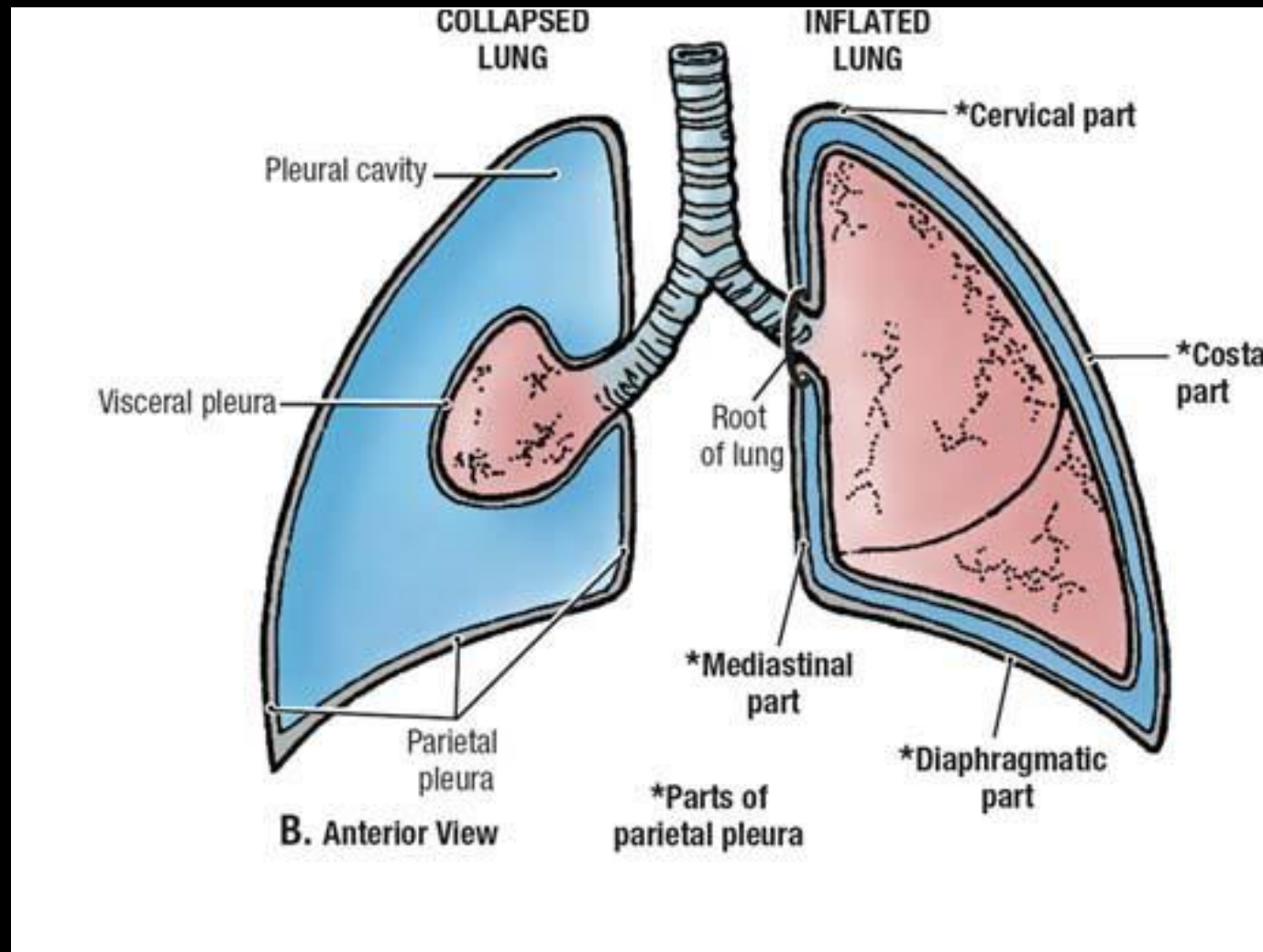
Heart – red

Pleura – blue

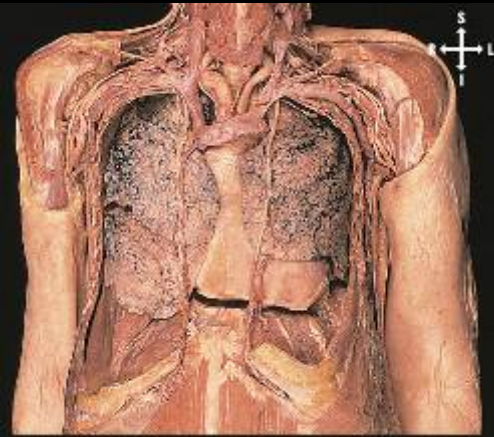
Lungs – green

Note the extent of the pleural cavities, one on each side with the mediastinum in the middle. In quiet respiration the lungs do not reach the lower parts of the pleural cavities.

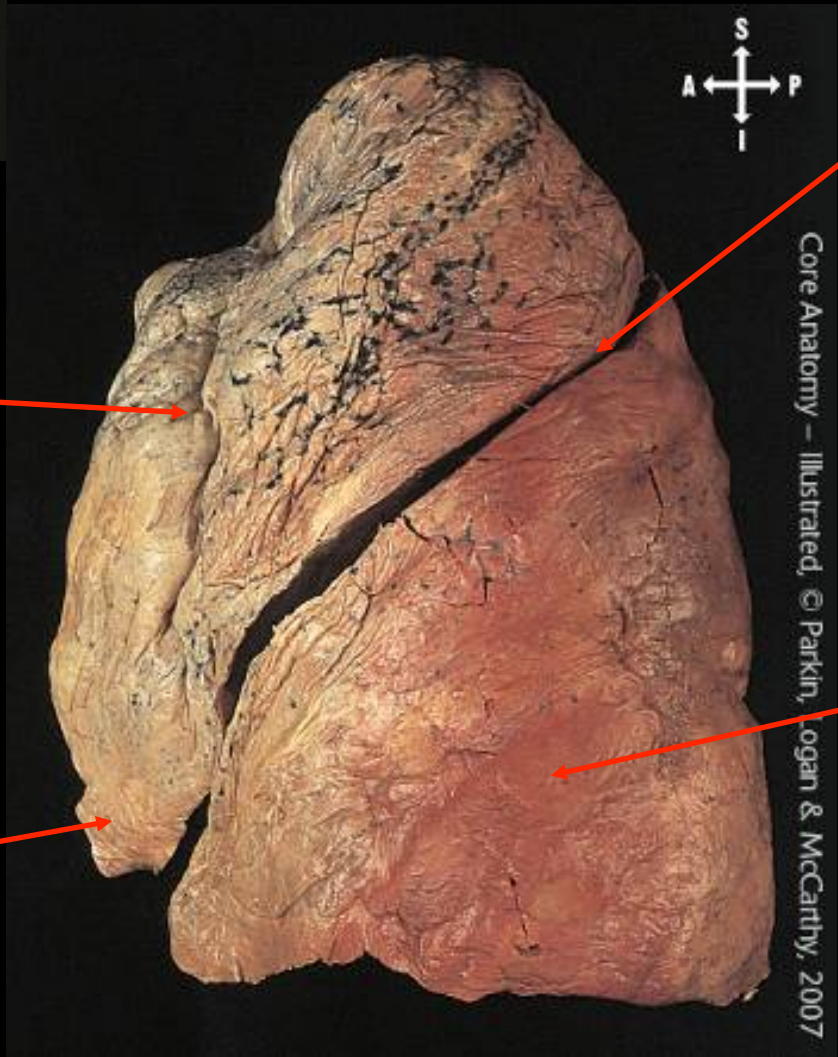
The left and right pleural cavities have Visceral and Parietal layers which are continuous with each other and effectively a balloon that forms a lubricated potential space for movement.



Left Lung, lateral view



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Upper Lobe

Lingula

Oblique Fissure

Lower Lobe

Left Lung, mediastinal surface and hilum

Pulmonary Artery

Left Main Bronchus

Lower Lobe



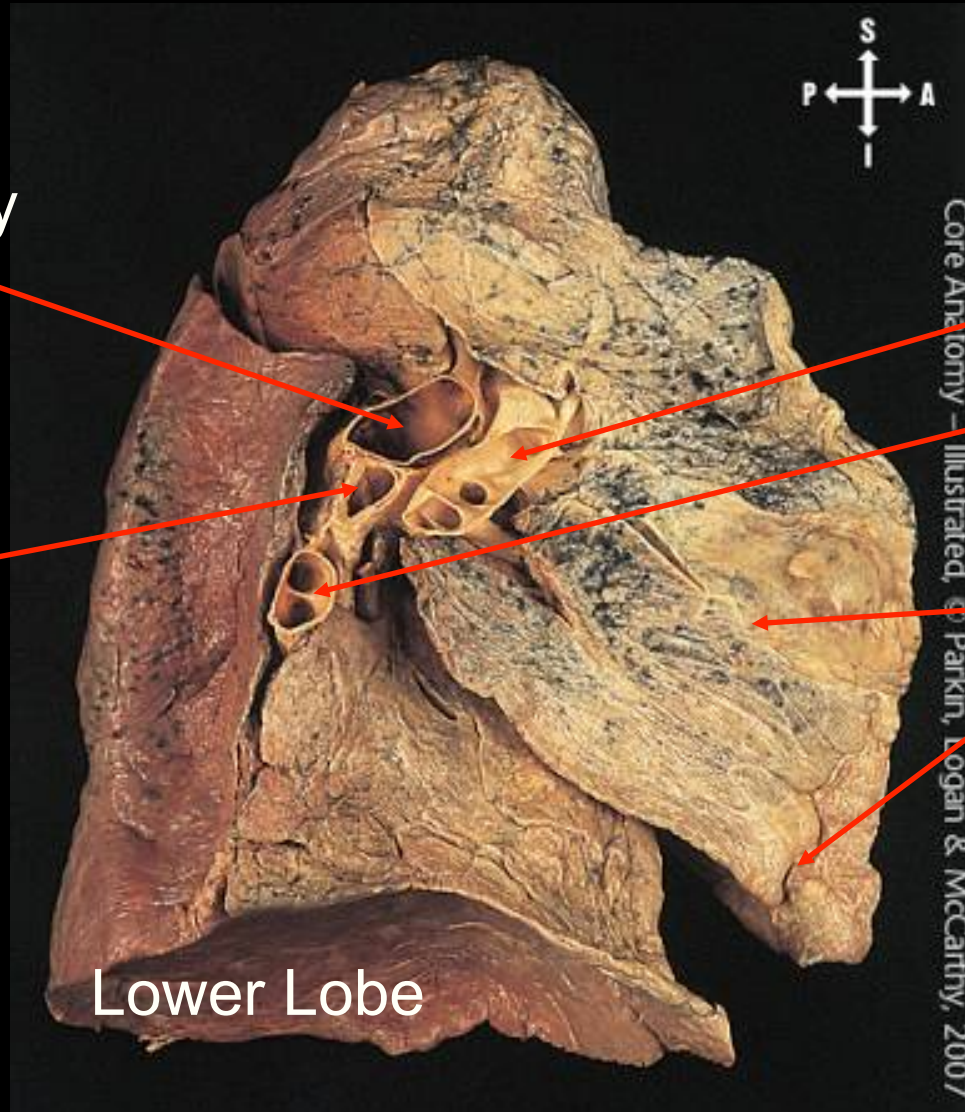
Pulmonary Veins

Superior

Inferior

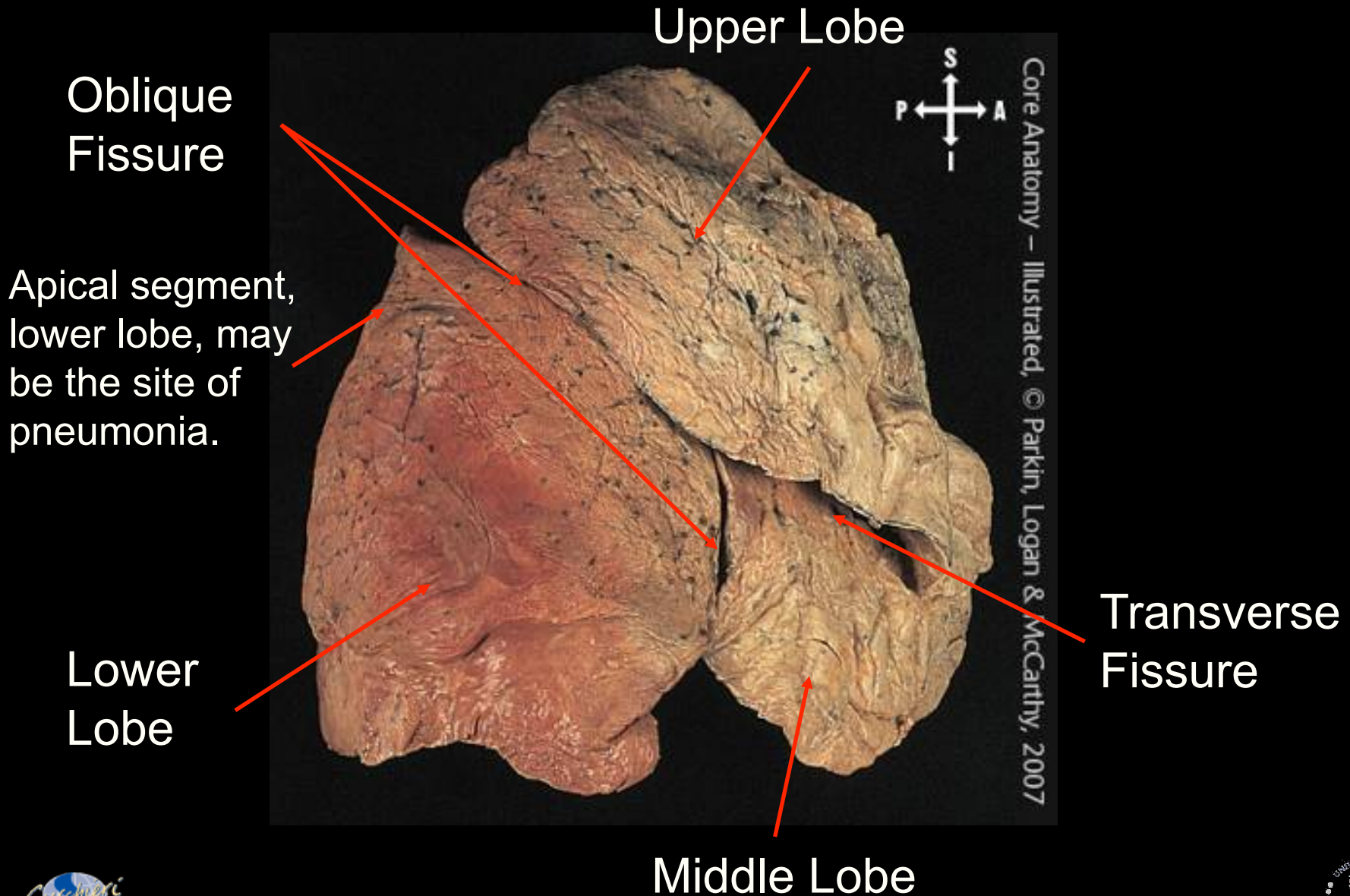
Upper Lobe

Lingula



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Right Lung lateral view



Right Lung, mediastinal surface and hilum

Pulmonary
Arteries

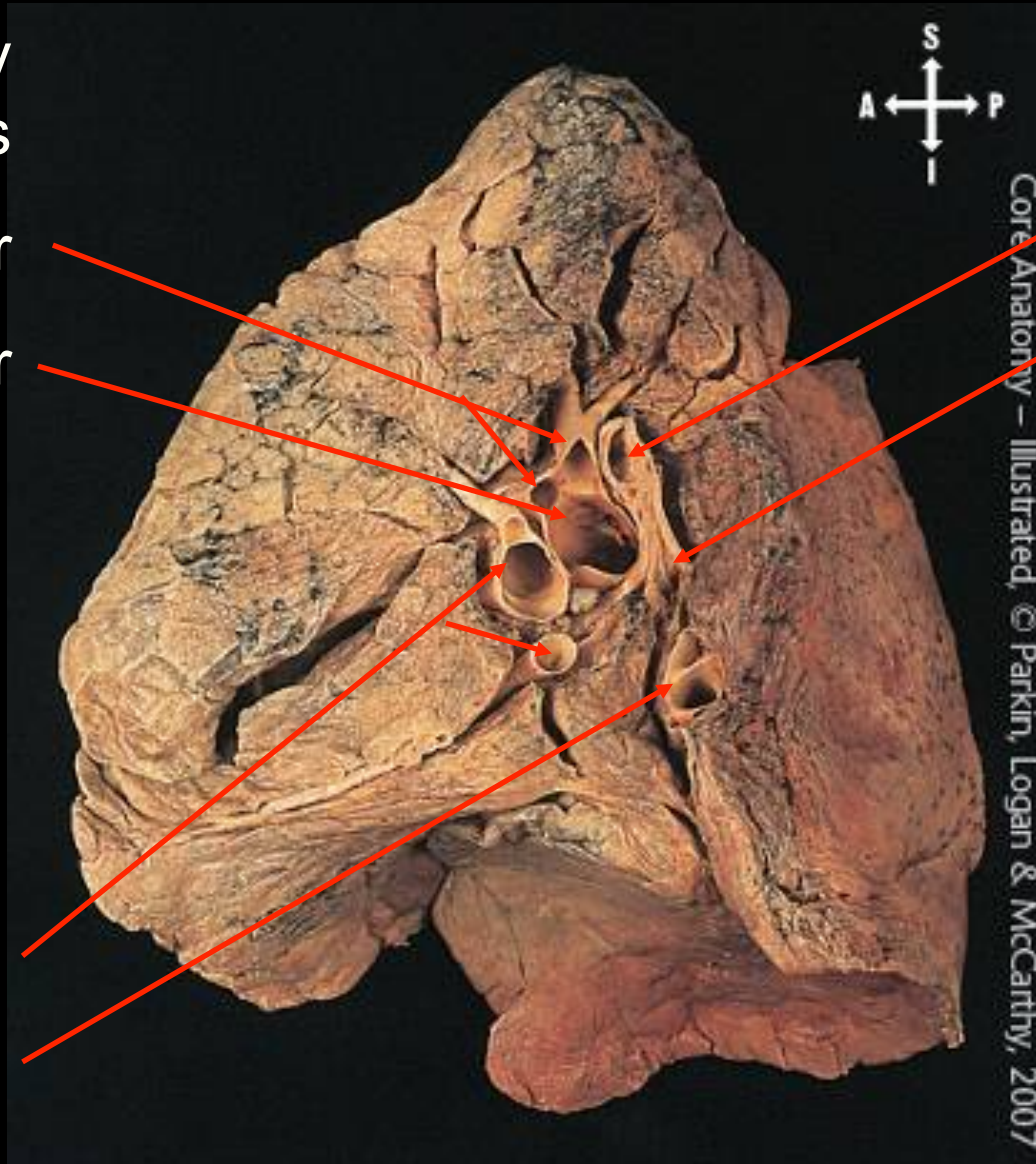
Superior

Inferior

Pulmonary
Veins

Superior

Inferior

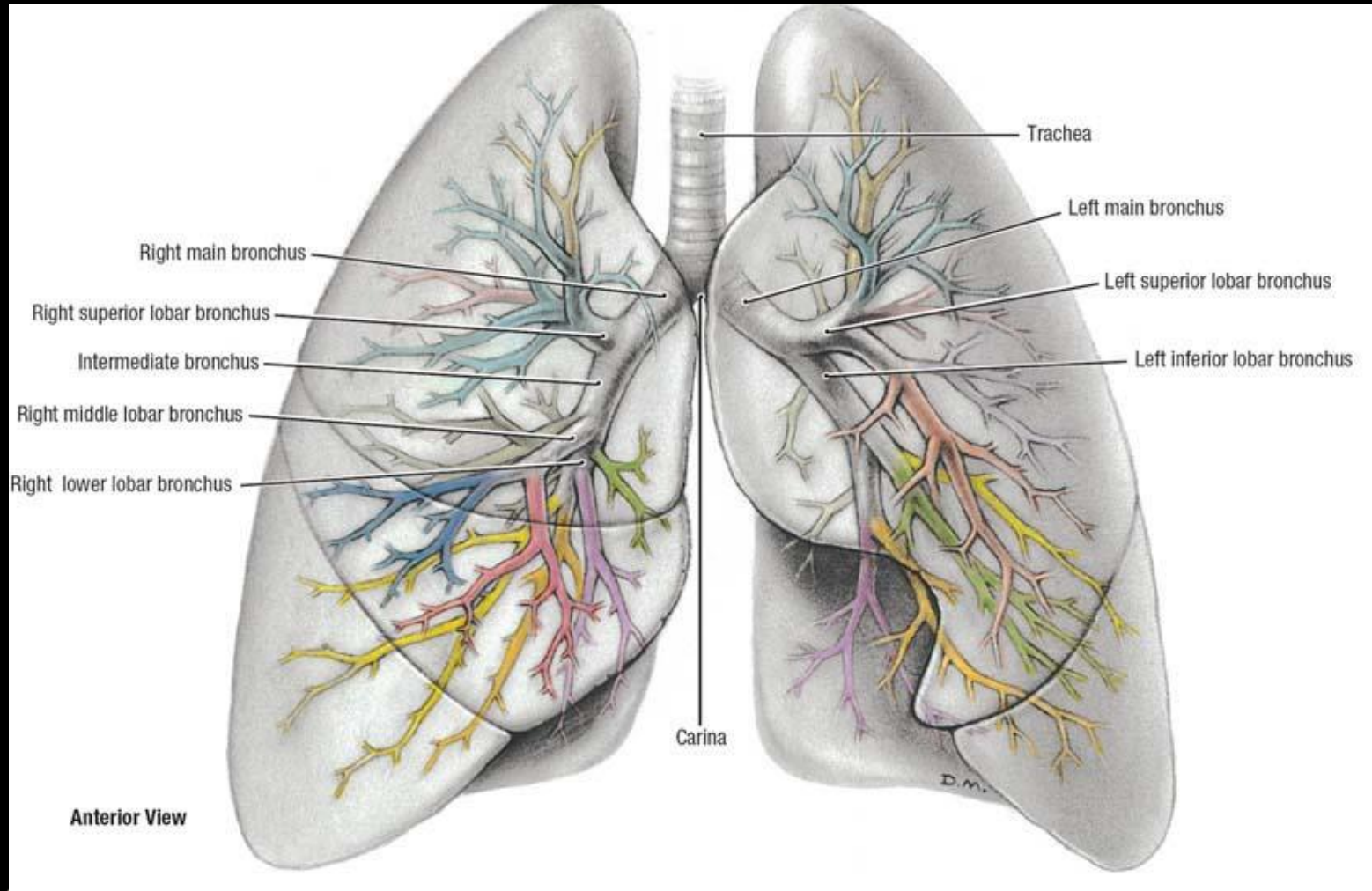


Right Main
Bronchi

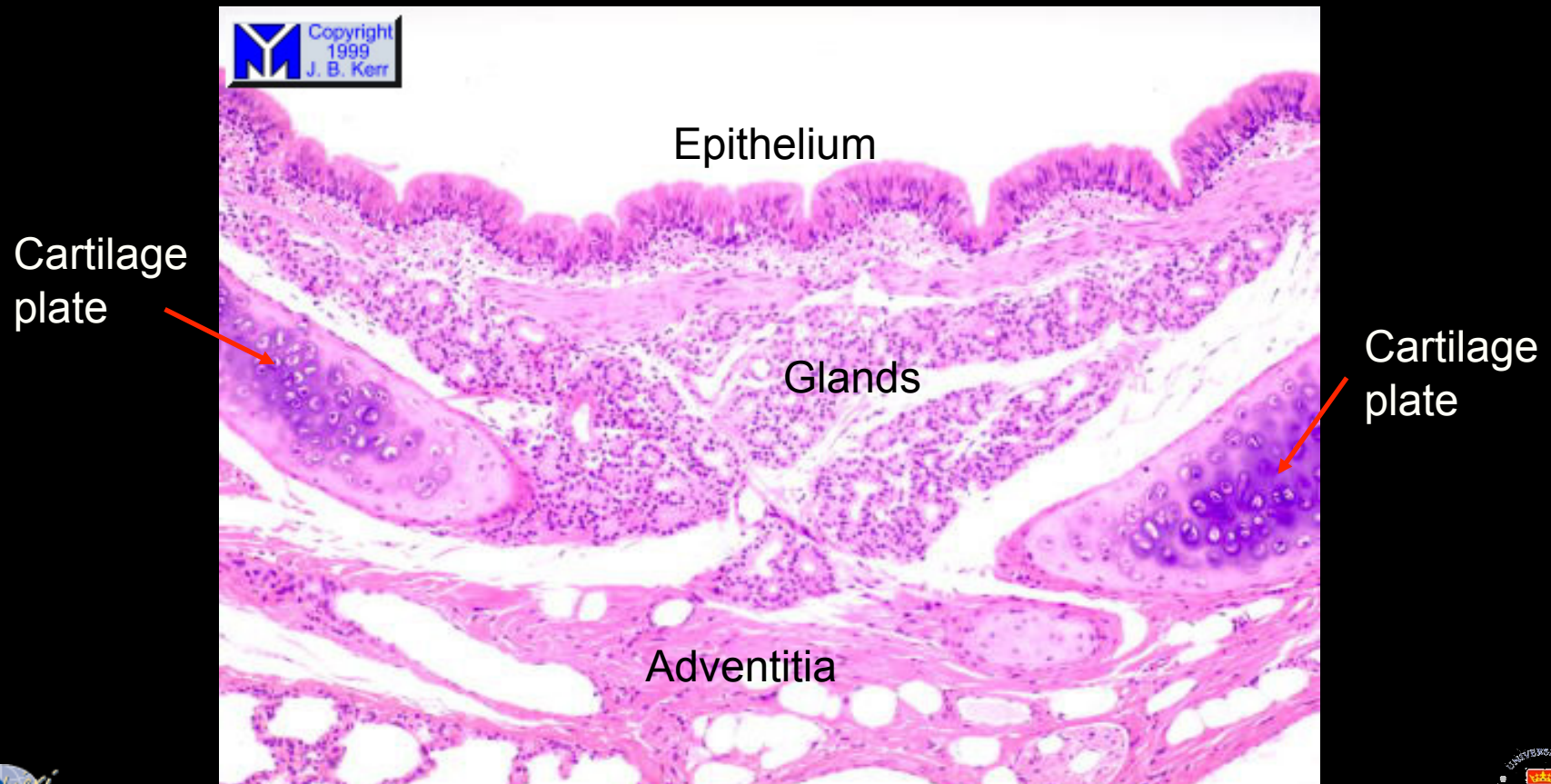
Superior

Inferior

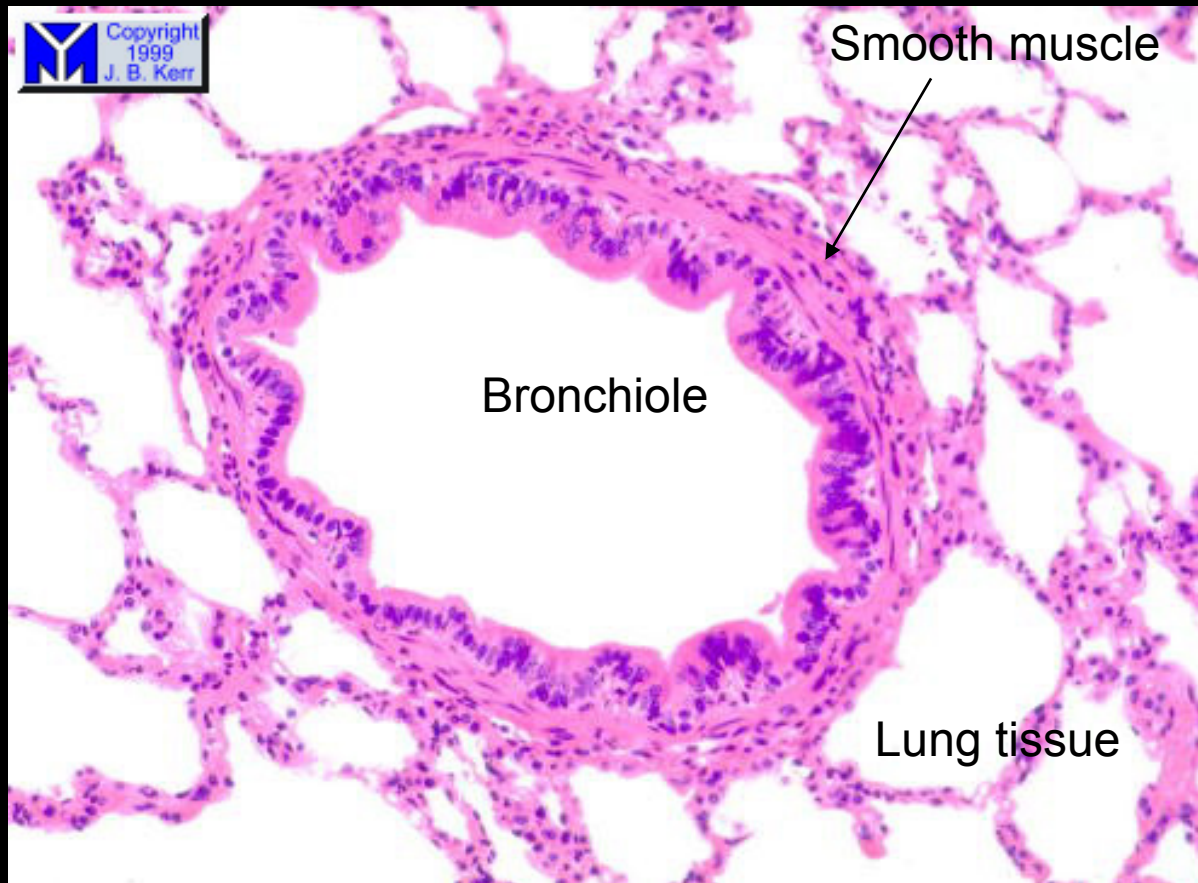
The Bronchi divide like a tree into the lung substance, decreasing in diameter to become terminal and then respiratory bronchioles, and finally alveoli.



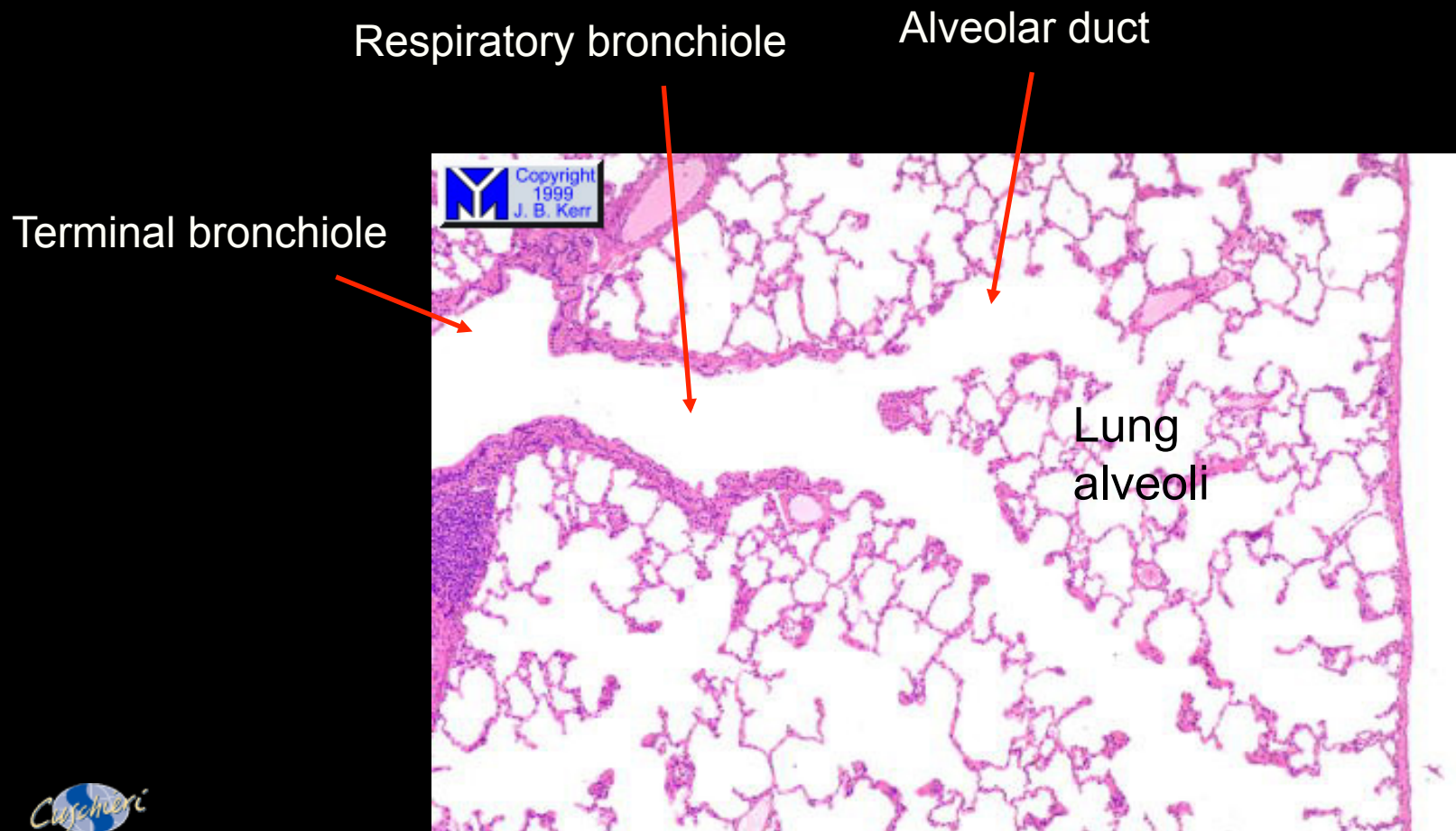
The bronchus is similar in structure to the trachea, but branching into the lungs, and the C-shaped cartilage rings are replaced by plates. The epithelium is still pseudostratified, ciliated columnar, but height decreases.



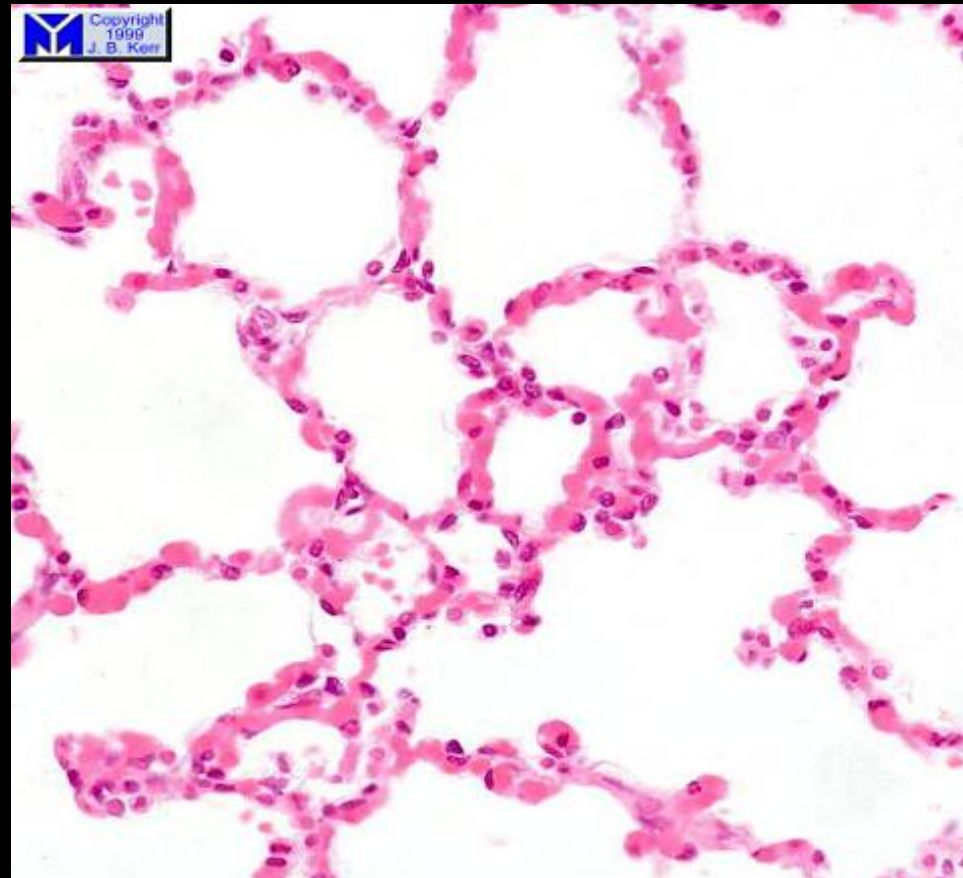
The bronchial tree divides and eventually forms **bronchioles** with a lumen of 1mm or less in diameter. The epithelium becomes ciliated columnar. Cartilage and glands disappear and the bronchiole is held open by the surrounding lung tissue. The smooth muscle in the wall may excessively narrow the lumen in asthma.



In the Terminal and Respiratory Bronchioles the epithelium becomes non-ciliated cuboidal and goblet cells disappear. Gas exchange begins to occur in the respiratory alveoli that bud from the respiratory bronchioles.

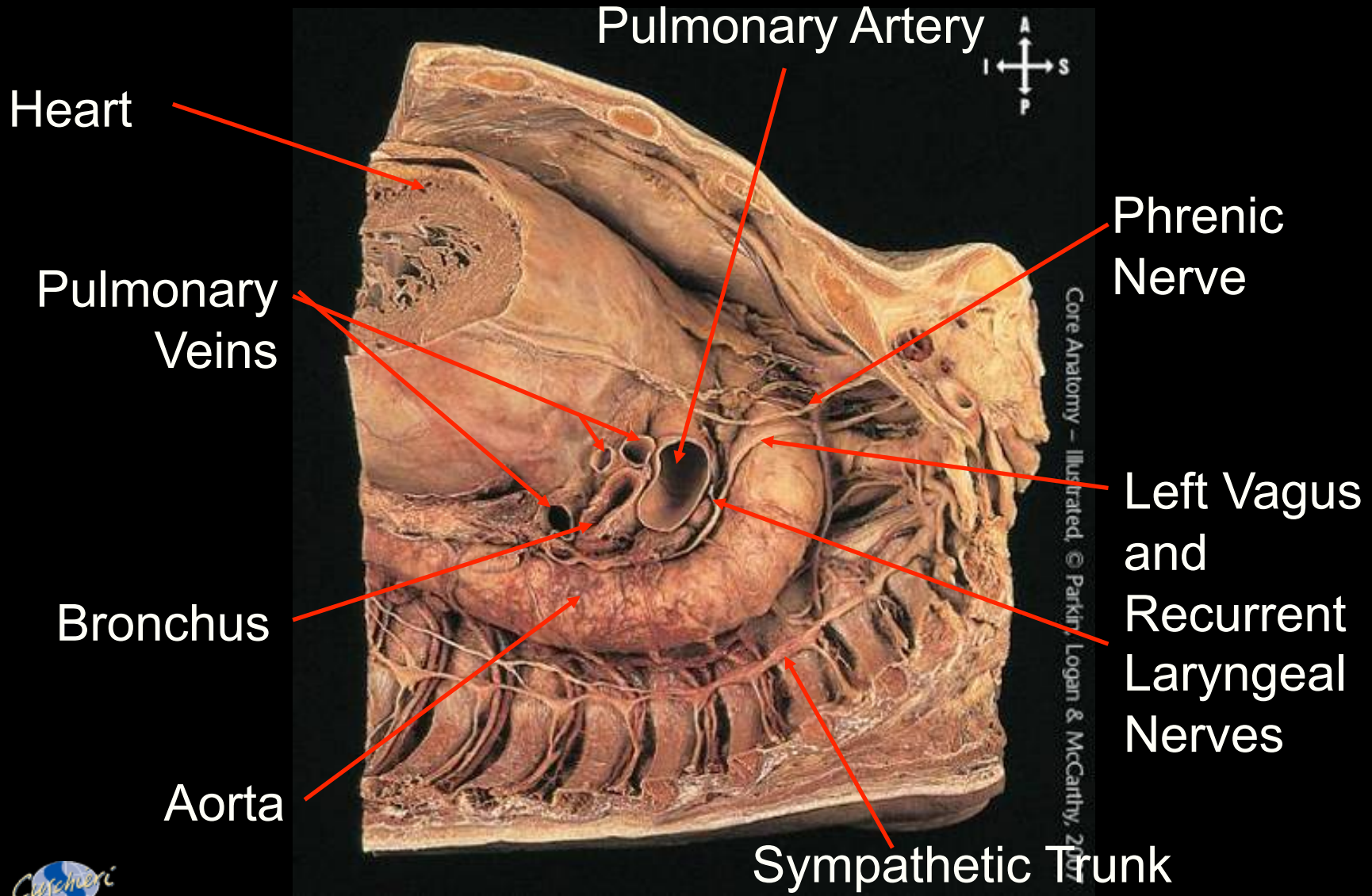


The **alveoli** are the functional unit of the **lung** where gaseous exchange takes place. They are outpocketings of respiratory bronchioles, alveolar ducts and alveolar sacs. The most conspicuous feature of the alveolar wall is the presence of many small capillaries in the septae between them. Opposite the septae the alveoli are open to allow air entry.

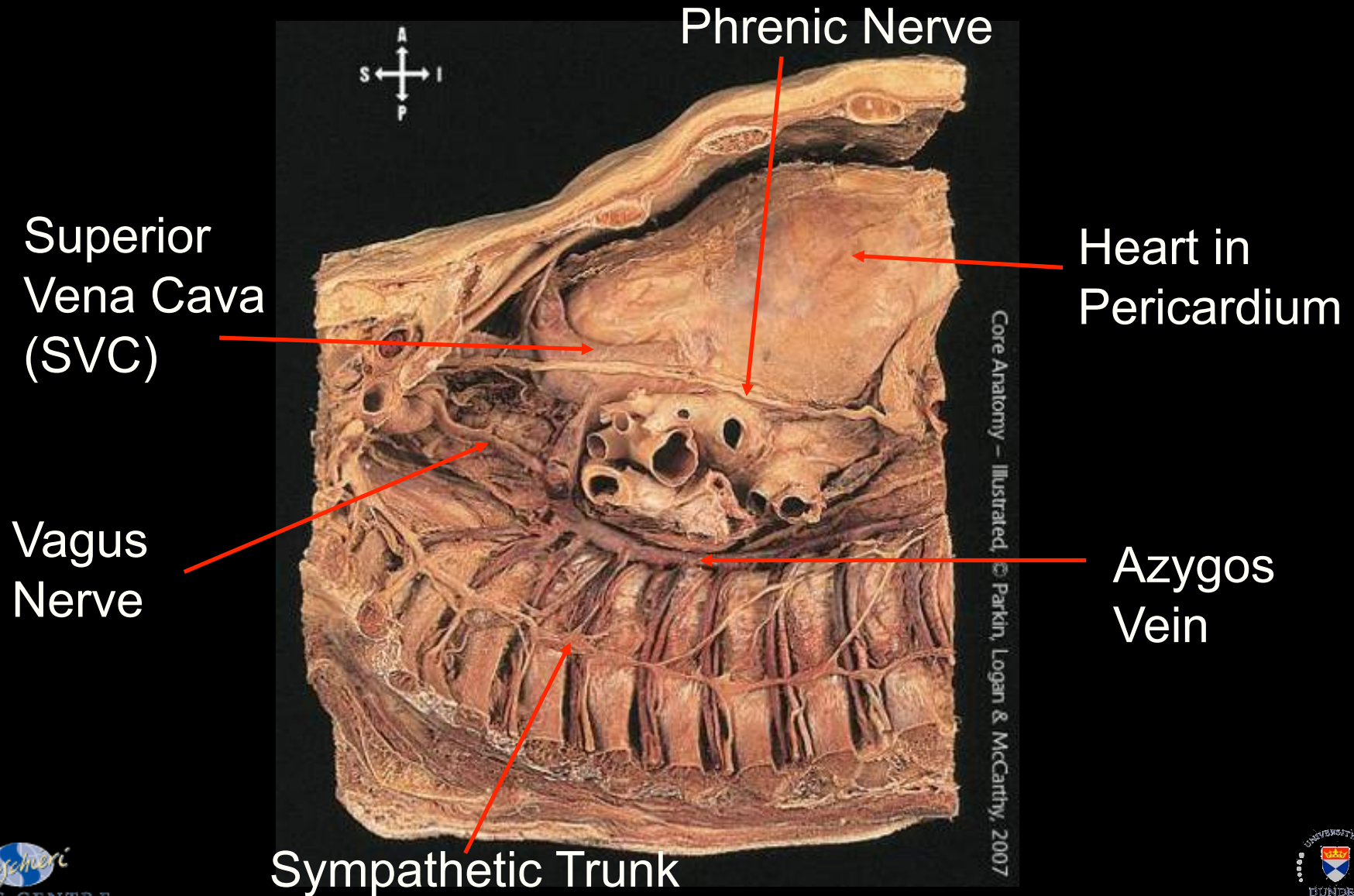


- Pulling the plunger out of a bicycle pump sucks air through the nozzle; similarly, increasing thoracic diameter by raising the ribs or lowering the domes of the diaphragm sucks air through the nasal (or oral) cavity, down the airway and into the lungs via the bronchi.
- De-oxygenated blood enters the lungs from the right ventricle via the pulmonary arteries.
- Oxygenated blood leaves the lungs to reach the left atrium via the pulmonary veins.
- Oxygenation, plus the removal of CO_2 occurs at the alveoli.
- The bronchi are supplied with oxygenated blood via the bronchial arteries; lung lymph drainage is via a sub-pleural plexus and a plexus alongside the bronchi to hilar lymph nodes.

Relations of lungs: Mediastinum from left



Relations of Lungs: Mediastinum from right



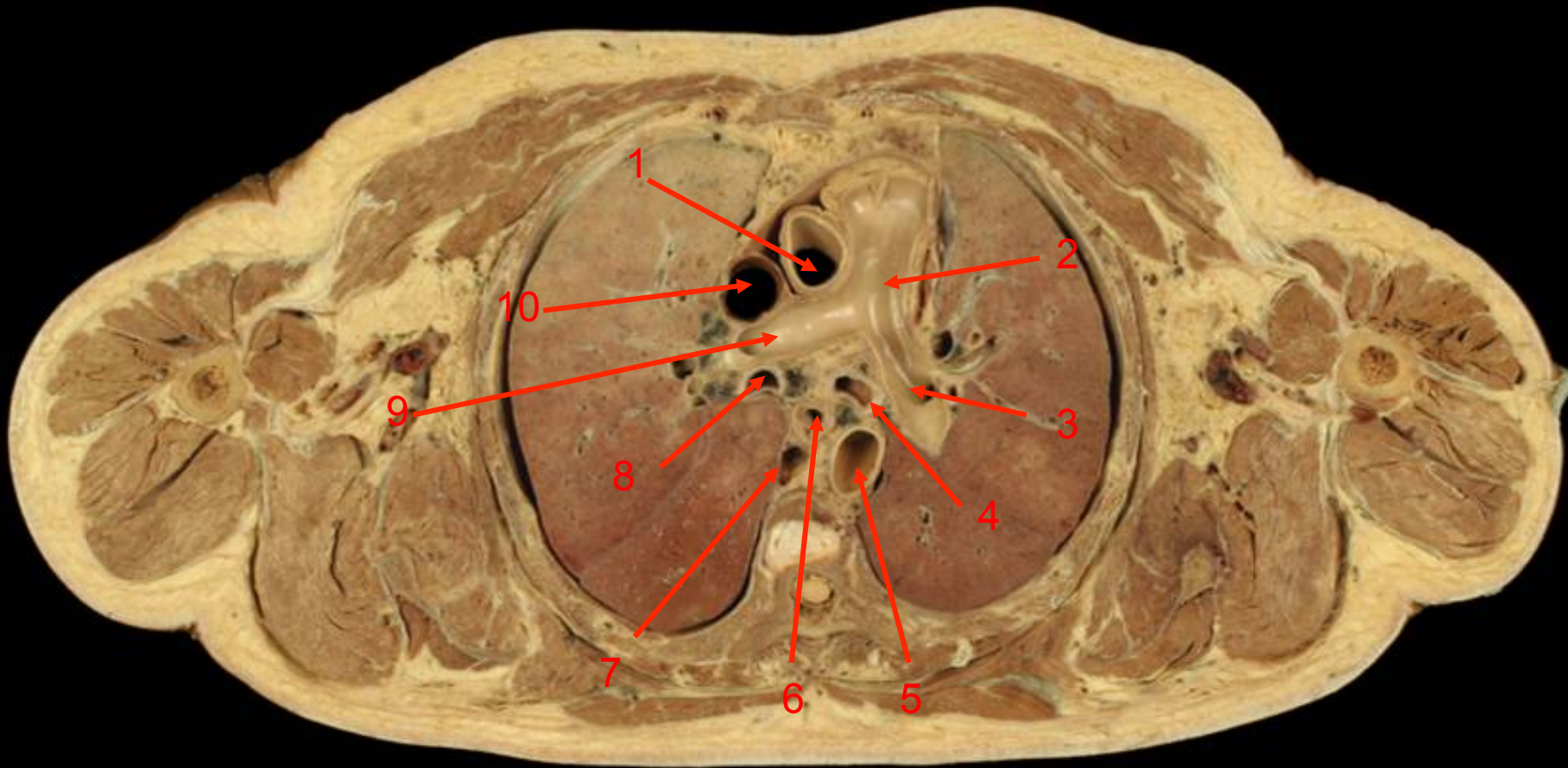
On both sides:

1. Tumour may impinge upon the phrenic nerve to cause paralysis of the diaphragm on the affected side.
2. Tumour may impinge upon the sympathetic trunk and embarrass sympathetic supply to the head, causing Horner's Syndrome, which is a drooping eyelid with a constricted pupil, and a dry but flushed face on the affected side.

On the left side only:

Tumour (or affected lymph nodes) may impinge upon the recurrent laryngeal nerve to cause hoarseness of the voice.

1 Ascending aorta; 2 Pulmonary trunk (artery); 3 Left PA; 4 Left bronchus; 5 Descending aorta; 6 Oesophagus; 7 Azygos vein; 8 Right bronchus; 9 Right PA; 10 Superior vena cava.



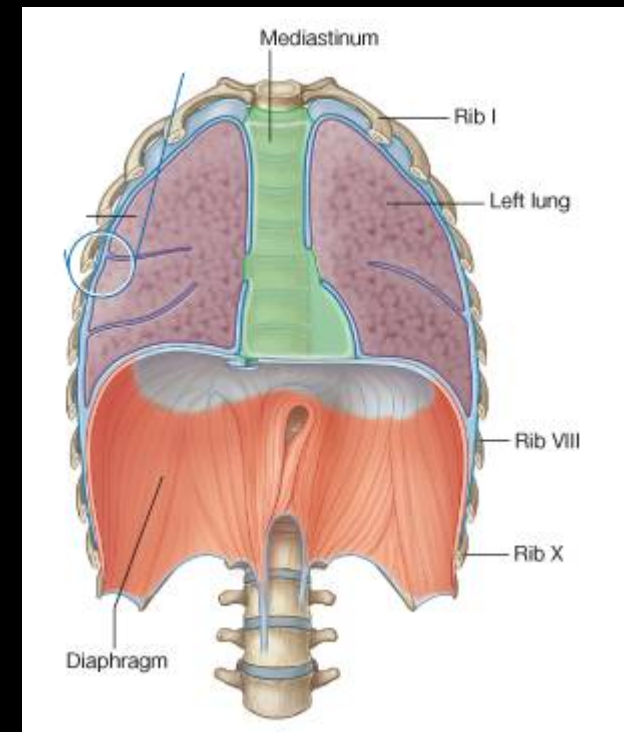
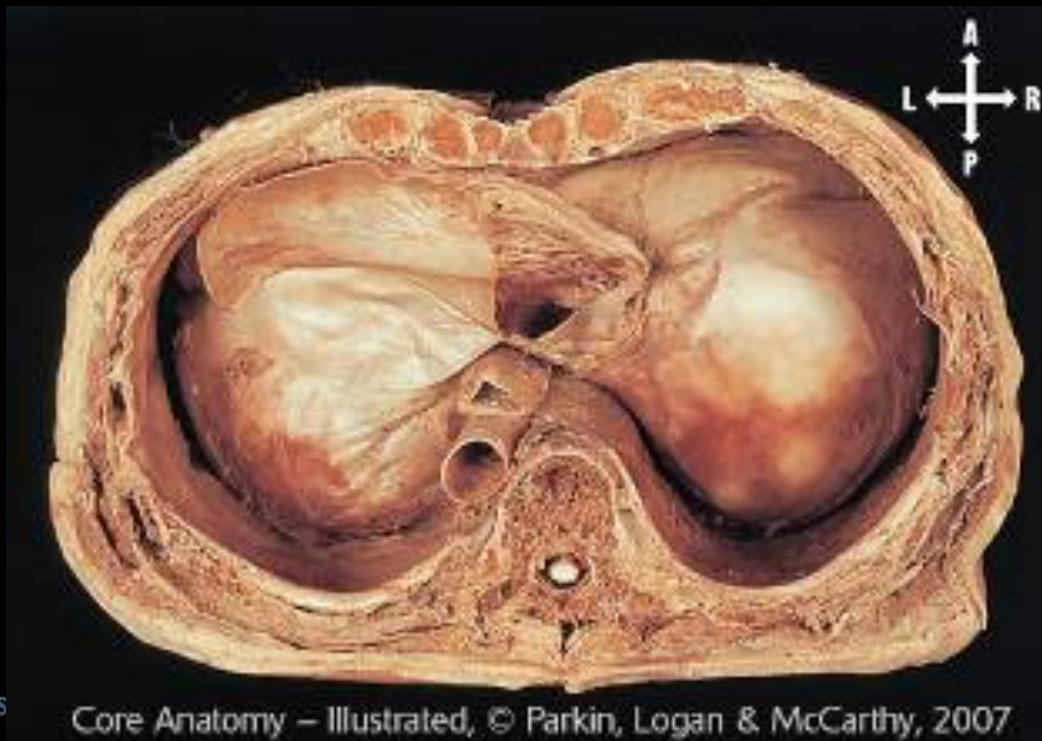
Lung Relations, Upper Thorax in Cross Section

Mechanisms of Respiration

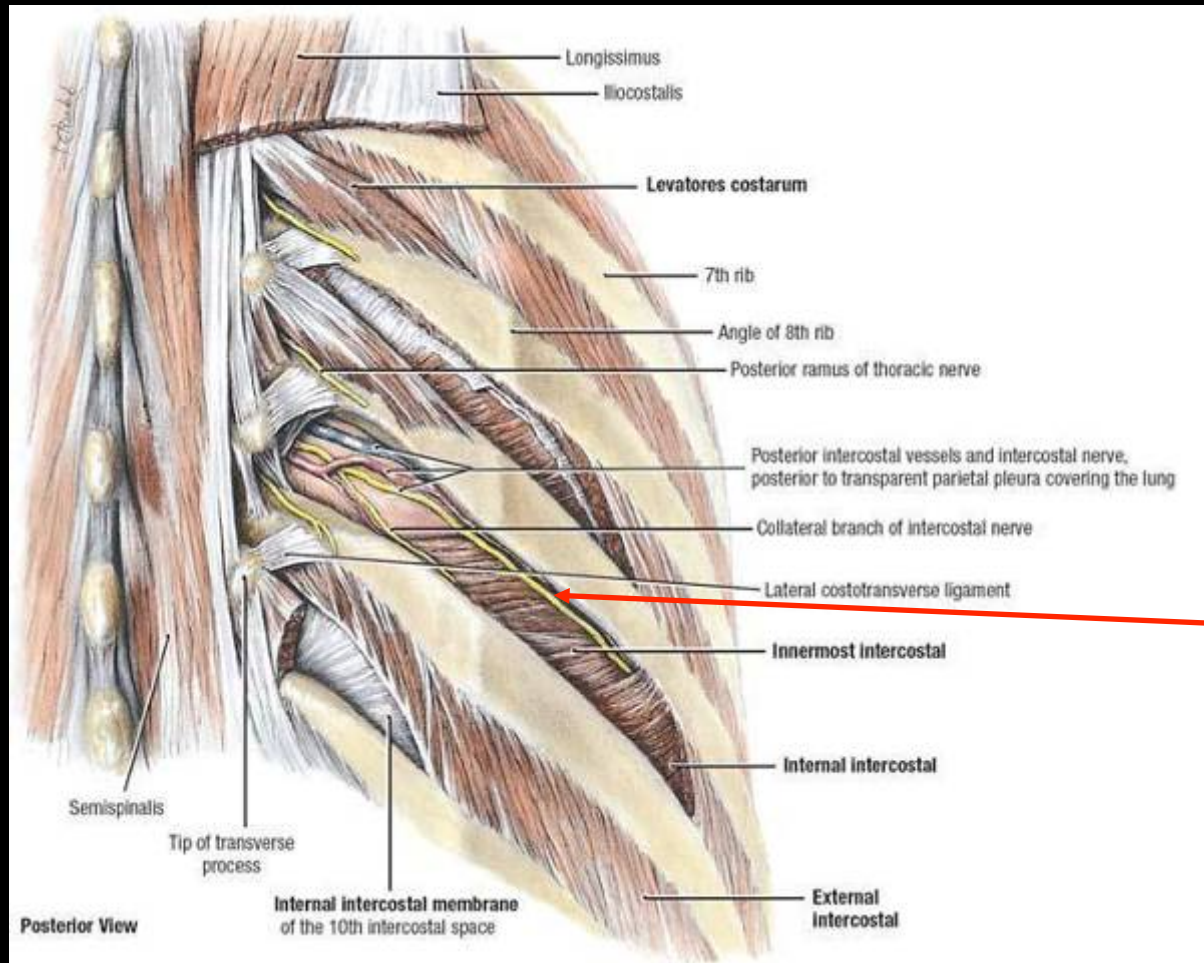
- Respiration may vary from quiet as at rest, through the whole range to forced as in severe exercise or respiratory distress.
- Inspiration must increase the diameters of the thorax to create a negative pressure, which sucks air into the lungs via the trachea and larynx etc.
- Diaphragmatic contraction causes its descent to increase vertical diameter.
- Rib elevation pushes the sternum up and forward, and the ribs outward, to increase anteroposterior and lateral diameters.
- Exhalation is by muscle relaxation and elastic recoil (remember the high amount of elastic tissue in the lungs and bronchi).

The diaphragm is muscular at its periphery, but is tendinous centrally and it has left and right domes as seen in these superior and coronal views. Motor and sensory supply is by the PHRENIC NERVE (C3, 4, 5).

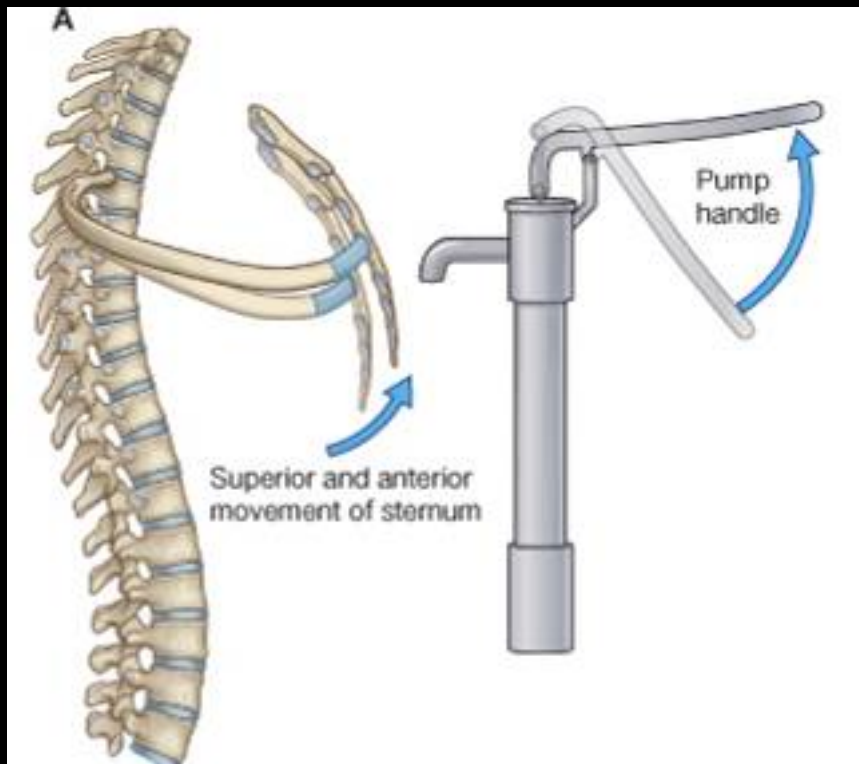
During inspiration the domes descend, causing negative intrathoracic pressure, but raising intra-abdominal pressure.



Between the ribs are layers of intercostal muscles that raise the ribs in inspiration, but some may act in forced expiration to help lower the ribs.

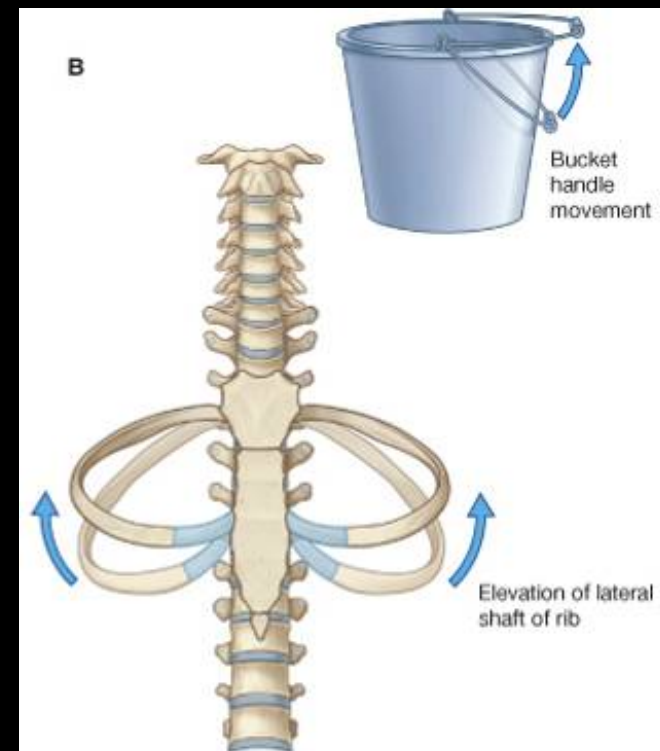


Intercostal neurovascular bundle at the lower edge of the rib



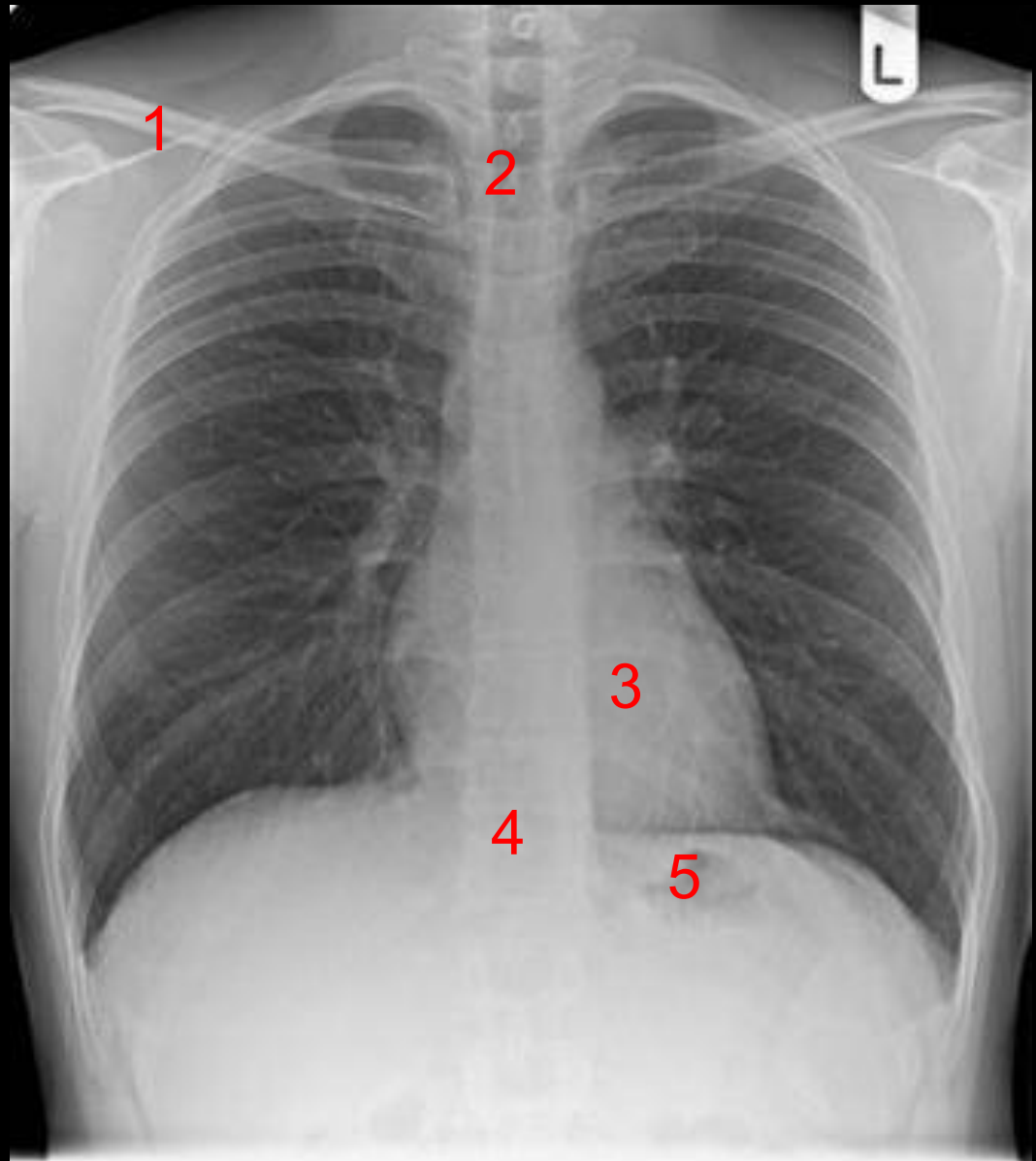
Rib elevation to push the sternum up and forward is often called “pump handle” inspiration, while lateral rib movement with their eversion is called “bucket handle”.

Big muscles that attach to the head and upper limbs, as well as the abdominal wall muscles, may be used as Accessory Muscles of Respiration when more power is required.

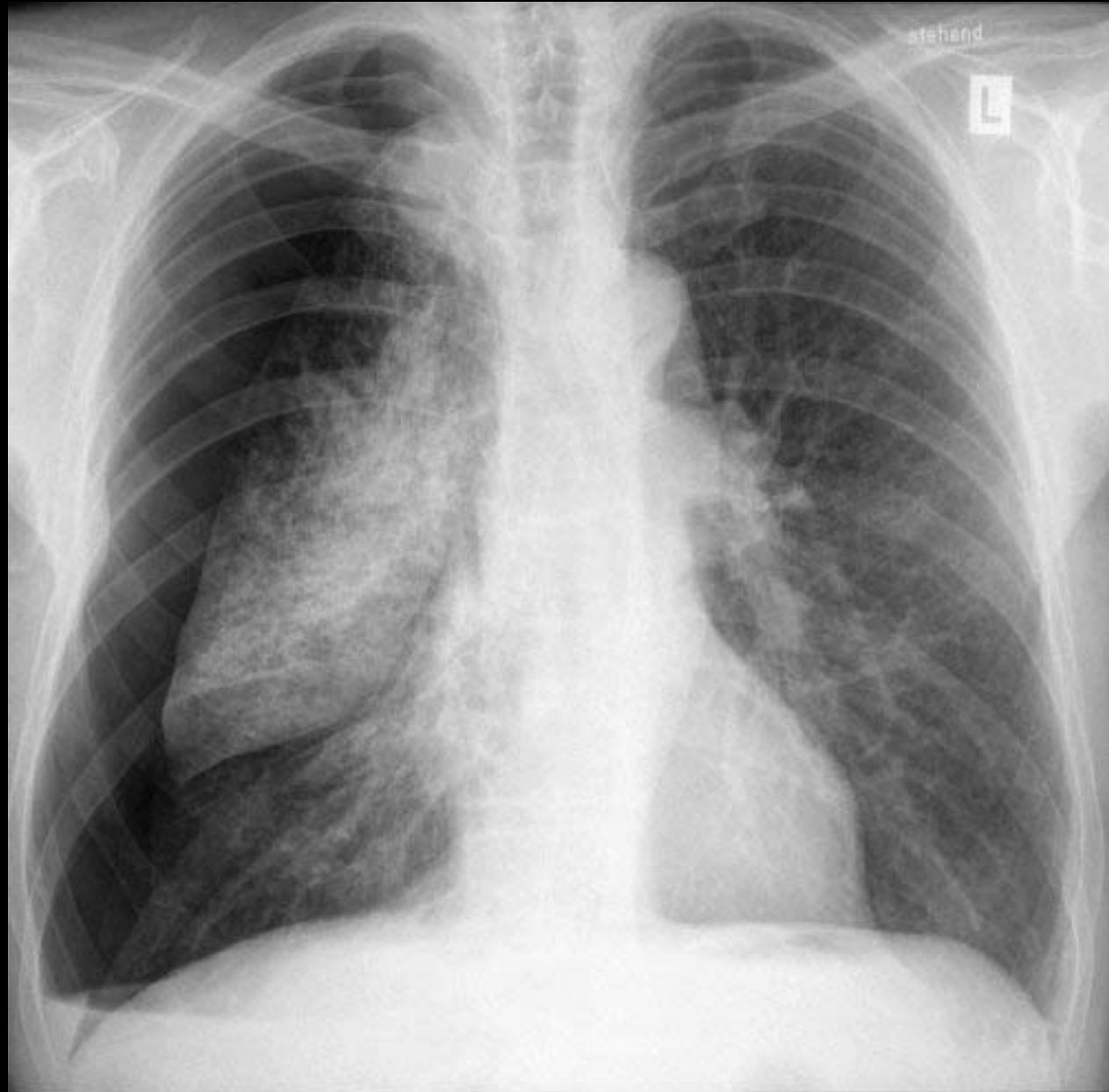


Normal Chest Radiograph

- 1 clavicle;
- 2 trachea, centrally positioned;
- 3 heart shadow;
- 4 vertebral column;
- 5 gas in fundus of stomach.
- Note the lung vascular markings fill the thoracic cavity

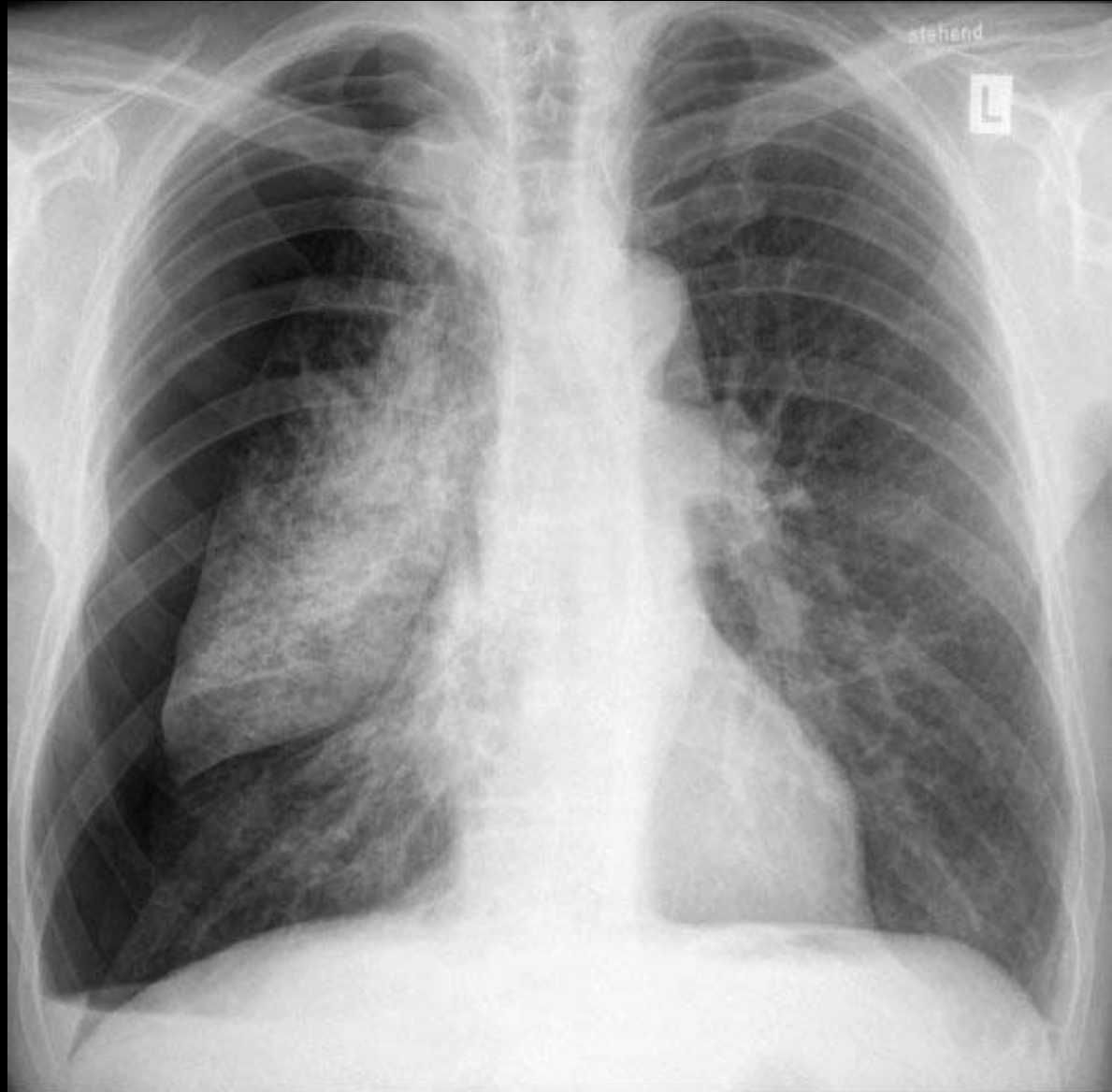


Here is a very obvious right-sided pneumothorax, note how the lung markings stop and the right lung only fills about half of the right thoracic cage.



The air is clearly in the wrong place and must be removed to allow the lung to expand again.

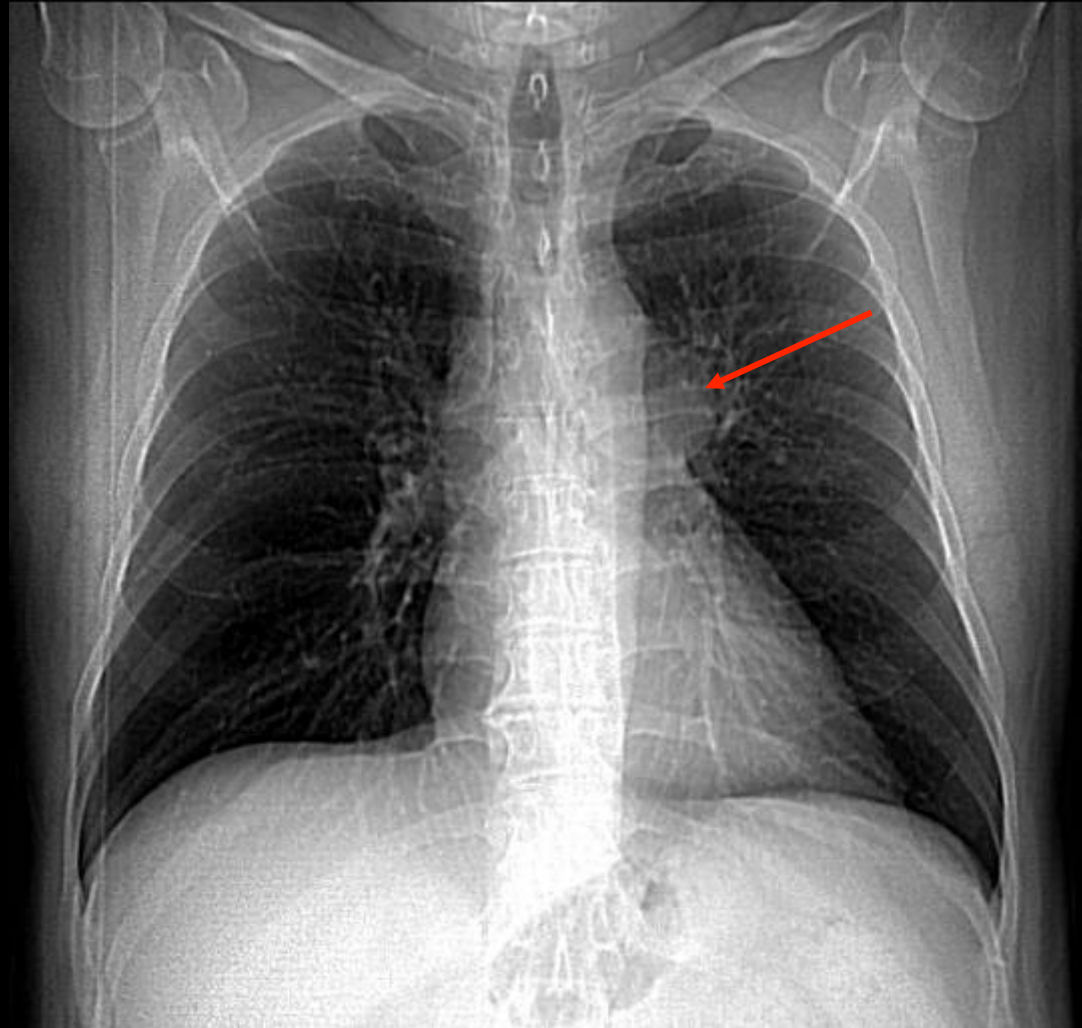
A needle is inserted just above the rib to avoid damage to the neurovascular bundle that runs just inferior to each rib.



Lung Tumour

The arrow indicates a mass near the left lung hilum.

This could impinge upon the left recurrent laryngeal nerve and the patient may present with hoarseness of the voice.



Formative Assessment

1. Select the correct word in the description of Respiratory Epithelium:

Pseudostratified, ciliated, interspersed with goblet cells.

squamous cuboidal columnar transitional

Formative Assessment

2. Which of the following statements is FALSE?

- A. The nasal cavity warms, filters and humidifies inhaled air
- B. The maxillary sinus opening is high in its medial wall
- C. Air sinuses open into the meati, below and lateral to the turbinates
- D. The larynx is a sphincter to protect the airway
- E. The laryngeal inlet is closed by laryngeal elevation
- F. The laryngeal inlet is between the vocal folds

When you have established which one is false, what would be the correct answer?

Formative Assessment

3. Match the following structures with their function

Bronchus

Pulmonary Artery

Bronchial Artery

Pulmonary Vein

Carries oxygenated blood to the bronchi and lung tissue

Carries oxygenated blood to the left atrium

Carries de-oxygenated blood to the lung

Transports air to the lung

Formative Assessment

4. Fill in the missing words:

During inspiration, descent of the domes of the increases the vertical thoracic diameter. Rib elevation pushes the sternum up and forward like a handle to increase anteroposterior diameter. Quiet expiration is by recoil. The diaphragm is supplied by the nerve. More power is added to respiration by the use of muscles during severe exercise or respiratory distress. A needle or cannula must be inserted into the pleural cavity immediately the rib to avoid the neurovascular bundle. Tumour impingement on the left recurrent laryngeal nerve may cause

elastic above phrenic pump hoarseness diaphragm accessory

Further Reading

Clinically Oriented Anatomy, Moore, Dalley, Agur 6th Ed.
Lippincott, Williams & Wilkins

Nose, nasal cavity and sinuses P's. 955 to 965

Larynx and trachea P's. 1022 to 1032

Lungs and bronchi P's. 108 to 127

Thoracic wall P's. 81 to 97

Diaphragm P's. 306 to 309

The End