



UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA

**DNS** DEPARTMENT OF NEUROSCIENCE

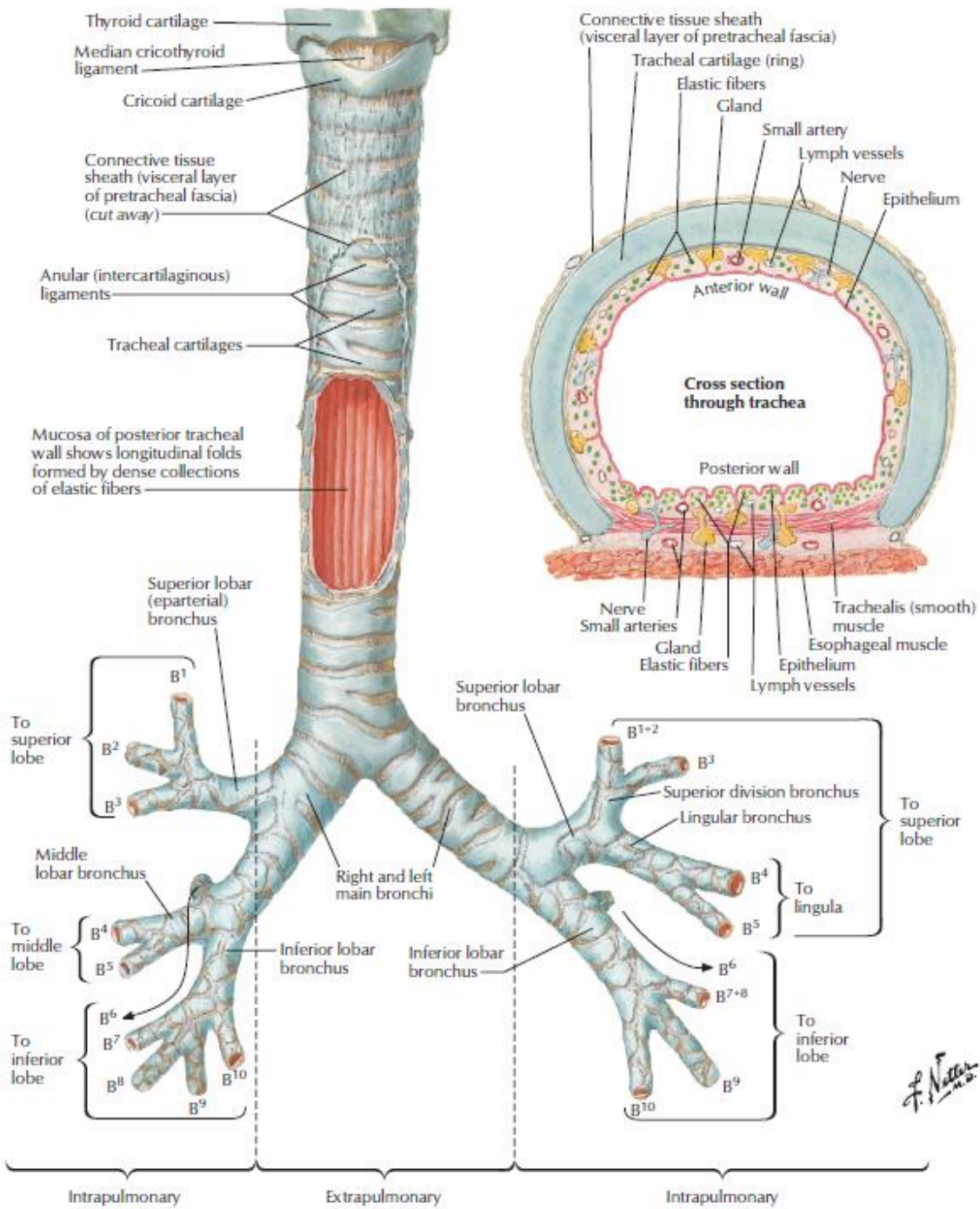


ANATOMY AND PHYSIOLOGY (C.I.)

HUMAN ANATOMY  
(Mod. A)

THE RESPIRATORY SYSTEM

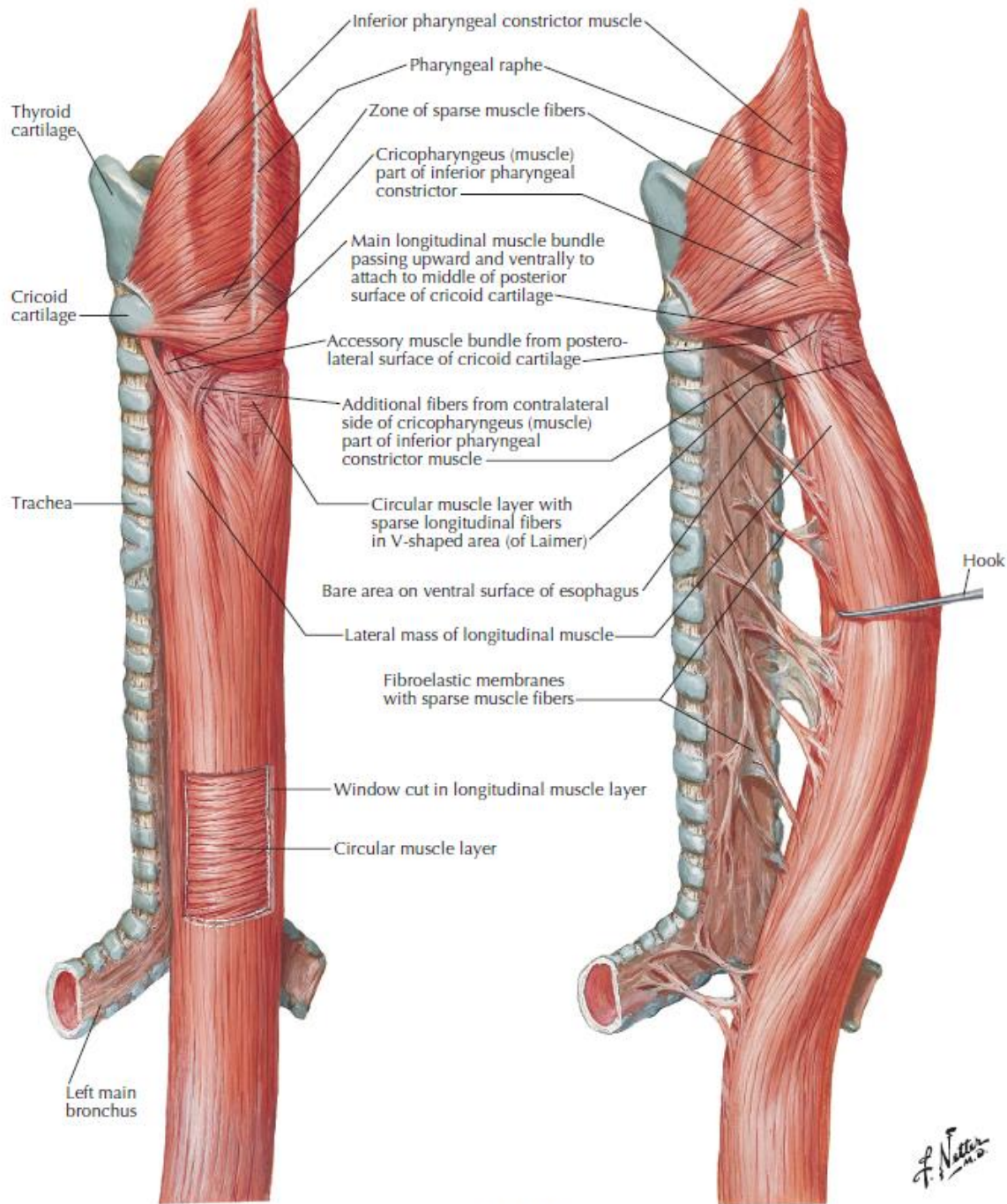
TRACHEA



# TRACHEA

It is a TUBULAR STRUCTURE that develops **after the larynx**, being directed downwards in a more or less vertical direction:

- it passes through the neck
- then it enters the thoracic cavity
- and at the level of the fourth thoracic vertebra (**T4**) it **bifurcates into the two main bronchi**, the right and the left bronchus



Posterolateral view

It consists of a series of **C-shaped rings** (= posteriorly incomplete rings) of **hyaline cartilage** that are connected by dense connective tissue.

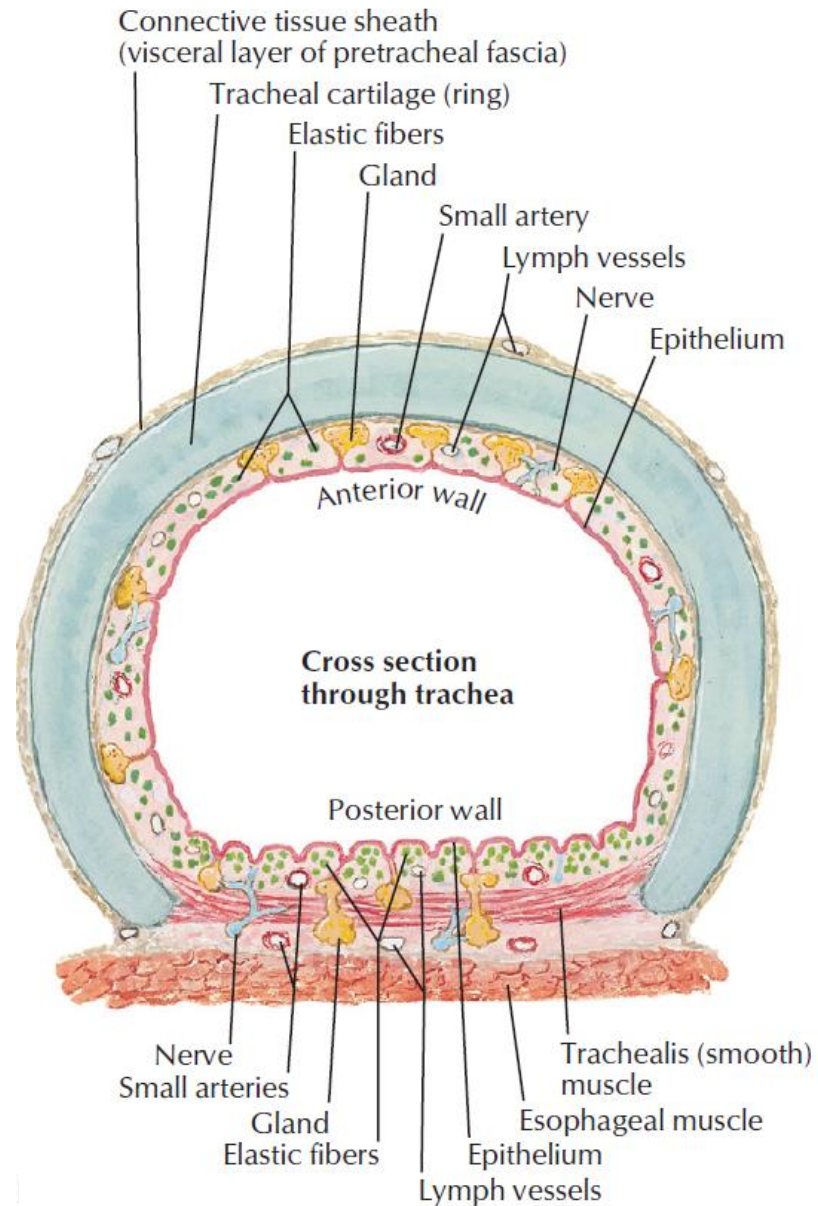
On the **posterior side** the **PARS MEMBRANACEA** is present, consisting of a band of smooth muscle named the **TRACHEALIS MUSCLE** (= *posterior wall of the trachea*)

The trachealis muscle is connected to the esophagus (which is located immediately behind the trachea) by

↓  
**sparse MUSCLE FIBERS**  
 which together form the

↓  
**TRACHEO-ESOPHAGEAL MUSCLE**





The TRACHEAL LUMEN is internally lined with

- a MUCOSA, consisting of an epithelium and a lamina propria made up of elastic connective tissue and containing the excretory ducts of the tracheal glands
- a SUBMUCOSA, which contains tracheal glands → *mixed sero-mucous glands*

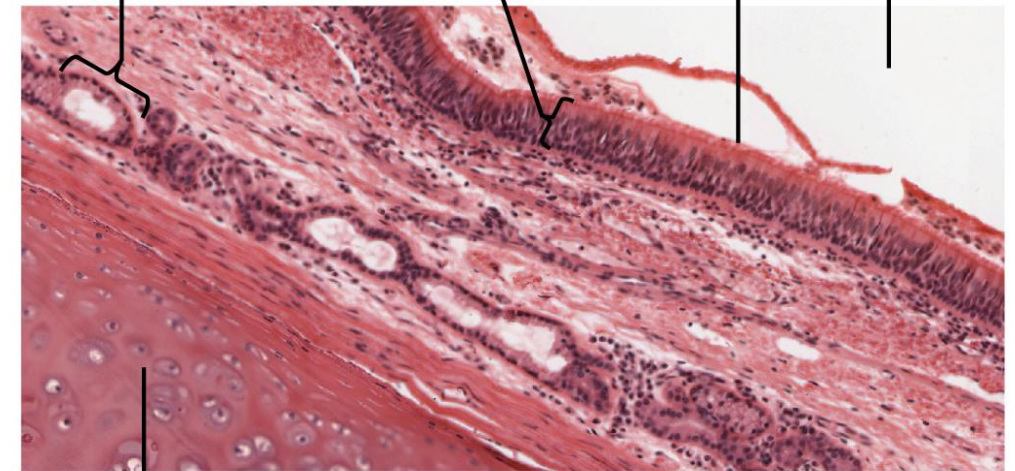
The **LINING EPITHELIUM** of the mucosa is a typical

**RESPIRATORY EPITHELIUM**

↓  
columnar pseudostratified epithelium  
with cilia and goblet cells

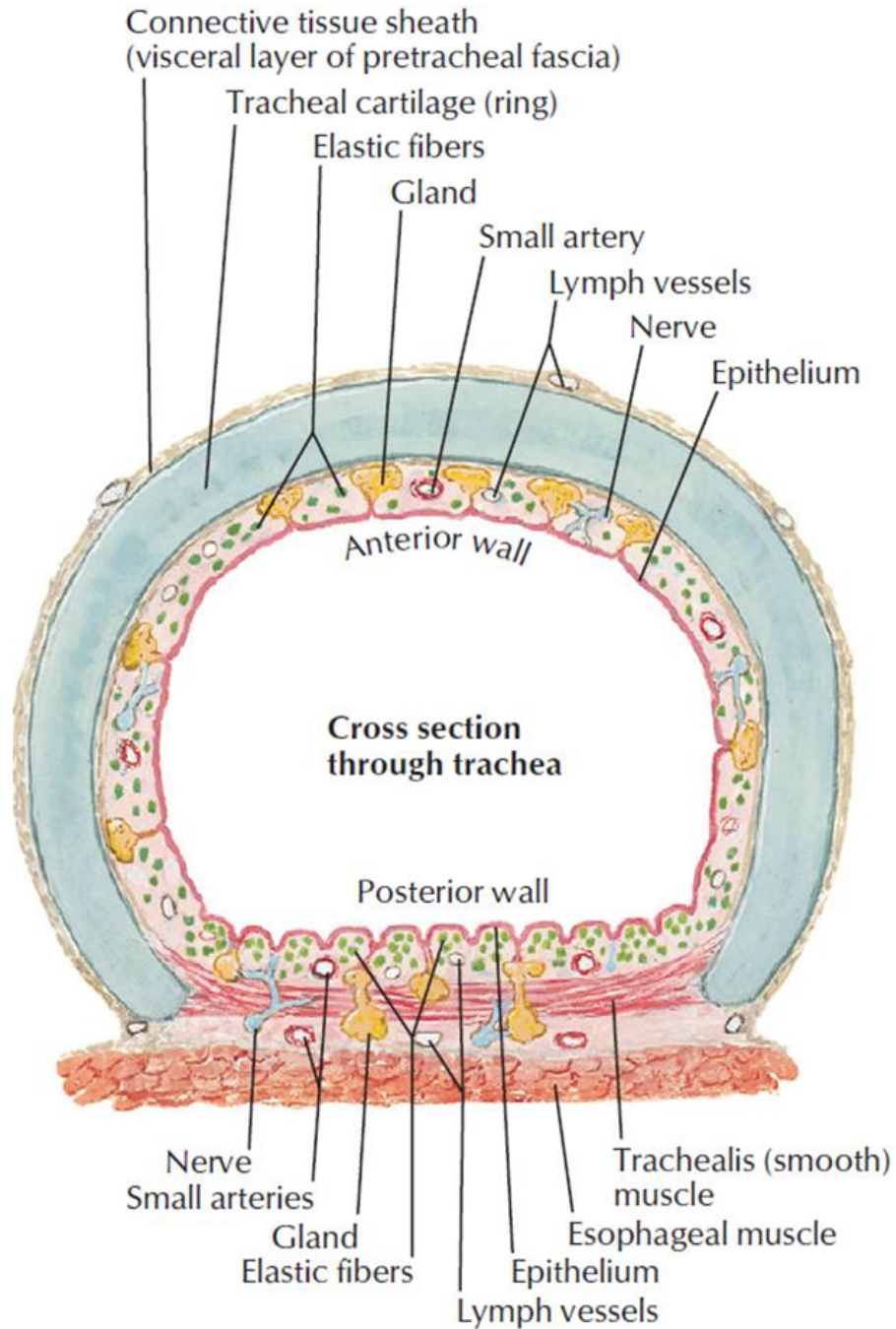
*It is the same type of epithelium found in the laryngeal cavity, nasopharynx and nasal cavities*

Submucosal seromucous glands      Pseudostratified columnar epithelia      Cilia      Lumen



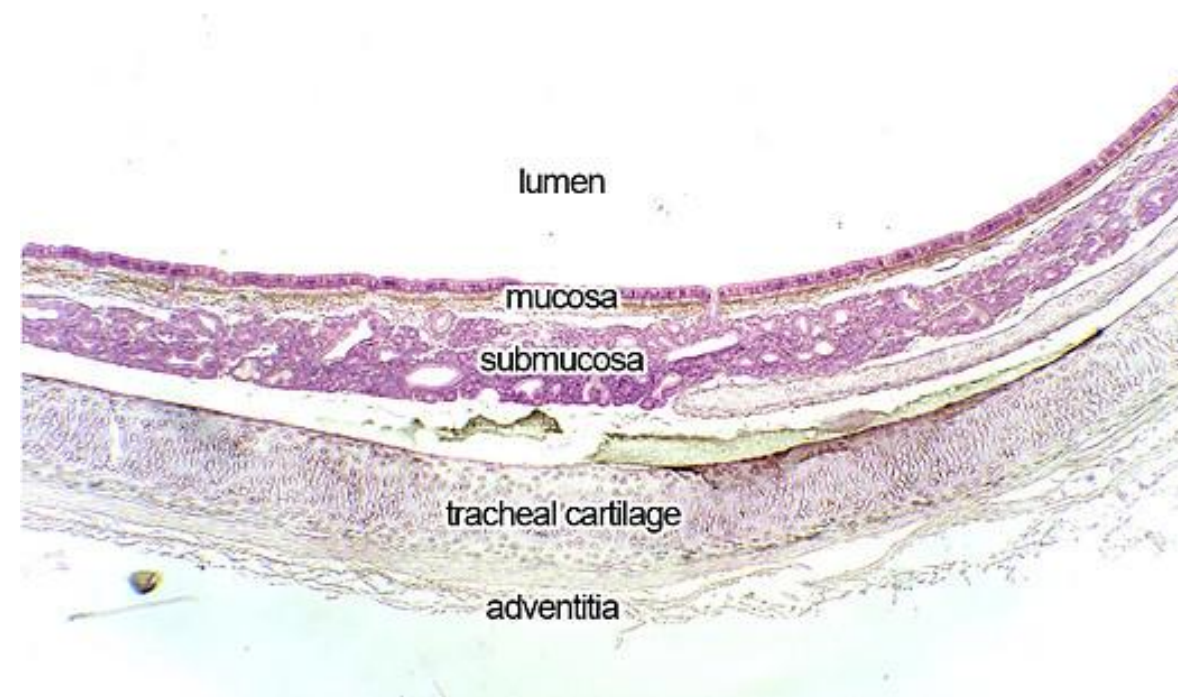
Hyaline cartilage

The figure represents the cross section of a tracheal ring, consisting of cartilage and completed dorsally by the muscle band made up of the **TRACHEALIS MUSCLE**. Posteriorly, the esophageal musculature is present

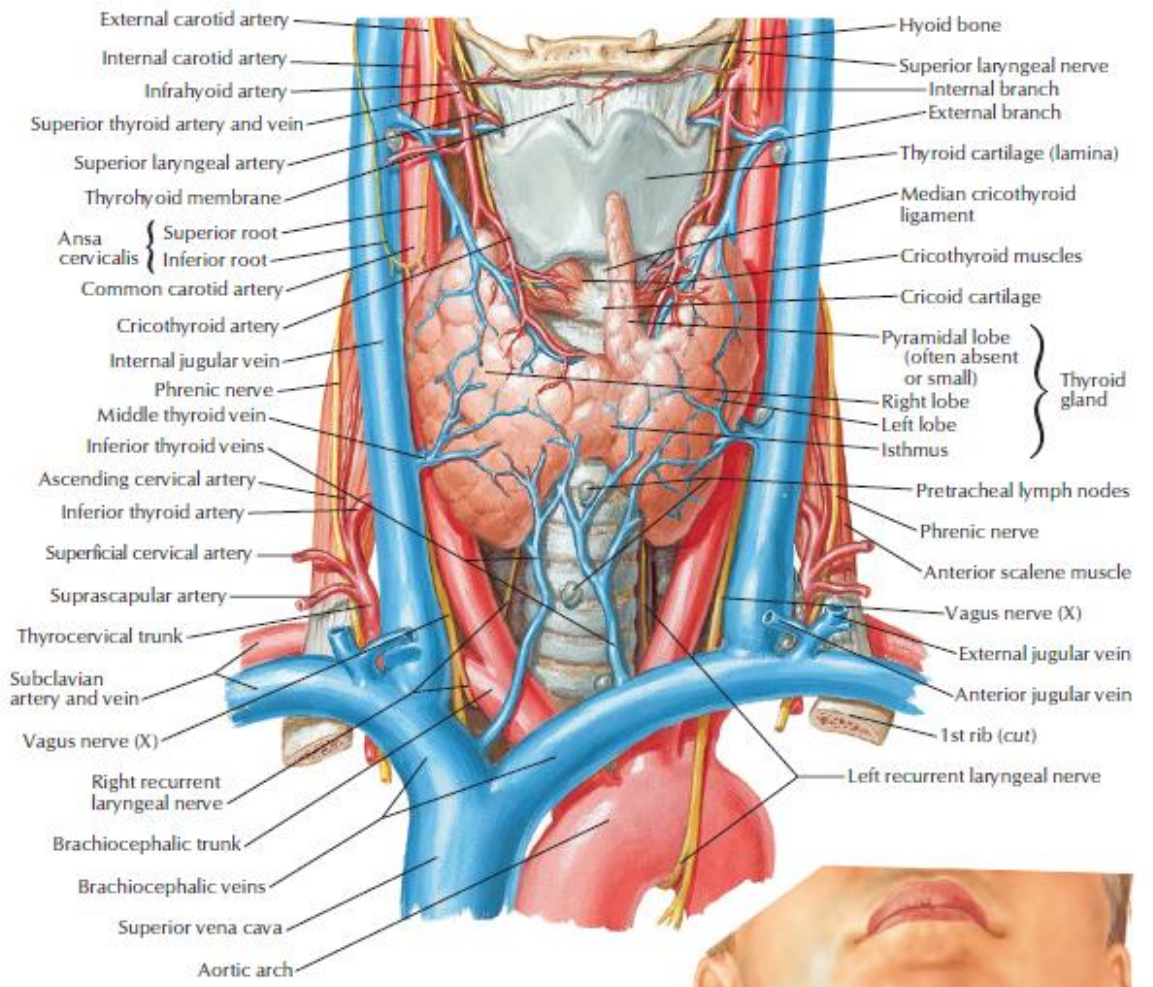


- Externally to the submucosa, the third layer of the tracheal wall is the **MUSCLECARTILAGINOUS LAYER** which is represented by the cartilaginous rings and intervening smooth muscle.
- Lastly, the outermost layer is provided by the **ADVENTITIA**, a fibroelastic connective tissue layer which surround the cartilage ring.

Trachea, cross section, 40x



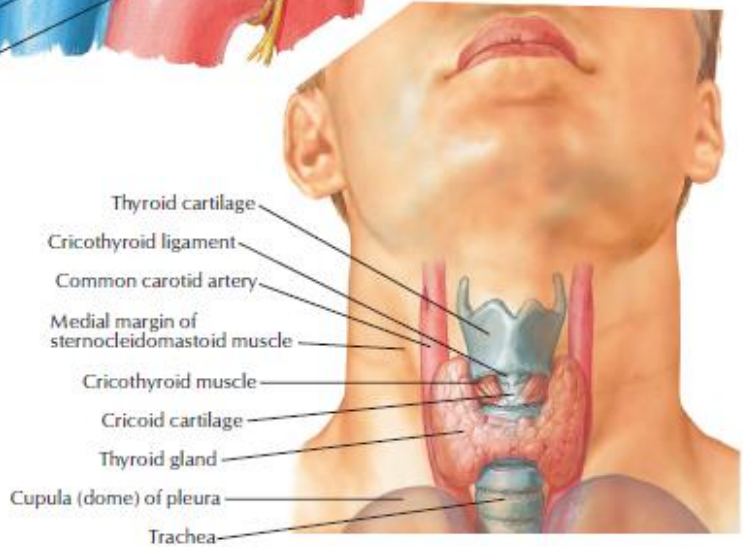




*The trachea is close to the THYROID*

Topographically, the thyroid gland is located in front of the larynx and trachea

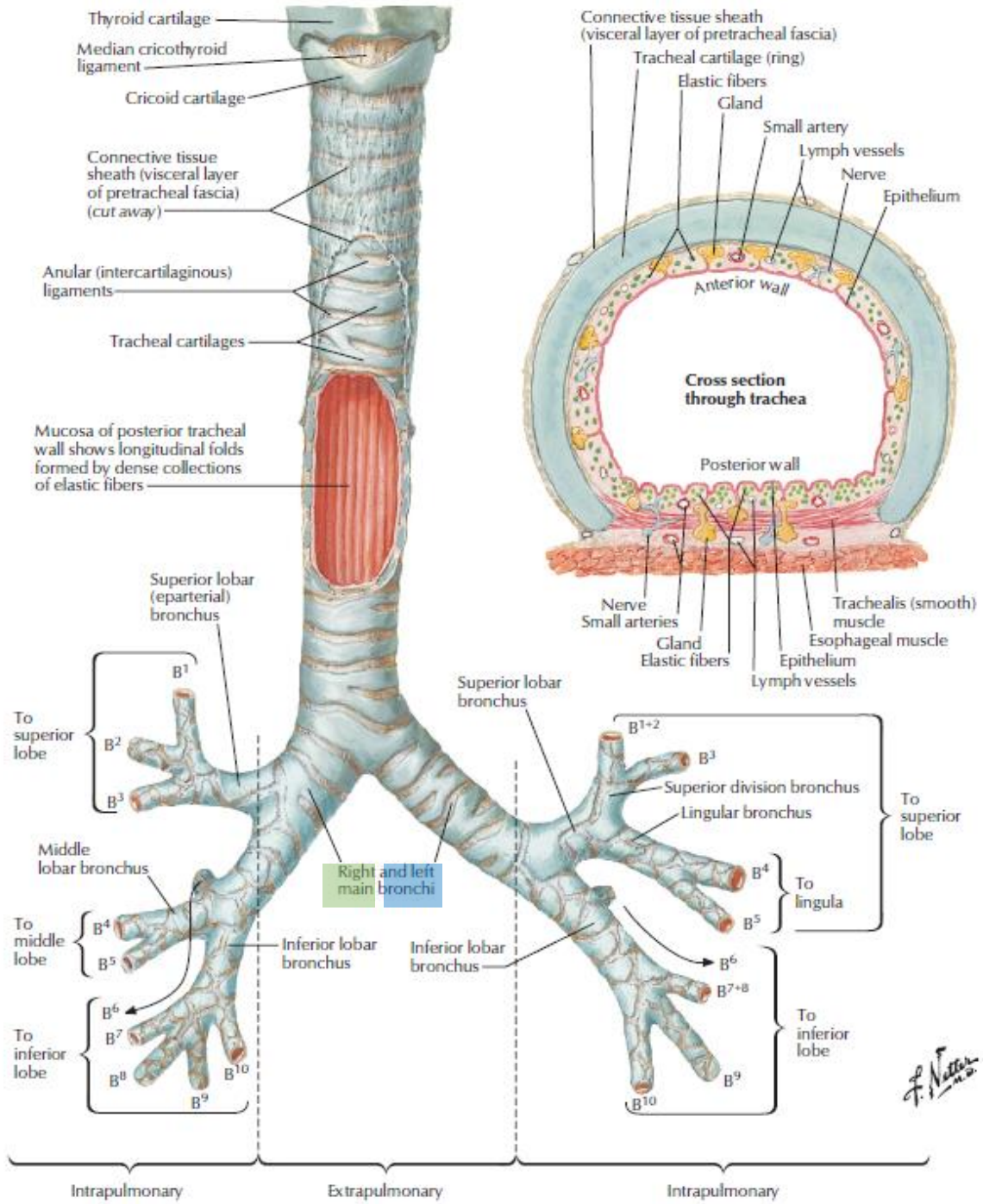
Thyroid consists of two lateral lobes connected to each other by a median isthmus which is located at the level of the first cartilaginous rings of the trachea



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**PRIMARY BRONCHI**





### PRIMARY (MAIN) BRONCHI

At the CARINA\*, the trachea branches into the two main bronchi:

**RIGHT MAIN BRONCHUS**  
**LEFT MAIN BRONCHUS**

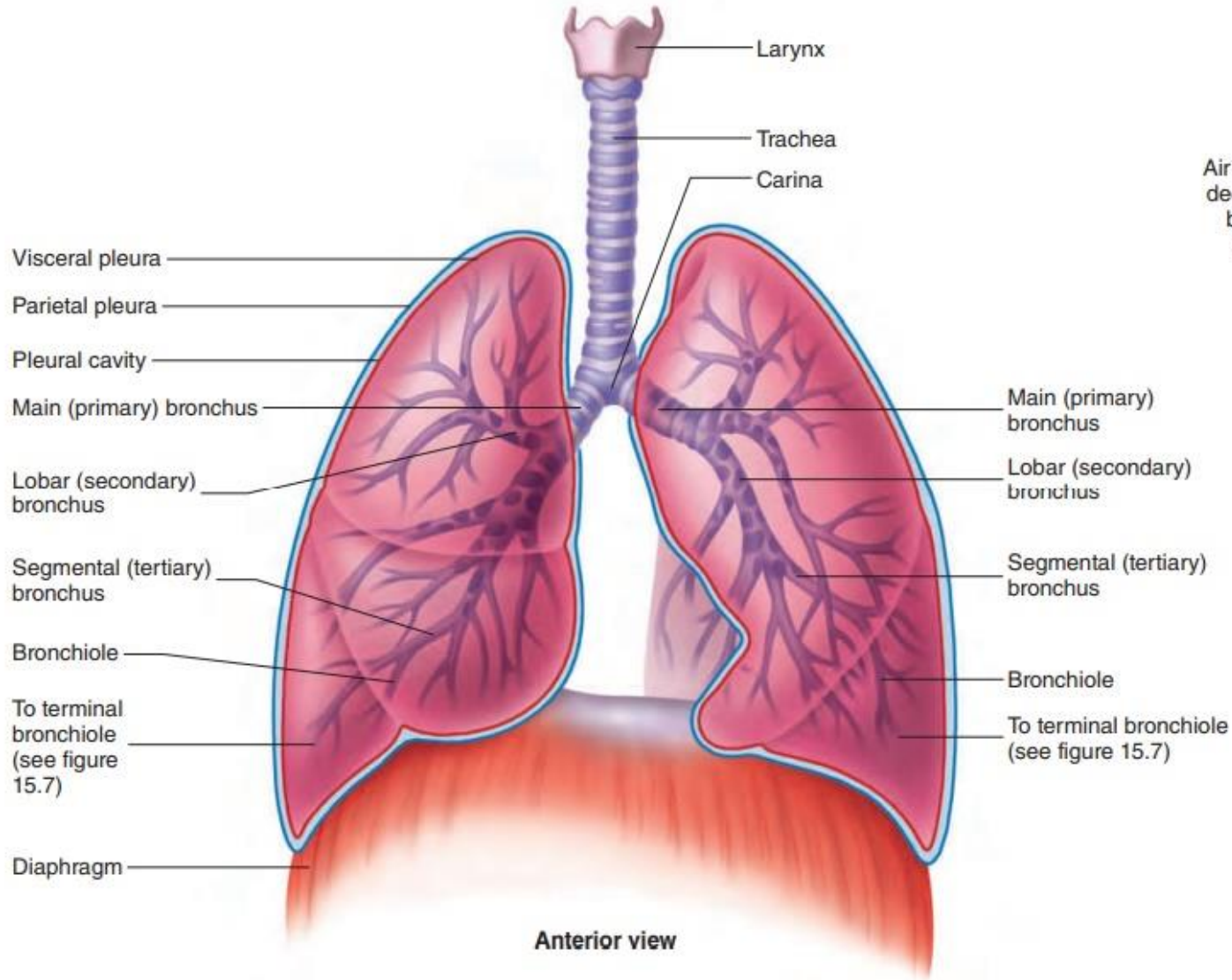
With different characteristics

**RIGHT MAIN BRONCHUS:**  
 it is SHORTER (approximately 2 cm) but has a LARGER DIAMETER.

**LEFT MAIN BRONCHUS:**  
 it is LONGER (up to 5 cm) but has a SMALLER DIAMETER.  
 It presents a HIGHER INCLINATION ANGLE relative to the central axis of the trachea, getting closer to a horizontal plane

**The main bronchi are also made up of C-shaped cartilaginous rings (posteriorly incomplete rings)**

\* The carina of trachea (or tracheal carina) is a ridge of cartilage at the terminal portion of the trachea separating the openings of the left and right main bronchi



Air passageways decrease in size but increase in number.

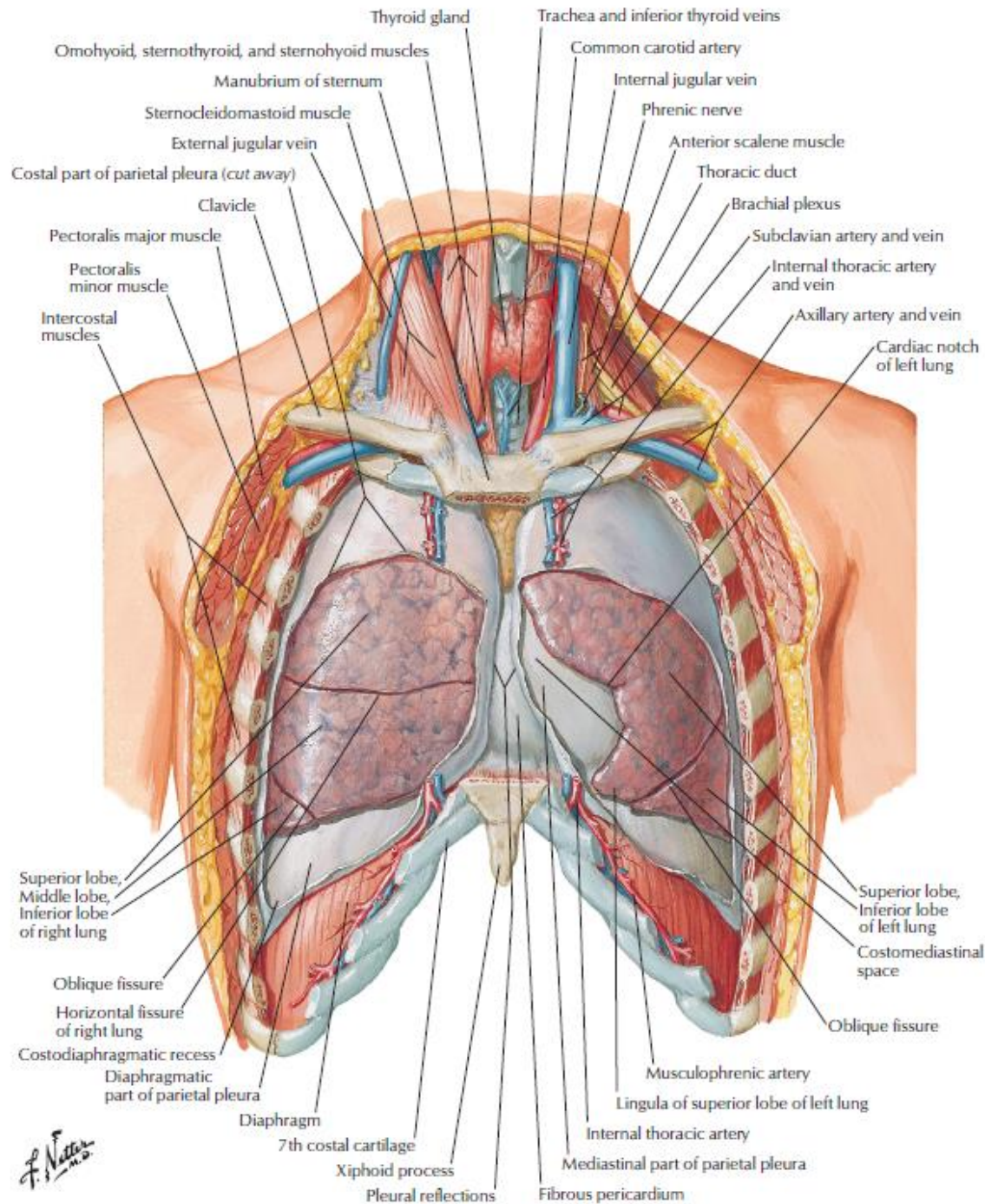


*The right main bronchus and the left main bronchus enter respectively the right lung and the left lung at each pulmonary **hilum**.*

*After that, the main bronchi branch into narrower and narrower bronchial divisions forming the bronchial tree, which will constitute the lung parenchyma.*

## THE LUNGS – The Pleurae



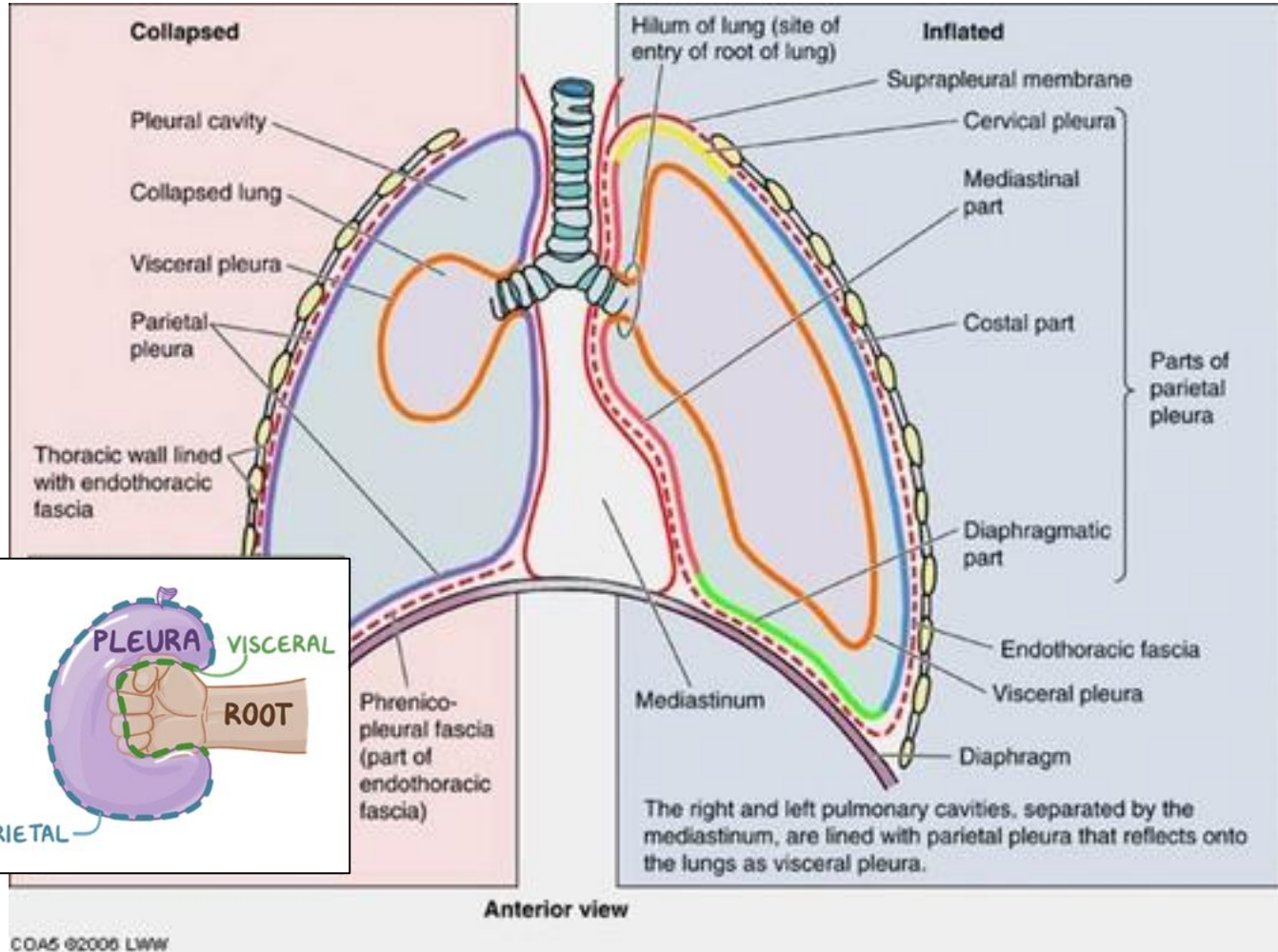


LUNGS are located in the thoracic cavity, laterally, in the so-called

↓  
**PLEURO-PULMONARY SPACES**

The lungs are lined by the PLEURAE which behave like the pericardium at the level of the heart

There are 2 PLEURAE, the RIGHT and the LEFT PLEURA, which remain separated from each other

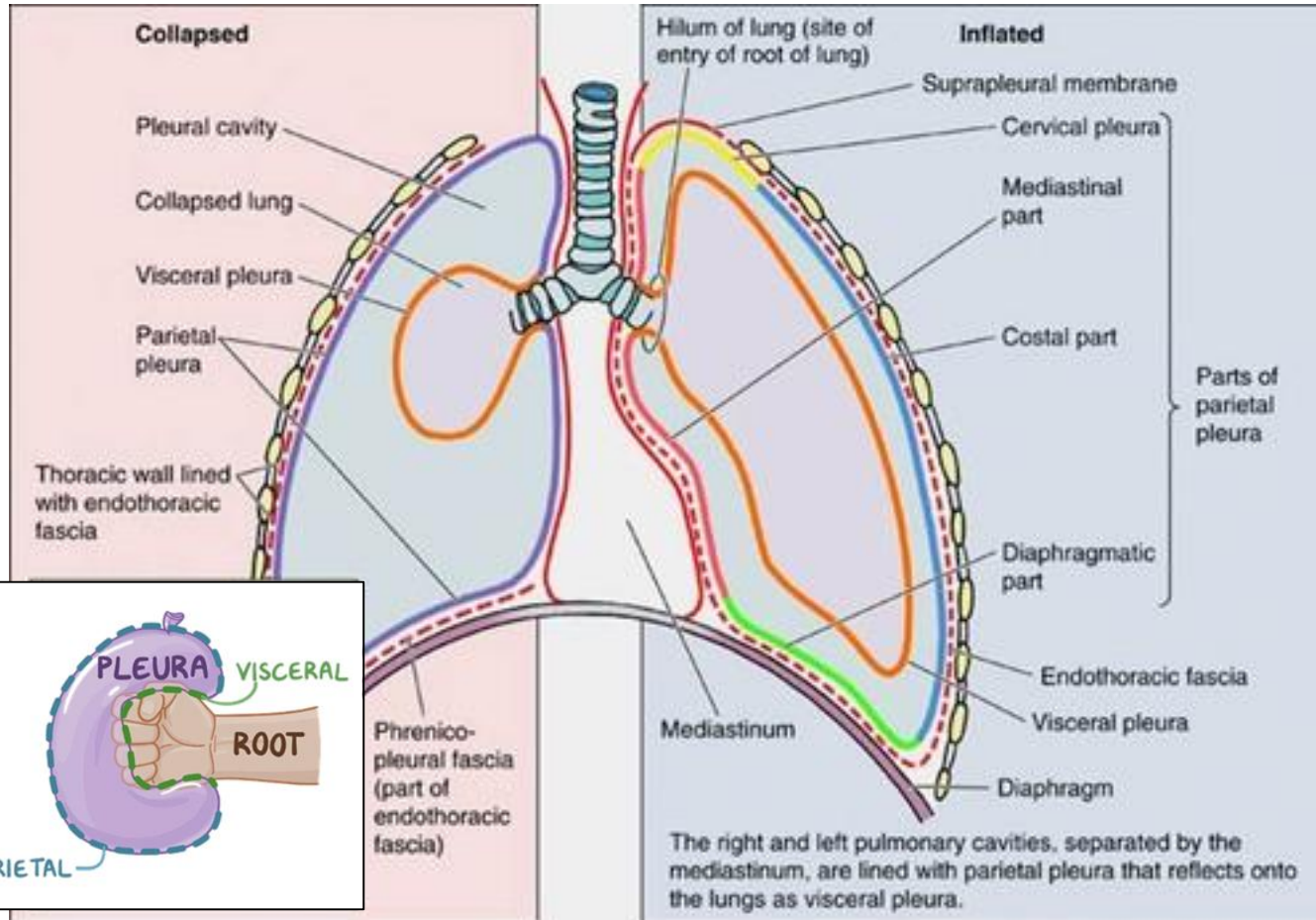


*The pleura covers the lung like a closed and empty nylon bag that covers the entire fist*

The lung is directly covered by **the visceral layer of the pleura (VISCERAL PLEURA)**

This visceral layer covers the entire lung and reaches the hilum of the lung (= structure on the medial face of the lung where the bronchus enters and the main vessels enter/exit);

At the level of the hilum of the lung, the visceral pleura turns on itself and continues with the **PARIETAL PLEURA**, which is a more external cover of the lung



Anterior view

The **PARIETAL PLEURA** consists of different portions:

- ✓ the **MEDIASTINAL LAYER** of the parietal pleura, or **MEDIASTINAL PLEURA**
- ✓ the **DIAPHRAGMATIC PLEURA**, the portion of parietal pleura that lines the superior side of the diaphragm
- ✓ the **COSTAL PLEURA**, which line the internal side of the ribs

Between the visceral and the parietal pleura, the **PLEURAL CAVITY** is present.

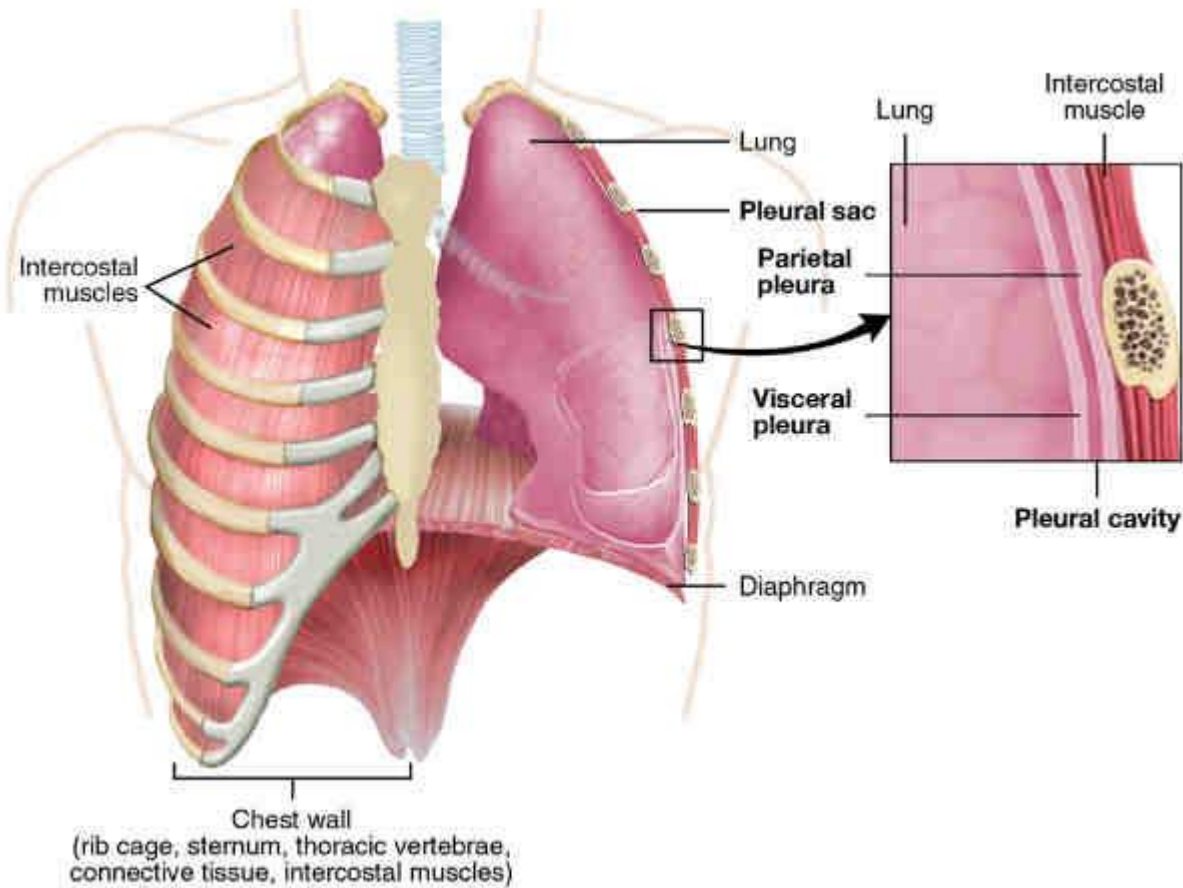


## THE PLEURAL CAVITY

It does not contain lung, but it is an almost empty space which contains a minimal amount of fluid

*The lung is lined by the pleura, NOT contained in the pleural cavity*

The parietal pleura is closely attached to the wall structures: internal side of the ribs and diaphragm



**WHAT IS THE PLEURA FUNCTION?**

It is essential to **KEEP THE LUNG EXPANDED AND ENSURE THAT IT FOLLOWS THE MOVEMENTS OF THE THORACIC CAVITY**



At rest, in the pleural cavity there is an air pressure that tends to be negative compared to atmospheric pressure and therefore **it tends to keep the lung expanded**

When we inhale air:

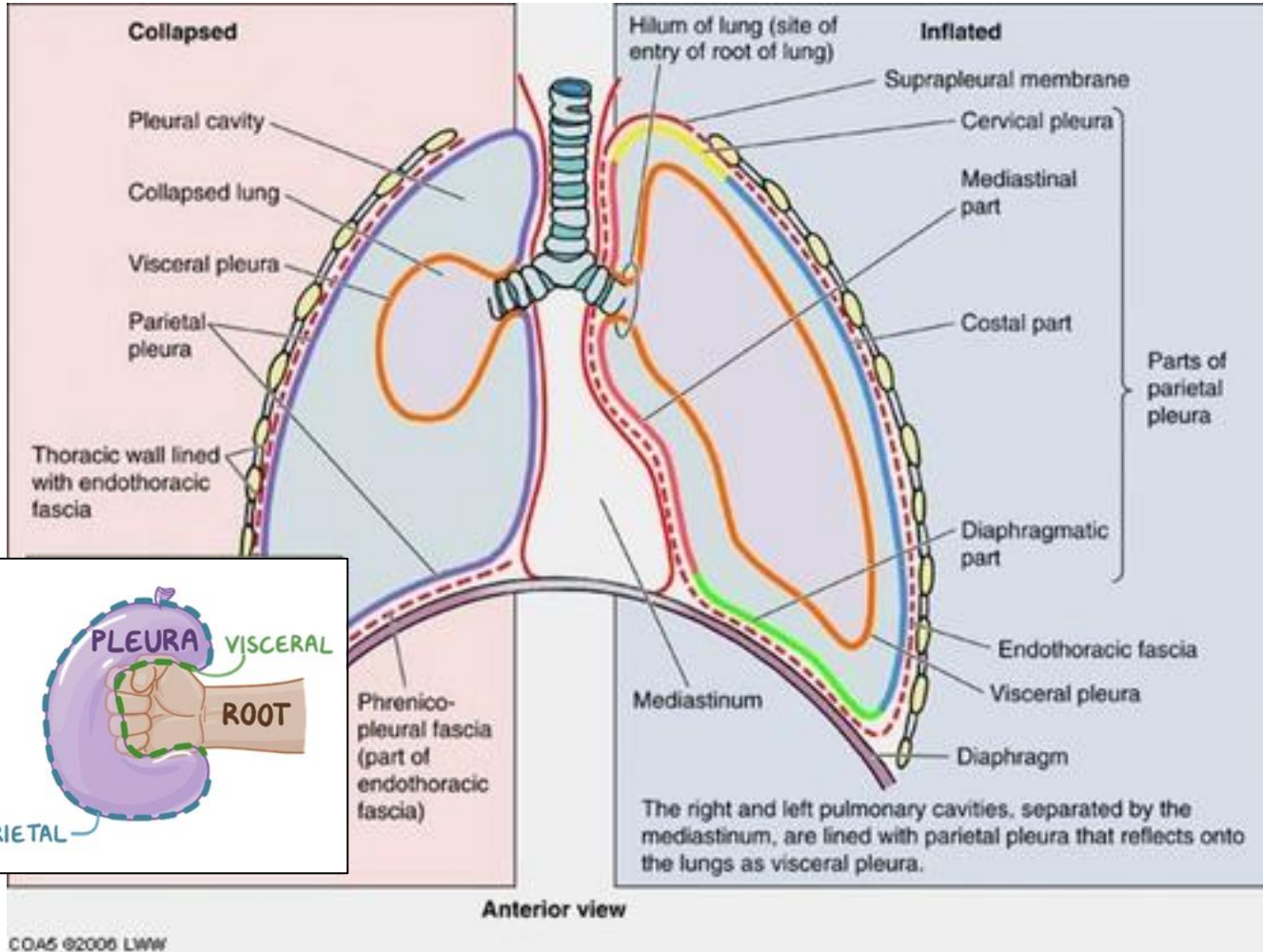
- the volume of the thoracic cavity increases
- the pleural cavity, which follows the wall structures, also increases its volume, and the pressure inside the cavity becomes even more negative

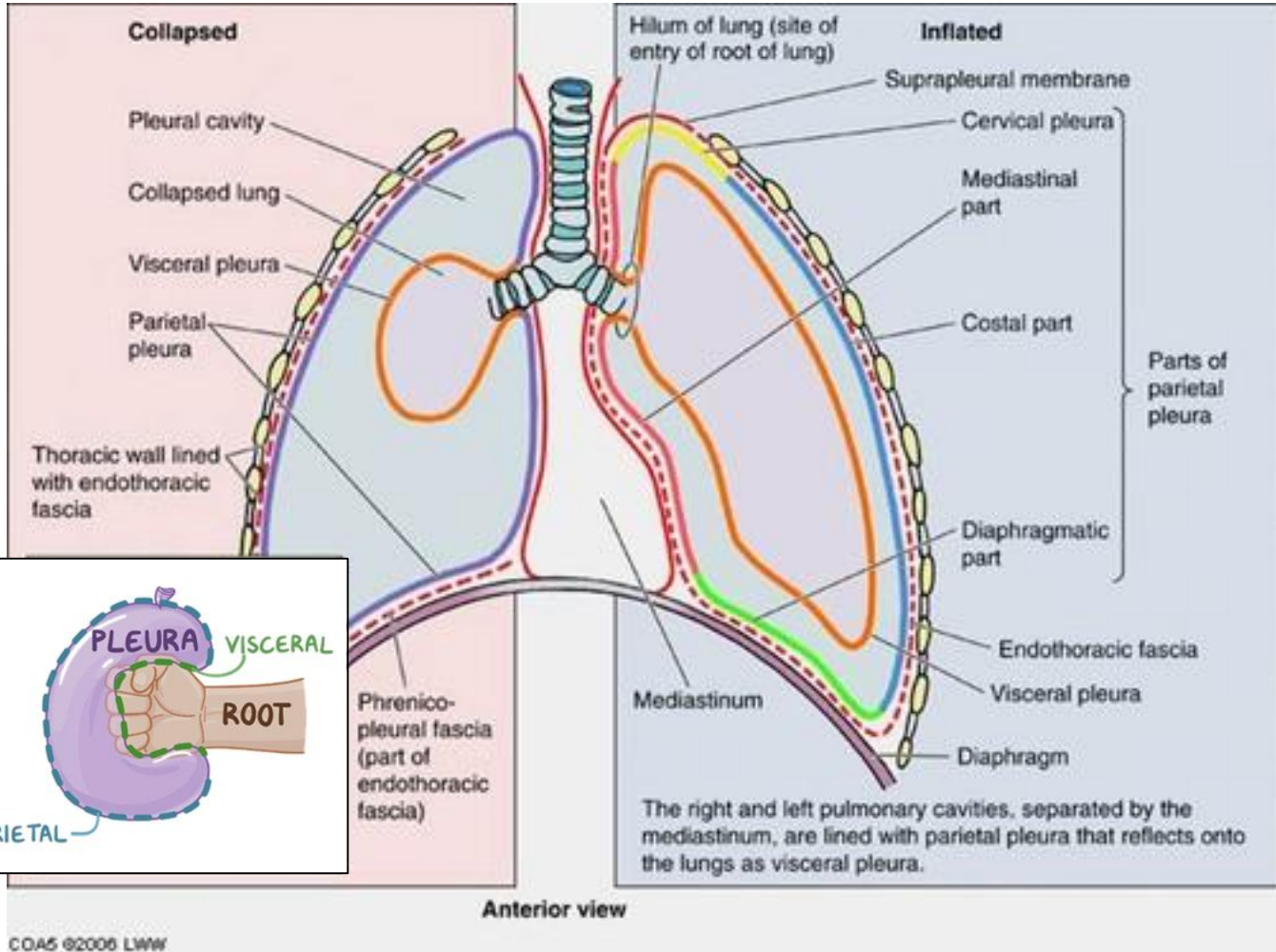
**This causes the lungs to follow this volume expansion of the thoracic cavity and to EXPAND**



The expansion of the lung causes the pressure inside it to become more negative, creating a pressure imbalance that draws in air from the external environment!

= Lung expansion is the process during which the lungs increase in volume to accommodate inhaled air.





**Collapsed lung**  
(left side of the figure)

↓  
**PNEUMOTHORAX**

**Caused by a LESION to the parietal or visceral pleura**

- Injury to the **parietal pleura** caused by a stab wound or rib fracture → air enters the pleural cavity creating a pressure imbalance which results in the loss of the negative pressure that keeps the lung expanded → the lung collapses (e.g., *traumatic pneumothorax*)

- Injury to the **visceral pleura** due to a superficial air bubble that suddenly bursts and causes rupture of the visceral pleura, allowing air to pass from the lung to the pleural cavity (e.g., *spontaneous pneumothorax*)



# THE LUNGS

## THE LUNGS

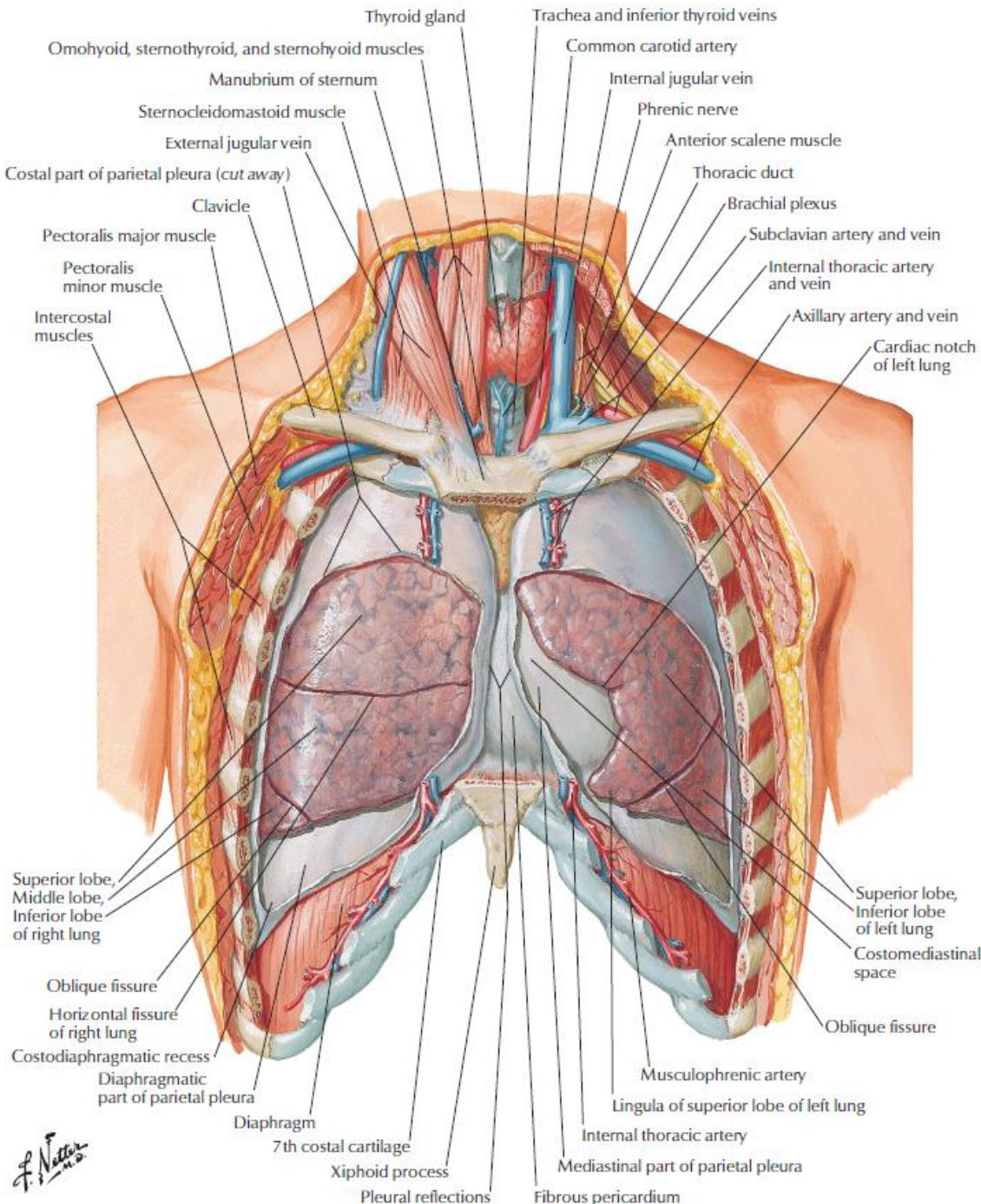
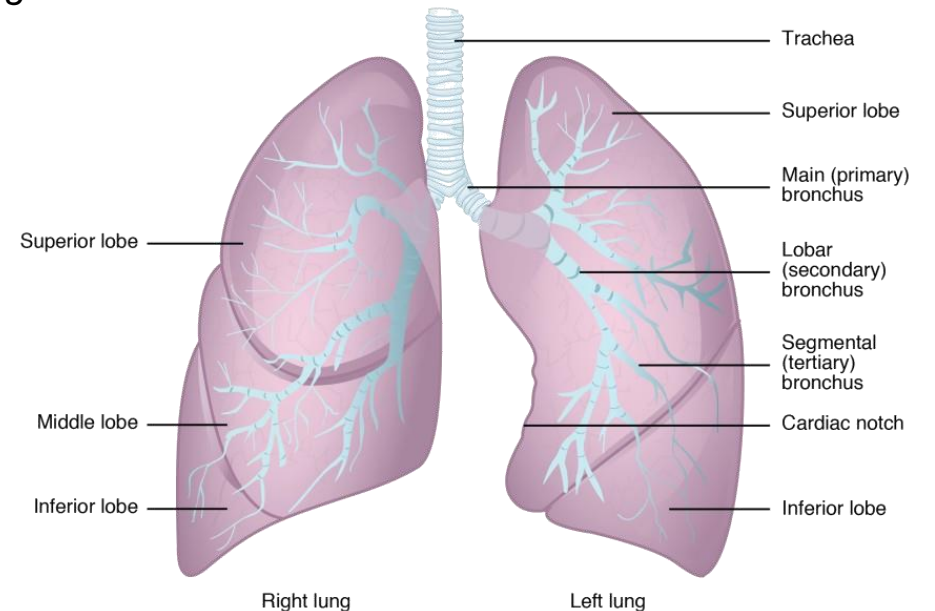
They are located in the thoracic cavity, laterally, in the so-called

↓  
**PLEURO-PULMONARY SPACES**

The lungs are lined by the RIGHT and LEFT PLEURA, separated from each other

The two lungs have **different volume and weight** due to the presence of the heart, which protrudes towards the left side and so reduces the volume of the left lung.

*Left lung: 600-620 g*  
*Right lung: 680 g*

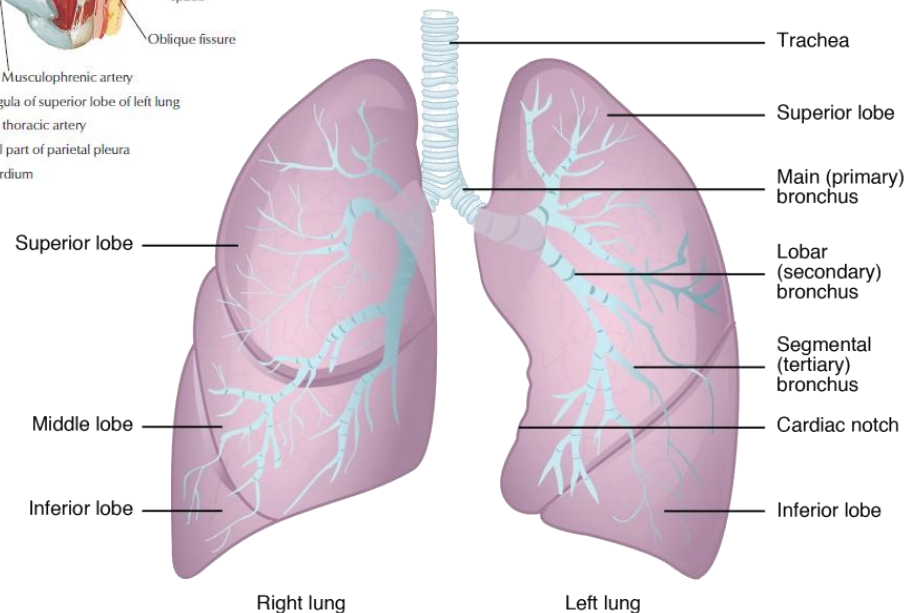
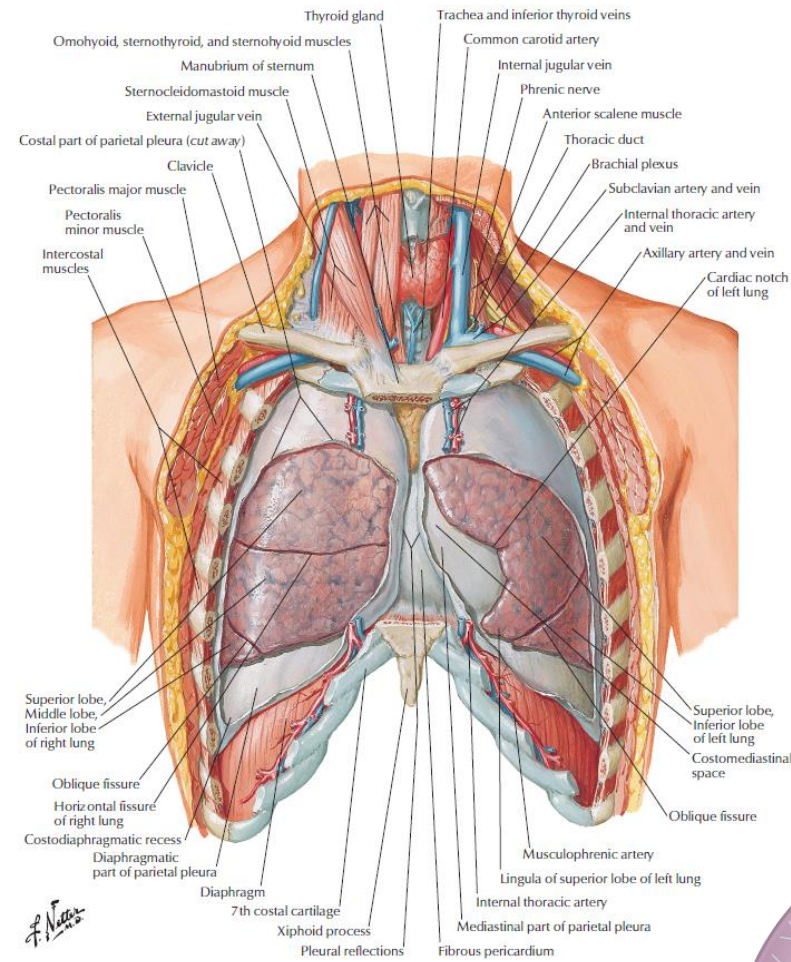


## Morphology

Regarding their morphology, lungs can be considered **CONICAL** in shape

This means that for each lung it is possible to identify:

- a **LUNG BASE**, the lower surface, which rests on the diaphragm
- an **APEX**, the narrow, rounded portion that faces upwards
- a **COSTAL-VERTEBRAL SURFACE** that is in relation with the vertebrae and ribs
- a **MEDIAL SURFACE**, also called **MEDIASTINAL surface**, because it looks towards the mediastinum



We can also recognize **MARGINS**:

- **BOTTOM MARGIN**
- **ANTERIOR MARGIN**
- **POSTERIOR MARGIN**

*The anterior margin of the left lung has a particular appearance because it presents a notch, called the **CARDIAC NOTCH OF THE LEFT LUNG***



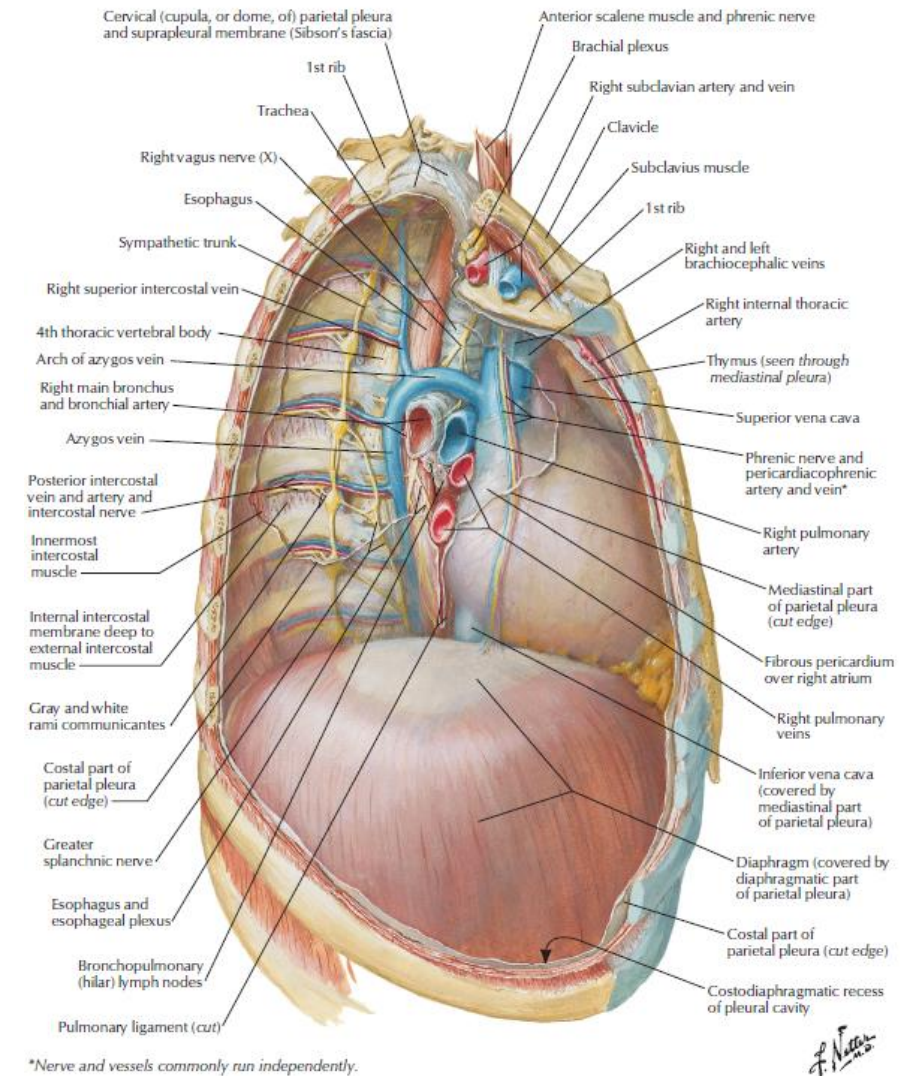
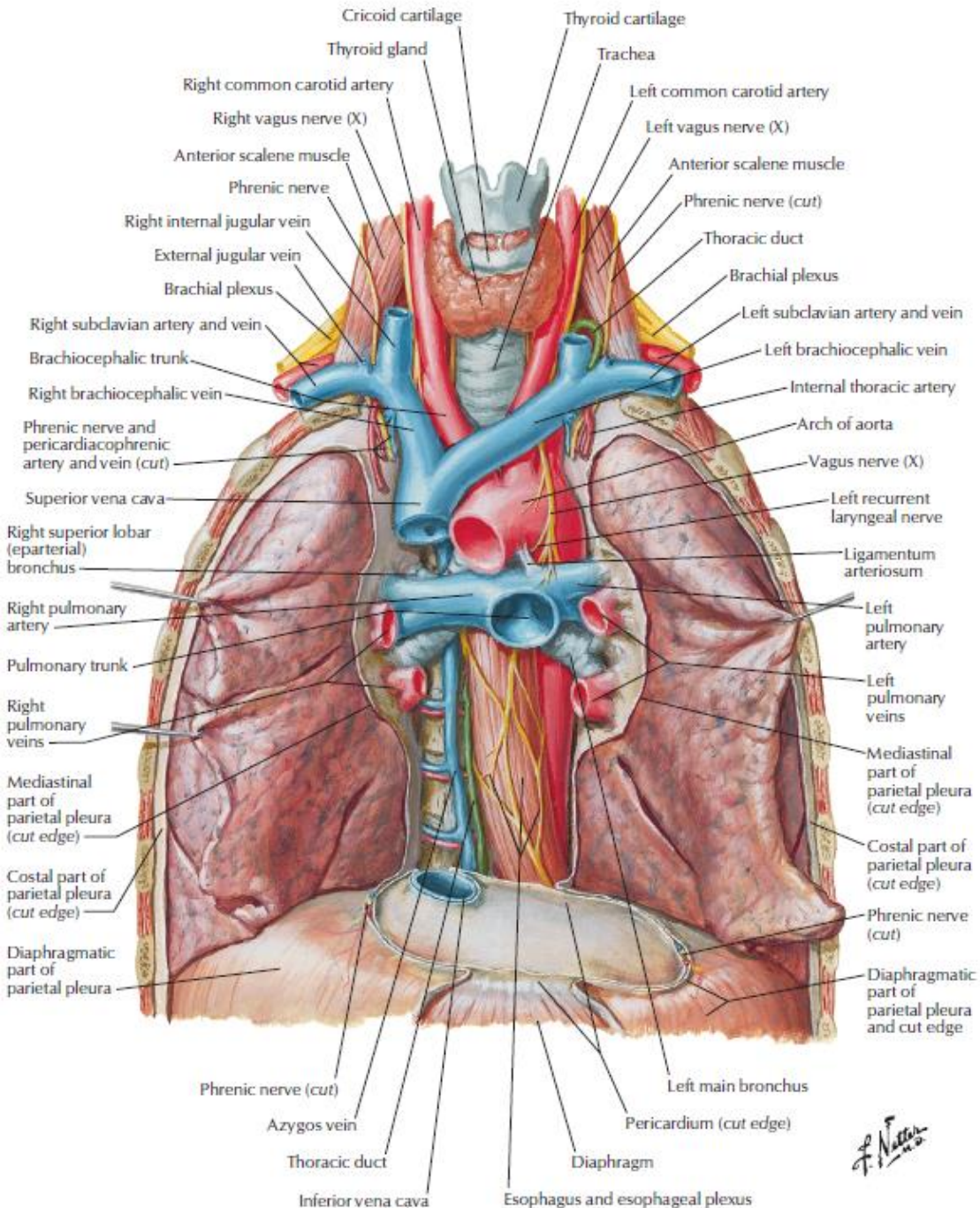
## Morphology

On the medial (or mediastinal) surface of the two lungs the **PULMONARY HILUM** is recognizable

It is the site where:

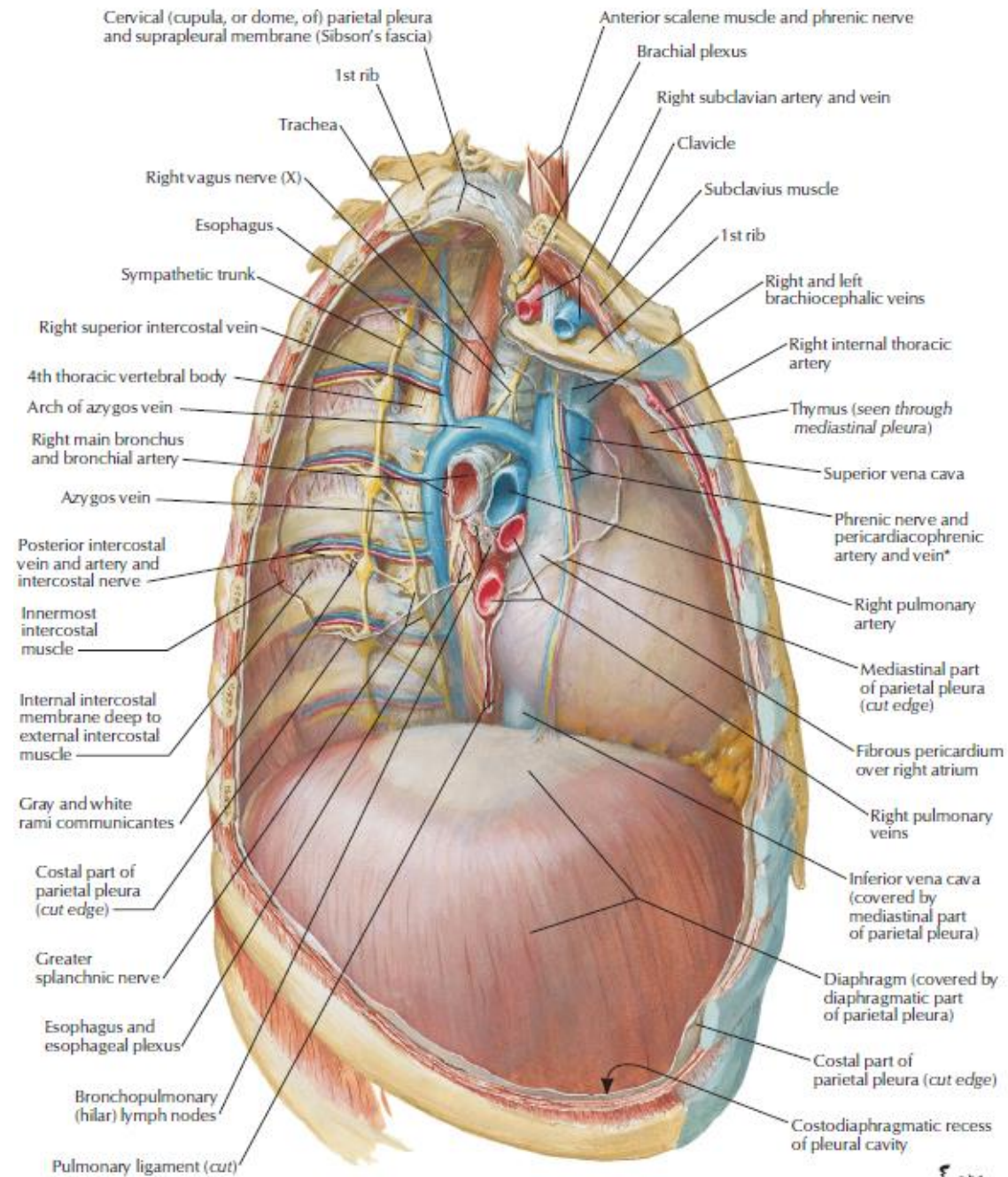
- the main bronchus  
- the pulmonary artery  
**ENTER THE LUNG**

- the 2 pulmonary veins  
**EXIT THE LUNG**



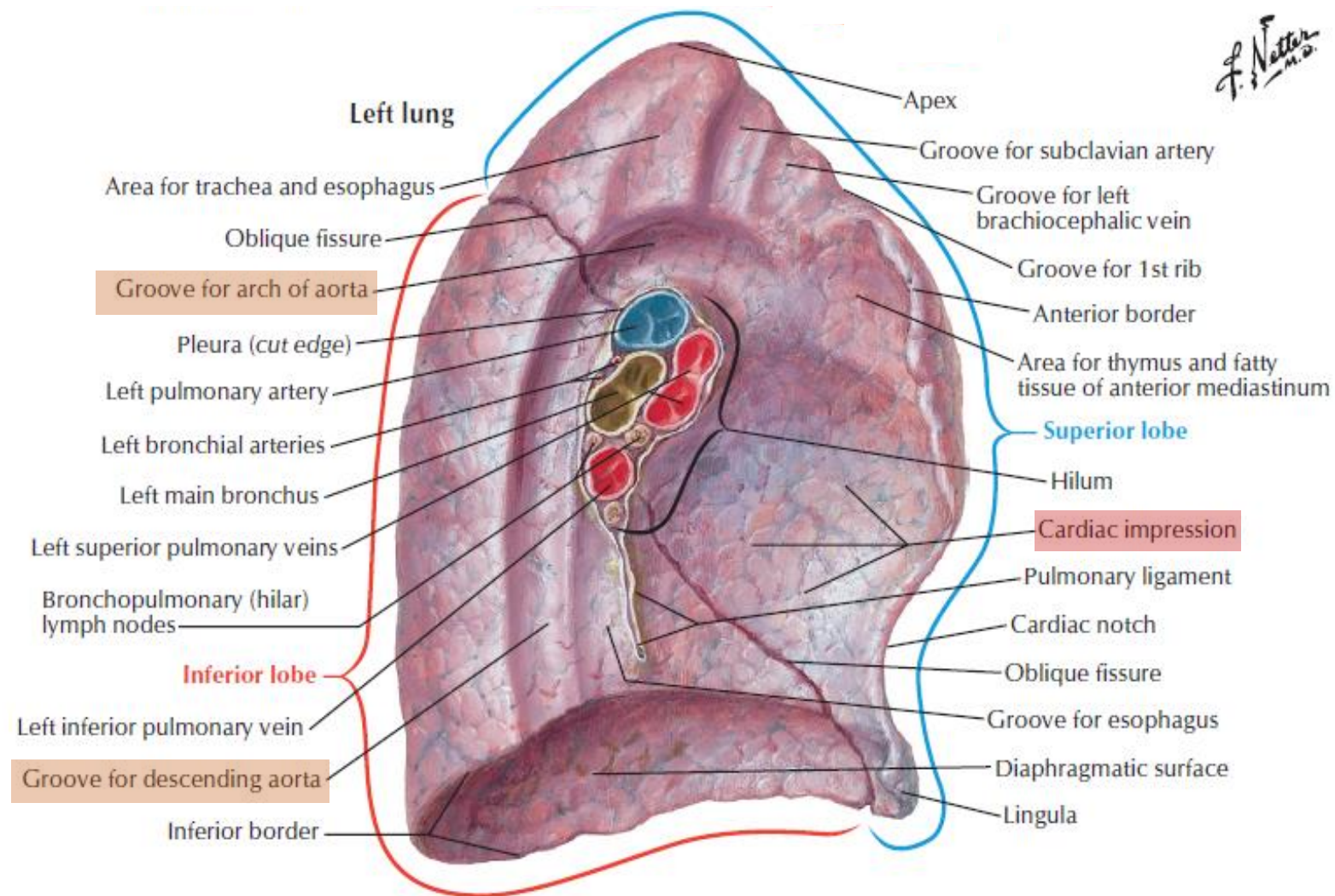
\*Nerve and vessels commonly run independently.





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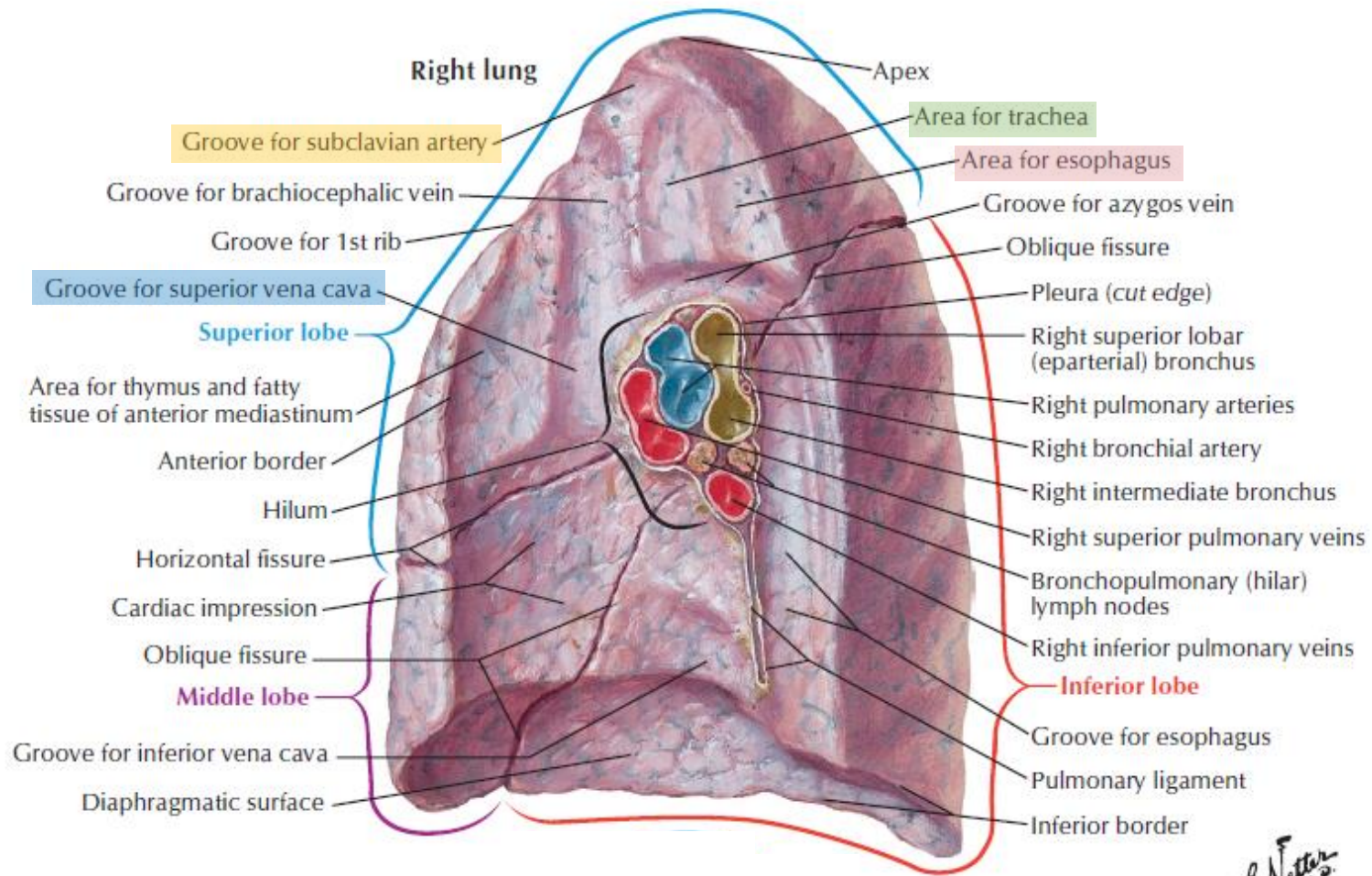


On the mediastinal side of the lungs, in addition to the pulmonary hilum, there are **IMPRESSIONS** due to the relationship with the mediastinal viscera

On the mediastinal side of the left lung we distinguish:

- the **CARDIAC IMPRESSION**  
it is anterior and inferior to the pulmonary hilum
- the **AORTIC IMPRESSION**  
given by the *groove for arch of aorta and the groove for descending aorta*





On the mediastinal side of the right lung we distinguish:

- The **CARDIAC IMPRESSION**, less marked

Impression created by:

- **SUPERIOR VENA CAVA**
- **SUCCLAVIAN ARTERY**
- **TRACHEA**
- **ESOPHAGUS**

*F. Netter M.D.*

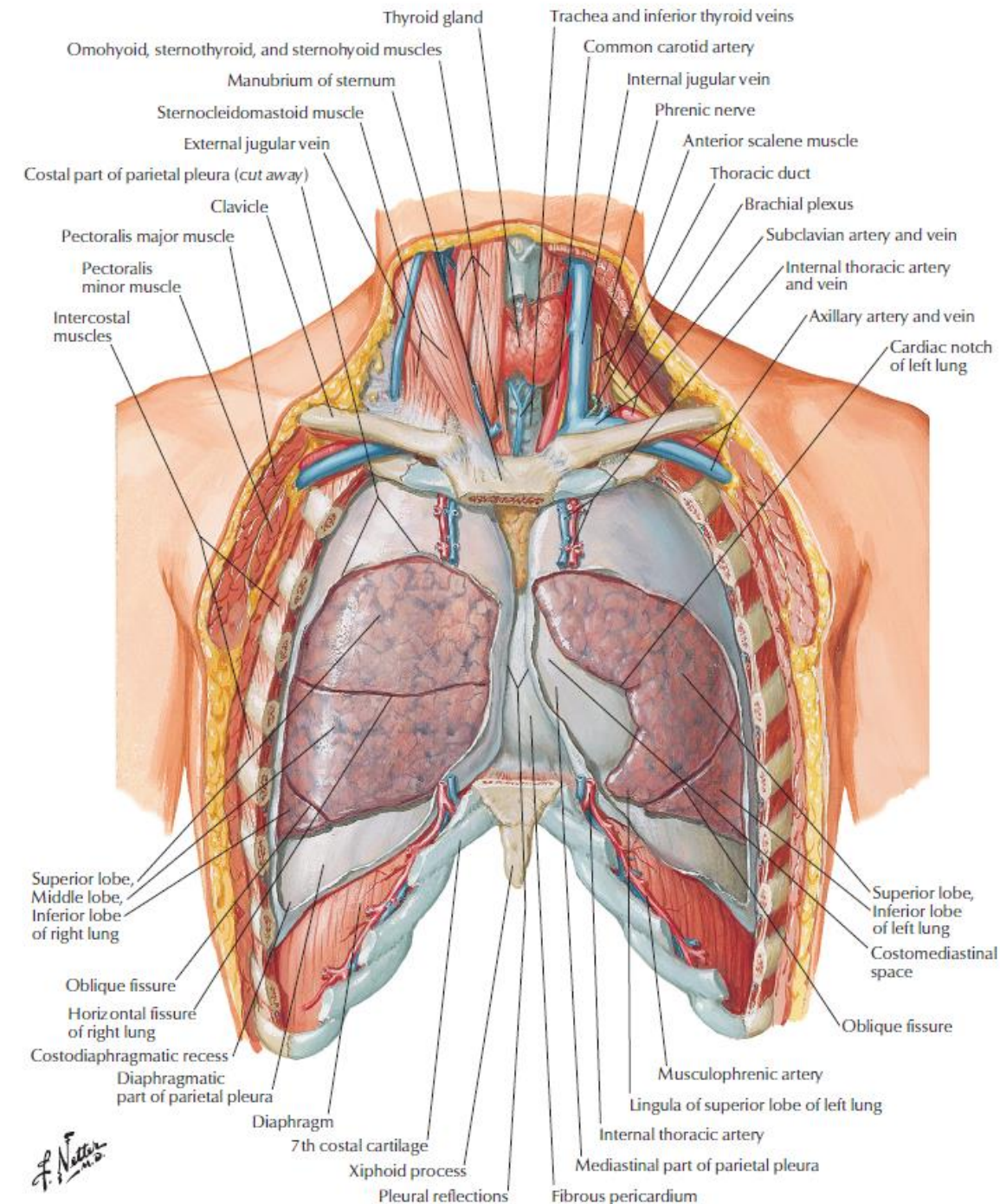
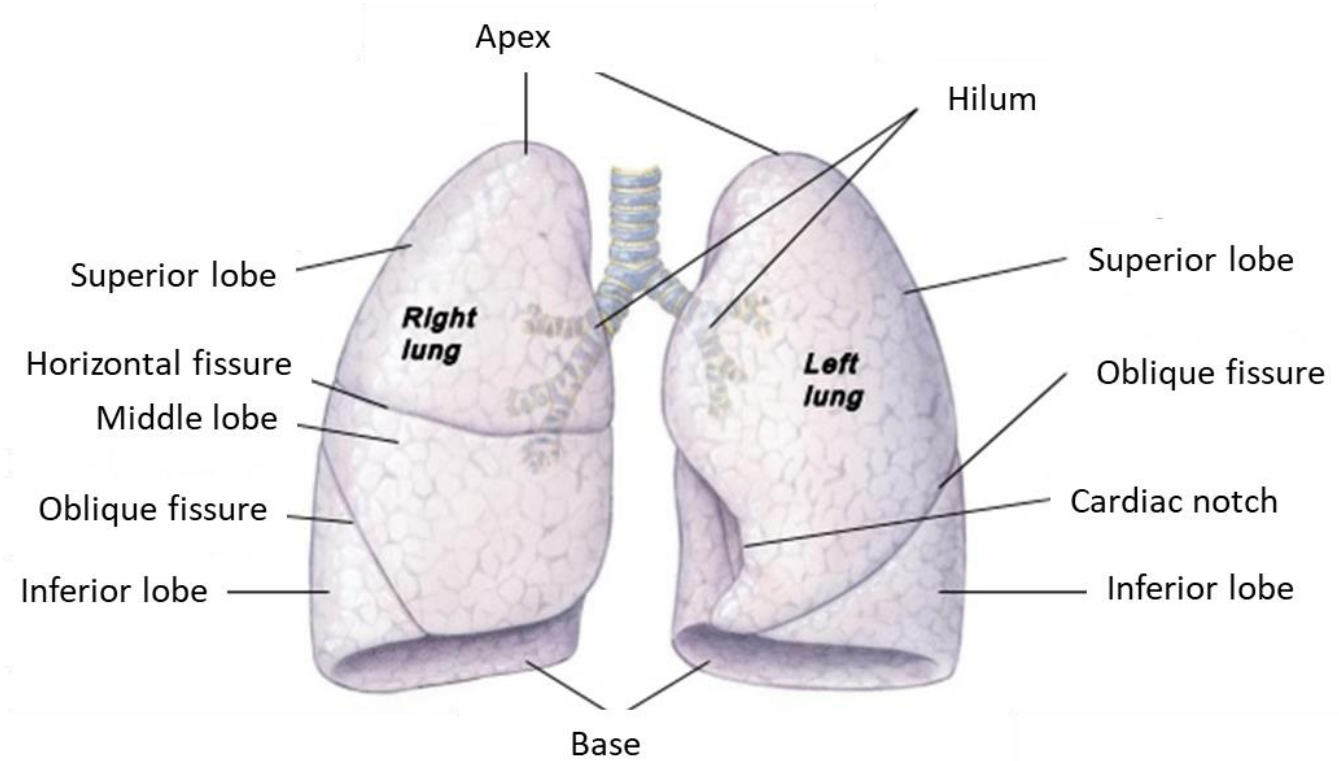
## Lungs are DIVIDED into PULMONARY LOBES by FISSURES

The **RIGHT LUNG** is divided by **2 FISSURES**:

- **primary or oblique fissure**
- **secondary or horizontal fissure**

These 2 fissures divide the lung into **3 LOBES**:

- **SUPERIOR LOBE**
- **MIDDLE LOBE**
- **INFERIOR LOBE**





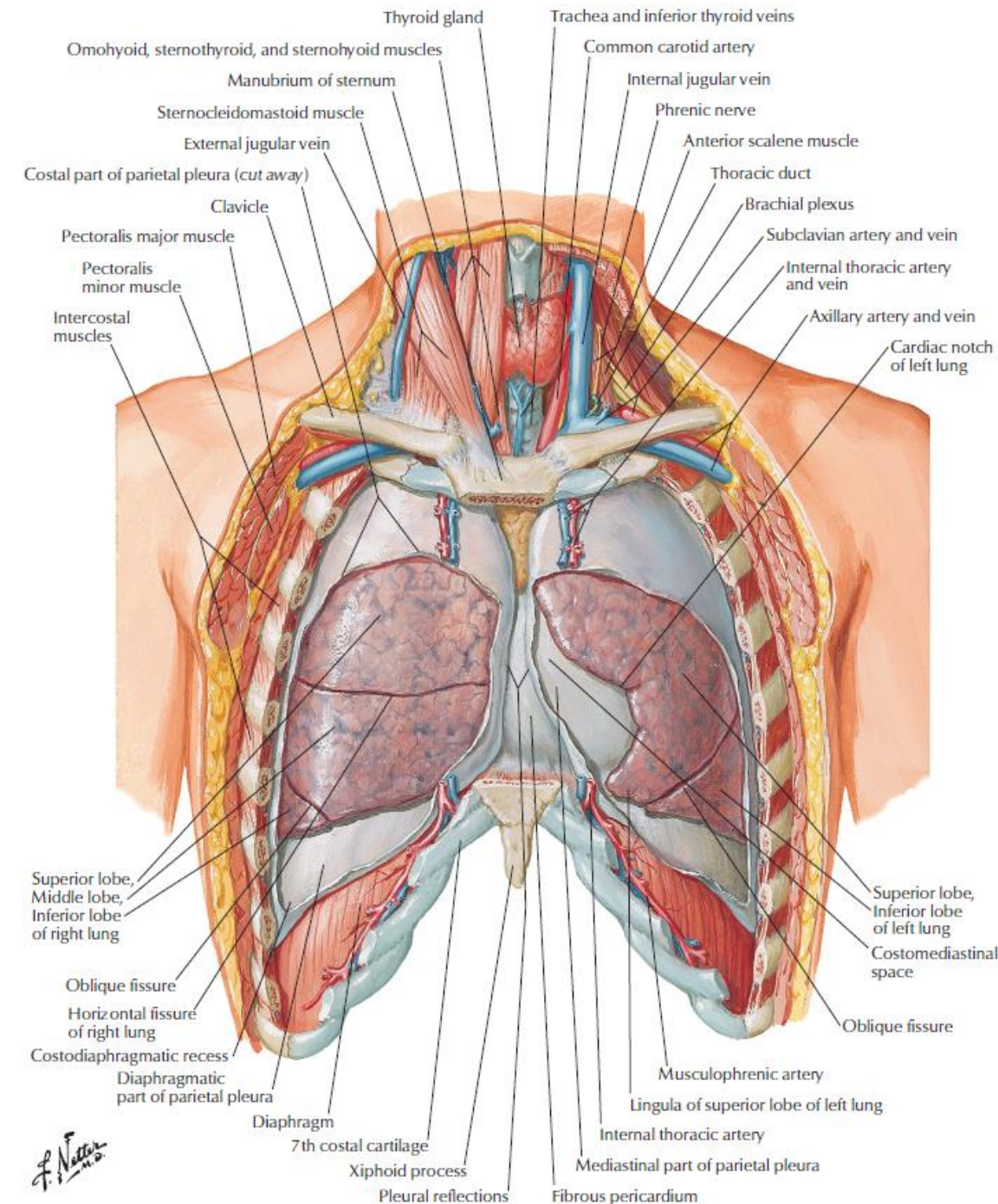
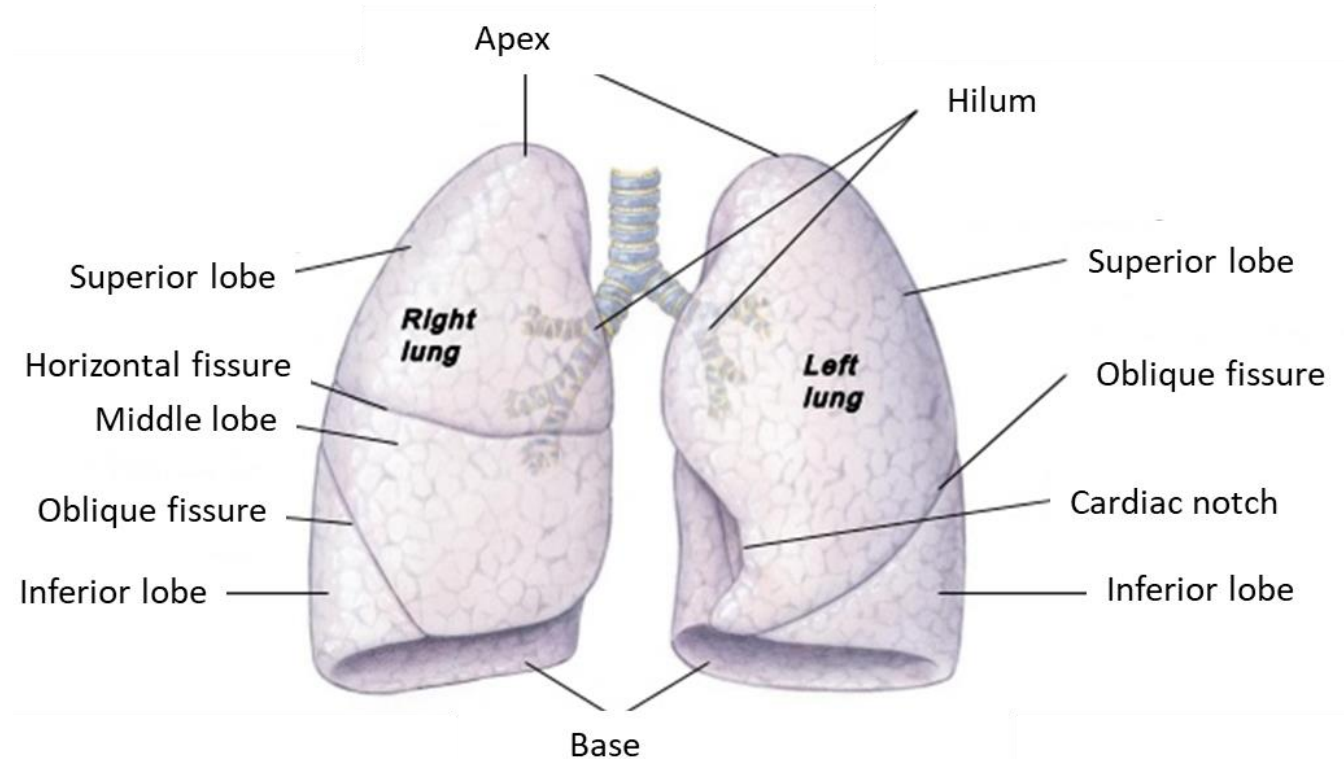
Lungs are DIVIDED into **PULMONARY LOBES** by FISSURES

The **LEFT LUNG** is divided by **only 1 fissure**:

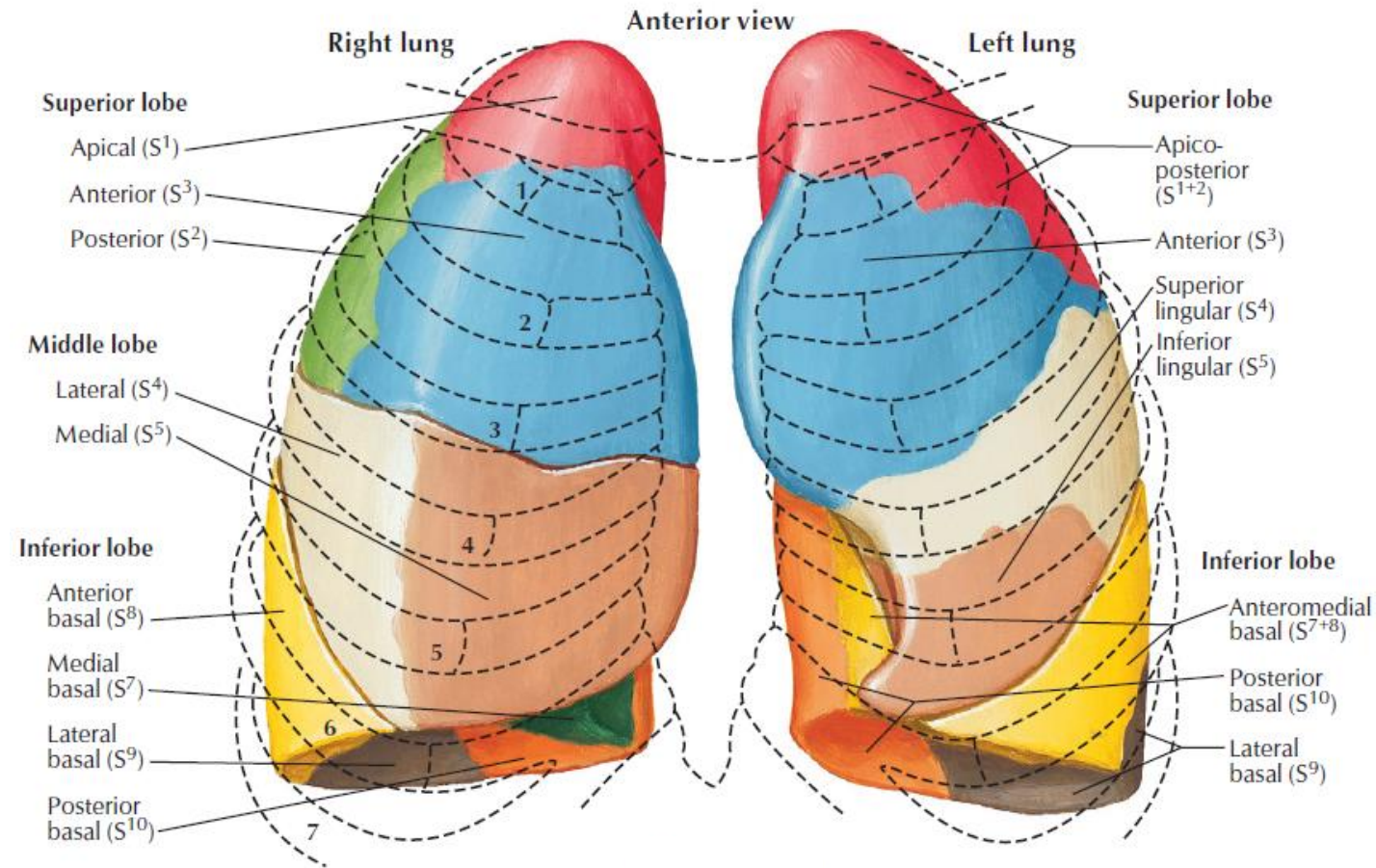
- **oblique fissure**

This fissure divides the lung into **2 LOBES**:

- **SUPERIOR LOBE**
- **INFERIOR LOBE**







## LEFT LUNG:

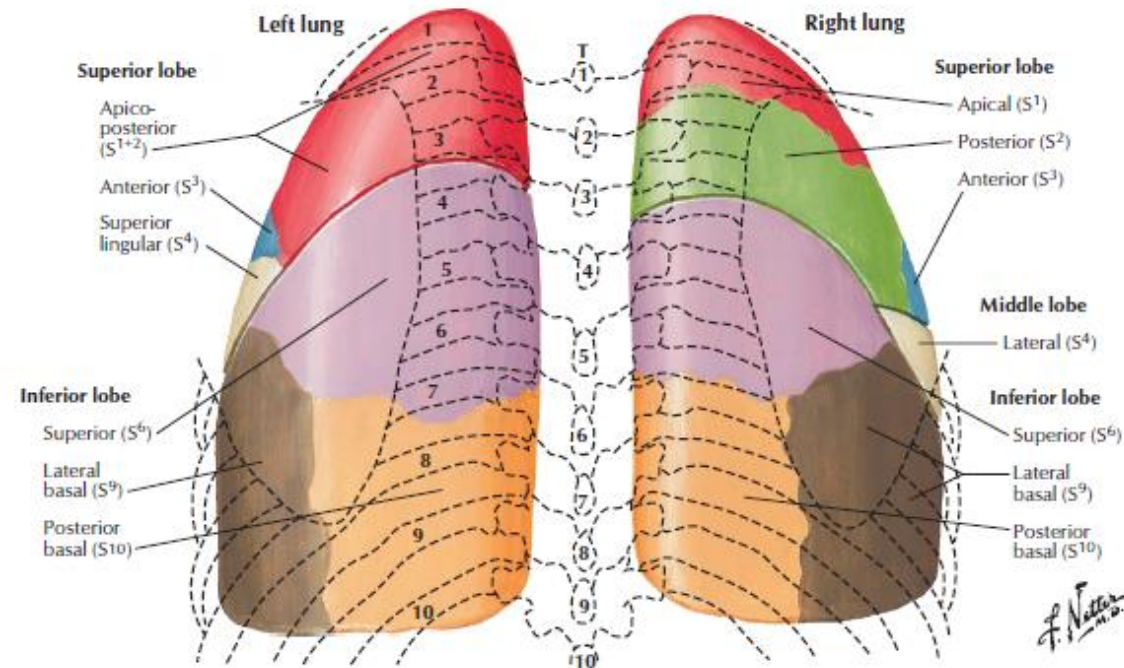
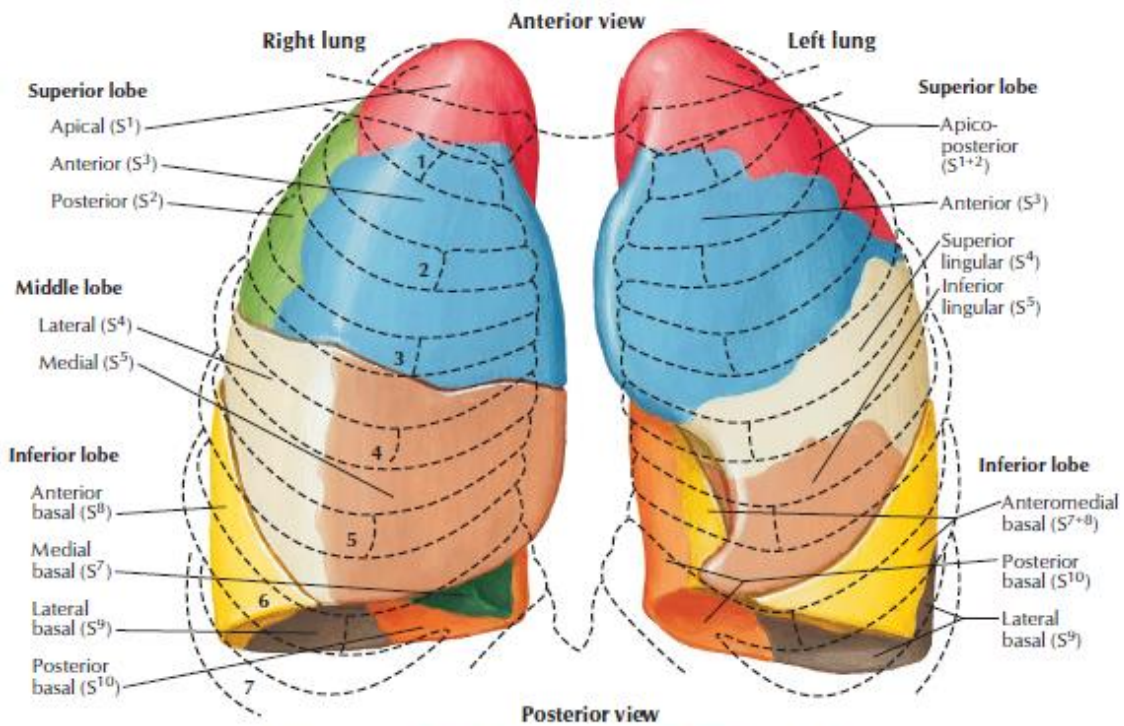
*The anterior margin of the left lung, due to the protrusion of the heart towards the left side, presents a notch called **CARDIAC NOTCH** of the **LEFT LUNG***

Between the fissure of the left lung and the cardiac notch, a portion of the superior lung lobe extends forward and downward, acquiring a narrow and elongated profile

↓  
Narrow and elongated portion of the superior lobe

▼  
**LINGULA**  
of the superior lobe of the left lung

*Lingula means little tongue (in Latin) and it is also referred to as the tongue in the lung.*

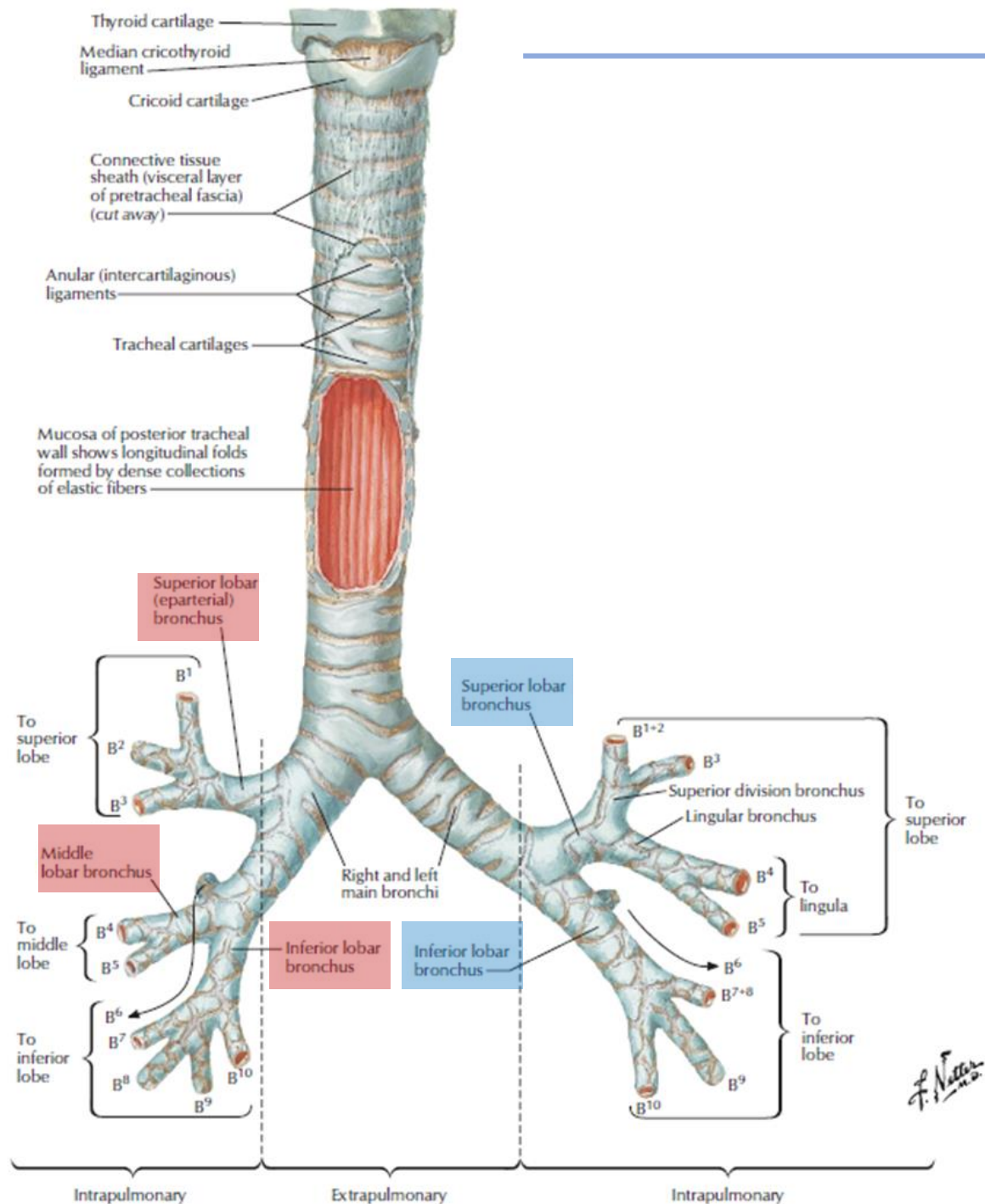


The lungs are divided into further anatomical and functional units, which are smaller units than the lung lobes, represented in the figure in different colors



The subdivision of the anatomical and functional units of the lungs reflects the subdivision of the bronchi within the lungs





The BRONCHI are divided into:

- RIGHT MAIN BRONCHUS, which delivers oxygen to the right lung
- LEFT MAIN BRONCHUS, which delivers oxygen to the left lung

Then, the main bronchi continue to branch into a **bronchial tree**.

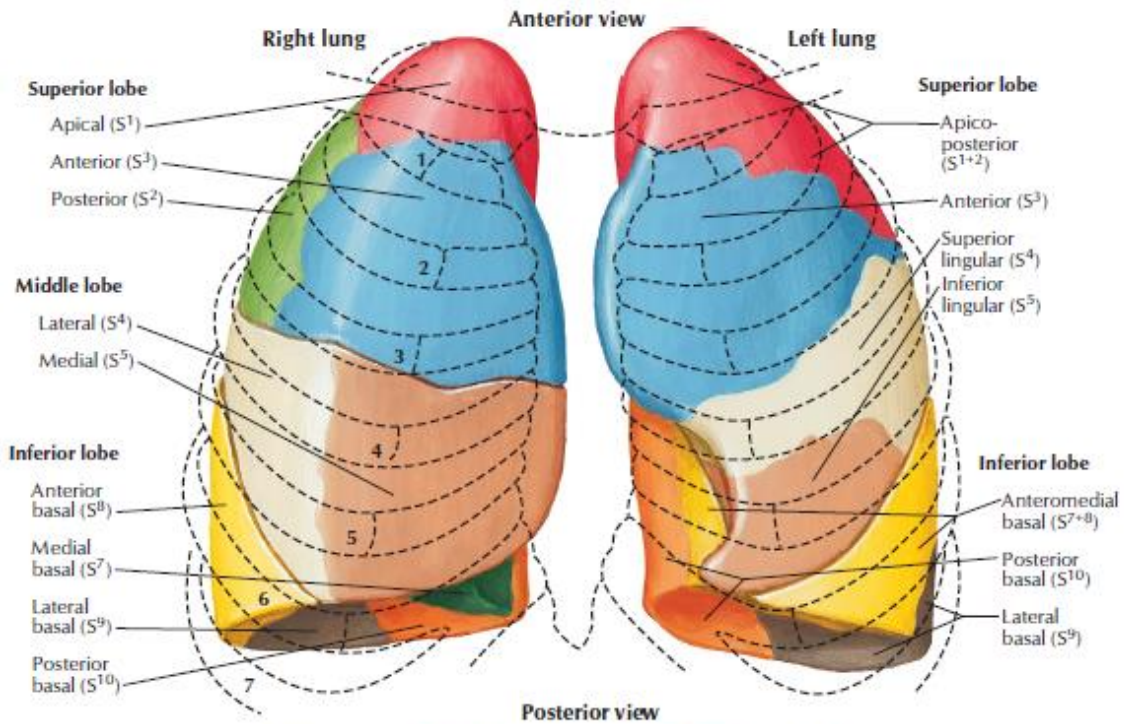
A *bronchial tree (or respiratory tree)* is the collective term used for these multiple-branched bronchi.

First, the **MAIN BRONCHI – right and left** – subdivide into **SECONDARY BRONCHI** (also known as LOBAR BRONCHI), which deliver oxygen to the PULMONARY LOBES

So, it is possible to identify:

- **3 RIGHT LOBAR BRONCHI** (superior, middle and inferior lobar bronchi)
- **2 LEFT LOBAR BRONCHI** (superior and inferior lobar bronchi)





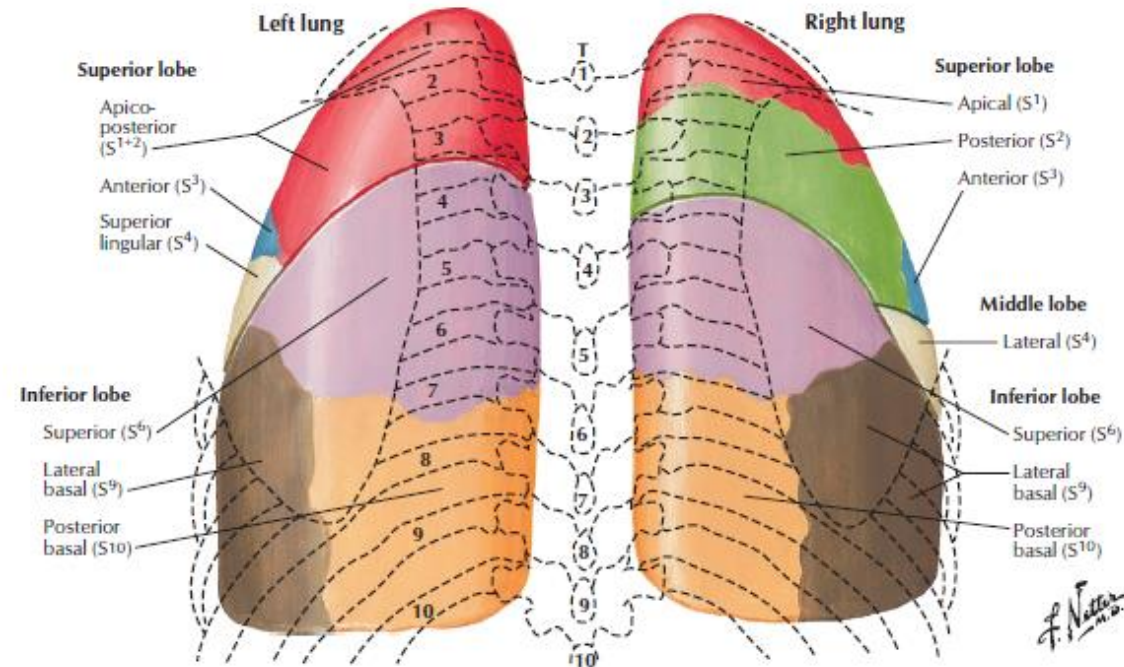
The figure represents the subdivision of the lung lobes into further anatomical/functional units, represented in different colors, which are called

↓  
**LUNG SEGMENTS**

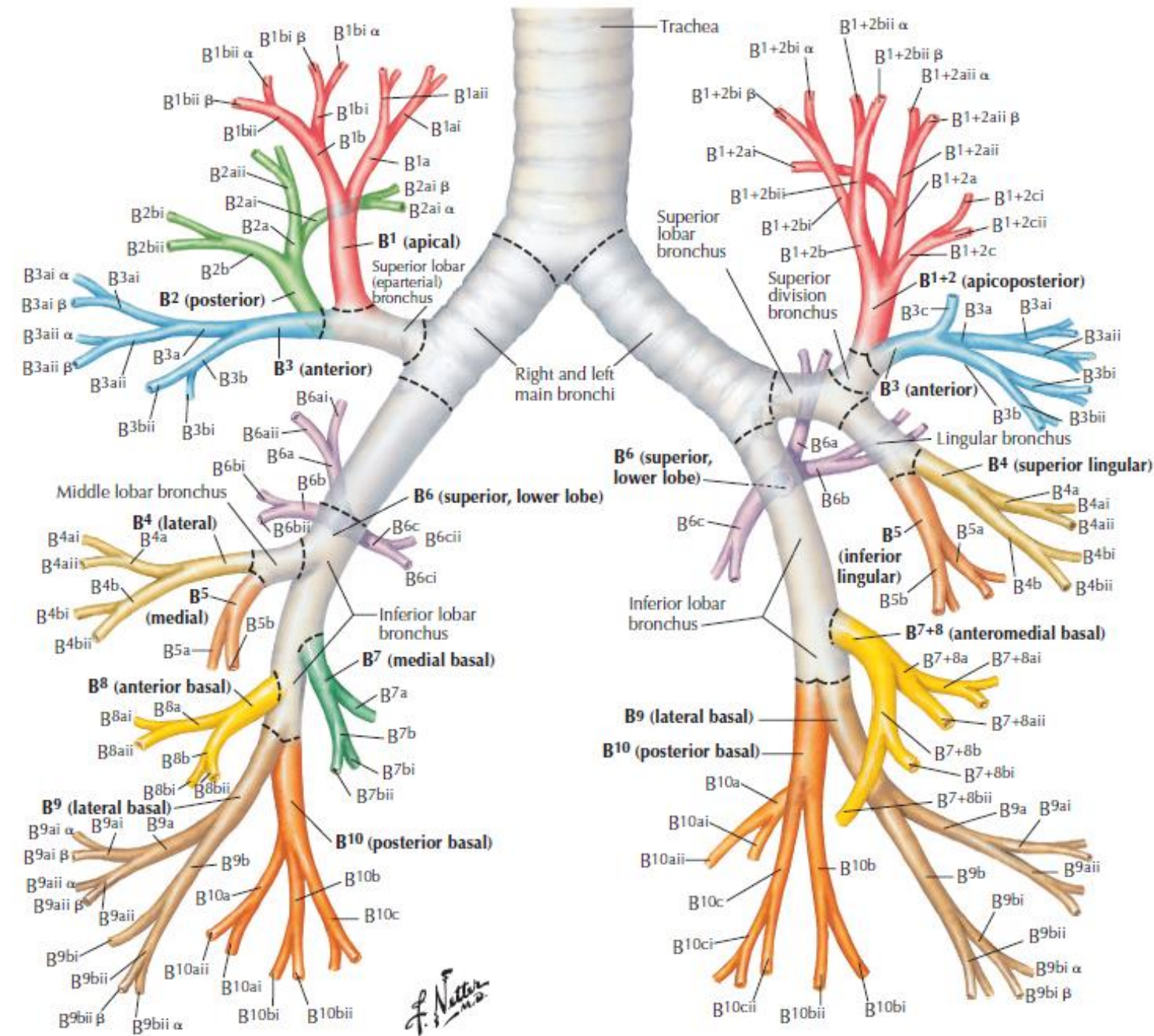
*How a pulmonary lobe is divided into segments?*

*If the lung lobes are divided based on the pulmonary fissures, the lung segments are not separated from each other by grooves or anatomical structures*

**THE SUBDIVISION OF THE LUNG SEGMENTS IS BASED ON THE ORGANIZATION OF THE BRONCHIAL TREE**







In fact, continuing with the divisions of the bronchial tree:

each secondary or lobar bronchus divided into smaller **TERZIARY BRONCHI** or **SEGMENTAL BRONCHI**, each of one delivering oxygen to the corresponding **LUNG SEGMENT**

*The figure shows the subdivision of the bronchi into progressively smaller bronchial branches, identified with colors that reflect the reference of the lung segments*

**The bronchopulmonary segment is a portion of lung supplied by its own bronchus (and artery)**

Nomenclature in common usage for bronchopulmonary segments (Plates 197 and 198) is that of Jackson and Huber, and segmental bronchi are named accordingly. Ikeda proposed nomenclature (as demonstrated here) for bronchial subdivisions as far as the 6th generation. For simplification on this illustration, only some bronchial subdivisions are labeled as far as the 5th or 6th generation. Segmental bronchi (B) are numbered from 1 to 10 in each lung, corresponding to pulmonary segments. In the left lung,

B1 and B2 are combined as are B7 and B8. Subsegmental, or 4th order, bronchi are indicated by the addition of lower-case letters a, b, or c when an additional branch is present. Fifth order bronchi are designated by Roman numerals i (anterior) or ii (posterior) and 6th order bronchi by Greek letters  $\alpha$  or  $\beta$ . Several texts use alternate numbers (as proposed by Boyden) for segmental bronchi.

Variations of the standard bronchial pattern shown here are common, especially in peripheral airways.

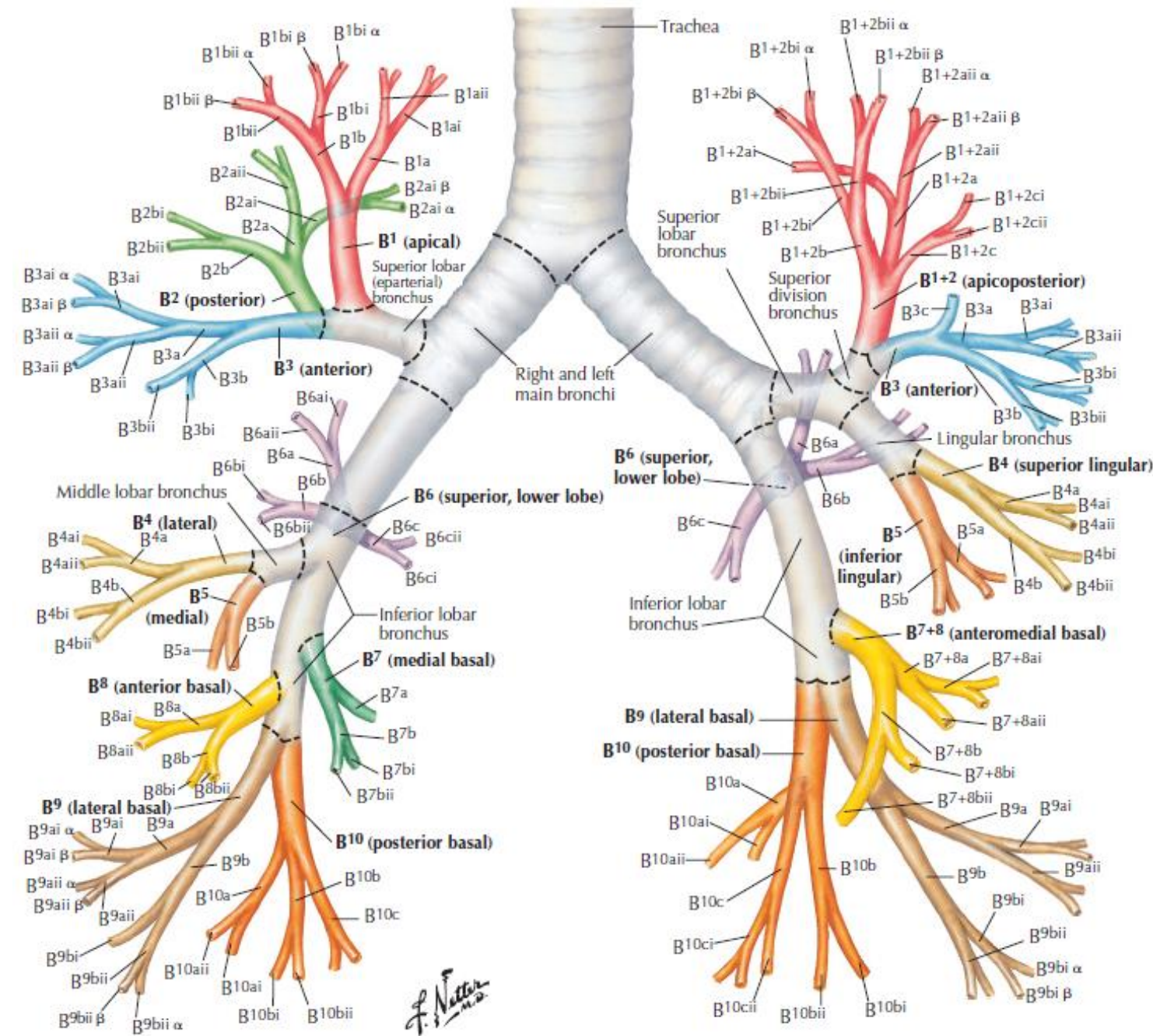


## THE BRONCHIAL TREE

1. Trachea divides into the 2 **RIGHT** and **LEFT MAIN BRONCHI**
2. The main bronchi divide into **LOBAR BRONCHI**:
  - the right main bronchus divides into the 3 superior, middle and lower lobar bronchi
  - the left main bronchus divides into the 2 superior and inferior lobar bronchi
3. Each lobar bronchus divides into **FURTHER BRANCHES** in a relatively repetitive manner (with some differences). Each of these branches **deliver oxygen to a specific LUNG SEGMENT** forming subsequent and smaller bronchial branches

The smaller bronchial branches that immediately follow each lobar bronchus are called

↓  
**SEGMENTAL BRONCHI**



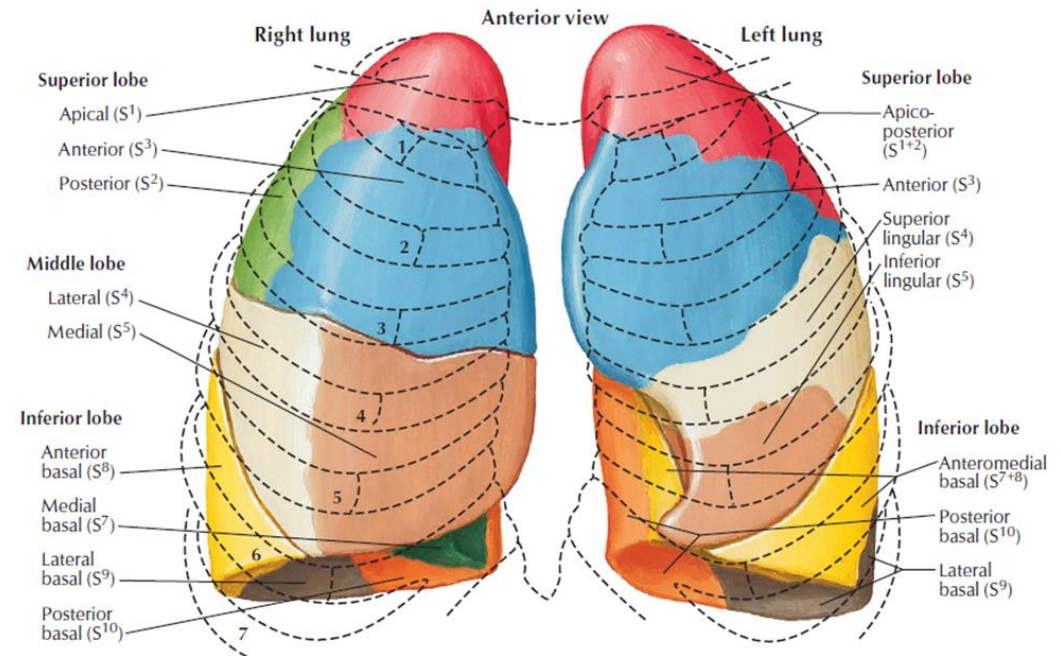
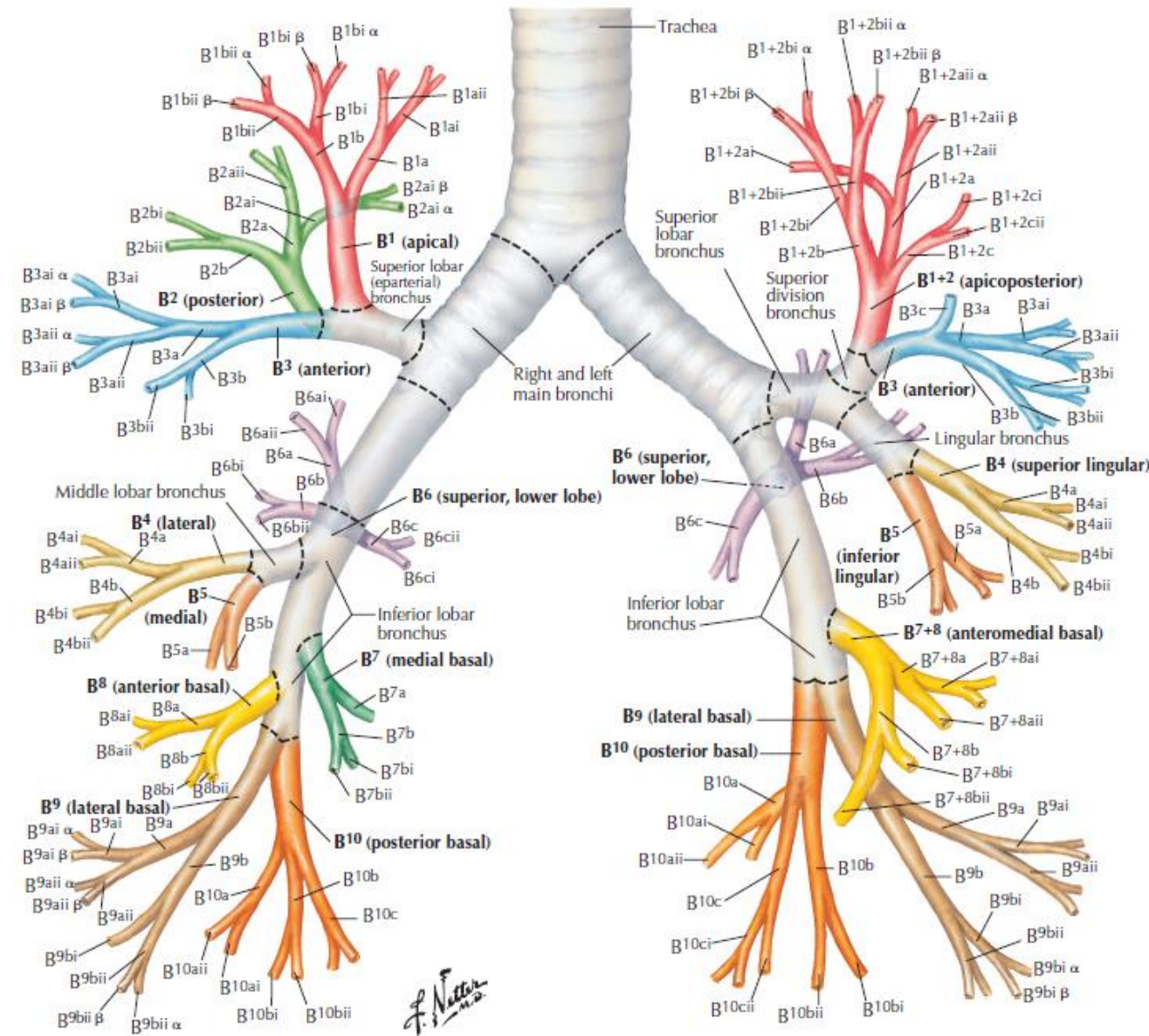


The right superior lobar bronchus divides into:

- an **APICAL SEGMENTAL BRONCHUS**
- a **POSTERIOR SEGMENTAL BRONCHUS**
- an **ANTERIOR SEGMENTAL BRONCHUS**

These 3 segmental bronchi will constitute the pulmonary parenchyma of the 3 pulmonary segments of the superior lobe of the right lung:

- APICAL SEGMENT**
- POSTERIOR SEGMENT**
- ANTERIOR SEGMENT**

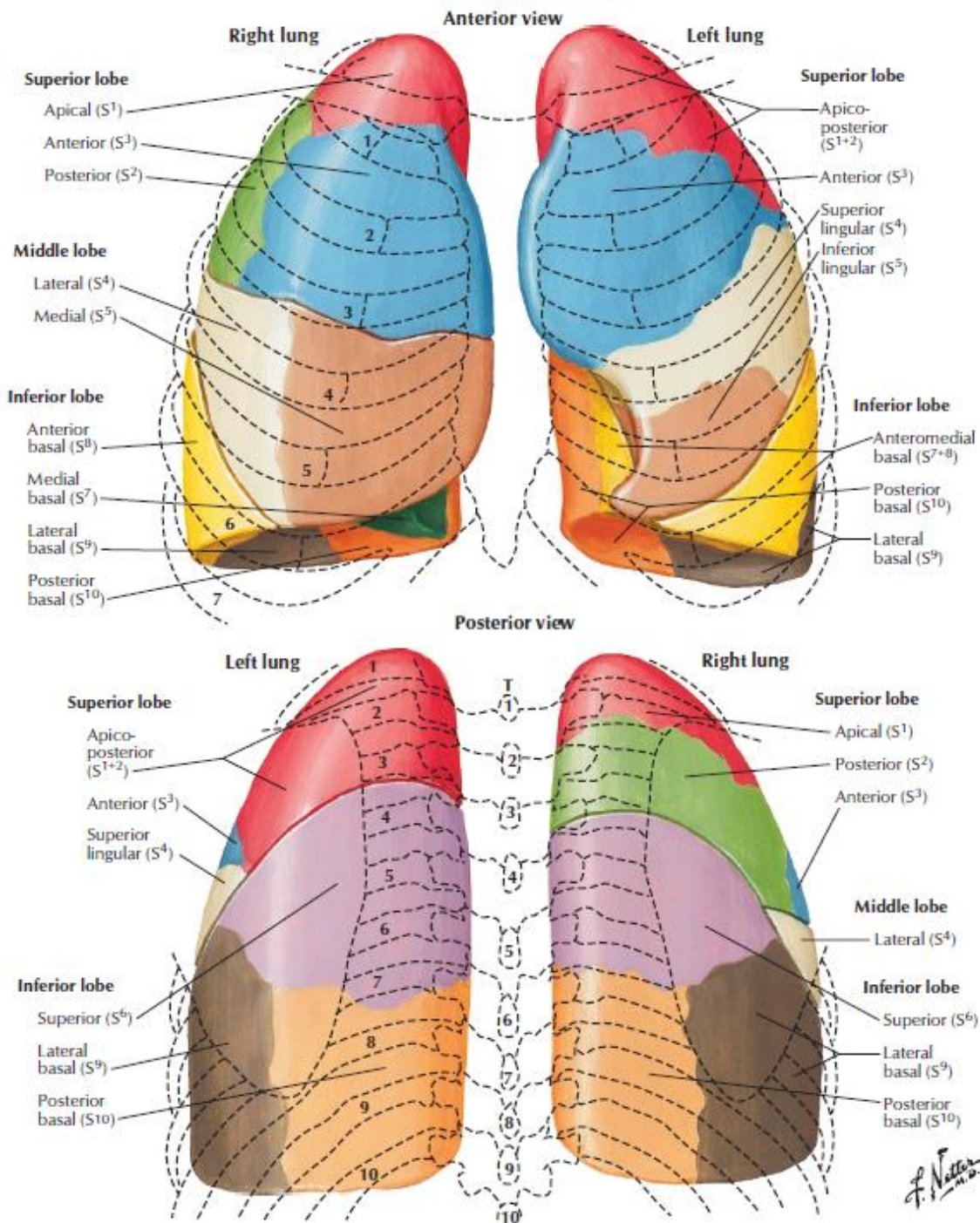


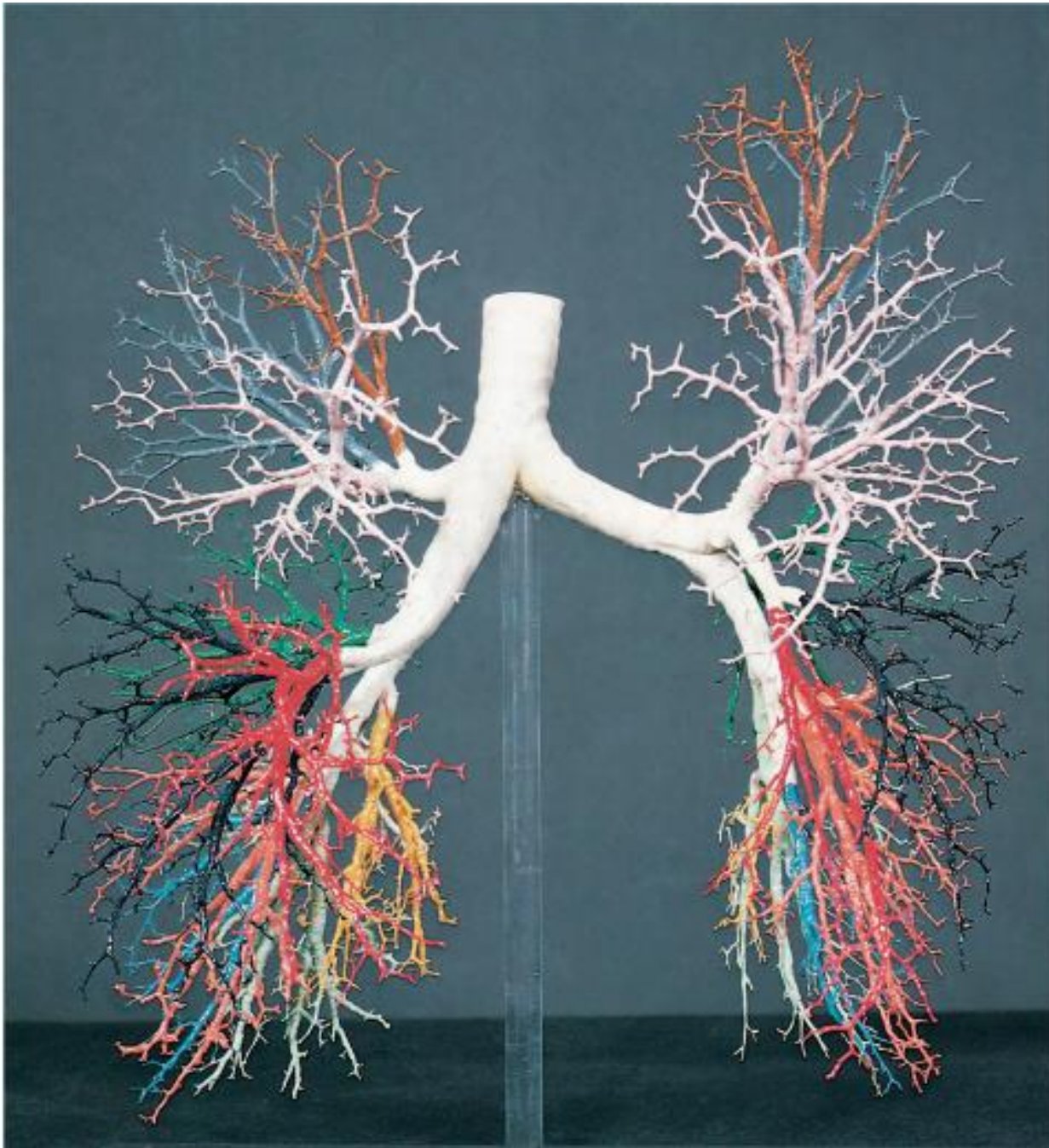


*How a pulmonary lobe is divided into segments?*

**Each lung segment is defined by a SPECIFIC BRONCHIAL BRANCH which derives from a LOBAR BRONCHUS**

Each lobar bronchus produces further branches, each of which is called segmental bronchus, which will ventilate/constitute a specific portion of lung parenchyma





The image represents the CASTING MOLD of the BRONCHIAL TREE, with the respective SEGMENTAL BRONCHI highlighted in different colors, determining the individual LUNG SEGMENTS

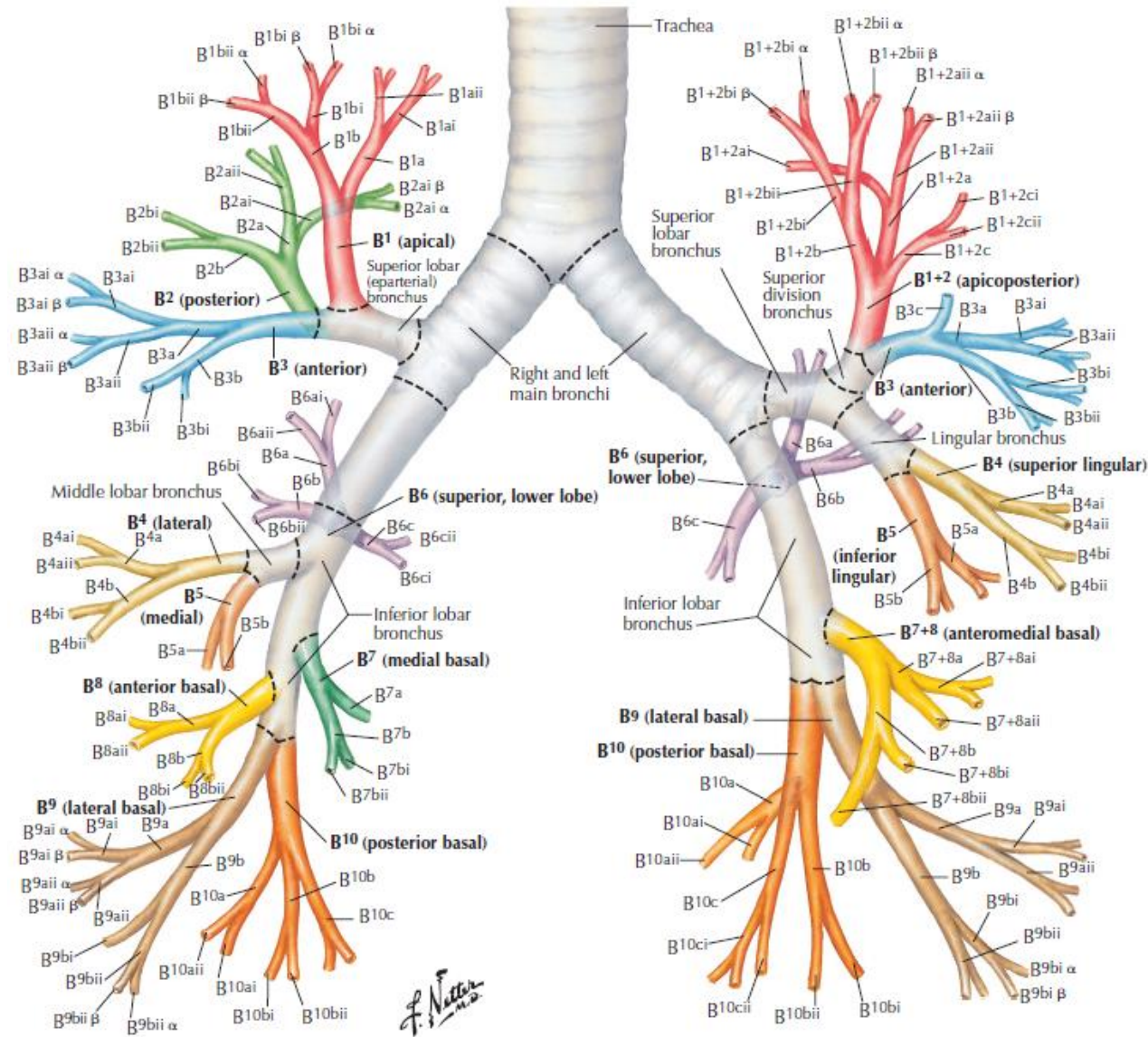
Each segmental bronchi further branch into smaller bronchial subdivisions, which are named the



**SUB-SEGMENTAL BRONCHI**







Going on with smaller and smaller branches formation within the bronchial tree, the bronchial division become a **DICHOTOMIC DIVISION**

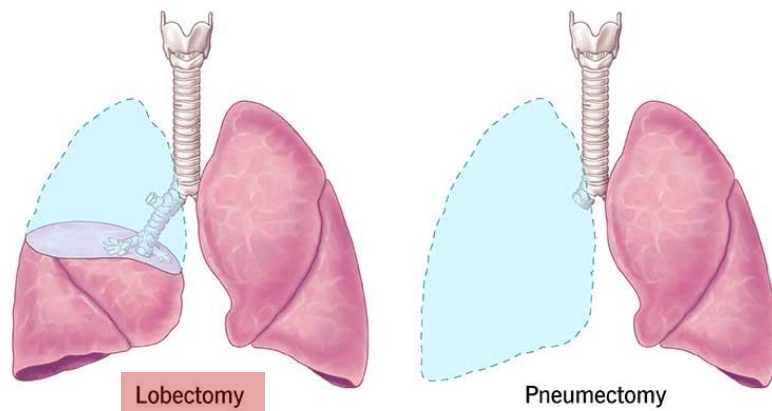
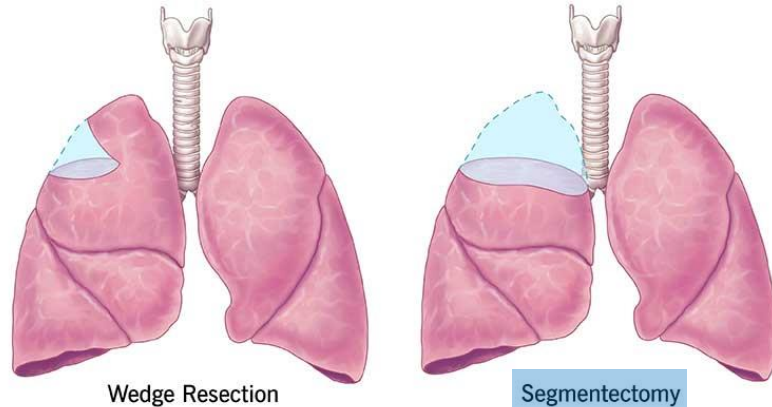
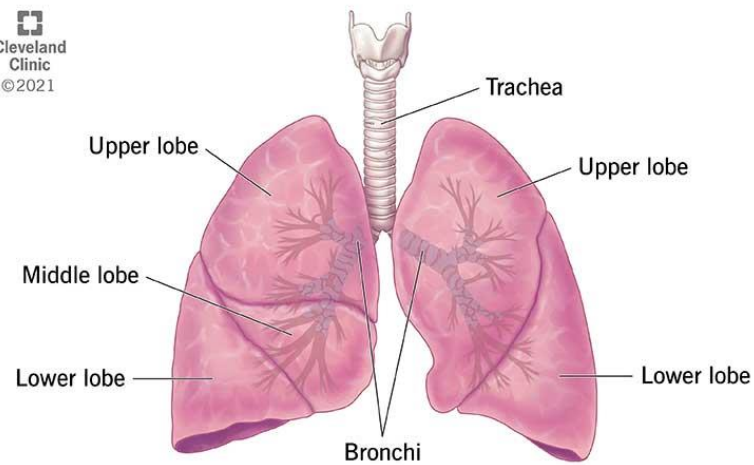


2 branches originate from the original bronchial branch, forming a "V" shape = each branch splits into branches of equal caliber which no longer form an acute angle between them, but an obtuse angle



None of the 2 bronchial branches follows the axis of the original bronchus





The division into pulmonary segments and segmental bronchi has an important surgical meaning

If there is a need to remove part of a lung due to the onset of LUNG CANCER, the surgical approach may be different

**Tumor located on the upper portion  
of the right superior lobe of the lung**



*Different intervention strategies:*

- a more invasive surgery may involve the removal of the entire superior lobe of the right lung (e.g., **PULMONARY LOBECTOMY**)
- a less invasive surgery involves the removal of the only the lung segment affected by the tumor (e.g., **PULMONARY SEGMENTECTOMY**)



