Thorax IIb

1. Lung, bronchopulmonary segments, blood supply of the lunge, venous drainage, lymphatics, and nerve supply.
2. Mediastinum, parts of mediastinum, superior mediastinum, posterior mediastinum, middle mediastinum, pericardium, heart, anatomical features, chambers of the heart, valves of the heart, blood supply of the heart, conducting system of the heart

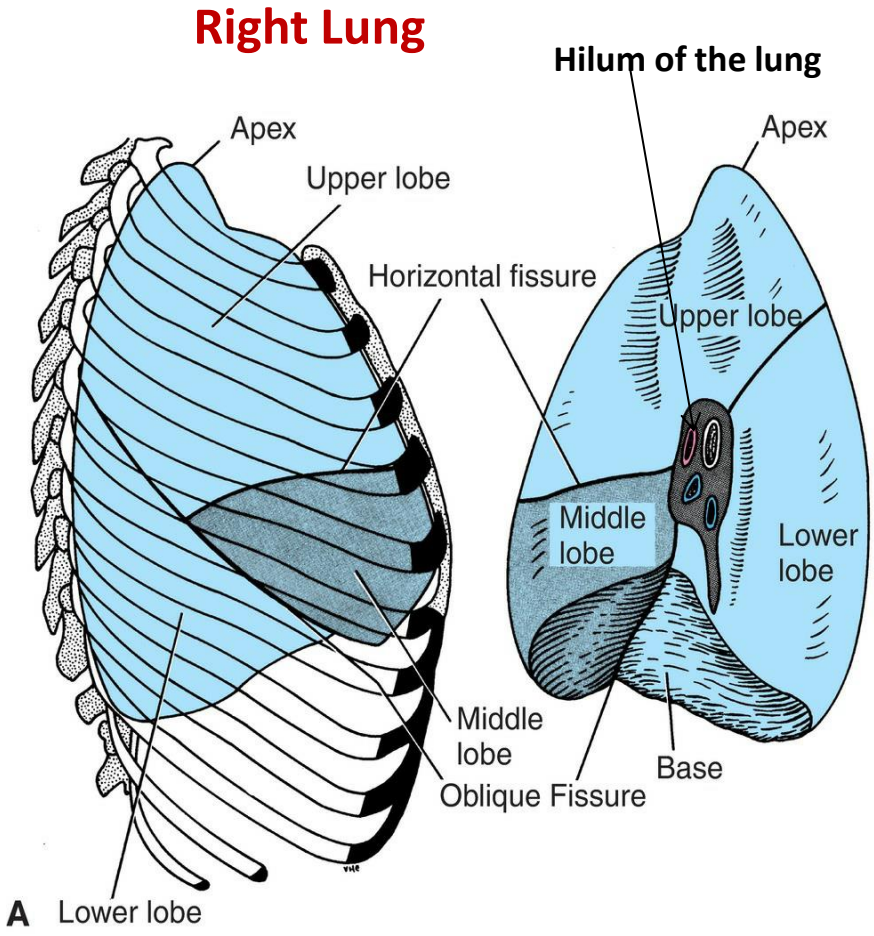
The Lungs

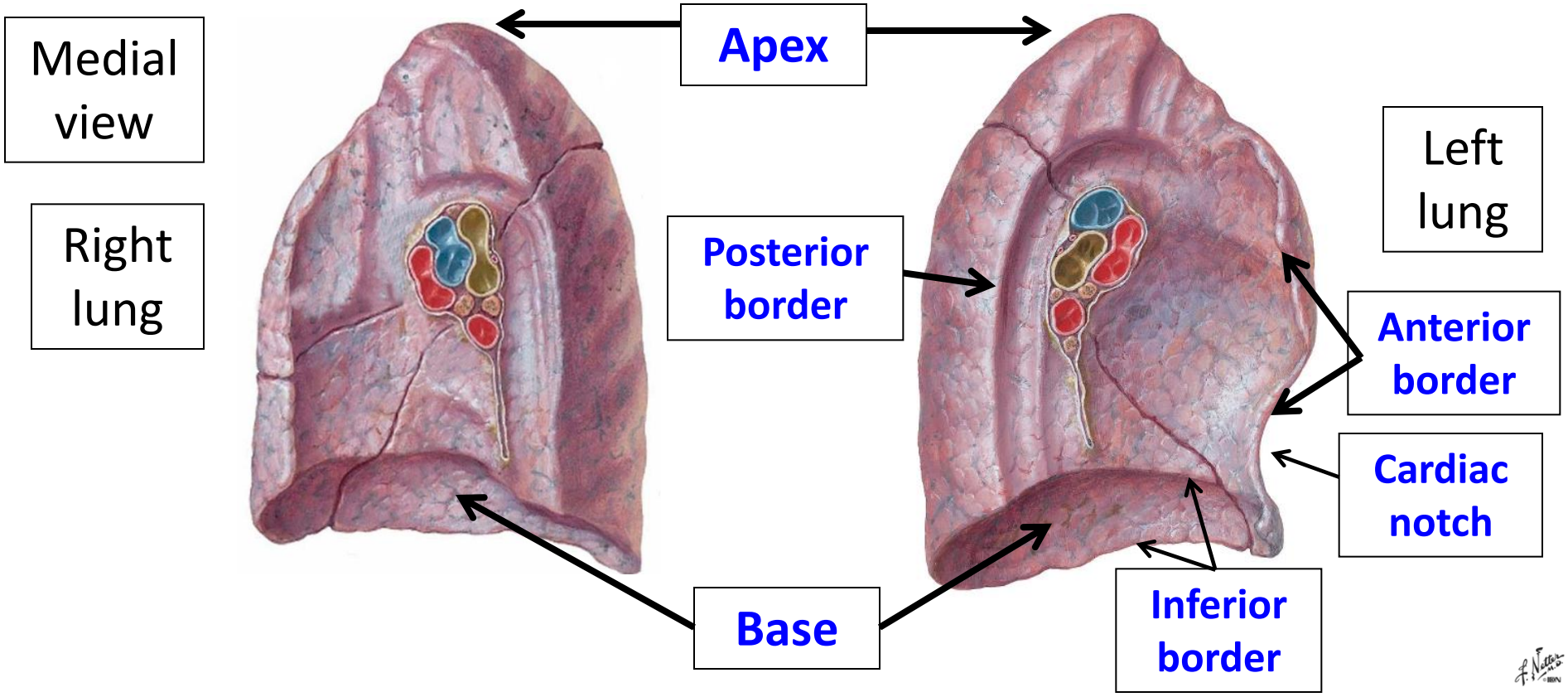
External features: Each lung is conical, covered with visceral pleura, attached to the

mediastinum by its root, and lies free in its own pleural cavity.

Each lung has **1) a blunt apex**, which projects upward into the neck for

about 2.5 cm above the clavicle; **2) a concave base** that sits on the diaphragm; **3) a convex costal surface**, which corresponds to the concave chest wall; and **4) a concave mediastinal surface,** which is molded to the pericardium and other mediastinal structures. **5)The anterior lung borders** are thin and overlap the heart. **6)The posterior border** of each lung is thick and lies beside the vertebral column.





- Each lung has:

1) An **apex** – the superior end of the lung, extends **above medial 1/3rd clavicle** (into the root of the neck)

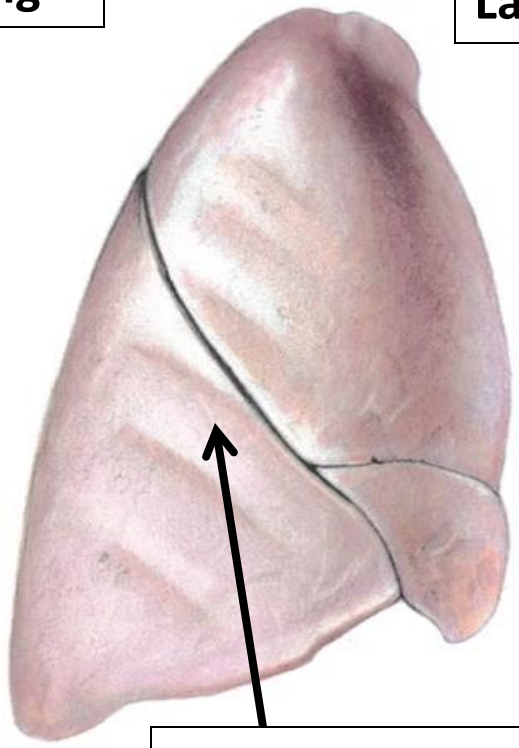
2) **3 borders** – anterior, posterior and inferior

3) **3 surfaces** – costal, mediastinal and diaphragmatic (base)

Lung - Surfaces

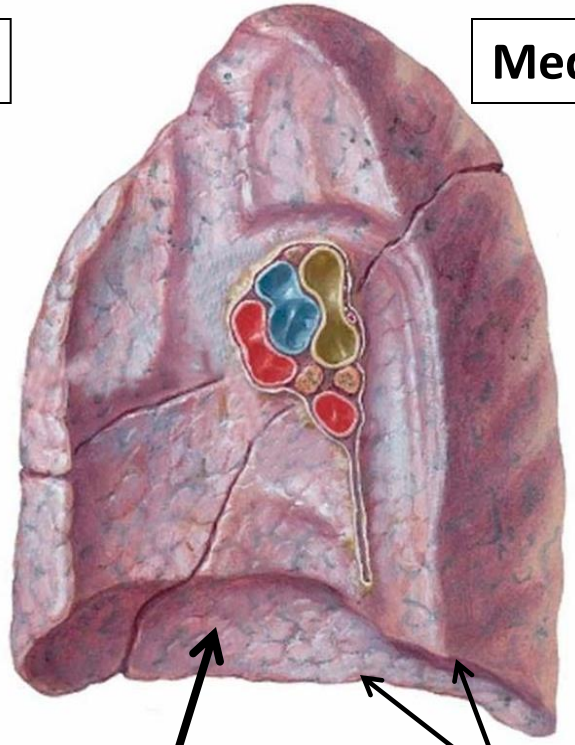
Right lung

Lateral view



Costal surface

Medial view



Diaphragmatic surface

Inferior border

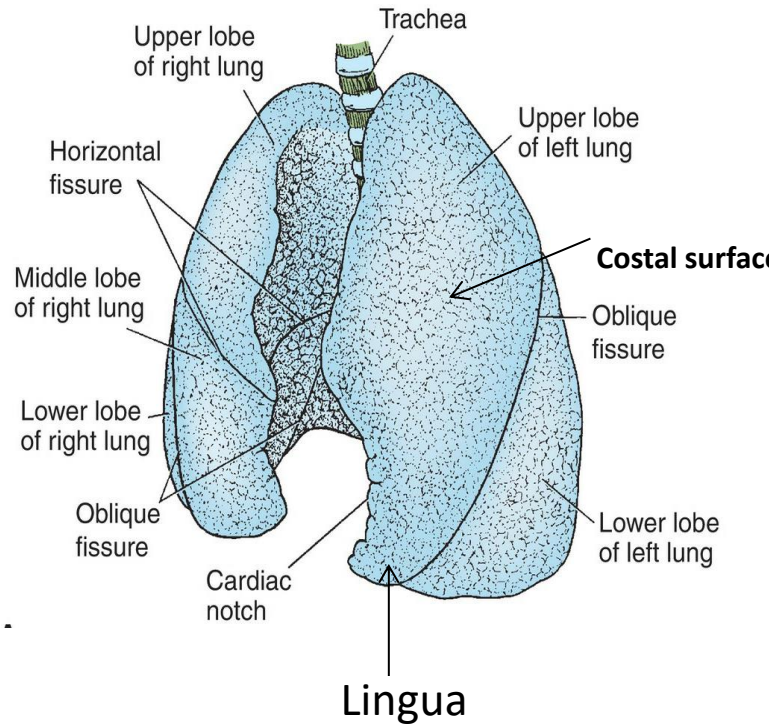
1) **Costal surface** - lies adjacent to **ribs**, costal cartilages and innermost intercostal muscles

2) **Diaphragmatic surface** - forms the **base** of lung. Rests on diaphragm.

At about the middle of the mediastinal surface of each lung there is the **hilum**, which is a depression in which the **root** of the lung attaches. The structures that enter or leave the lung form the root of the lung, these are, **the bronchi, pulmonary artery and veins, lymph vessels, bronchial vessels, and nerves.**

The root is surrounded by a **tubular sheath of pleura,** which joins the mediastinal parietal pleura to the visceral pleura covering the lungs.

The cardiac notch is a concave indentation of the anterior margin of the left lung. The **lingula** is the tongue-like projection of the anterior margin of the left lung that extends from the inferior end of the cardiac notch.



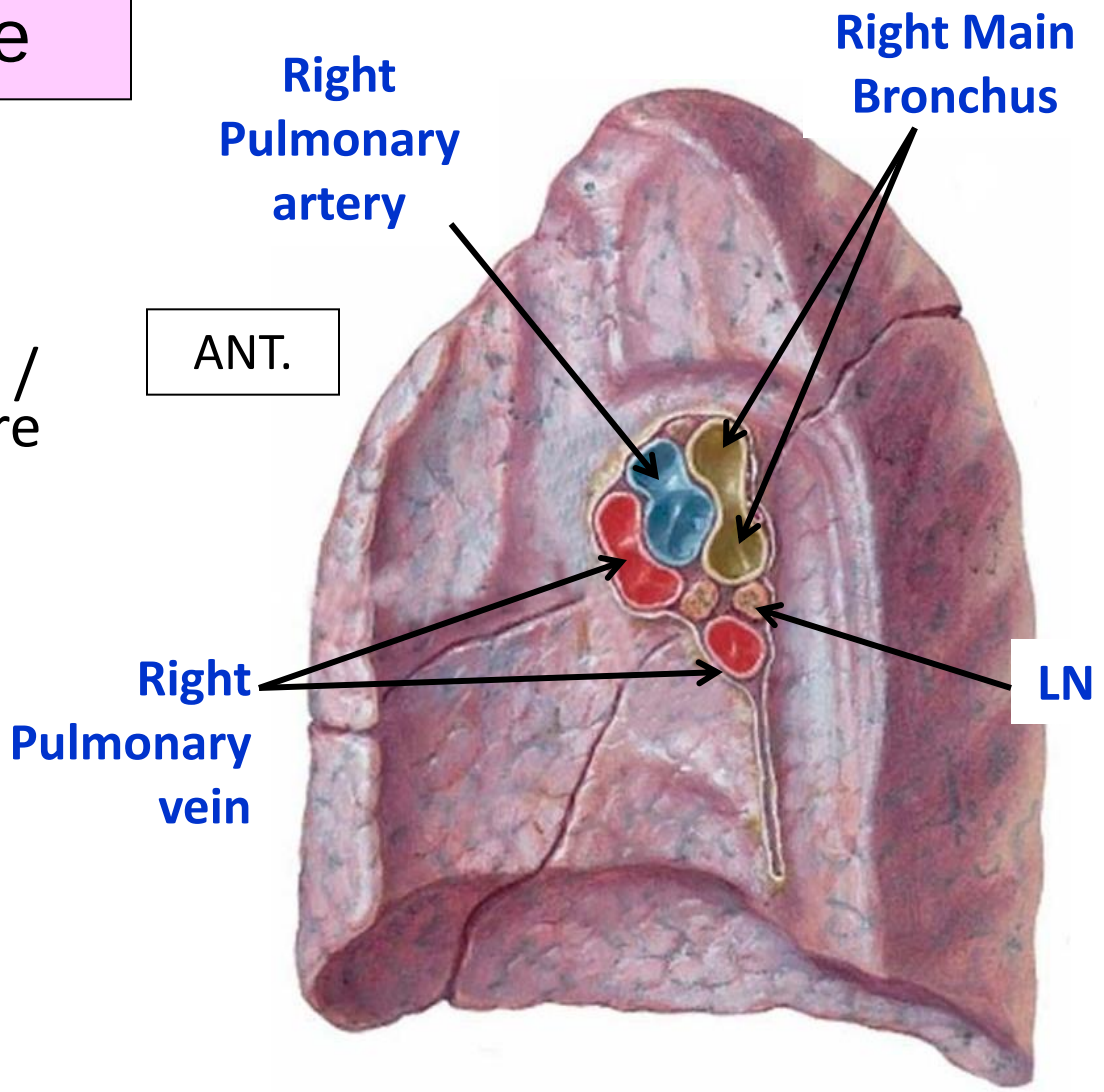
Mediastinal surface

1) Hilum of Lung:

- The structures that enter / leave the lung at hilum are called **root of the lung**

- Root of lung consist of:

1) main bronchus
2) pulmonary artery
3) 2 pulmonary veins (superior & inferior)
4) bronchial arteries and veins
5) Nerve plexus
6) lymphatic vessels & lymph nodes

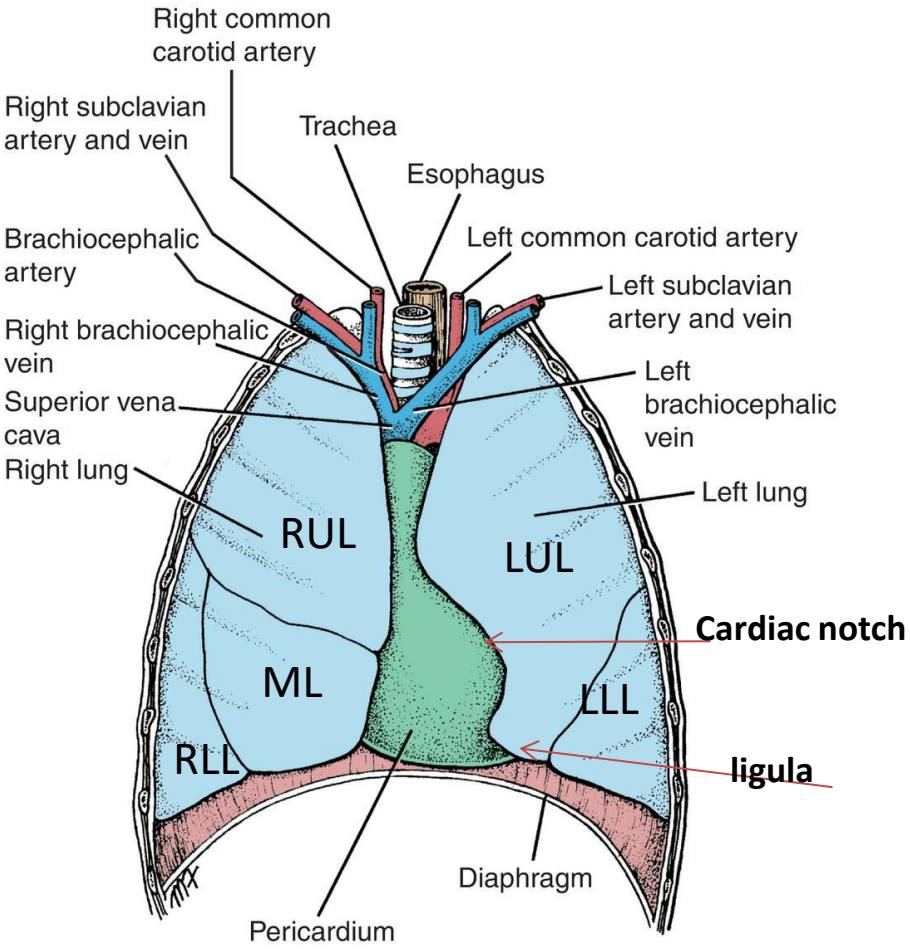


Medial view of right lung

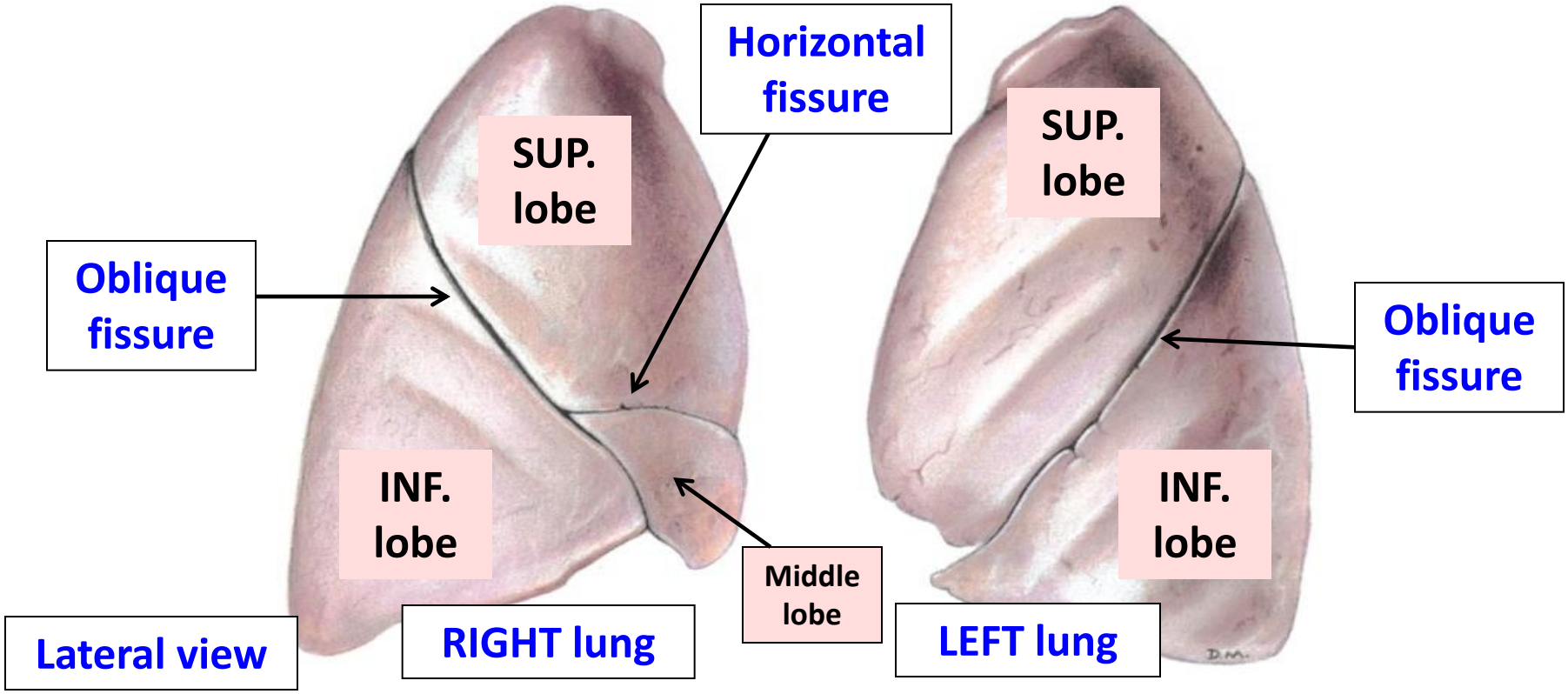
	Fissures	Lobes
Right Lung (slightly larger)	1. Horizontal: runs along approximately the horizontal line of the fourth costal cartilage to intersect the oblique fissure in the midaxillary line. 2. Oblique: runs at roughly a T2 (posterior) to T6 (anterior) angulation.	1. Upper (superior) 2. Middle 3. Lower (inferior)
Left Lung	1. Oblique: similar course as in the right lung. No horizontal fissure.	1. Upper (superior) 2. Lower (inferior)

Lobes and Fissures of the lung

Deep fissures divide the right and left lungs into unequal numbers of lobes. Note: In both lungs, the upper lobes lie more anteriorly, whereas the lower lobes lie more posteriorly. The middle lobe is a small triangular lobe that lays antero-inferiorly, between the other two lobes, bounded by the horizontal and oblique fissures.



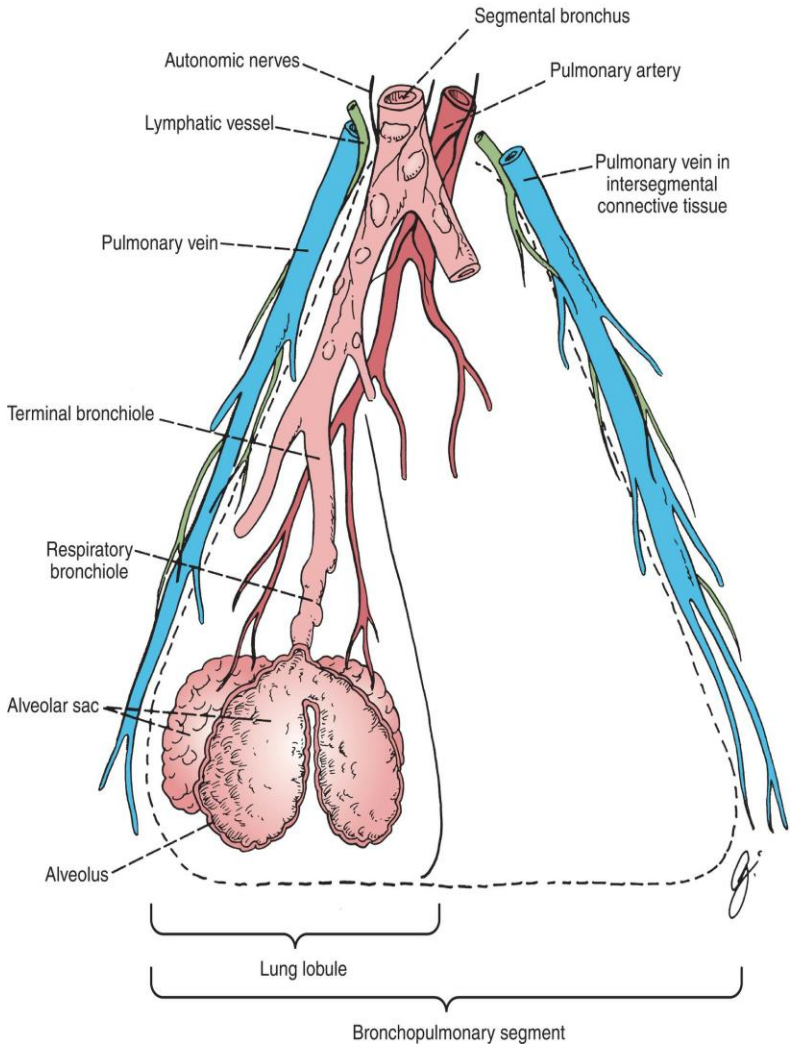
Lungs – Subdivisions: Lobes and fissures



- Lungs divided into lobes by fissures.
- **Right lung** divided into **3 lobes** (superior, middle & inferior lobes) by **2 fissures** (horizontal & oblique fissures)
- **Left lung** divided into **2 lobes** (superior & inferior lobes) by **1 fissure** (only oblique fissure)

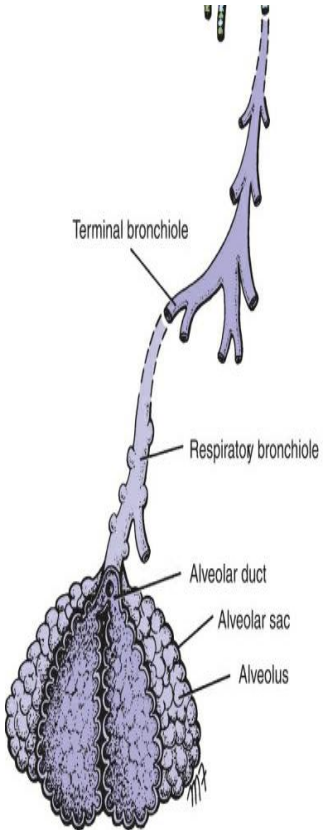
Bronchopulmonary Segments

The bronchopulmonary segments are the **anatomic, functional, and surgical units** of the lungs. Each lobar (secondary) bronchus, which passes to a lobe of the lung, gives off branches called **segmental (tertiary) bronchi**. Each segmental bronchus passes to a structurally and functionally independent unit of a lung lobe called a **bronchopulmonary segment**, which is bounded by connective tissue walls. A branch of the pulmonary artery accompanies the segmental bronchus, but the tributaries of the pulmonary veins run in the connective tissue between adjacent bronchopulmonary segments. Each segment has its own lymphatic vessels and autonomic nerve supply.



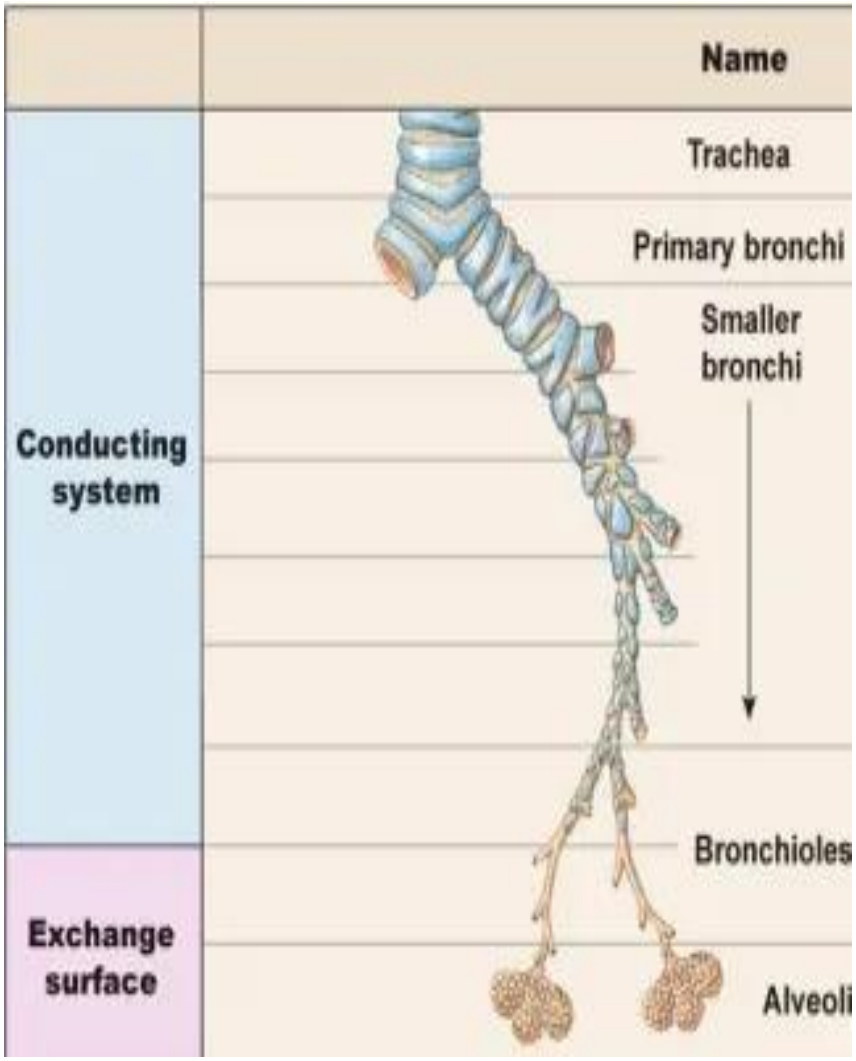
Each segmental bronchus divides repeatedly upon entering a bronchopulmonary segment. As the bronchi become smaller, irregular plates of cartilage gradually replace the tracheal rings. The smallest bronchi divide and give rise to **bronchioles**, which are <1 mm in diameter. Bronchioles possess no cartilage in their walls and are lined with columnar ciliated epithelium.

The submucosa possesses a complete layer of circular smooth muscle fibers. The bronchioles then divide and give rise to **terminal bronchioles.** These terminal bronchioles give rise to **the respiratory bronchiols** which show delicate outpouchings from their walls. Gaseous exchange between blood and air takes place in the walls of these outpouchings, which explains the name **respiratory bronchiole**.



The lower respiratory tract, including the trachea, bronchi, bronchioles(terminal and respiratory), alveolar ducts, alveolar sacs, and alveoli.

The diameter of a respiratory bronchiole is about 0.5 mm. The respiratory bronchioles end by branching into **alveolar ducts**, which lead into tubular passages with numerous thin-walled outpouchings called **alveolar sacs**. The alveolar sacs consist of several **alveoli** opening into a single sac. A rich network of blood capillaries surrounds each alveolus. Gaseous exchange takes place between the air in the alveolar space and the blood in the capillaries in the alveolar wall.



The main characteristics of a **bronchopulmonary segment** are as follows:

1. It is a subdivision of a lung lobe.

2.It is pyramid shaped, with its apex directed toward the lung root.

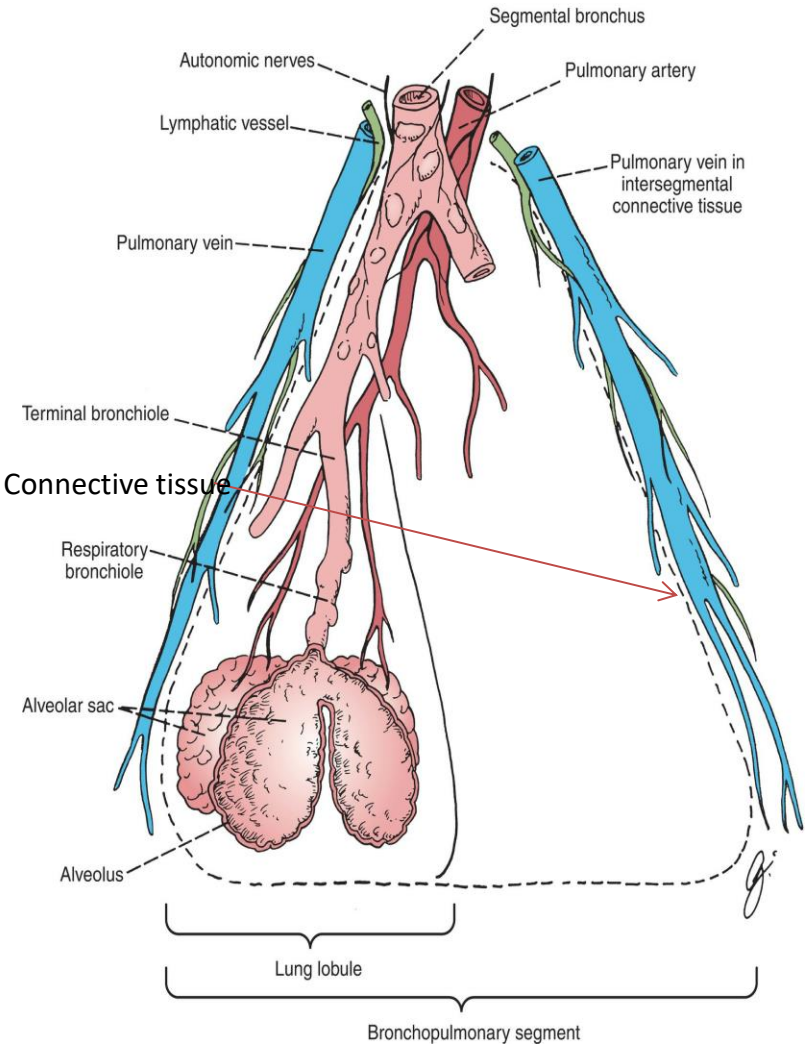
3. It is surrounded by connective tissue.

4. It has three defining components: a centrally located segmental

(tertiary) bronchus, a segmental artery that accompanies the segmental bronchus, and intersegmental veins located in the connective tissue walls between adjacent bronchopulmonary segments.

5. It has its own lymph vessels and autonomic nerves.

6. Because it is a structural unit, a diseased segment can be removed surgically.



The functional flow pattern within each bronchopulmonary segment is as follows:

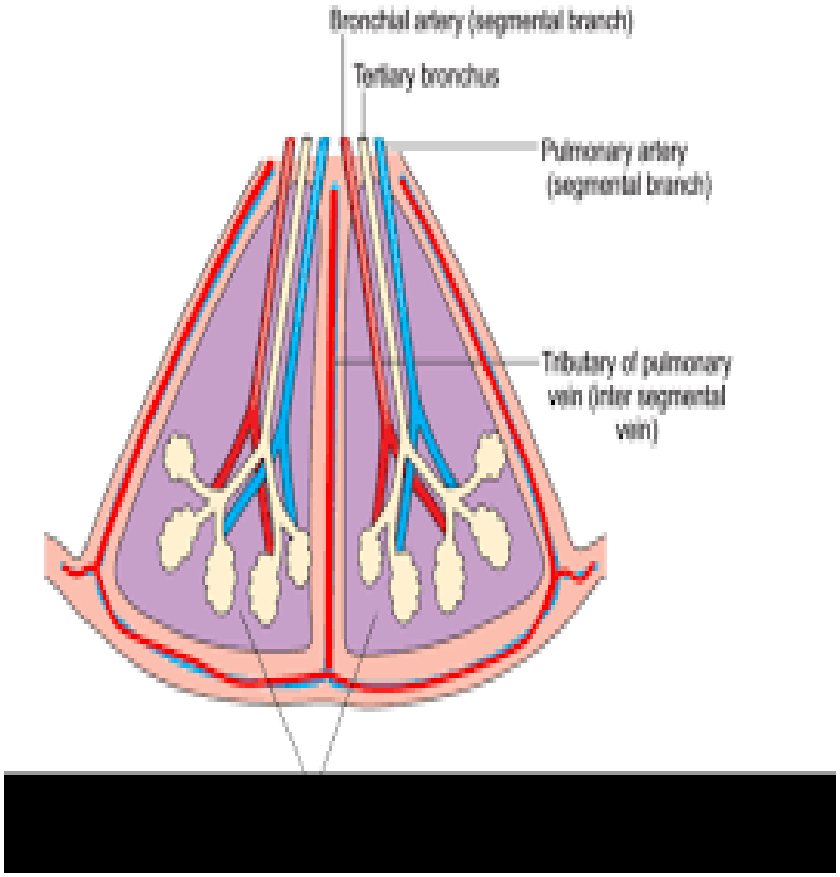
1. Air enters and leaves each bronchopulmonary segment via the segmental bronchus.

2. Deoxygenated blood enters each bronchopulmonary segment via the segmental artery (a branch of the pulmonary artery).

3.Oxygenated blood leaves the bronchopulmonary segment via the intersegmental veins located around the periphery of each segment.

4. These veins drain into the pulmonary veins.

Typically, the right lung has 10 bronchopulmonary segments and the left lung has 8 to 10.



Although the general arrangement of the bronchopulmonary segments is clinically important, memorizing the details is not essential for anyone not intending to specialize in pulmonary medicine or surgery. The main bronchopulmonary segments are as follows:

Right lung

Superior lobe: Apical segment, posterior segment, and anterior segment. **Middle lobe:** Lateral segment and medial segment ; **Inferior lobe:** Superior (apical) segment, medial basal segment, anterior basal, lateral basal, and posterior basal segment.

Left lung

Superior lobe: Apical, posterior, anterior; **lingual lobe,** superior lingular, inferior lingular; **Inferior lobe:** Superior (apical), medial basal, anterior basal,

lateral basal, posterior basal.

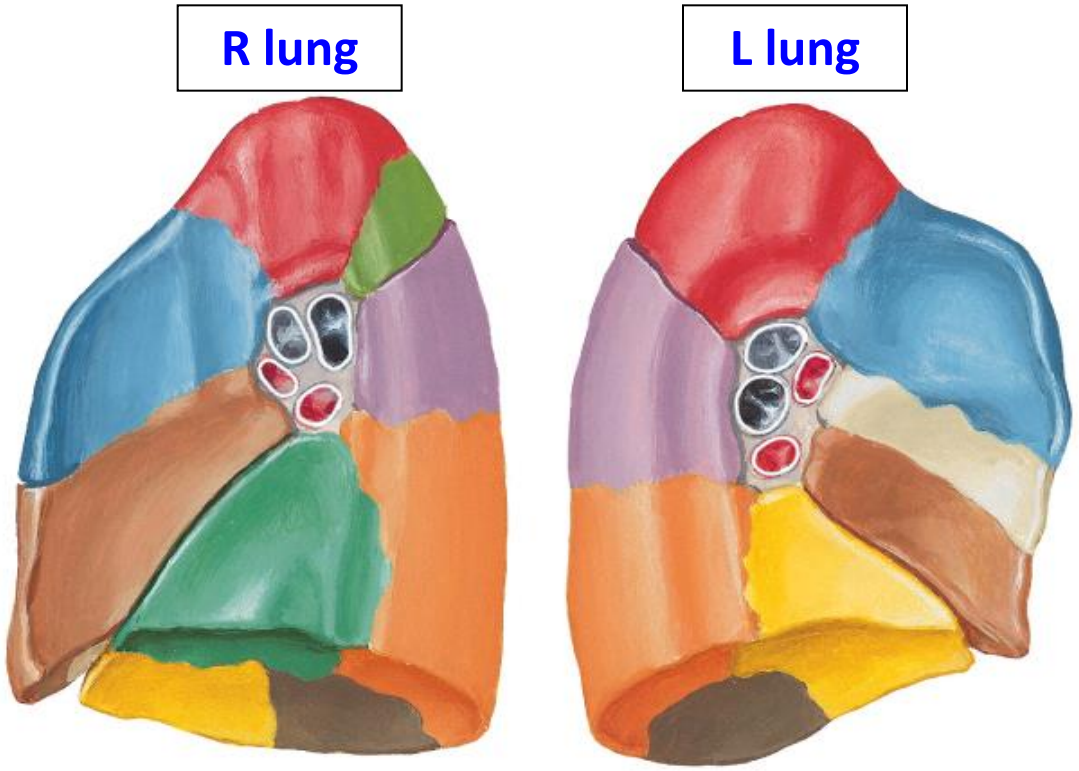
Lungs – Subdivisions: Bronchopulmonary segments

- Lung lobes are further subdivided into **bronchopulmonary segments**.

- Each segment is **pyramidal-shaped**:

1) apex – towards the lung root
2) base – towards pleural surface

- Segments are separated from each other by **connective tissue septa.**

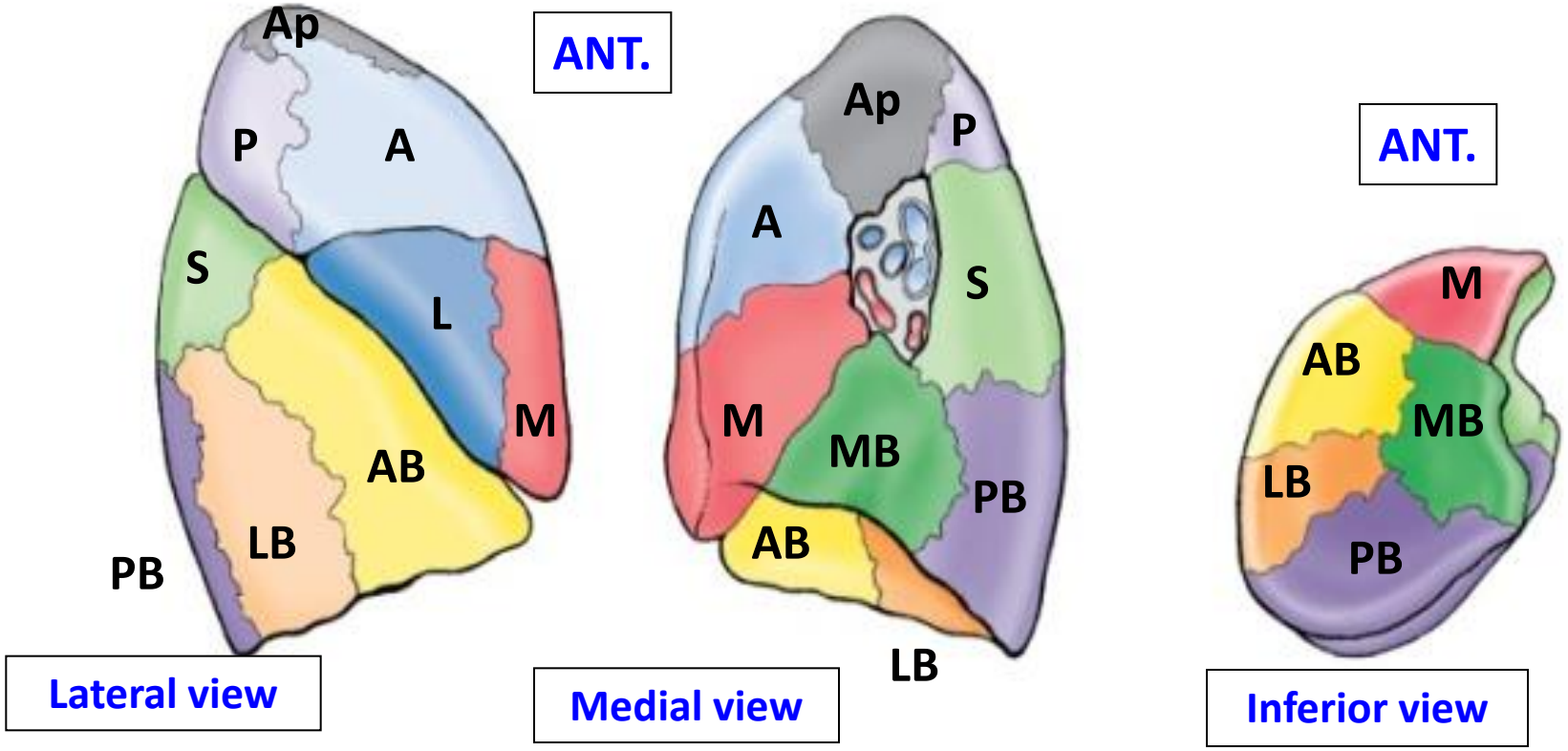


Medial view

Bronchopulmonary Segments

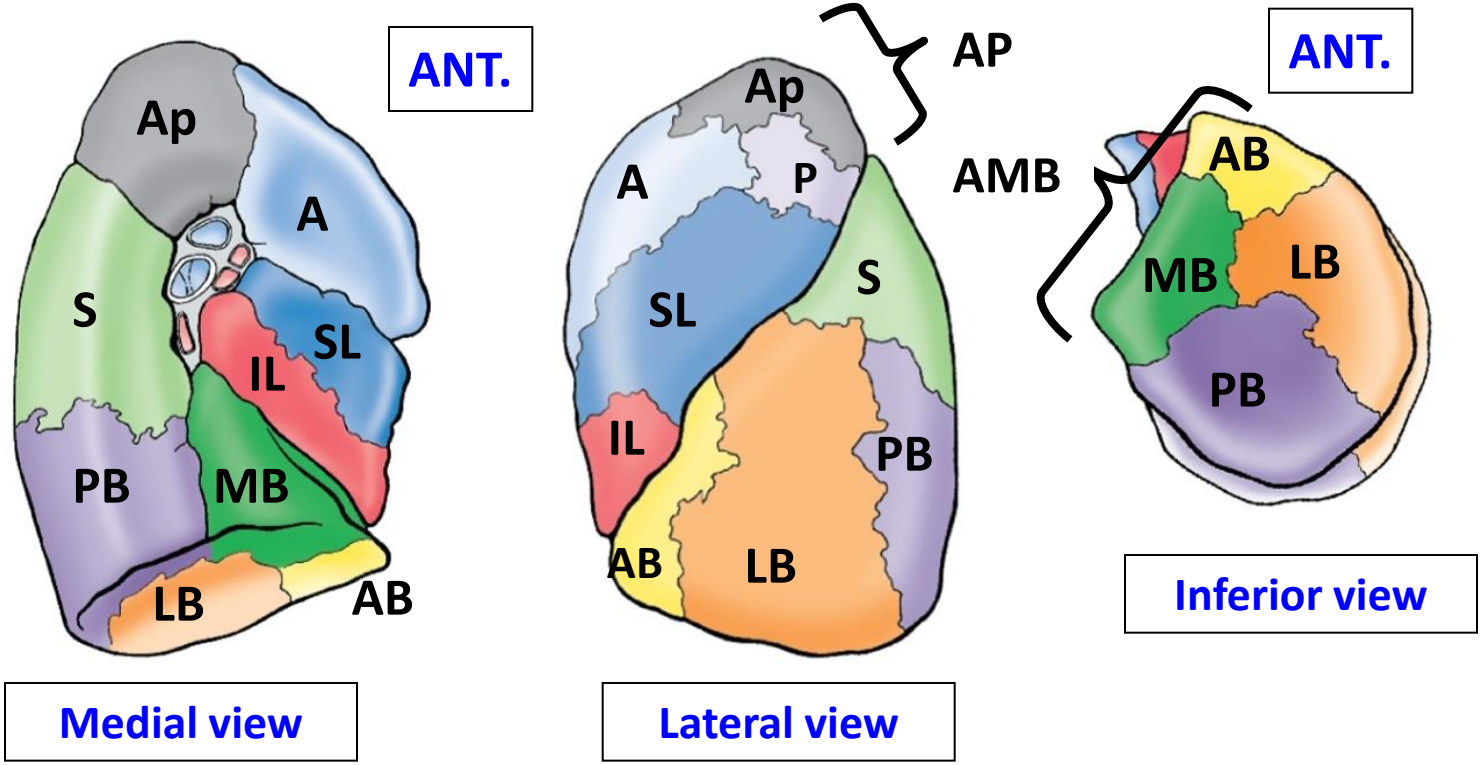
RIGHT Lung (10)		LEFT Lung (8-10)	
Superior Lobe	Apical	Superior Lobe	Apical (*)
	Anterior		Anterior
	Posterior		Posterior (*)
Middle Lobe	Medial		Superior Lingular
	Lateral		Inferior Lingular
Inferior Lobe	**Superior**	Inferior Lobe	**Superior**
	Anterior **Basal**		Anterior **Basal** (*)
	Posterior **Basal**		Posterior **Basal**
	Medial **Basal**		Medial **Basal** (*)
	Lateral **Basal**		Lateral **Basal**

(*) Often combined



Right Lung: 10 Bronchopulmonary Segments

1) **Superior lobe** – **A**pical (Ap), **P**osterior (P), **A**nterior (A)
2) **Middle lobe** – **L**ateral (L), **M**edial (M)
3) **Inferior lobe** – **S**uperior (S), **M**edial basal (MB), **A**nterior basal (AB), **L**ateral basal (LB), **P**osterior basal (PB)



Left Lung: 8 – 10 Bronchopulmonary Segments

1) **Superior lobe**
   - apicoposterior **AP** (apical+posterior), anterior (**A**), superior lingular (**SL**), inferior lingular (**IL**)
2) **Inferior lobe**
   - superior (**S**), anteromedial basal **AMB** (anterior basal+medial basal), posterior basal (**PB**), lateral basal (**LB**)

4-5

4-5

Blood Supply of Lung

Arterial Supply

- The lungs have a **dual (2)** blood supply.
- 2 arteries carry blood to the lungs:

1)Pulmonary artery

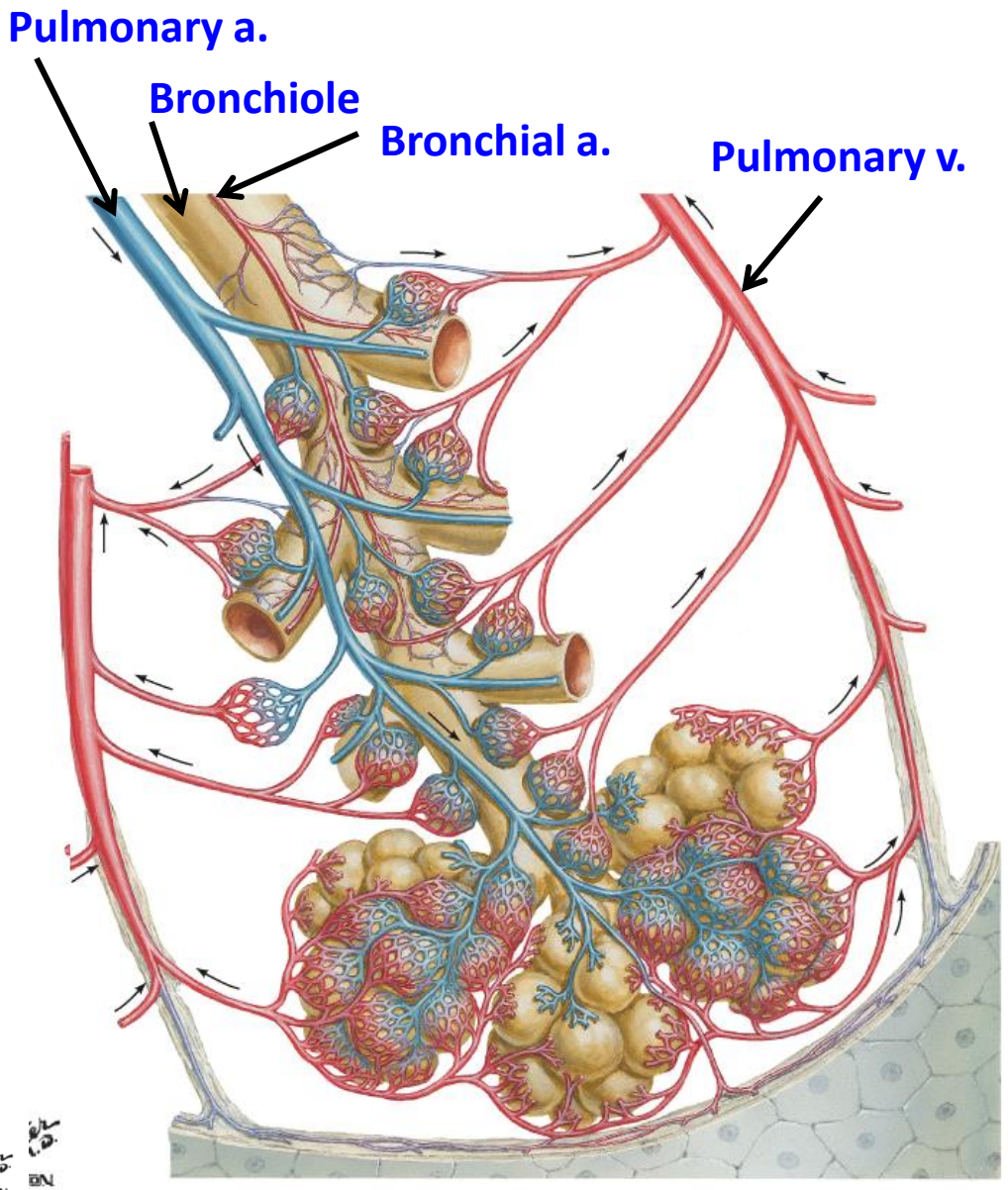
2)Bronchial artery

Venous Drainage

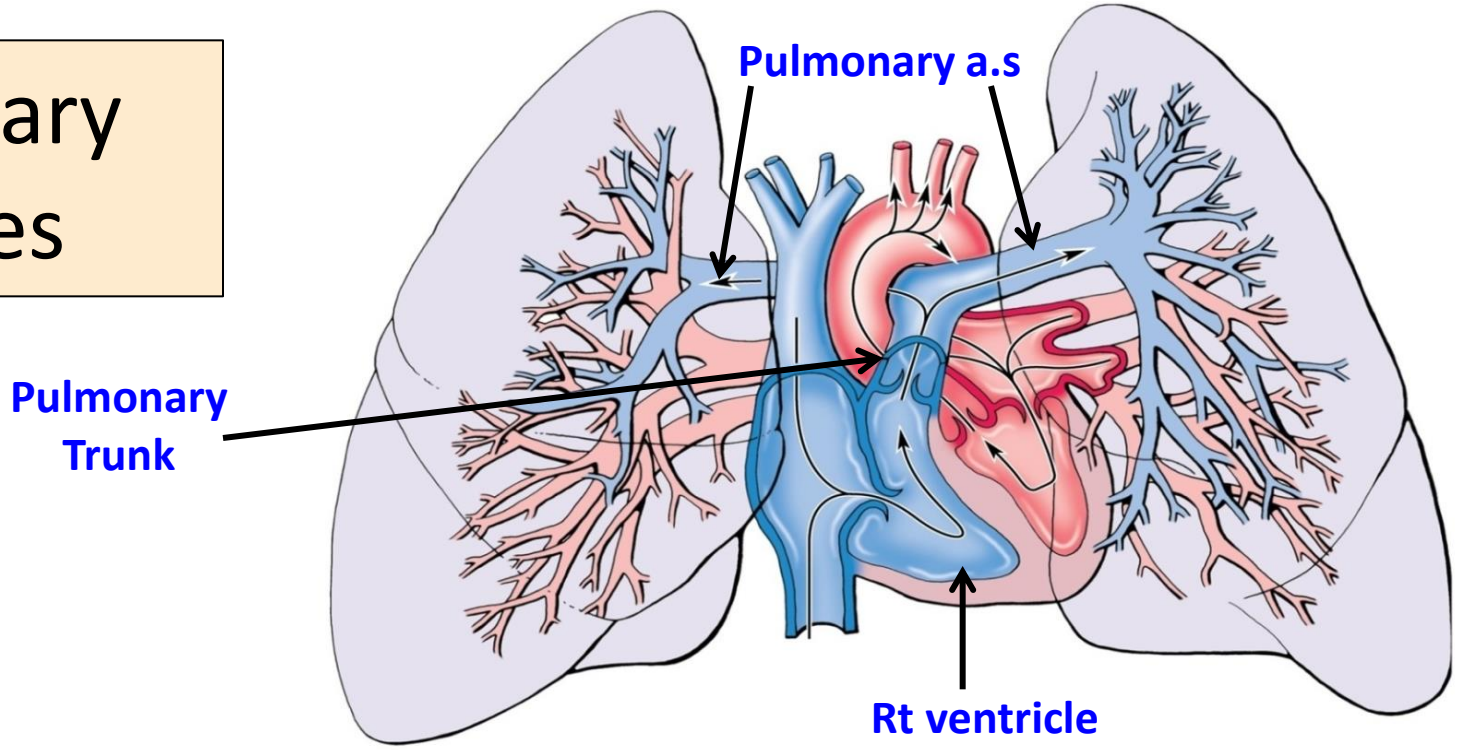
- 2 veins drain the lungs:

1)Pulmonary vein

2)Bronchial vein



Pulmonary Arteries



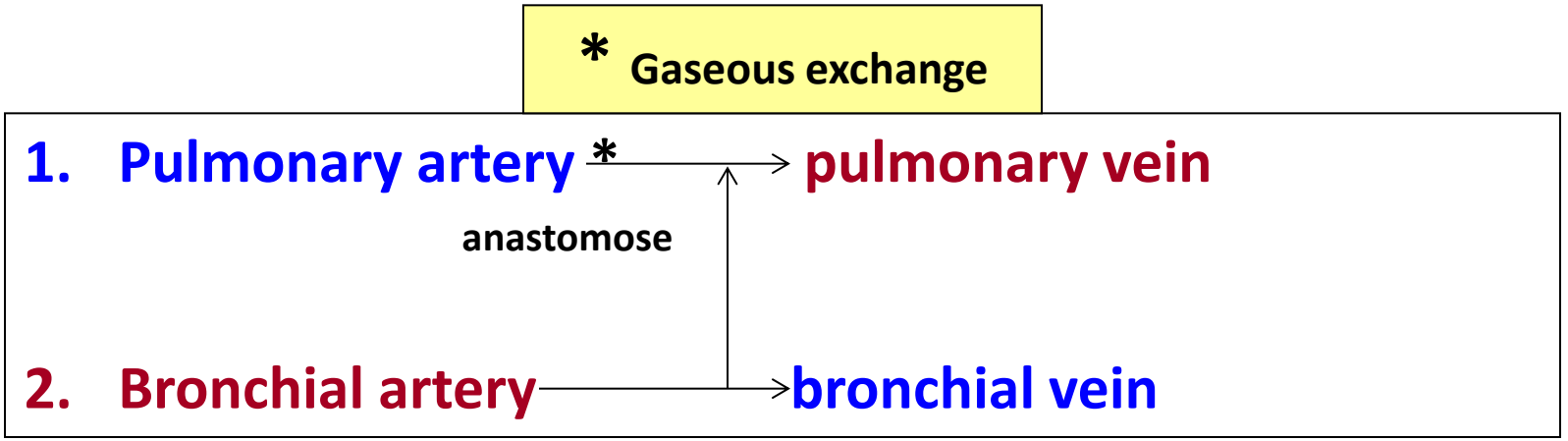
- Pulmonary trunk carries **deoxygenated blood** from **Rt ventricle** → divides into right and left **pulmonary arteries**
- Within the lung, each pulmonary artery divides into:
  - **Lobar arteries** - to each lobe
  - **Segmental arteries** - to each bronchopulmonary segment
  - Eventually, divide - **pulmonary capillaries** (gas exchange)
- Supplies the alveolar duct, alveolar sac & alveoli
- Oxygenated blood returned to heart through **pulmonary veins**

Bronchial Arteries

- Supply **oxygenated** blood to the **non-respiratory tissues** of the lung:

1) **Lung stroma** (connective tissue)
2) Structures of **root of lungs** (eg: bronchi to the level of terminal/respiratory bronchioles, lymph nodes)
3) **Visceral pleura**

- There are pre-capillary **anastomoses** between branches of bronchial & pulmonary arteries.
- Blood from the bronchial artery drains into the **pulmonary veins & bronchial veins.**



Bronchial Arteries

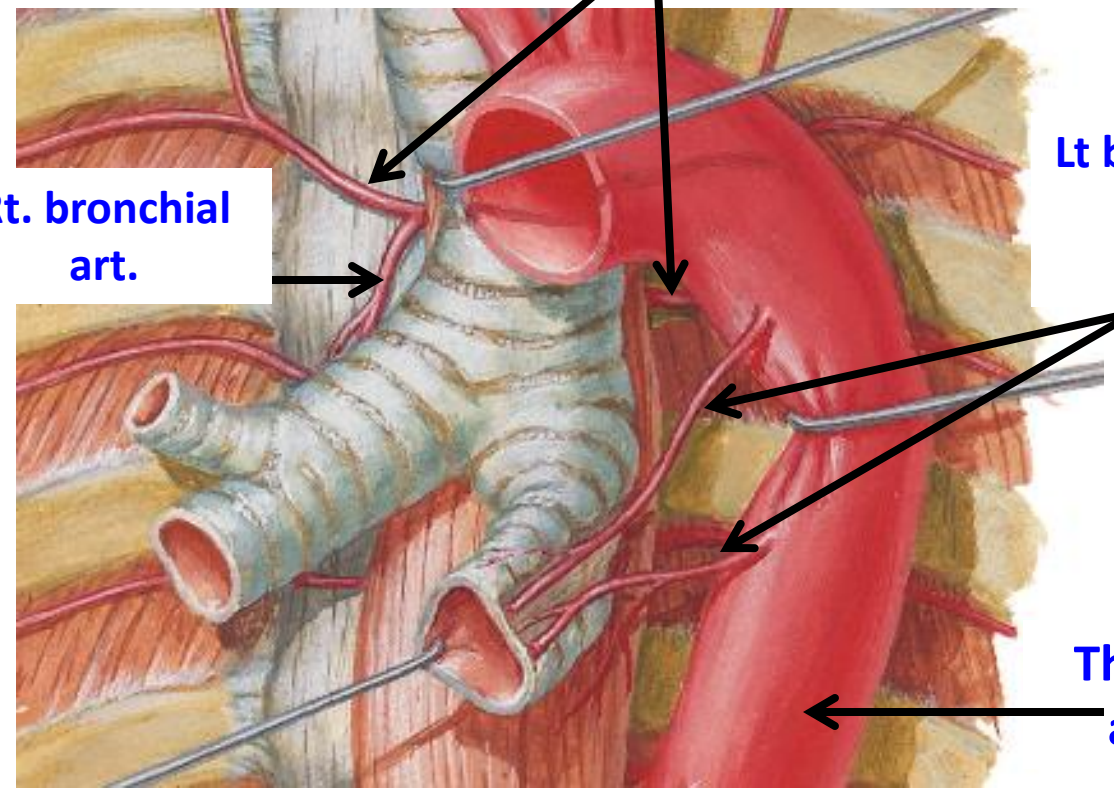
- There are 3 bronchial arteries:

1)2 Left bronchial arteries

- arise directly fror the **thoracic aorta**

2)1 Right bronchial artery

- Commonly arise from the **3rd right posterior intercostal artery (indirectly** from thoracic aorta)



Pulmonary veins

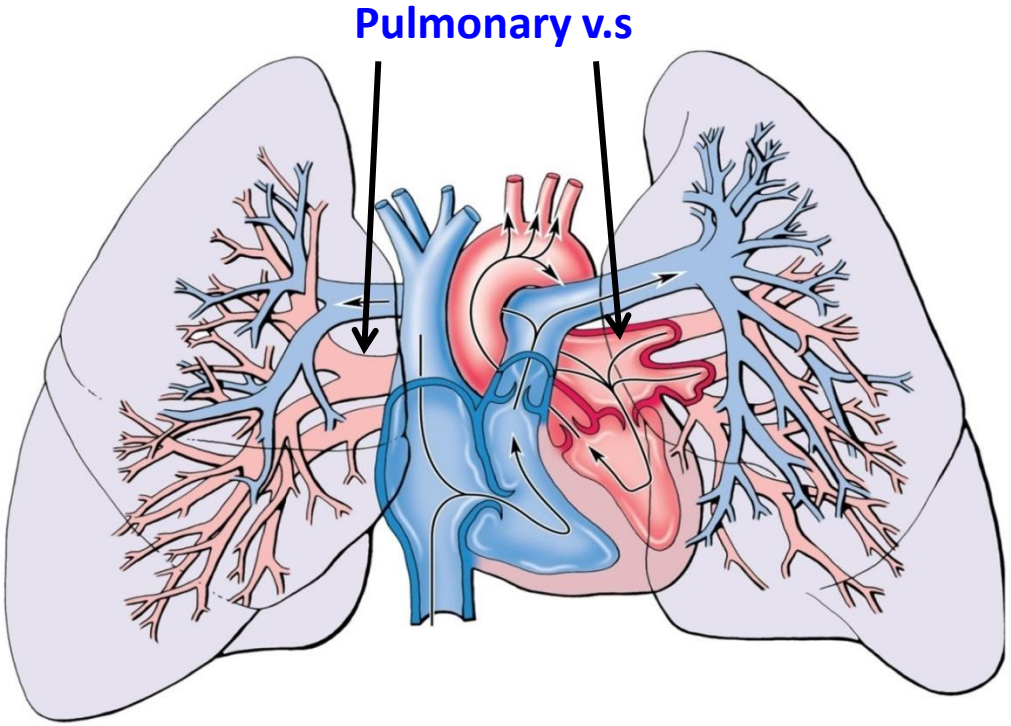
- Each lung has **2 pulmonary veins** (superior and inferior)

- Drains blood from:

1) **Oxygenated blood** from **alveoli**

2) **De-oxygenated blood** from (drains some of blood brought in by **bronchial arteries**):

i. Peripheral parts of lungs
ii. Distal parts of root of lung
iii. Visceral pleura

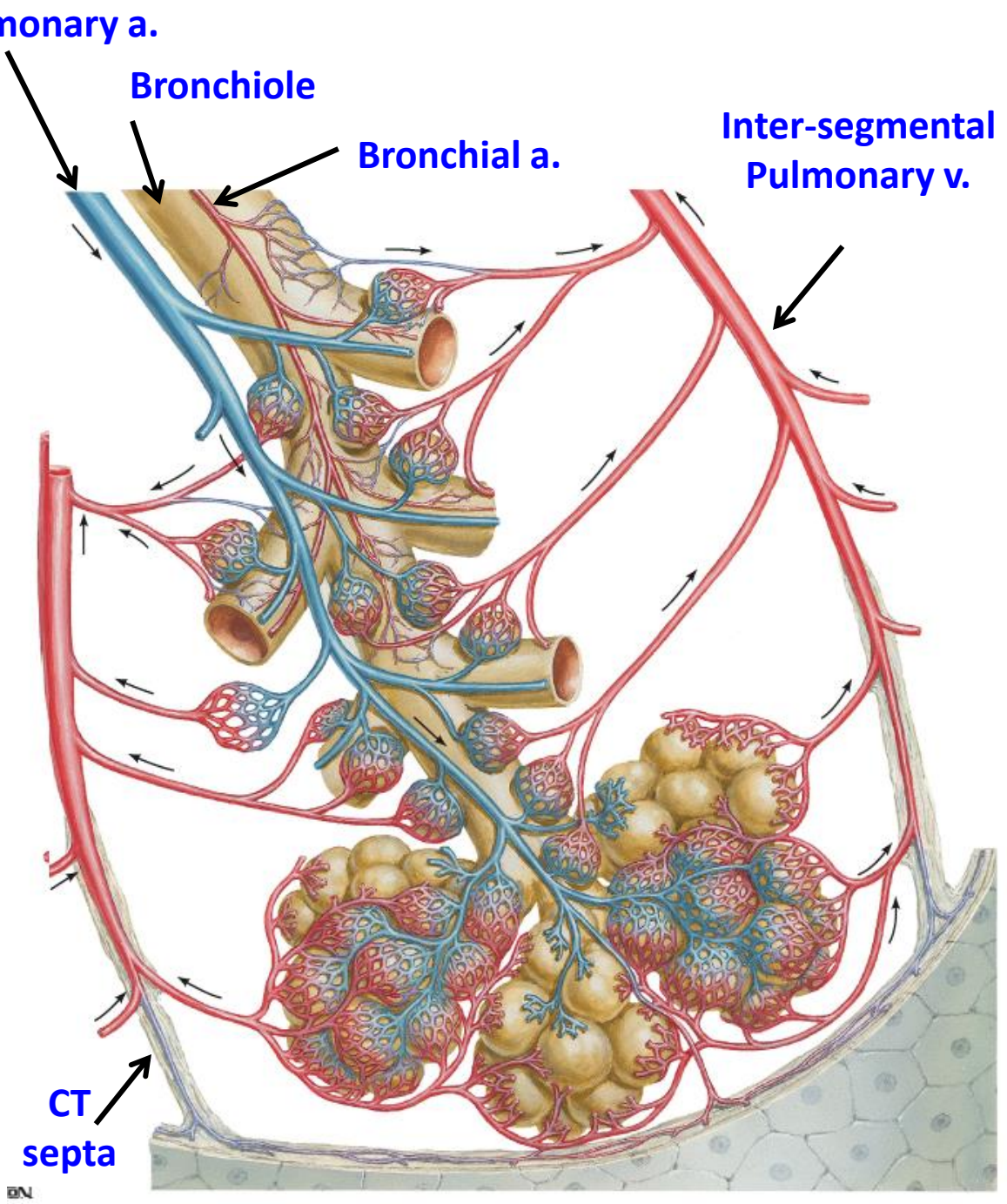


Pulmonary artery * → **pulmonary vein**

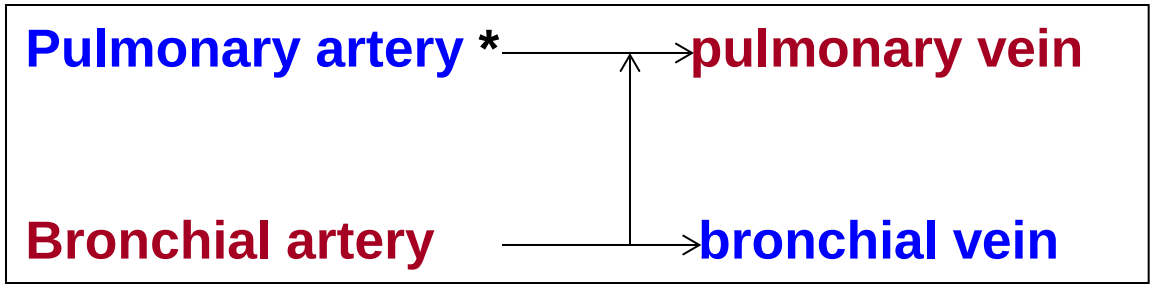
Bronchial artery → **bronchial vein**

Pulmonary Veins

- **Pulmonary capillaries** → **intrasegmental** pulmonary veins → **intersegmental** pulmonary veins (in **CT septa** separating bronchopulmonary segments)
- The pulmonary veins run separately from the arteries and bronchi
- Drains blood into **Lt atrium**

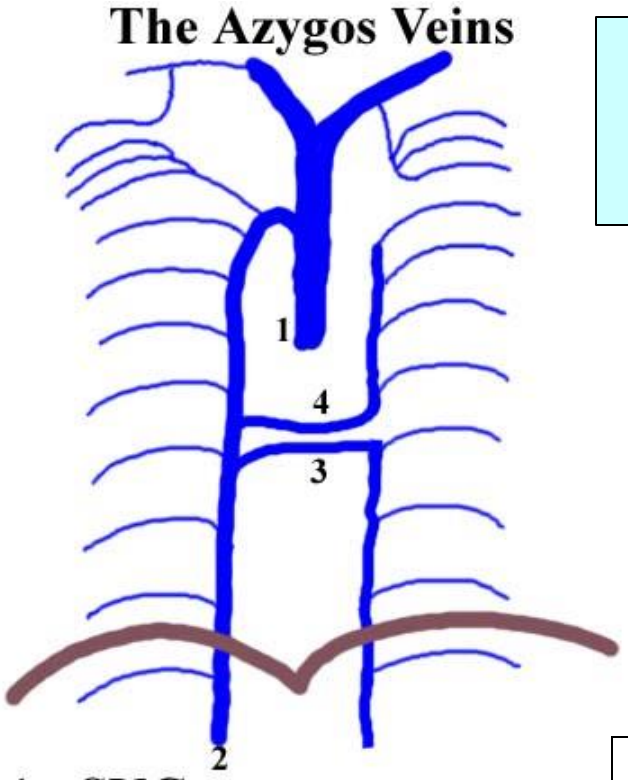


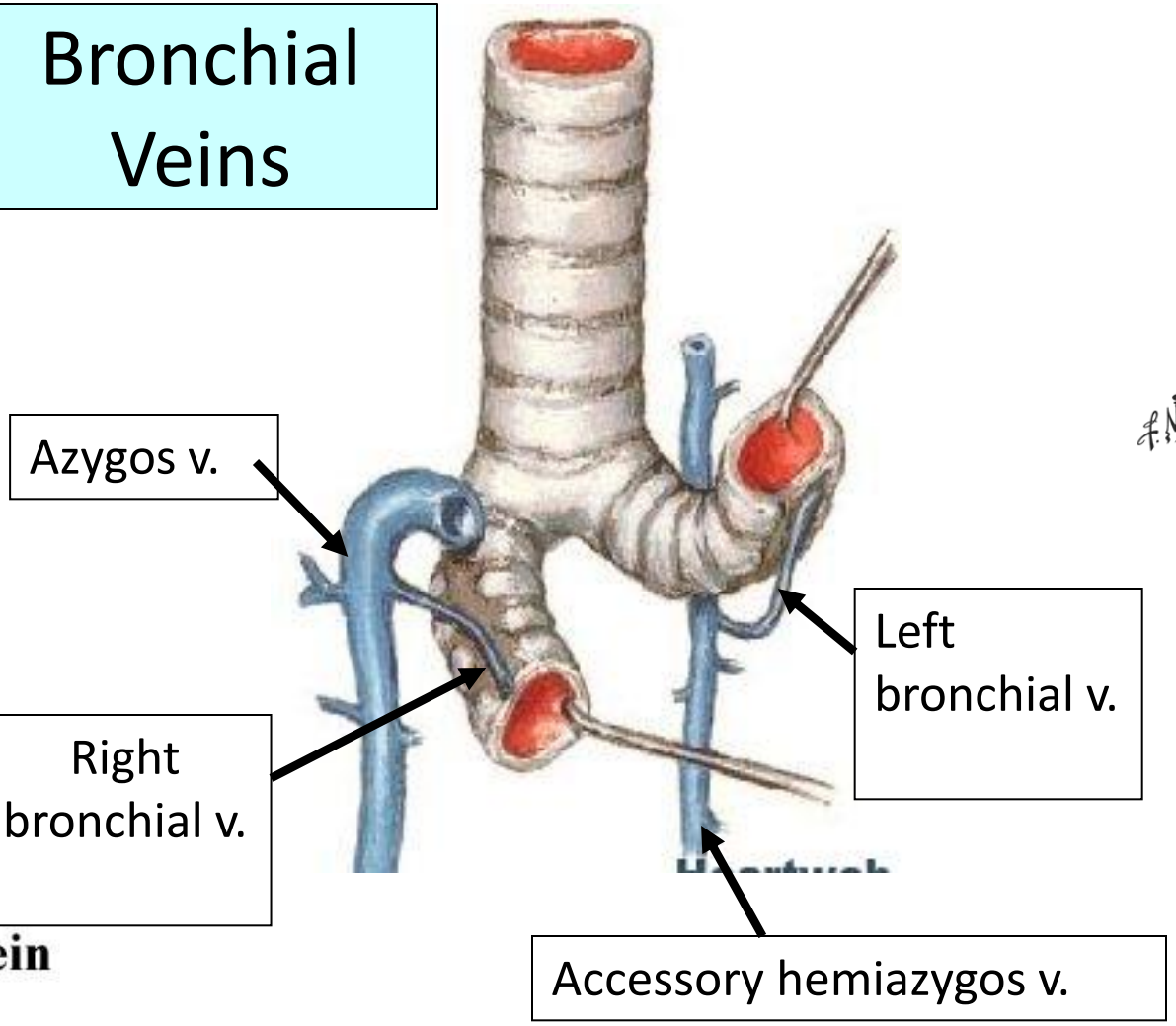
Bronchial Veins



- Drain **only part** of the blood supplied to the lungs by the **bronchial arteries** – mainly blood from proximal part of roots of lungs.

Bronchial Veins





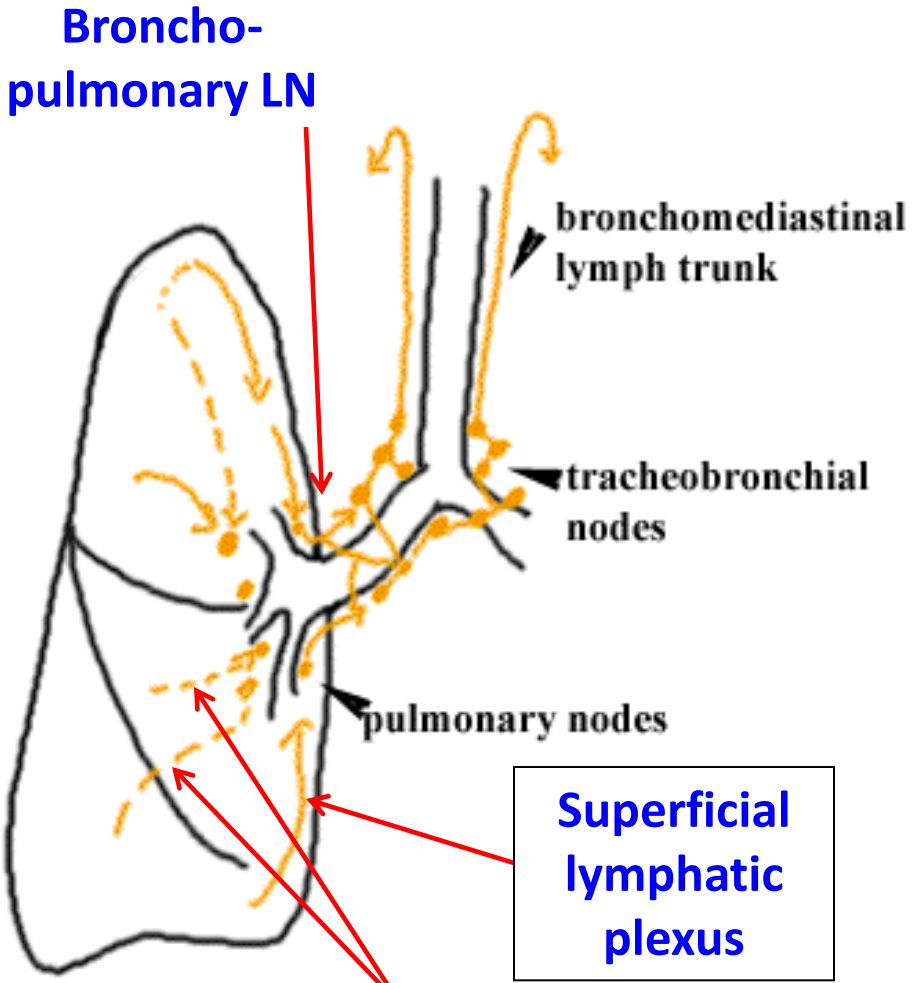
- **Right** bronchial v. drains into **azygos v**.
- **Left** bronchial v. drains into **accessory hemiazygos v.**

	Pulmonary artery	Bronchial artery
Arises from	Right ventricle	Thoracic aorta
Supplies	Alveoli	Supplies lung stroma, structure of root of lung (eg: bronchi) & visceral pleura

	Pulmonary vein	Bronchial vein
Drains blood from	Pulmonary capillaries, peripheral parts of lungs, distal parts of root of lung & visceral pleura	Proximal part of roots of lungs
Drains into	Left atrium	Azygos system of veins

Lymphatic Drainage

Lymphatic Plexus	Drain
1) Superficial (sub-pleural)	Drains over the **surface of lung** toward hilum → **bronchopulmonary** (hilar) **LN**
2) Deep	Drains along **bronchi** toward **hilum** → **bronchopulmonary** (hilar) **LN**

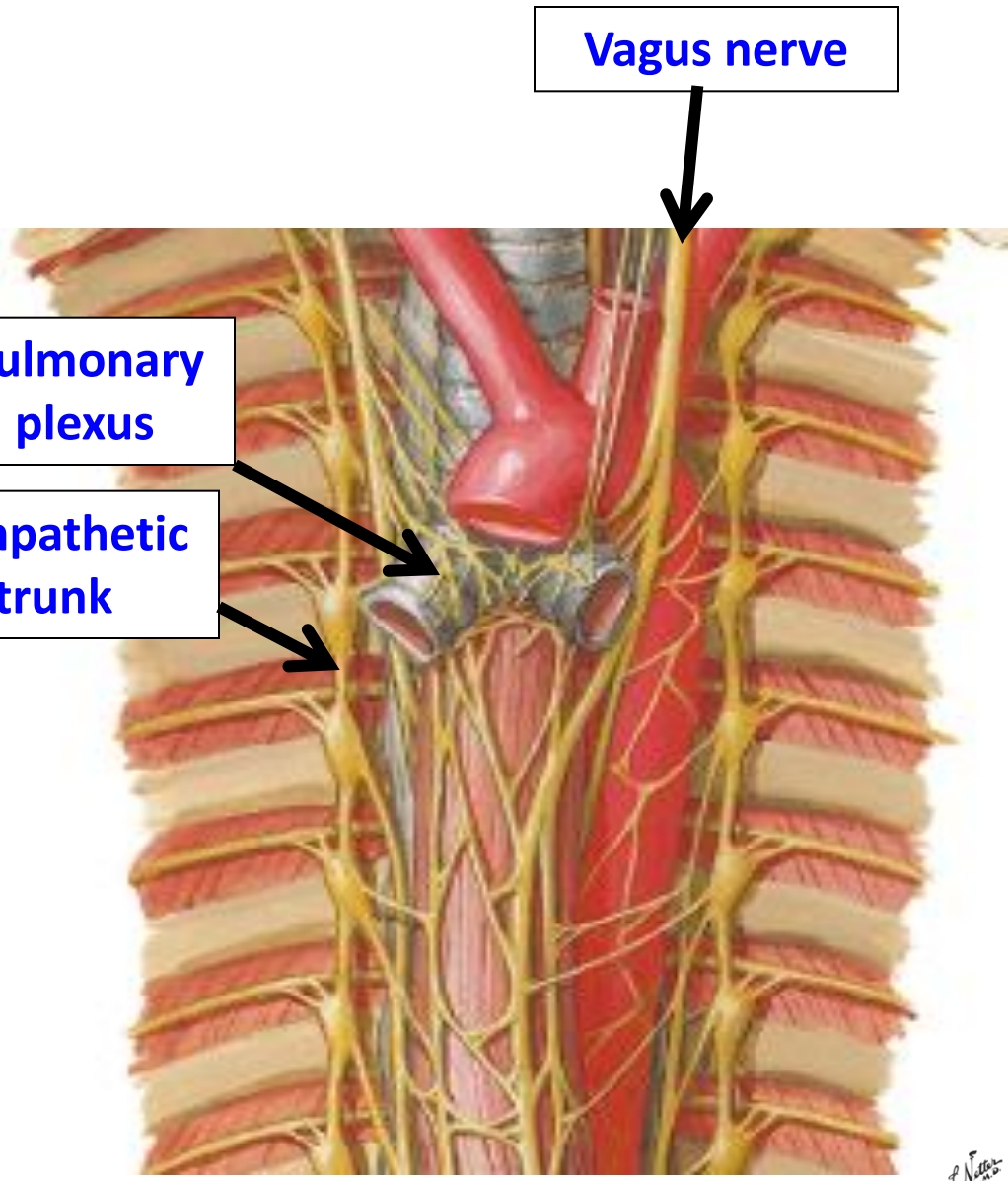


Bronchopulmonary LN → tracheobronchial LN → bronchomediastinal lymph trunk → junction of the subclavian and internal jugular veins

Nerve supply - Lungs & Visceral pleura

- Nerves of lungs & visceral pleura are from pulmonary plexuses.
- Pulmonary plexuses located anterior & posterior to lung roots.
- It contains:

1. **Parasympathetic fibres from vagus nerve**
2. **Sympathetic fibres from sympathetic trunks**



Parietal Pleura – Blood supply, Lymphatic Drainage & Innervation

- Parietal pleura is supplied by **arteries** that supply the thoracic wall (intercostal, internal thoracic, musculophrenic arteries).
- Blood from the parietal pleura drain into the **veins** in the thoracic wall.
- **Lymph** from parietal pleura drains into lymph nodes of the thoracic wall (intercostal, parasternal, mediastinal and phrenic)

Nerve supply: **Parietal** pleura

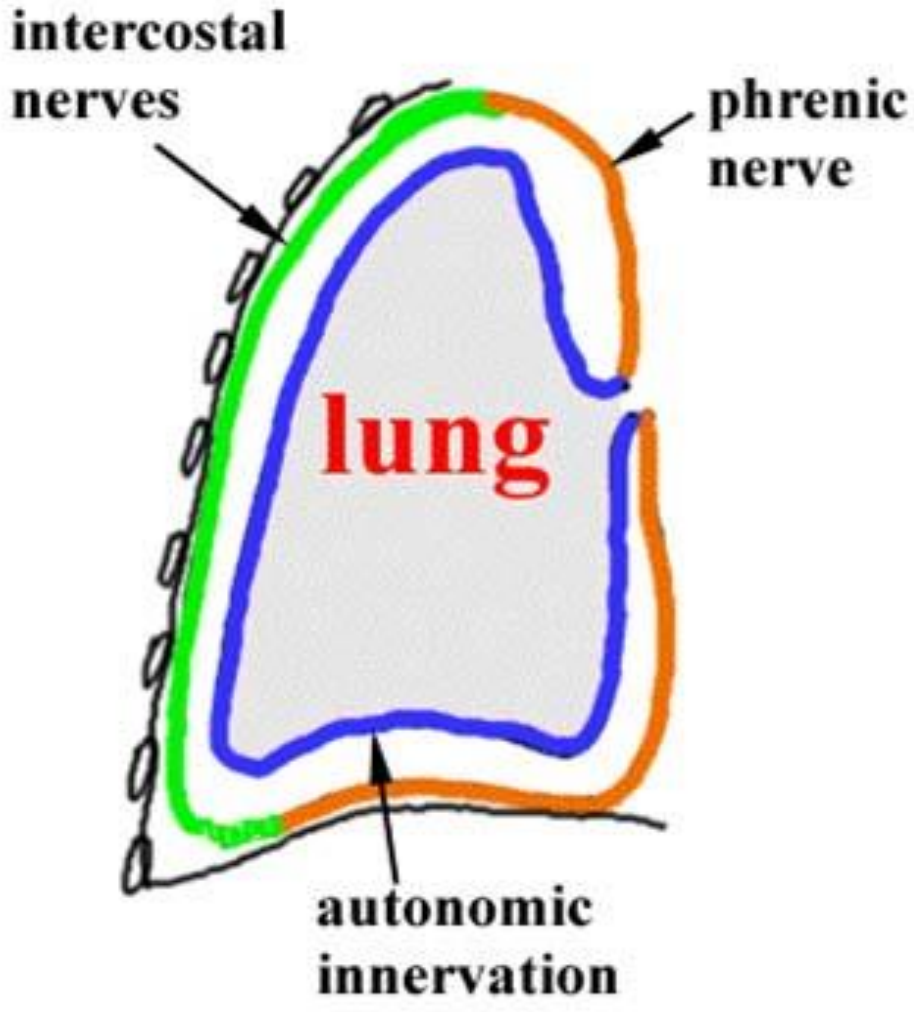
- Innervated by intercostal and phrenic nerves (sensations of touch and pain)

- **Intercostal nerves** supply the:

1) costal pleura
2) peripheral part of the diaphragmatic pleura

- **Phrenic nerves** supply the:

1) Central part of the diaphragmatic pleura
2) Mediastinal pleura



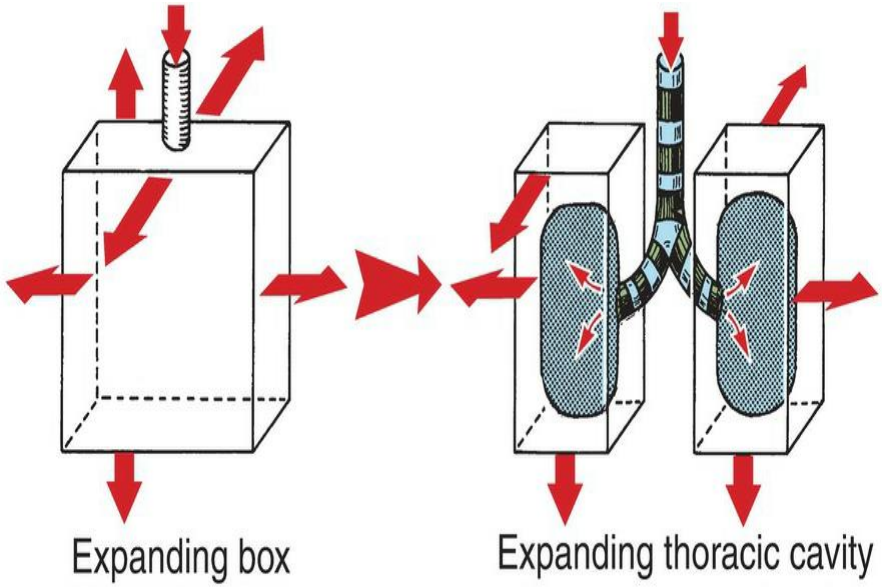
***3 Ps: Parietal Pleura** innervated by the **P**hrenic nerve

Mechanics of Respiration

Respiration consists of two alternating phases, **inspiration** and **expiration**, which are accomplished by increasing and decreasing the capacity of the thoracic cavity. The mechanics of each phase differ depending if respiration occurs under quiet or forced conditions. The rate of respiration varies between 16 and 20 per minute in normal resting patients and is faster in children and slower in older adults.

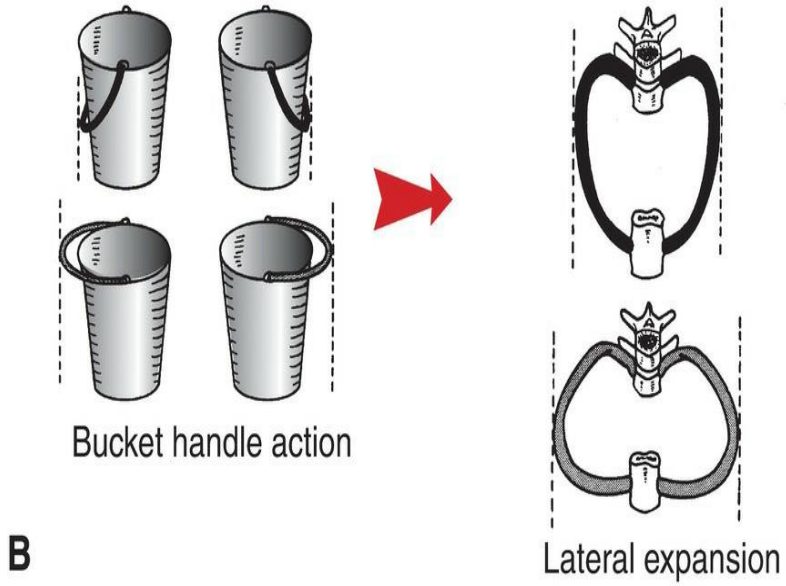
Quiet Inspiration

Compare the thoracic cavity to a box with a single entrance at the top, which is a tube called the trachea Elongating all its diameters increases the capacity of the box, resulting in air under atmospheric pressure entering the box through the tube. Now consider the three diameters of the thoracic cavity and how they may be increased .



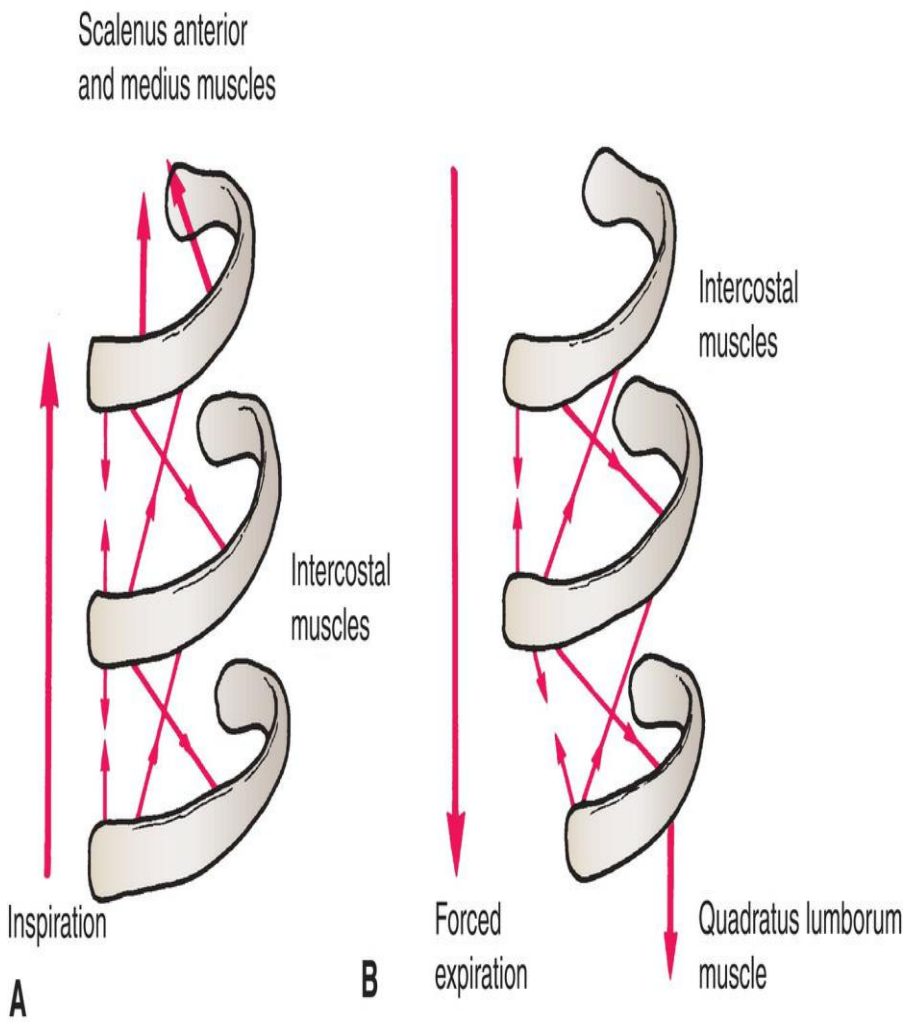
Vertical Diameter

Theoretically, the roof could be raised and the floor lowered. The roof is formed by the suprapleural membrane and is fixed. Conversely, the mobile diaphragm forms the floor. When the diaphragm contracts, the domes flatten and the level of the diaphragm lowers, thus increasing the vertical diameter of the thoracic cavity



Anteroposterior Diameter

If the downward-sloping ribs were raised at their sternal ends, the anteroposterior diameter of the thoracic cavity would be increased, and the lower end of the sternum would be thrust forward. This happens when the first rib is fixed by the contraction of the scalene muscles of the neck and when the intercostal muscles contract. This mechanism stabilizes the sizes of the intercostal spaces and raises the ribs toward the first rib. The scalene muscles fix the first rib or, in forced inspiration, raise the first rib.



How the intercostal muscles can be used in forced expiration, provided that the 12th rib is fixed or is made to descend by the abdominal muscles.

Transverse Diameter

The ribs articulate in front with the sternum via their costal cartilages and

behind with the vertebral column. Because the ribs curve downward as well

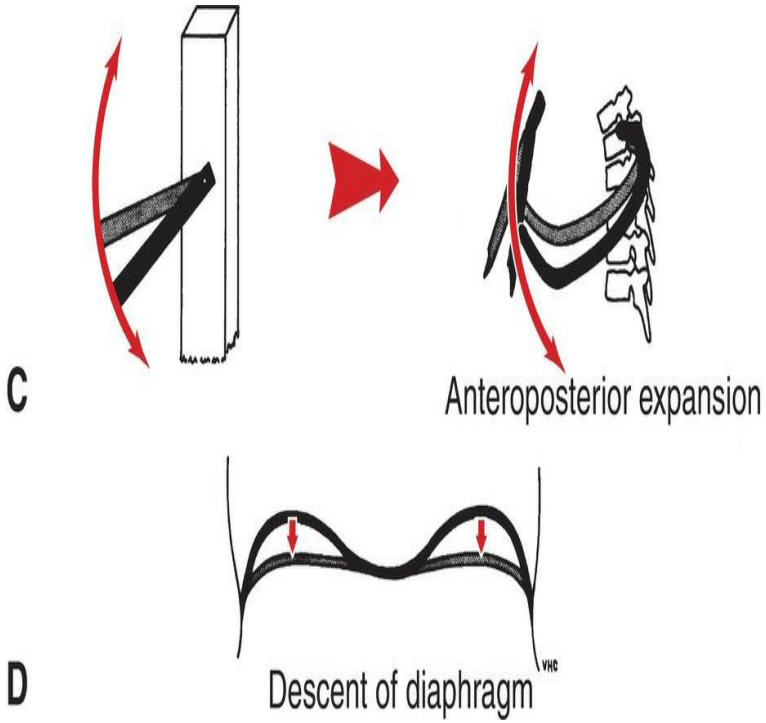
as forward around the chest wall, they resemble bucket handles.

It therefore follows that if the ribs are raised (like bucket handles), the

transverse diameter of the thoracic cavity will be increased. As described

previously, this occurs by fixing the first rib and raising the other ribs to it by

contracting the intercostal muscles



Lung Changes on Inspiration

In inspiration, the root of the lung descends and the level of the bifurcation of the trachea may lower by as much as two vertebrae. The bronchi elongate and dilate and the alveolar capillaries dilate, thus assisting the pulmonary circulation. Air is drawn into the bronchial tree as the result of the positive

atmospheric pressure exerted through the upper part of the respiratory tract and the negative pressure on the outer surface of the lungs brought about by the increased capacity of the thoracic cavity. With expansion of the lungs, the elastic tissue in the bronchial walls and connective tissue are stretched. As the diaphragm descends, the costodiaphragmatic recess of the pleural cavity opens, and the expanding sharp lower edges of the lungs descend to a lower level.

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Types of Respiration

In babies and young children, the ribs are nearly horizontal. Thus, babies have to rely mainly on the descent of the diaphragm to increase their thoracic capacity on inspiration. Because this is accompanied by a marked inward and outward excursion of the anterior abdominal wall, which is easily seen, respiration at this age is referred to as the **abdominal type of respiration**. After the 2nd year of life, the ribs become more oblique, and the adult form of respiration is established. A biological sex difference exists in the type of respiratory movements in adults. Females tend to rely mainly on the movements of the ribs rather than on the descent of the diaphragm on inspiration. This is referred to as the **thoracic type of respiration**. Males use both the thoracic and abdominal forms of respiration but mainly the abdominal form.

Physical Examination of the Lungs

For physical examination of the patient, remember that the upper lobes of the lungs are most easily examined from the front of the chest and the lower lobes from the back. Areas of all lobes can be examined in the axillae.

Pain and Lung Disease

Lung tissue and the visceral pleura are devoid of pain-sensitive nerve endings, so that pain in the chest is always the result of conditions affecting the surrounding structures. In tuberculosis or pneumonia, for example, pain may never be experienced. Once lung disease crosses the visceral pleura and the pleural cavity to involve the parietal pleura, pain becomes a prominent feature. Lobar pneumonia with pleurisy, for example, produces a severe tearing pain, accentuated by deep inspiration or coughing. Because the lower part of the costal parietal pleura receives its sensory innervation from the lower five intercostal nerves, which also innervate the skin of the anterior abdominal wall, pleurisy in this area commonly produces pain that is referred to the abdomen. This could result in a mistaken diagnosis of an acute abdominal lesion. In a similar manner, pleurisy of the central part of the diaphragmatic pleura, which receives sensory innervation from the phrenic nerve (C3 to 5), can lead to referred pain over the shoulder because the supraclavicular nerves (C3 and 4) supply the skin of this region.

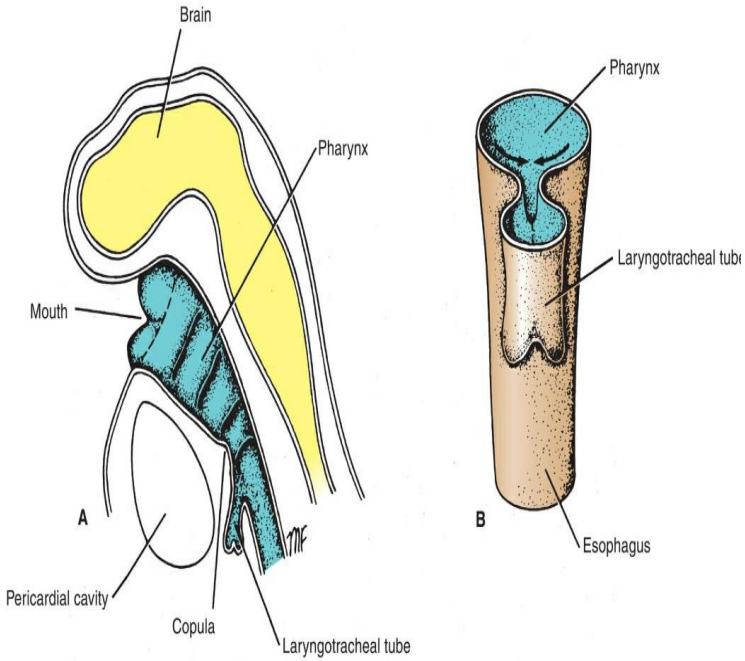
Development of the Lungs and Pleura

The lower respiratory tract develops from the embryonic foregut. Initially, a longitudinal groove, the **laryngotracheal groove**, develops in the endodermal lining of the floor of the pharynx. This gives rise to the

laryngotracheal tube (**respiratory diverticulum**, **lung bud**)). A **tracheoesophageal septum separates** the

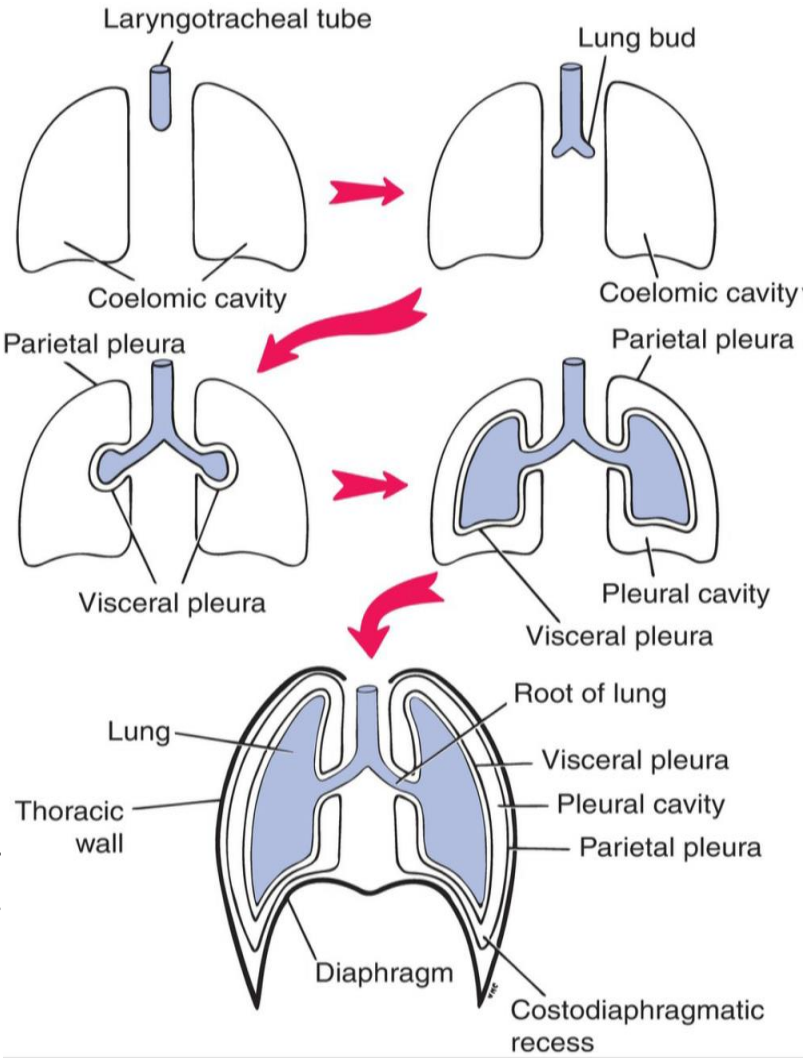
laryngotracheal tube from the foregut, forming two structures: a more dorsal **esophagus** and a more ventral (anterior) **respiratory primordium**. The laryngotracheal tube grows caudally into the splanchnic mesoderm and divides distally into the **right and left lung buds**. Cartilage develops in the mesenchyme surrounding the tube, and the upper part of the tube becomes the larynx, whereas the lower part becomes the trachea.

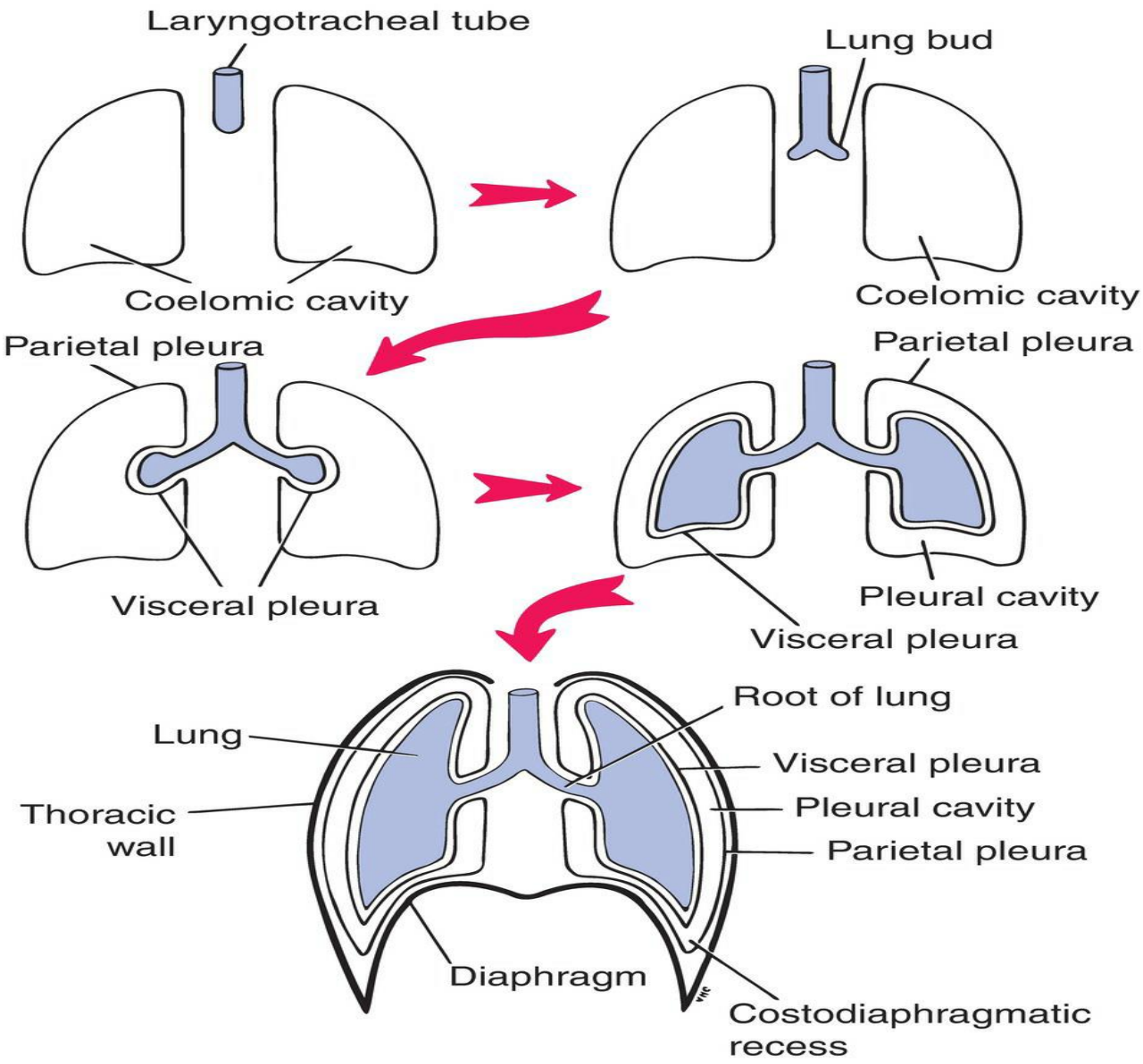
Each lung bud consists of an endodermal tube surrounded by splanchnic mesoderm; all the tissues of the corresponding lung are derived from this.



Each bud grows laterally and projects into the pleural part of the embryonic coelom. The lung bud divides into two or three lobes, corresponding to the number of main bronchi and lobes found in the fully developed lung. Each main bronchus then divides repeatedly in a dichotomous manner, until eventually the terminal bronchioles and alveoli form.

The division of the terminal bronchioles, with the formation of additional bronchioles and alveoli, continues for some time after birth. Splanchnic mesoderm forms the visceral pleura, whereas somatic mesoderm forms the parietal pleura. By the 7th month, the capillary loops connected with the pulmonary circulation are sufficiently well developed to support life, if premature birth take place. With the onset of respiration at birth, the lungs expand and the alveoli dilate. However, the alveoli in the periphery of each lung become fully expanded only after 3 or 4 days of postnatal life.




Laryngotracheal tube
Lung bud
Coelomic cavity
Coelomic cavity
Parietal pleura
Parietal pleura
Visceral pleura
Pleural cavity
Visceral pleura
Root of lung
Lung
Visceral pleura
Thoracic wall
Pleural cavity
Parietal pleura
Diaphragm
Costodiaphragmatic recess