

RESPIRATORY SYSTEM

ANATOMY



Title: Sheet #5 – Trachea and lungs

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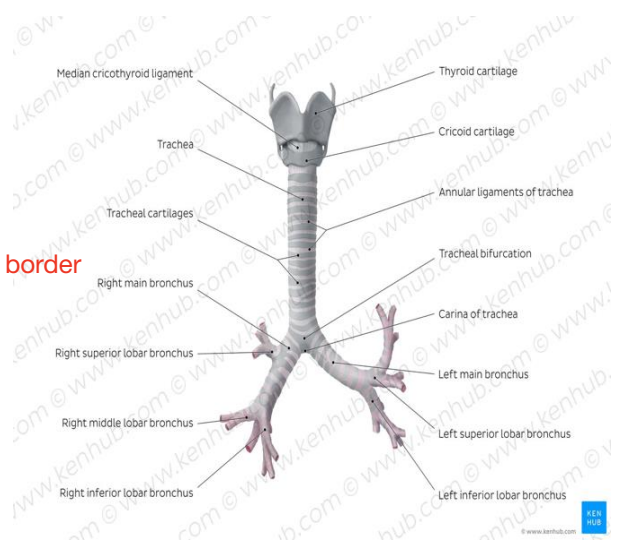
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Trachea and lungs ?

Trachea

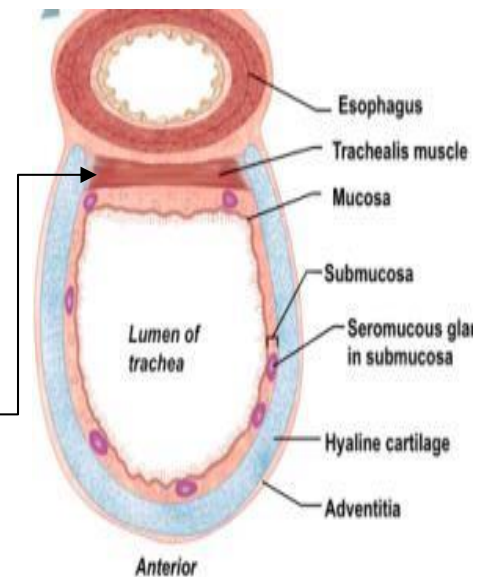
The trachea is a flexible tube, that extends from **C6 (The lower border of the cricoid cartilage)** to the level between **T4 and T5** (The level of the **angle of Louis** **Lower border of T4** sternal angle). Then it bifurcates to give the **right main bronchus and the left main bronchus. (Primary)**



❖ Structures of the trachea:

The trachea has 16-20 C-shaped hyaline cartilages. The function of these C-shaped hyaline cartilages is to keep the trachea open for the passage of air (unlike the esophagus, which is always collapsed until a bolus of food descends, allowing it to open).

Posteriorly, the trachea has a smooth muscle called Trachealis, which is complementary to the C-shaped cartilages.



Since it is a smooth muscle, it is supplied by autonomic nerves. It is located anterior to the esophagus, so it helps the oesophagus push the bolus of food downwards.

[the C-shaped cartilage is absent posteriorly]

Length and diameter of the trachea: The trachea is 4.5 to 5 inches long and has a diameter equal to that of the index finger. In children, the trachea is very narrow with a diameter of a pencil. This explains why tracheostomy is hard to perform on children.

During inspiration, the trachea lengthens and widens. During expiration, it returns to its normal size.

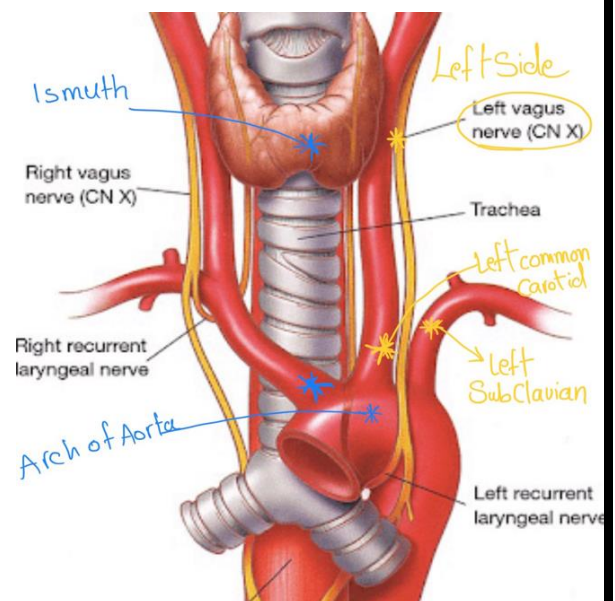
Relations of the trachea:

When looking at the trachea in an x-ray, you will see a column of black air that is deviated to the right because the **trachea is normally deviated to the right.**

- The **oesophagus is deviated to the left** because it opens in the left cupula of the diaphragm, at the level of T10, one inch to the left.
- The trachea gives the right main bronchus and the left main bronchus. The **left** is always **narrower**, more **horizontal** and **longer** than the right. The **right** is **wider**, more **vertical** and **shorter** than the left.

◆ ANTERIOR RELATIONS:

- 1- Aortic arch.
- 2- Thymus gland: it is rudimentary in adults, so there are only remnants of thymus.
- 3- Thyroid gland, especially the isthmus (which connects the right lobe with the left lobe of the thyroid). It is usually found in front of the 2nd, 3rd and 4th tracheal rings.
- 4- The origin of the brachiocephalic artery.
- 5- Manubrium sterni.



◆ LEFT SIDE RELATIONS:

1- **The arch of the aorta:** The arch begins anterior to the trachea, and then on the left side, because it is directed backwards and to the left.

The left common carotid artery is more **Anterior** than the left subclavian artery

2- **Left subclavian artery**

3- **Left common carotid artery**

4- **Left vagus nerve** →

The Vagus Nerve passes **behind** the root of the lung, and gives the recurrent laryngeal nerve, below the aortic arch level.

5- **Left phrenic nerve**, which passes anterior to the root of the lung.

6- **Left main bronchus**

● RIGHT SIDE RELATIONS:

1- **The azygous arch**, which ends in the superior vena cava.

2- **The brachiocephalic artery.**

3- **Right vagus nerve:** the vagus passes behind the root of the lung.

4- **Right phrenic nerve:** passes anterior to the root of the lung.

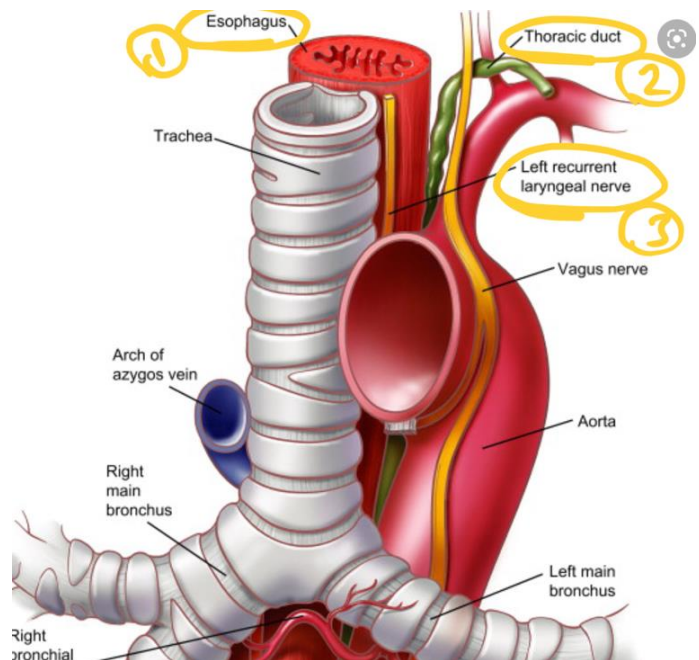
5- **Right main bronchus.**

- **POSTERIOR RELATIONS:**

1-The **esophagus**.

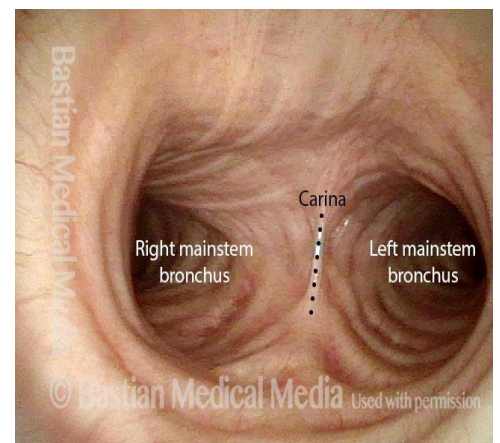
2-The **left recurrent laryngeal nerve** : Ascends between the trachea and oesophagus.

3-**Thoracic duct**: It is a lymphatic duct that starts from the opening of the descending aorta in the diaphragm, at the right side of the esophagus, and ascends in the chest, before it deviates to the left side, behind the trachea and esophagus at the level of T5.



Carina: Is a fold of mucosa found at the beginning of the main bronchi (at the beginning of the bifurcation).

This fold is very sensitive; when it is irritated, it causes coughing. The trachea ends at the sternal angle (between the 4th and 5th thoracic vertebra), so the carina is found there. During deep inspiration, the trachea elongates, and could reach the 6th thoracic vertebra.



Tracheostomy (or tracheotomy) and intubation:

- **Intubation**: It is the process in which a tube is inserted through the trachea, down to the lung. This tube can be used in patients with permanent damage in their larynx, in order to breathe. This tube must be below the true vocal cords, because they adduct. In surgery, when the patient is under anesthesia, the tube is put through the mouth, passes

between the true vocal cords and enters the trachea. In this case, the tube is called **endotracheal tube**. So, the difference between intubation and the endotracheal tube is that the first (Intubation) is inserted below the larynx (by opening the trachea below the larynx) so it is basically tracheostomy and the latter (endotracheal tube) is inserted through the mouth, or the nose.

- Tracheostomy:

It is the opening of the trachea, to relieve any obstruction to our breathing.

There are 2 types of tracheostomy:

1- Emergency tracheostomy (also called low or suprasternal tracheostomy):

During an **emergency** outside the hospital, when a person has an obstruction in the airway passage, and he/she turns blue in color, due to the inability to take up oxygen, you make a **suprasternal** opening to allow him to breathe through this opening. You feel the tracheal rings above the suprasternal notch and make an opening between two rings. Air will automatically enter through this opening, and the patient will finally be able to breathe again.

● There is a risk of bleeding in this procedure, because there are blood vessels in the suprasternal notch, like the **inferior thyroid vein, the anterior jugular arch** (Formed between the left and right anterior jugular veins), and sometimes, the **thyroid ima artery** is present. But in this situation, we do not worry about the bleeding as much as we worry about the inability to get air (the brain cells will die after 2-5 minutes without oxygen). The bleeding here can be easily stopped or may even stop spontaneously on its own, after a few minutes. it should not even be considered, because what is important is to get the patient breathing again.

2- High tracheostomy:

If there is **no emergency**, the opening is not necessarily done in the suprasternal notch. If you are performing a thyroidectomy and you made a bilateral partial cut in the recurrent laryngeal nerve, vocal cords will

adduct. So, in this case when performing a tracheostomy, the opening is formed below the vocal cords. The best place to do it is in the membrane between the cricoid cartilage and the trachea (Cricotracheal membrane).

BRONCHI

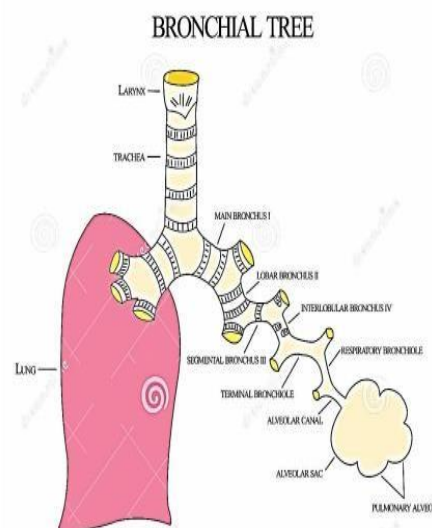
The trachea bifurcates to give the left and right main bronchi. The left is always narrower, more horizontal and longer (around 2 to 3 inches) than the right. The right is wider, more vertical and shorter (by around 1 inch) than the left. This is important clinically: Considering that the right bronchus is wider and more vertical, any foreign body that enters the respiratory tract **will usually go to the right bronchus**, not the left (very rare). So in an emergency, when using a bronchoscope, you examine the right bronchus first because it is more likely to have the foreign body in the right than the left.

	Right main bronchus	Left main bronchus
Length	Shorter (1")	Longer (2-3")
Lumen	Wider	Narrower
Alignment	More vertical (almost parallel to the trachea, with a small deviation)	More horizontal
IMPORTANT	In the hilum of the right lung, it divides into: <ul style="list-style-type: none"> - Eparterial bronchus (above pulmonary artery) - Hyparterial bronchus (below pulmonary artery) 	In the hilum of the left lung, it remains as one main bronchus.

❖ The bronchial tree

-The **right** and **left** main bronchi are called the **primary** bronchi.

-The **secondary** bronchi are called **lobar** bronchi. So, on the right side there are three lobar bronchi, since the right lung has three lobes (upper, middle and lower lobes), and on the left side there are two lobar bronchi, since



the left lung has two lobes (upper and lower lobes).

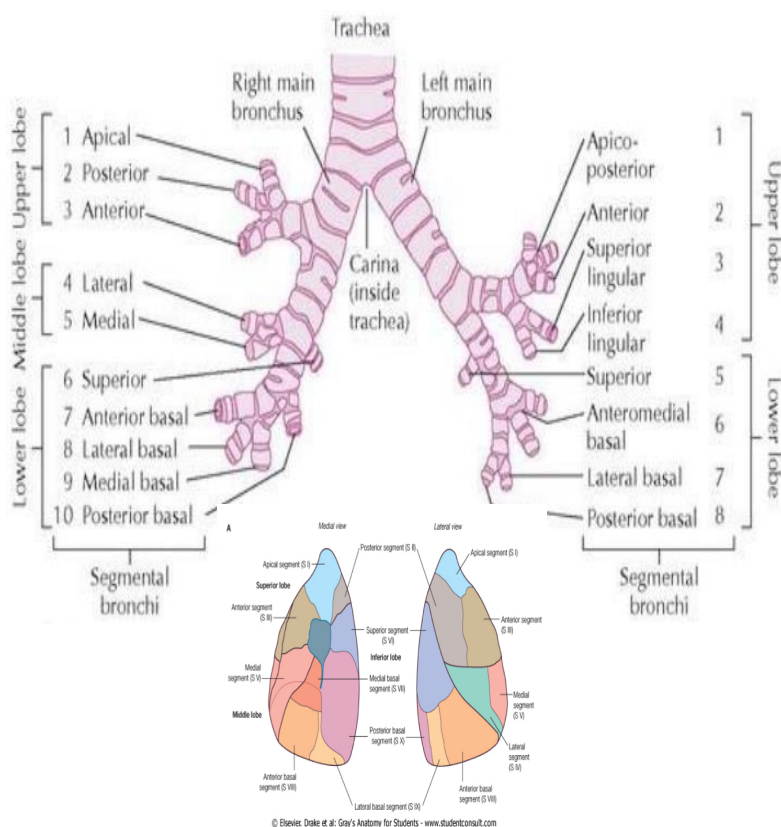
-The **tertiary** bronchi are called **bronchopulmonary segments**. There are 10 bronchopulmonary segments on the right and 10 on the left in adults.

In the right lung:

1-The upper lobe has three bronchopulmonary segments: **apical, anterior and posterior**.

2-The middle lobe has two segments: **medial and lateral**.

3-The lower lobe (the base) has five segments: **apicobasal (or apical), medial, lateral, anterior and posterior**.



In the left lung:

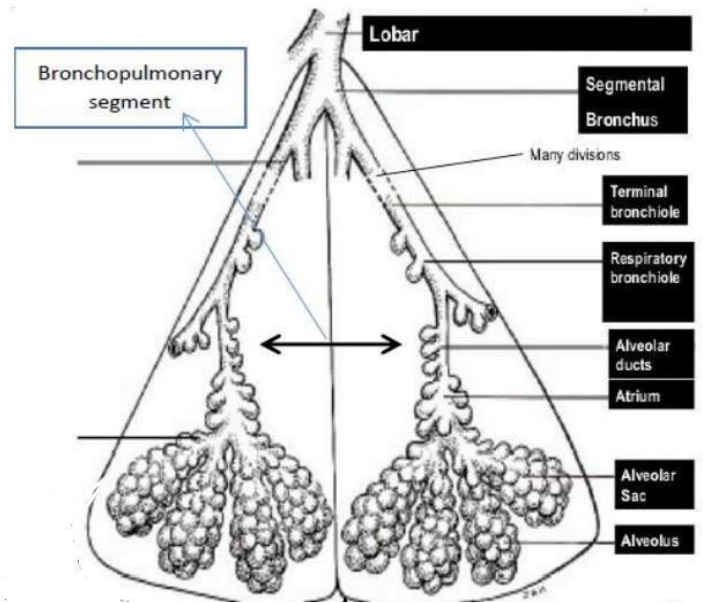
{The upper lobe has a special structure called the lingula, which is made by the cardiac notch}.

1-The upper lobe has 5 bronchopulmonary segments: **Apical, anterior, posterior, superior lingual and inferior lingual**.

2-The lower lobe (the base) has 5 bronchopulmonary segments; apicobasal (apical), anterior, posterior, medial and lateral.

Bronchopulmonary segment further divides into terminal bronchioles, which give rise to respiratory bronchioles, that end in the pulmonary unit (**important in surgery**).

-The importance of these bronchopulmonary segments -surgically- is that if you need to remove a part of the lung, these segments are removed (Segmentomy). In the past, the entire lobe was removed.



Pulmonary unit consist of alveolar ducts, atria, air sacs and pulmonary alveoli (**functional segment inside the bronchopulmonary segment**).

The walls of the bronchi are held open by discontinuous elongated plates of cartilage, but these are not present in bronchioles.

Why are the segments removed now instead of the lobes!?

Because it was found that they consist of units that have an apex and a base on the lateral surface of the lung. So, instead of removing a whole lobe, you can remove a smaller unit. These units have a segmental bronchus, a pulmonary artery and two pulmonary veins. All of which is surrounded by connective tissue. The segmental vein lies in the connective tissue, between adjacent bronchopulmonary segments. This unit also has lymphatic vessels, nerves and alveoli. So, when a surgeon removes a segment, he/she removes these structures, that are surrounded by connective tissue. In other words, all the structures that are between the two veins are removed, making these two veins a landmark for this surgery.

-Clinical notes:

When a person is standing, and he/she swallows a foreign body and this foreign body enters the respiratory tract, it will enter the right side (the right bronchus). What segment will it enter? The posterior segment of the lower lobe, because it is the lowest in that particular lobe, and it is continuous with the trachea.

When a person goes to the dentist and lays down to have a tooth removed, he/she accidentally swallows the tooth, and the tooth then enters the respiratory tract. It will enter the right side. What segment will it enter? The apicobasal segment.

In the embryo

- There is a difference between the number of bronchopulmonary segments in an adult and in an embryo. The difference is that the embryo has 8 in the left lung instead of 10. After delivery, they become 10 in number. Why is there a difference? In the upper lobe in the embryo, the apical and posterior segments join together as one segment called apicoposterior. After delivery, they are separated to give the apical and posterior segments. In the lower lobe (the base), the anterior segment and the medial segment join together forming one segment, called anteromedial segment. After delivery, they are also separated to give the anterior and medial segments.

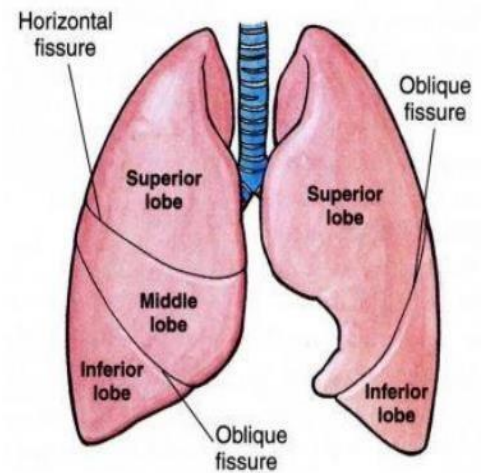
- **Clinical importance of bronchopulmonary segment**

- 1- They are important during surgery: Nowadays, segments are removed in surgeries instead of lobes. If there is an infection, it stays localized within a certain segment (between the connective tissue that surrounds the segment.)
- 2- There is no barrier between the segments, so if the infection spreads, it will affect the other segments.
- 3- In postural drainage, it is important to drain segments.
- 4- In bronchoscopy, you observe the segments.

*Be aware that the bronchioles are found inside the segments

Lungs

There are two lungs, one right and one left. Each lung has an apex and a base. The base sits on the diaphragm. We know that the diaphragm has two copulas, and these copulas are shaped like a dome. So, the right lung has its base on the right copula and the left lung has its base on the left copula.



The anatomical relation between the lungs and the diaphragm is that the lungs are **anterior, posterior and superior to the diaphragm.**

❖ Difference between the right and left lungs:

1- Dimensions: the right lung is shorter and wider than the left. This is because the liver pushes the diaphragm upwards on the right side, causing the right lung to be shorter and wider. The left lung is longer and narrower than the right lung.

2-Lobes: the **right** lung has **three** lobes; upper, middle and lower lobes. The **left** lung has **two** lobes, upper and lower lobes.

3-Fissures: the **left lung has an oblique fissure only.** The **right lung has oblique and horizontal fissures.**

4-The left lung contains a structure called **lingula**, as well as a **cardiac notch.**

5-The left lung has an artery called **apical artery** which is found at the **apex.**

- Fissures can be identified on the body using surface anatomy. They are important when using the stethoscope to know which lobe you are listening to.

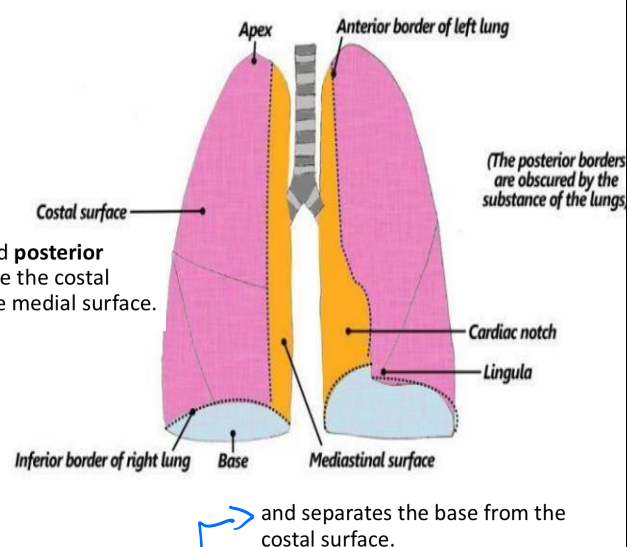
- The color of the lungs is **reddish** in normal people, while in smokers it becomes black, with black dots found due to the presence of nicotine.
 - Lungs are filled with elastic tissue. This elastic tissue surrounds the alveoli.
 - The apexes of the lungs extend above the clavicles and the first ribs. They are usually **1 inch above the medial third of the clavicle**. This could be dangerous when encountering a stab wound at the root of the neck.
- The apex may be damaged, and air will go inside the lung, which leads to lung deflation and collapse.
- The lungs weigh about 600-800gm, 90% air & 10% tissue.

❖ The function of the lungs:

Lungs receive blood from the right and left pulmonary artery. Both of those arteries originate from the pulmonary trunk, which bifurcates to give both arteries. These arteries reach the lung through the hilum. When air reaches the alveoli, oxygen moves to the blood, making it oxygenated. After that, oxygenated blood returns to the left atrium through the pulmonary veins. Pulmonary veins are 4 in number; 2 on the right and 2 on the left. After the blood reaches the left atrium, it goes into the left ventricle, and then to the aorta. In the end, blood reaches the cells to provide them with oxygen. All in all, the main function of the lungs is to oxygenate the blood.

❖ Borders and surfaces

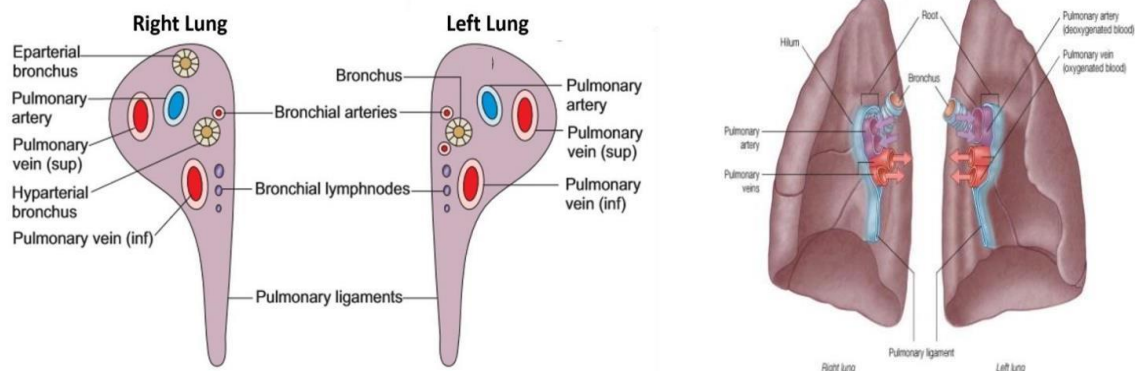
- Lungs have **anterior (sharp), posterior (rounded)** and inferior borders(**sharp**).
- The anterior border isn't the same in both lungs. The left lung has the cardiac notch on its anterior border between the 4th and 6th costal cartilages. This cardiac notch forms the shape of a semi-circle with a length of 1 inch.
- The inferior border is sharp, with the diaphragm located beneath it.
- Lungs have a **costal** surface and a **mediastinal** surface.



- The costal surface lies immediately adjacent to the ribs and intercostal spaces.
- The **mediastinal** surface lies against the mediastinum **anteriorly**, and the vertebral column **posteriorly**. {Don't forget that the mediastinum is the space between the lungs}.

❖ **The hilum:**

The lung also consists of a comma-shaped hilum, through which structures enter and leave.



- **Components of the right hilum:**

One pulmonary artery, two pulmonary veins (upper and lower) and the right bronchus. {You can identify the bronchi in the laboratory by identifying the cartilage that surrounds them}.

- The Bronchus that passes through the right hilum separate into ib-arterial bronchus (above the pulmonary artery) and hib-arterial bronchus (below the pulmonary artery).

- **Components of the left hilum:**

One pulmonary artery, two pulmonary veins (upper and lower) and the left bronchus. The difference in the left lung is that the bronchus doesn't separate into ib-arterial and hib-arterial bronchi.

❖ **The root and hilum**

- Within each root, and located in the hilum are:
 - 1-Pulmonary artery.
 - 2-Two pulmonary veins.
 - 3-Lymph nodes and vessels.
 - 4-Nerves (sympathetic and parasympathetic).
 - 5-Bronchial vessels.
 - 6-Bronchus.
 - 7-Ligaments.

- The **bronchial vessels** are the vessels that supply the lung tissue, not the pulmonary artery or the pulmonary veins!
- As we've mentioned previously, the bronchus in the right hilum separates into two bronchi. The bronchus in the left hilum remains as a single bronchus and does not divide/ separate.
- The root of the lung is found between **T5** and **T7**

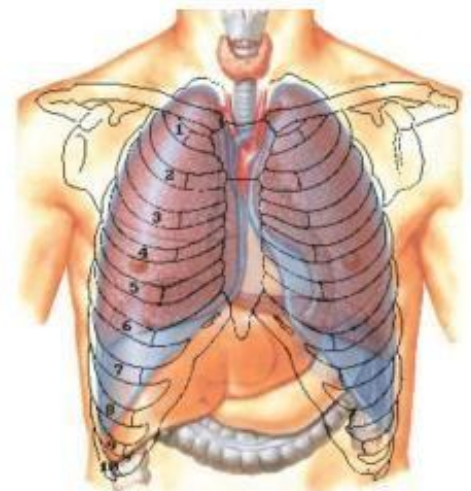
❖ The pleura:

- The pleura has two layers, **visceral and parietal**.
- The two layers are adherent at the **apex** of the lung and have a space between them at the **base**.
- The visceral and parietal layers of the pleura on the mediastinal surface around the hilum are pledged together to form one membrane.
- They surround the content of the hilum.
- Below the hilum, they form the pulmonary ligament.

Surface anatomy of the lung:

Surface anatomy means to identify structures in the body using landmarks found on the surface of the body.

How to identify the apex: the apex is found **1 inch above the medial end of the clavicle**. This is important clinically; when inserting a **cannula into the subclavian vein** (which is found on the upper surface of the first rib), to administer drugs to the patient. Common mistake: The cannula is inserted into the apex instead of the vein, and this could lead to lung collapse. To make sure the cannula did not go through the apex, an X-ray is taken after the cannula is inserted.



How to identify the posterior border: it starts from the **apex** and descends posteriorly until it reaches **T10**.

or
Posterior border Extend from
7th C vert. to the 10th T vert.
- lies 4cm from the midline

How to identify the anterior border: It starts from the **apex** → to the sternoclavicular joint → to the sternal angle. It descends down until it reaches the **6th costal cartilage in the midline**.

- There's a difference between the right & left lungs' anterior border:
- In the left lung: Between the 4th and 6th costal cartilage 0.5-1 inch (2cm) to the left, there is a semicircle cardiac notch at the anterior border.

How to identify the base: At the end of expiration, the base crosses the **midclavicular line at the 6th rib**, crosses the **midaxillary line at the 8th rib**, then posteriorly at the level of **T10**. This is not fixed, for when there is inhalation and expansion of the lung, the **base may reach the level of T12**.

↗ On the left lung begins between spinous processes of vertebrae T3 and T4

How to identify the oblique fissure: begins roughly at the spinous process of vertebra T4 level of the spine, crosses the fifth interspace laterally, and then follows the contour of 6th rib anteriorly

How to identify the horizontal fissure: start from the **4th intercostal space anteriorly** and then go along the **5th rib**.
From the sternum until it meets the oblique fissure

How to identify the pleura: the **visceral layer** is always adherent to the lung. The **parietal layer** is the layer that changes. Identifying the **parietal layer at the apex** is the same as identifying the apex itself, since the two layers (Parietal and visceral) are adherent at the apex. **At the anterior border**, it reaches the **6th or 7th rib** (the same as the lung). The difference is at the base, where the **parietal layer reaches two more spaces at the base**. So, at the **midclavicular line**, it reaches the **8th rib instead of the 6th**, at the **midaxillary line** it reaches the **10th rib instead of the 8th**, and it is at the level of **T12 instead of T10**. This difference between the lung and the pleura is important, to keep the lung surrounded by the pleura during expansion.

❖ Impressions on the visceral surface of the right lung Deoxygenated blood (vein)

- 1- Impression formed by the **right atrium and the associated superior vena cava and inferior vena cava** and azygos vein
- 2- The **esophagus** has an impression posterior to the hilum, and it reaches the apex.
- 3- **Trachea** has an impression anteriorly.
- 4- Impressions caused by the **contents** of the hilum (2 pulmonary veins, pulmonary artery, ib-arterial hib-arterial bronchi)

The right subclavian artery and vein arch over and are related to the superior lobe of the right lung as they pass over the dome of cervical pleura and into the axilla.

❓ **Impressions on the visceral surface of the left lung** Oxygenated blood (arteries)
 1- Impression for the **left ventricle**. *Pericardium covering*

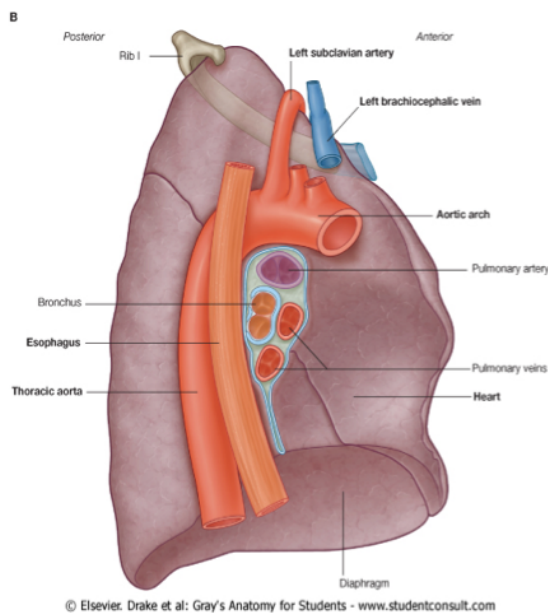
2- Impression for the **descending aorta and the arch of the aorta with its branches.**

3- The **esophagus** has an impression **anterior** to the descending aorta in the lower part of the **lung** because it goes through the diaphragm one inch to the left, so it crosses the descending aorta.

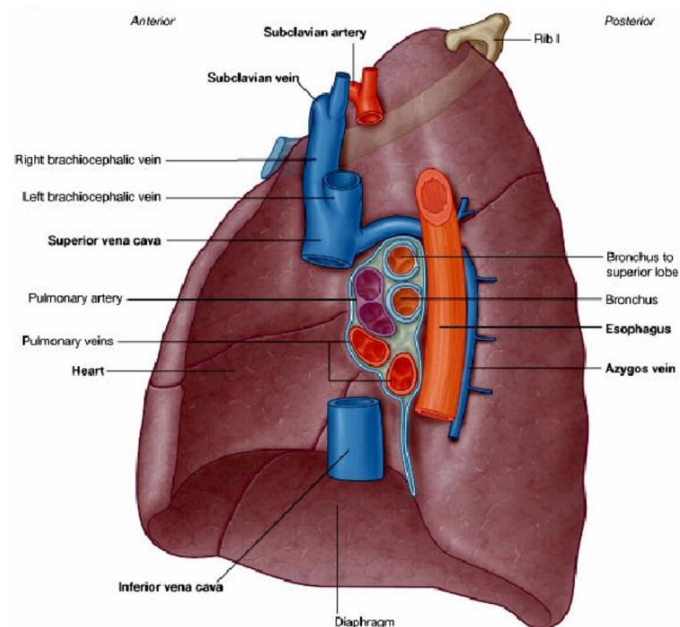
*The trachea doesn't have an impression on the left lung

- Brachiocephalic artery has no impression on the left lung (it is over thoracic aorta)

Left Lung



Right lung



- General notes about fissures:
- the **oblique fissure** separates the **inferior lobe (lower lobe)** from the superior lobe and the **middle lobe of the right lung**;
- the **horizontal fissure** separates the **superior lobe (upper lobe)** from the middle lobe.
- The **left lung** is smaller than the right lung and has two lobes separated by an oblique fissure
- **oblique fissure** of the left lung is slightly more oblique than the corresponding fissure of the right lung

