MD Program
UNIVERSITY OF TORONTO

Anatomy

UNIT 3: Anatomy of the Cardiorespiratory System

Lab 9

CLICK TO ENTER

Unit 3 Overview

Unit 3 describes the anatomy of the cardiorespiratory system. It will build on your introduction to the thorax in Unit 1, Lab 2. Over the course of three labs, you will have the opportunity to study, through dissection and exploration, i) the anatomy of the heart, internal and external, including the coronary circulation, ii) the skeleton and fascial compartments of the limbs, and the peripheral vascular system, iii) the detailed anatomy of the superior and posterior mediastinum, and iv) a more in-depth study of the lungs, pleural cavity and the mechanics of respiration.

The skeleton is quite sensibly divided into an **axial division** and an **appendicular division**. You've already studied the axial division, consisting of the vertebral column (including the bony thorax), and the skull, in Units 1 and 2, respectively. In Unit 3, you will learn the appendicular skeletons of the upper and lower limbs. You are learning the skeleton of the limbs at this point because so much of the language of anatomy (and therefore medicine), including its vasculature, is based on the names of its bones. In Lab 7 you will learn the skeleton of the lower limb. In Lab 8, you will continue with the skeleton of the upper limb.

Note that the anatomy of the musculoskeletal system will be studied in CPC-2, next September, and it is then that you will learn about articulations, muscles and innervation of the limbs. Your current objectives in Unit 3 are to learn the skeleton, fascial compartments and blood supply of the limbs.

Lab 9 Instructions

Lab 9 is spread over two half-days, one in each of Weeks 20 and 21. Each lab session begins with a Lab RAT on Pre-lab Exercise 9A. **Arrive 10 minutes early** so that you can log into Turning Point. If you encounter problems with the app on your phone, you will then have time to **log in on a computer** and still **be ready to start the quiz at 9:00**.

Lab 9 begins with all student at their cadavers, **Pairs 1 and 2 at Cadaver 1** and **Pairs 3 and 4 at Cadaver 2**. Students will work through the brief **Exercise 9.0, Pleural Cavities and Recesses**. Once completed, Pairs will move on to the exercise that corresponds to their pair number, as outlined below, and switch at 10:30 am.

Note that **Exercise 9.3**, The Diaphragm and Mechanism of Respiration, is located in **MS1162 / 64**.

	Week 20 9:00-10:30	Week 20 10:30-12:00	Week 21 9:00-10:30	Week 21 10:30-12:00
Ex. 1 Lungs and Airways	Pairs 1	Pairs 4	Pairs 3	Pairs 2
Ex. 2 / 4 Posterior Mediastinum	Pairs 2 on cadaver 1	Pairs 1 on cadaver 1	Pairs 4 on cadaver 1	Pairs 3 on cadaver 1
Ex. 3 Diaphragm and Respiration	Pairs 3	Pairs 2	Pairs 1	Pairs 4
Ex. 2 / 4 Posterior Mediastinum	Pairs 4 on cadaver 2	Pairs 3 on cadaver 2	Pairs 2 on cadaver 2	Pairs 1 on cadaver 2

Unit 3: Lab 9

Select an exercise to begin:

Pre-lab SLM

9A PRELAB SLM

Lab 9 Exercise

9.0 PLEURAL CAVITIES AND RECESSES

9.1 THE LUNGS AND AIRWAYS

9.2 / 9.4 THE POSTERIOR MEDIASTINUM

9.3 THE DIAPHRAGM AND MECHANICS OF RESPIRATION

If you finish any exercise early…

9.5 FIELD TRIP

Review Lab 9

QUIZLANDIA 9

9A Pre-lab SLM

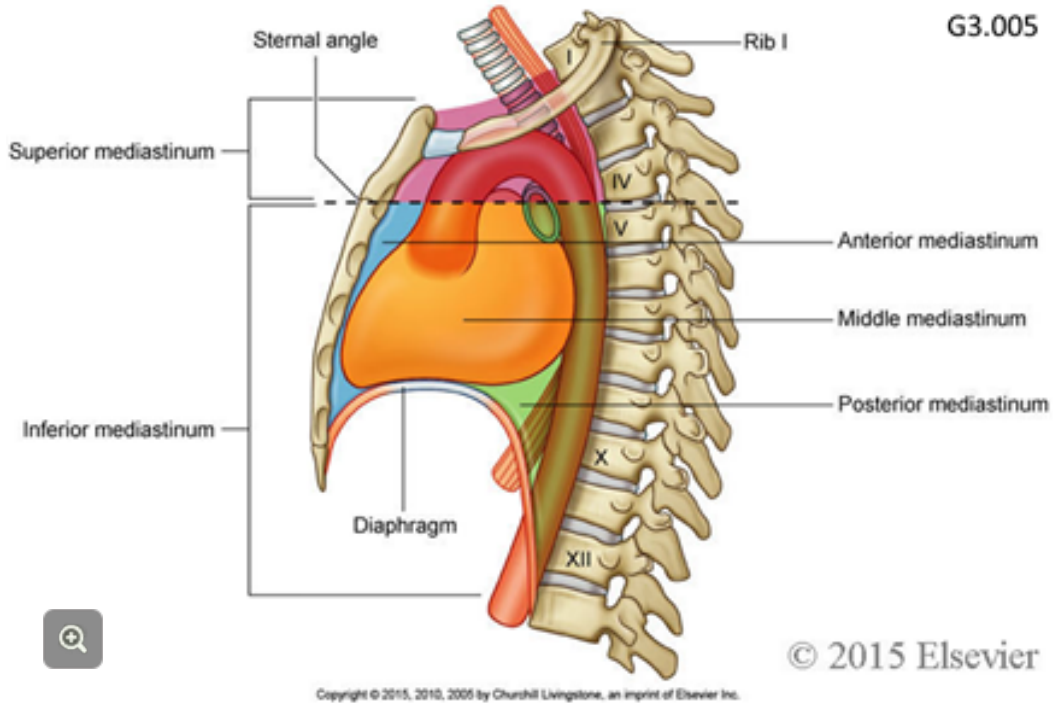
Objectives Part 1: The Posterior Mediastinum

When you have learned the material presented in this exercise, you will be able to describe the:

- boundaries of the posterior mediastinum
- viscera, vessels, nerves and lymphatics of the posterior mediastinum, their relationships to each other and to structures of adjacent regions

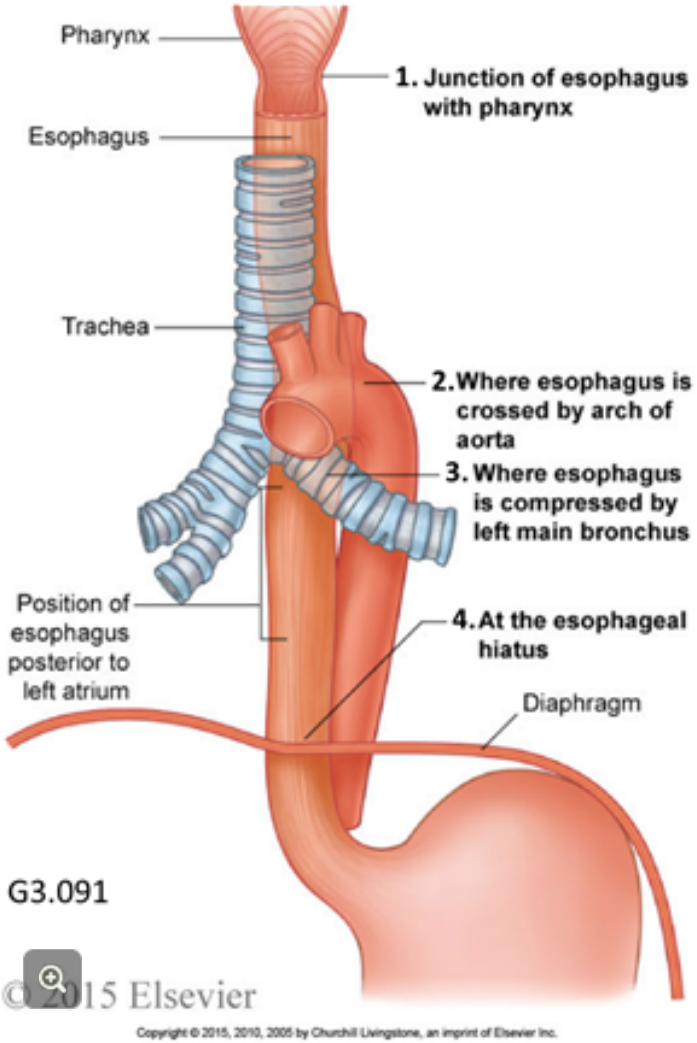
The **borders** of the posterior mediastinum are:

- **anteriorly**, the pericardial sac and diaphragm
- **posteriorly**, the bodies of vertebrae T_5 - T_{12}
- **superiorly**, a horizontal plane passing through the sternal angle and intervertebral disc between vertebrae T_4 and T_5
- **inferiorly**, the attachment of the diaphragm to the vertebral column
- **laterally**, the mediastinal parietal pleura



The posterior mediastinum contains:

- the **esophagus** and its associated nerve plexus
- the thoracic **aorta** and its branches
- the **azygos** system of veins
- the **thoracic duct** and associated lymph nodes
- the **sympathetic trunks** and the **thoracic splanchnic nerves**.



The Esophagus is a muscular tube, 25 cm in length and 2 cm in diameter. It begins at the **upper esophageal sphincter** (the **cricopharyngeus**, a component of the **inferior pharyngeal constrictor**) at the level of the C_6 vertebra. It passes through the **esophageal hiatus** of the diaphragm at the level of the T_{10} vertebra. It ends at the lower esophageal sphincter (also known as the cardiac sphincter of the stomach) at the level of the T_{11} vertebra.

As illustrated in the accompanying diagram, the esophagus is narrowed, or may become compressed, at **four locations** along its length. **Make note of these locations.** Clinically, these are the more likely places where:

i. a swallowed object may become lodged, or

ii. where more damage can be done by a swallowed corrosive substance, the passage of which is slowed at these sites, or

iii. where the passage of instruments may be more problematic.

Ramifying over the surface of the esophagus is the **esophageal plexus**, which innervates the distal portion of the esophagus.

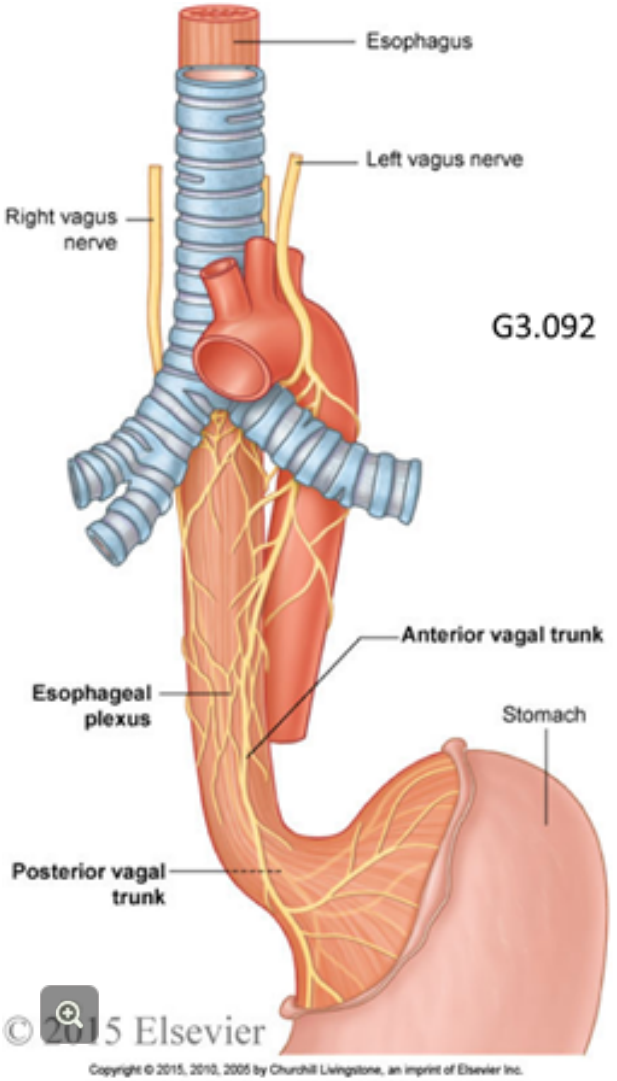
The esophageal plexus receives **parasympathetic preganglionic** input from the vagus nerves.

The **right vagus nerve** crosses the anterior surface of the right subclavian artery and passes posterior to the root of the right lung to the esophagus and its plexus.

The **left vagus nerve** crosses the left lateral aspect of the arch of the aorta and passes posterior to the root of the left lung to the esophagus and its plexus.

The esophageal plexus receives **sympathetic postganglionic** contributions from the upper thoracic levels via the sympathetic chain ganglia and the **esophageal (splanchnic) nerves**.

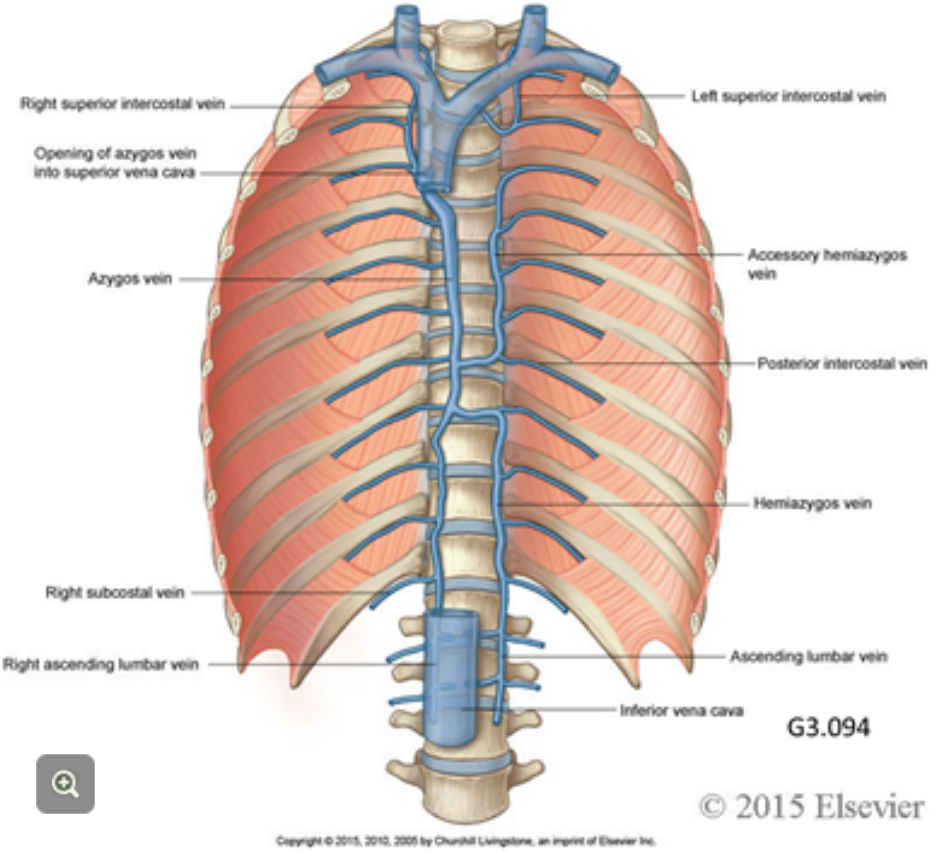
Distal to the esophageal plexus, vagal fibres coalesce to form the **anterior and posterior vagal trunks**. The **anterior** vagal trunk is largely formed from the **left** vagus nerve, and the **posterior** vagal trunk is formed largely from the **right** vagus nerve. The anterior and posterior vagal trunks **accompany the esophagus through the esophageal hiatus of the diaphragm** to the abdominal cavity. As you will learn, the vagi provide parasympathetic input to much of the digestive tract.

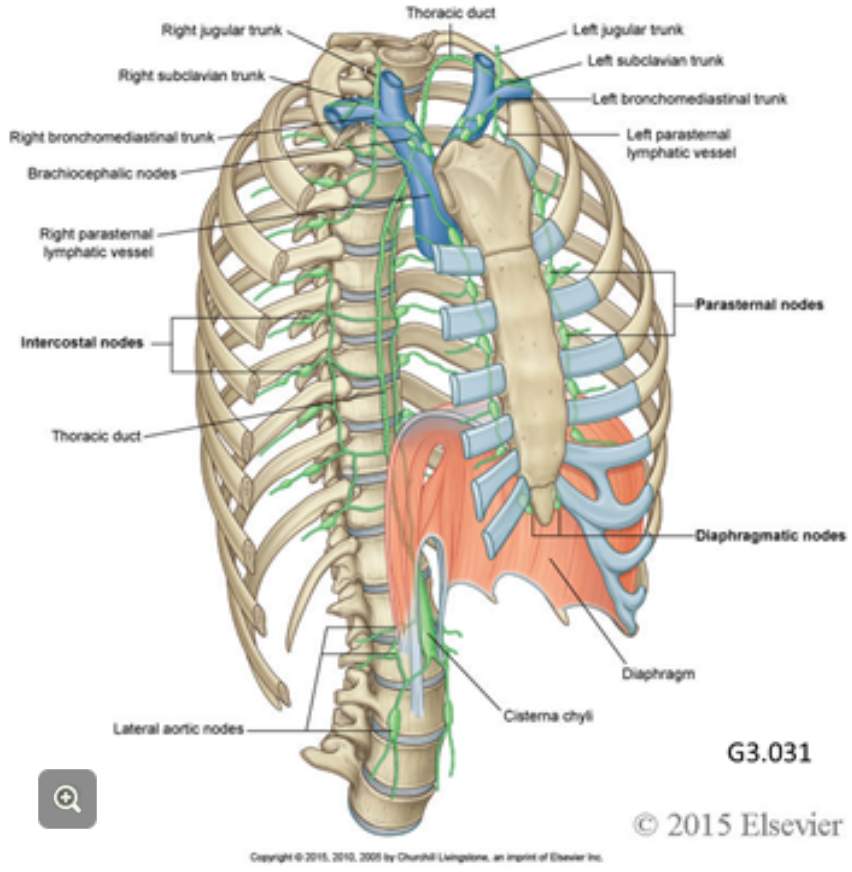


The **azygous system of veins** drains the posterior body wall to the superior vena cava and the right side of the heart. It is also a clinically significant anastomotic route by which venous blood can return to the right side of the heart if the IVC is occluded.

The **azygous vein** begins in the abdomen at the level of the L_1 or L_2 vertebra, and passes through the diaphragm via the **aortic hiatus** (or the right crus of the diaphragm). It ascends through the thorax to the right of the midline, and **at the level of the sternal angle** it arches over the root of the right lung to empty into the SVC. The azygous veins receive blood from the right side of the thoracic wall via the **right posterior intercostal veins**.

The **hemiazygous** and **accessory hemiazygous veins** are located in the posterior body wall to the **left of the midline**. They receive blood from the left side of the thoracic wall via the **left posterior intercostal veins**. Both the hemiazygous and accessory hemiazygous veins drain across the midline into the azygous vein. In this manner, the azygous vein ultimately drains the posterior thoracic wall, bilaterally.





The thoracic duct **conveys most of the lymph from the body to the venous system**.

Lymph trunks in the abdomen, carrying lymph derived from the lower limbs, pelvis, perineum, abdominal walls and abdominal organs converge to form the **cisterna chyli** at the L2 vertebral level. The **thoracic duct** arises from the cisterna chyli and enters the thorax by passing through the **aortic hiatus** of the diaphragm posterior to the aorta.

In the thorax, it ascends to the right of the midline, **between the thoracic aorta and the azygous vein**, and **posterior to the esophagus**. On entering the superior mediastinum, the thoracic duct moves to the left and enters the neck.

It is joined by the **left jugular** and **subclavian trunks** and empties into the **left venous angle**. The **left bronchomediastinal trunk** empties into the left venous angle independently.

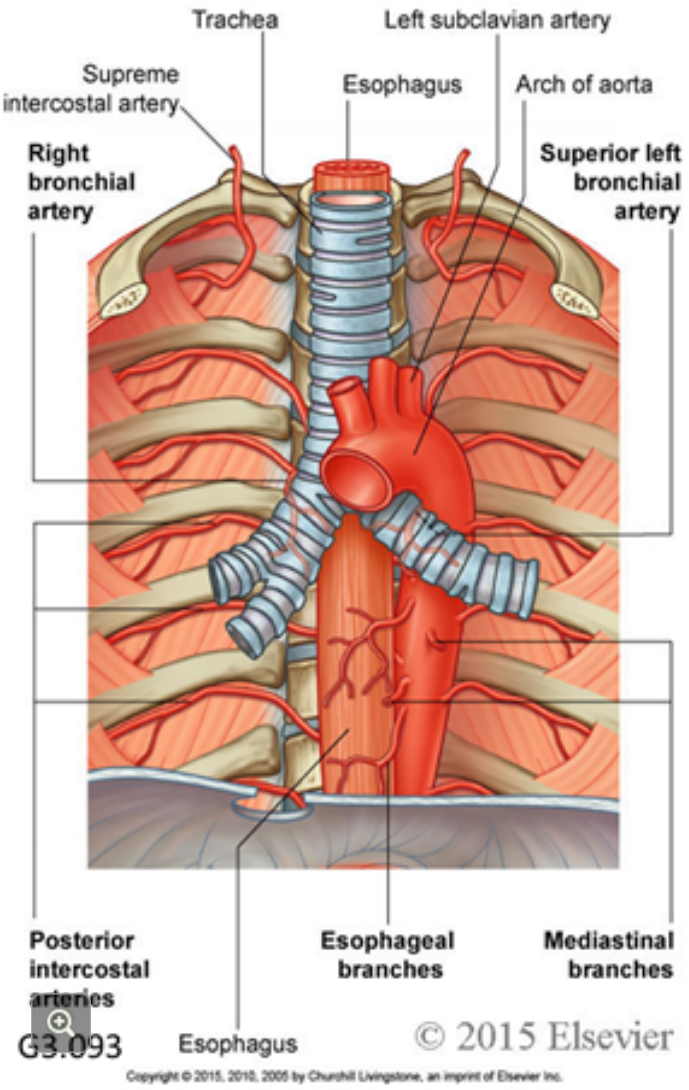
In the thorax, the thoracic duct receives lymph from the **lower six intercostal spaces, bilaterally**, and the **upper five intercostal spaces on the left**. It also receives lymph from ducts draining the posterior mediastinal and posterior diaphragmatic nodes. Note that the **upper five intercostal spaces on the right** drain into the **right bronchomediastinal trunk**, which empties into the **right venous angle**.

The **thoracic aorta** begins at the sternal angle (the level of the disc between the T_4 and T_5 vertebra). It ends at the level of the T_{12} vertebral body where it passes behind the diaphragm through the **aortic hiatus** to become the **abdominal aorta**.

Superiorly, the thoracic aorta begins to the **left of the vertebral column**. As it descends toward the diaphragm it shifts toward the midline and takes up a position **posterior to the esophagus**. It ultimately passes through the aortic hiatus in the midline, **anterior to the T_{12} vertebral body**.

The **visceral branches of the thoracic aorta** are the **bronchial and esophageal arteries.** The bronchial arteries supply the **conducting portions of the respiratory system**; that is, they supply the system of airways that conduct air toward and away from the gas-exchange surfaces of the lungs. The esophageal arteries supply the middle third of the esophagus with blood.

The **parietal branches of the thoracic aorta** are the bilaterally-paired **posterior intercostal arteries**. These run in the intercostal spaces with their companion vein, nerve and lymphatic. Because the aorta is largely a left-sided structure, **the right posterior intercostal arteries cross the midline**. They do so anterior to the thoracic vertebral bodies and posterior to the esophagus.

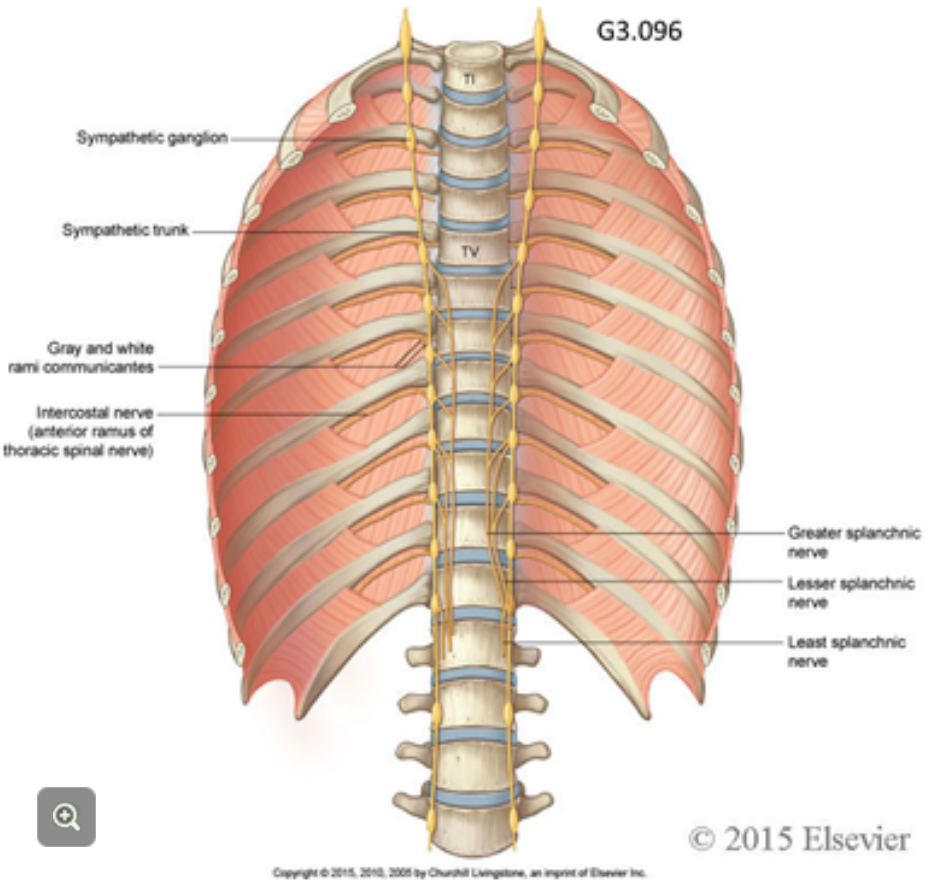


From superior to inferior, the sympathetic chains **gradually move medially**, starting at the necks of the first ribs, then more inferiorly, crossing the heads of the ribs, and finally at the lower thoracic levels, lying more anteriorly, on the lateral aspect of the T_{10} -T_{12} vertebral bodies.

Each intercostal nerve is associated with a **sympathetic ganglion**. This is **unlike in the cervical region**, where there are only three ganglia, superior (stellate), middle and inferior.

Each sympathetic ganglion is connected to its companion intercostal nerve via a **white and grey rami communicantes**. The white rami are located lateral to the grey rami.

The white rami carry the myelinated preganglionic sympathetic fibres from the intermediolateral (IML) cell column (lateral horn cells) of the spinal cord to the cell body of the sympathetic postganglionic neurons located within a sympathetic chain ganglion. Recall also, that if the sympathetic postganglionic neuron in the chain is to innervate targets in the body wall, its axon will pass through the grey ramus communicans back to the ventral ramus / intercostal nerve or the dorsal ramus.

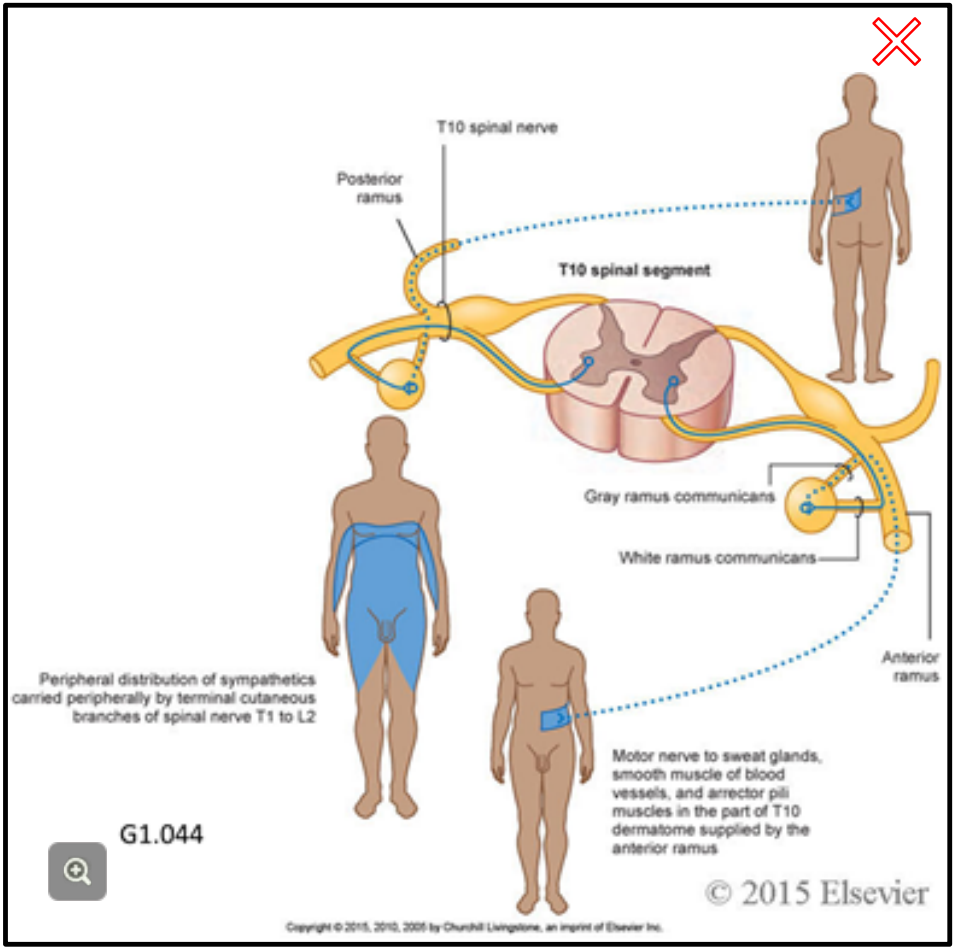


From superior to inferior, the sympathetic chains **gradually move medially**, starting at the necks of the first ribs, then more inferiorly, crossing the heads of the ribs, and finally at the lower thoracic levels, lying more anteriorly, on the lateral aspect of the T_{10} -T_{12} vertebral bodies.

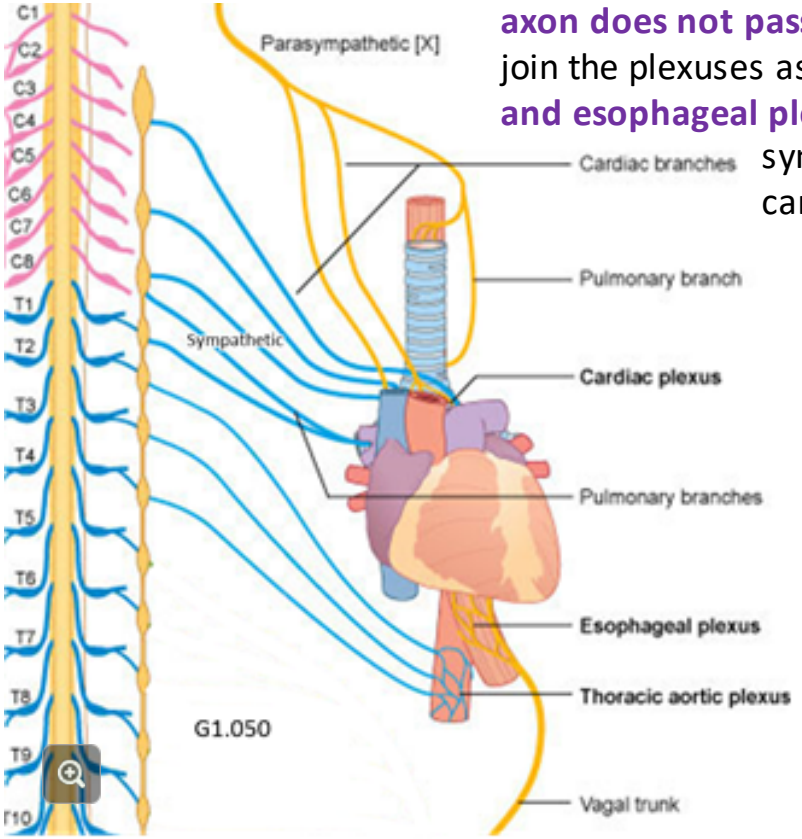
Each intercostal nerve is associated with a **sympathetic ganglion**. This is **unlike in the cervical region**, where there are only three ganglia, superior (stellate), middle and inferior.

Each sympathetic ganglion is connected to its companion intercostal nerve via a **white and grey rami communicantes**. The white rami are located lateral to the grey rami.

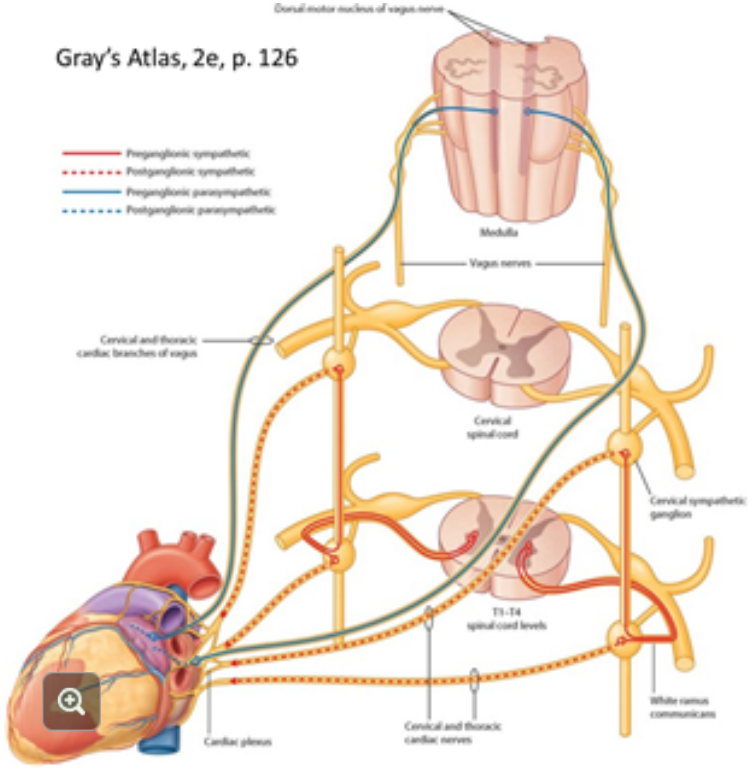
The white rami carry the myelinated preganglionic sympathetic fibres from the intermediolateral (IML) cell column (lateral horn cells) of the spinal cord to the cell body of the sympathetic postganglionic neurons located within a sympathetic chain ganglion. Recall also, that if the sympathetic postganglionic neuron in the chain is to innervate targets in the body wall, its axon will pass through the grey ramus communicans back to the ventral ramus / intercostal nerve or the dorsal ramus.



Thoracic visceral plexuses



HOWEVER, if the sympathetic postganglionic neuron in the chain is to innervate thoracic visceral targets such as the heart, lungs or esophagus, **its axon does not pass through the grey ramus**, but it forms nerves that join the plexuses associated with these organs, the **cardiac, pulmonary and esophageal plexuses**. Remember, as illustrated on the left, that sympathetics may travel through the chain before arising as cardiac, pulmonary or esophageal splanchnic nerves (blue).



In the plexuses, these sympathetic postganglionic fibres overlap the **parasympathetic preganglionic fibres delivered by the vagus nerves**.

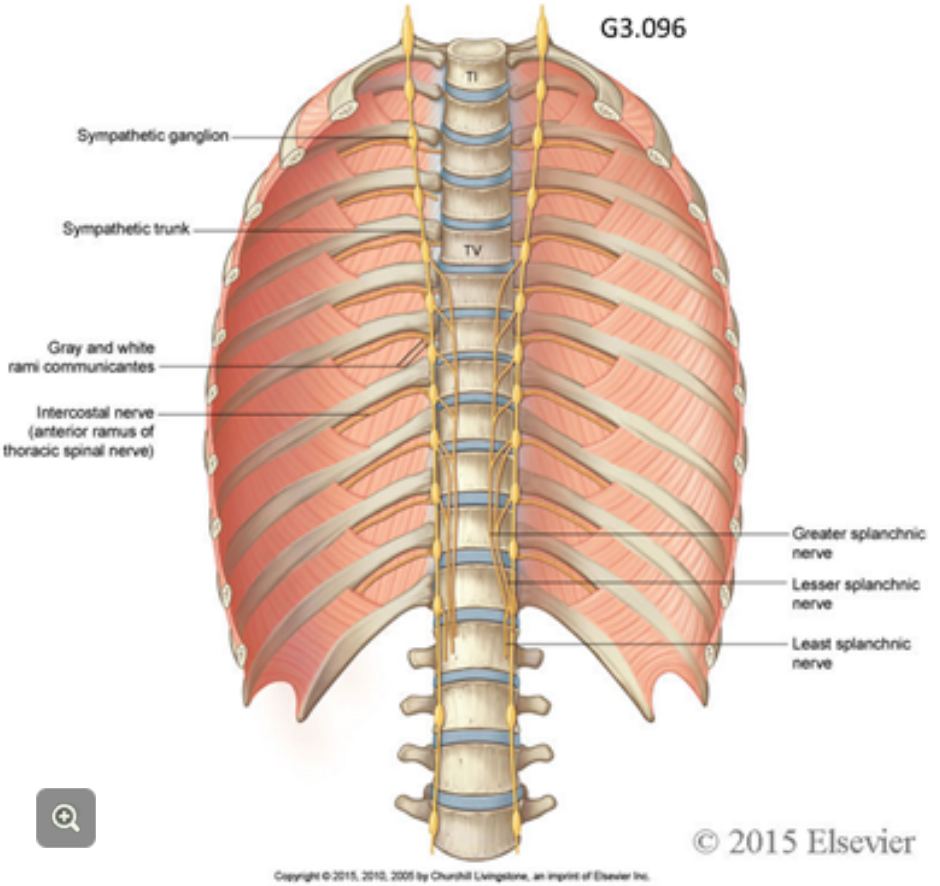
Sympathetic preganglionic fibres destined to innervate **abdominal and pelvic viscera** arise from lateral horn cells of the **T_5-L_2 levels** and **pass through the sympathetic chain without synapsing**. On arising from the sympathetic chain, the preganglionic sympathetic fibres from the **T_5-T_9 levels** form the **greater splanchnic nerves**, those from the **T_{10}-T_{11} levels** form the **lesser splanchnic nerves**, and those from the **T_{12} level** form the **least splanchnic nerves**.

Preganglionic sympathetic fibres from the L_1-L_2 levels arise from chain ganglia at lumbar levels to form the **lumbar splanchnic nerves**. Other fibres from the L_1-L_2 levels descend through the sympathetic chain to arise from ganglia at sacral levels as the **sacral splanchnic nerves**.

In all cases, these splanchnic nerves deliver **sympathetic preganglionic fibres** to the **prevertebral (preaortic) plexuses**.

The greater, lesser and least splanchnic nerves gain access to the preaortic plexuses of the abdomen by passing behind the diaphragm through the **aortic hiatus** with the aorta.

The details of the innervation of abdominopelvic viscera will be covered in Unit 4 with the digestive and genitourinary systems.



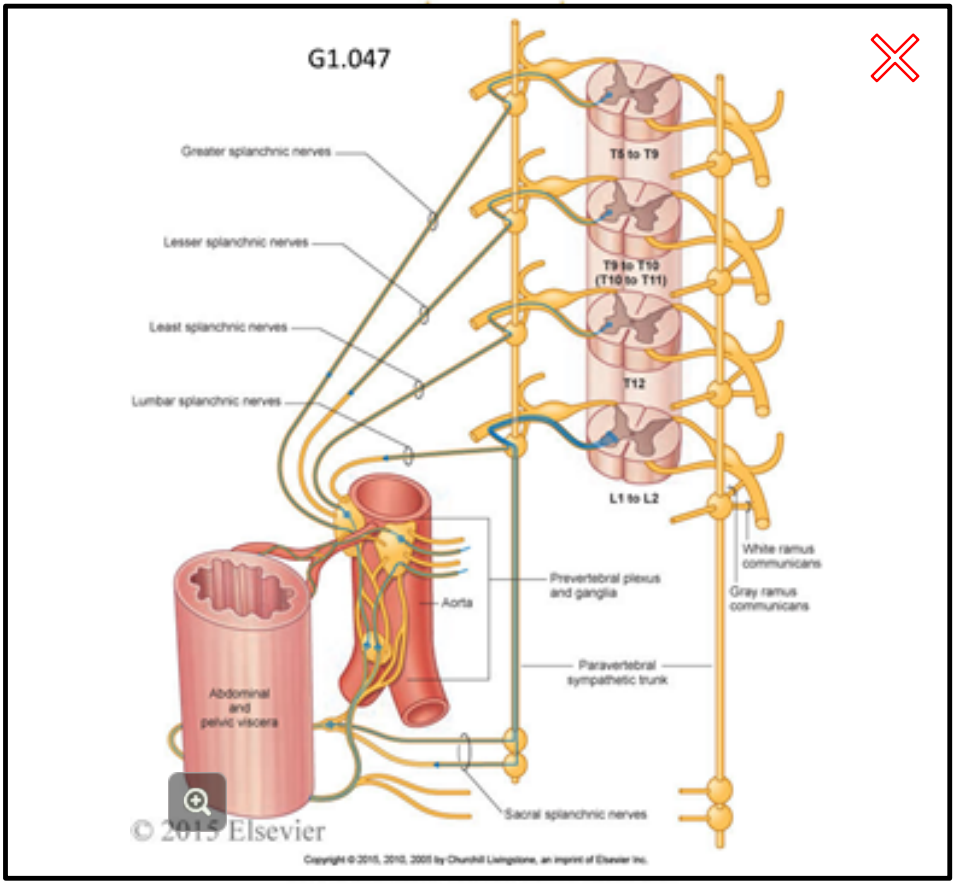
Sympathetic preganglionic fibres destined to innervate **abdominal and pelvic viscera** arise from lateral horn cells of the **T_5-L_2 levels** and **pass through the sympathetic chain without synapsing**. On arising from the sympathetic chain, the preganglionic sympathetic fibres from the **T_5-T_9 levels** form the **greater splanchnic nerves**, those from the **T_{10}-T_{11} levels** form the **lesser splanchnic nerves**, and those from the **T_{12} level** form the **least splanchnic nerves**.

Preganglionic sympathetic fibres from the L_1-L_2 levels arise from chain ganglia at lumbar levels to form the **lumbar splanchnic nerves**. Other fibres from the L_1-L_2 levels descend through the sympathetic chain to arise from ganglia at sacral levels as the **sacral splanchnic nerves**.

In all cases, these splanchnic nerves deliver **sympathetic preganglionic fibres** to the **prevertebral (preaortic) plexuses**.

The greater, lesser and least splanchnic nerves gain access to the preaortic plexuses of the abdomen by passing behind the diaphragm through the **aortic hiatus** with the aorta.

The details of the innervation of abdominopelvic viscera will be covered in Unit 4 with the digestive and genitourinary systems.

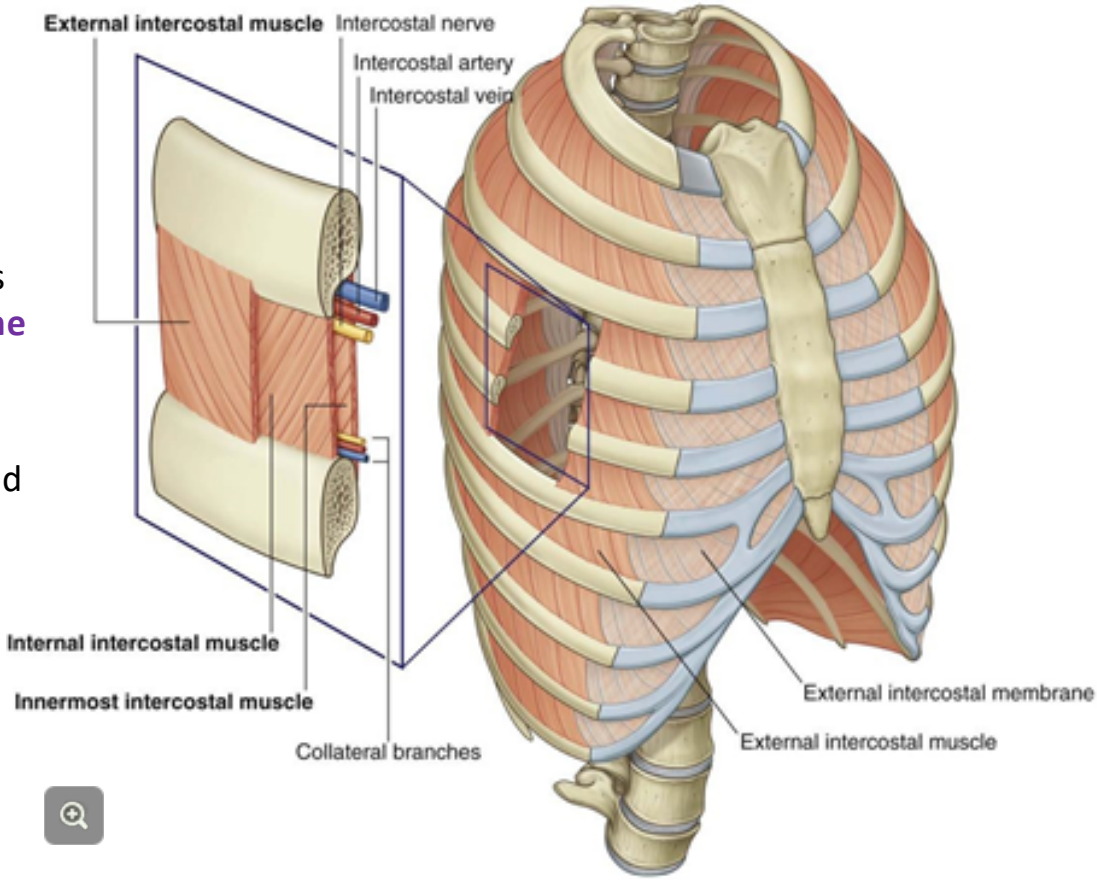


The muscles of the thoracic wall play an important role in respiration. By moving the ribs and sternum relative to each other and to the vertebral column, these muscles alter the shape and volume of the thorax during the respiratory cycle. Increased volume of the thorax draws air into the lungs, and decreased volume of the thorax, along with the inherent elasticity of lung tissues, expels air from the lungs.

There are three layers of **intercostal muscles** that join adjacent ribs. From superficial to deep, these are the **external**, **internal** and **innermost intercostal muscles**.

Major intercostal nerves, arteries, veins and lymphatics are located **between the internal and innermost** intercostal muscles.

Intercostal muscles can be distinguished by the direction of their muscle fibres. The external intercostal muscles run **inferomedially**, while the internal and innermost intercostal muscles run **superomedially**.



9A Pre-lab SLM

Objectives Part 2: The Lungs, Diaphragm and Mechanics of Respiration

When you have learned the material presented in this exercise, you will be able to describe:

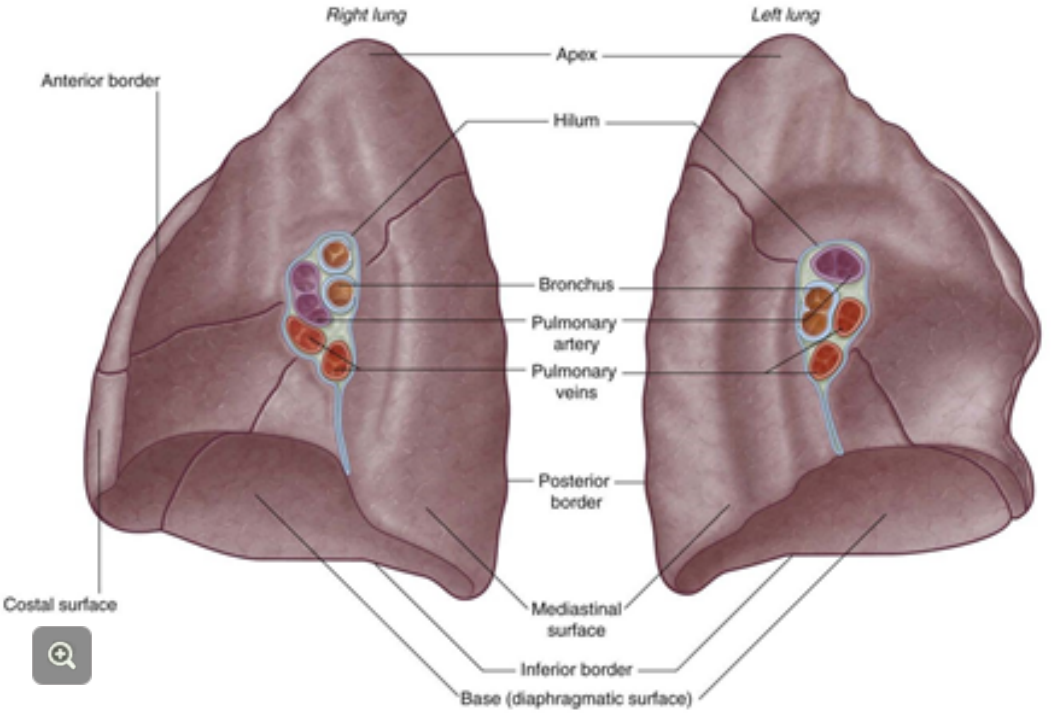
- the surfaces, borders and lobes of the lung
- the branching pattern of the airways of the right and left lung
- bronchopulmonary segments
- the nerve supply and lymphatic drainage of the lungs
- the anatomy of the diaphragm, including its blood and nerve supply and its role in determining thoracic volume during respiratory movements

Each lung has three surfaces, **costal**, **diaphragmatic** and **mediastinal**. The lung is pyramidal in shape. Its **apex** is superior and its base, also known as its diaphragmatic surface, is inferior.

Each lung has a sharp **anterior border** adjacent to the sternum, and a rounded **posterior border** adjacent to the vertebral column. The **inferior border** of the lung, too, is **sharp**.

Each lung has an **oblique fissure** which divides it into **superior** and **inferior lobes**. The **superior lobe** is largely **anterior** and the **inferior lobe** is largely **posterior**. In addition, the right lung has a **horizontal fissure**, which separates its **middle lobe** from its superior lobe.

Because the heart impinges to a greater extent onto the mediastinal surface of the left lung, it creates an indentation in its anterior border, the **cardiac notch**. The **lingula** is an inferomedial projection of its superior lobe that is homologous to the middle lobe of the right lung.

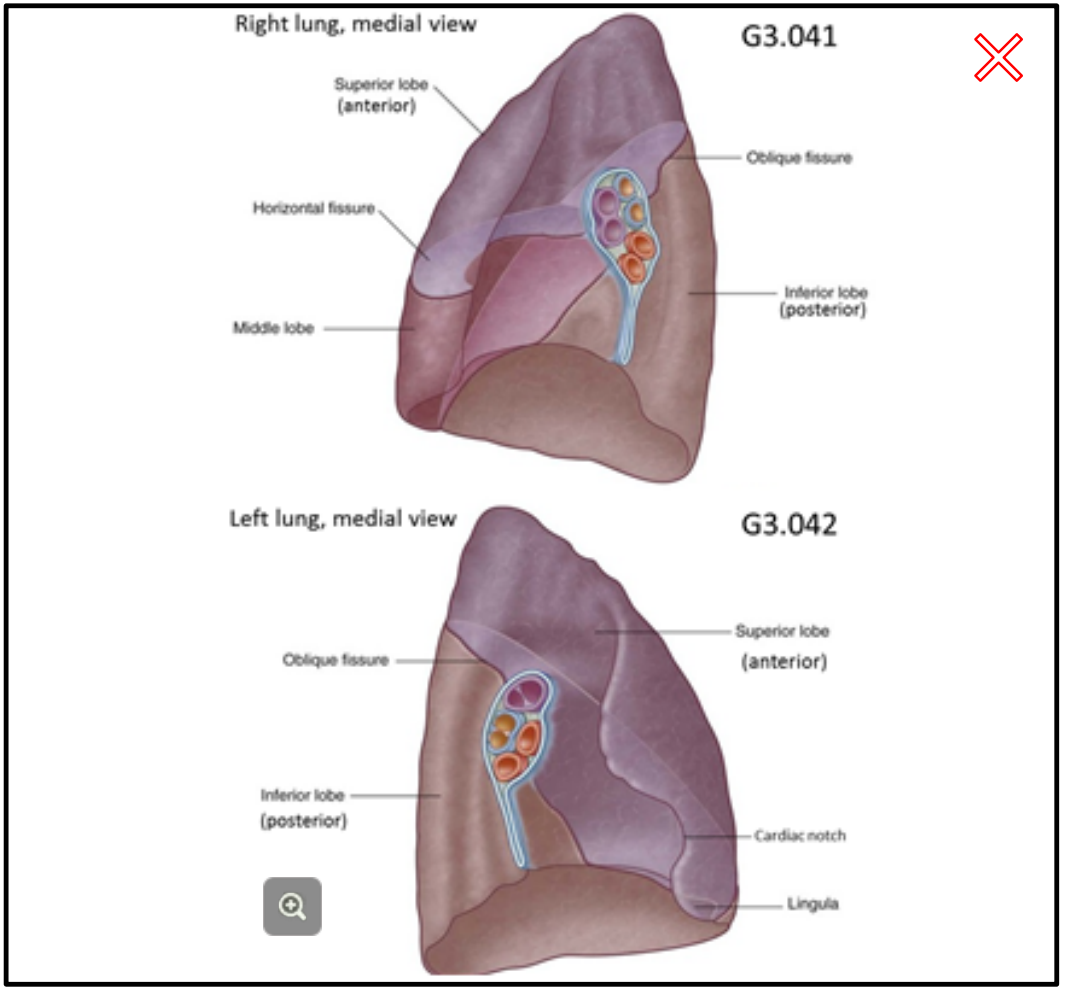


Each lung has three surfaces, **costal**, **diaphragmatic** and **mediastinal**. The lung is pyramidal in shape. Its **apex** is superior and its base, also known as its diaphragmatic surface, is inferior.

Each lung has a sharp **anterior border** adjacent to the sternum, and a rounded **posterior border** adjacent to the vertebral column. The **inferior border** of the lung, too, is **sharp**.

Each lung has an **oblique fissure** which divides it into **superior** and **inferior lobes**. The **superior lobe** is largely **anterior** and the **inferior lobe** is largely **posterior**. In addition, the right lung has a **horizontal fissure**, which separates its **middle lobe** from its superior lobe.

Because the heart impinges to a greater extent onto the mediastinal surface of the left lung, it creates an indentation in its anterior border, the **cardiac notch**. The **lingula** is an inferomedial projection of its superior lobe that is homologous to the middle lobe of the right lung.



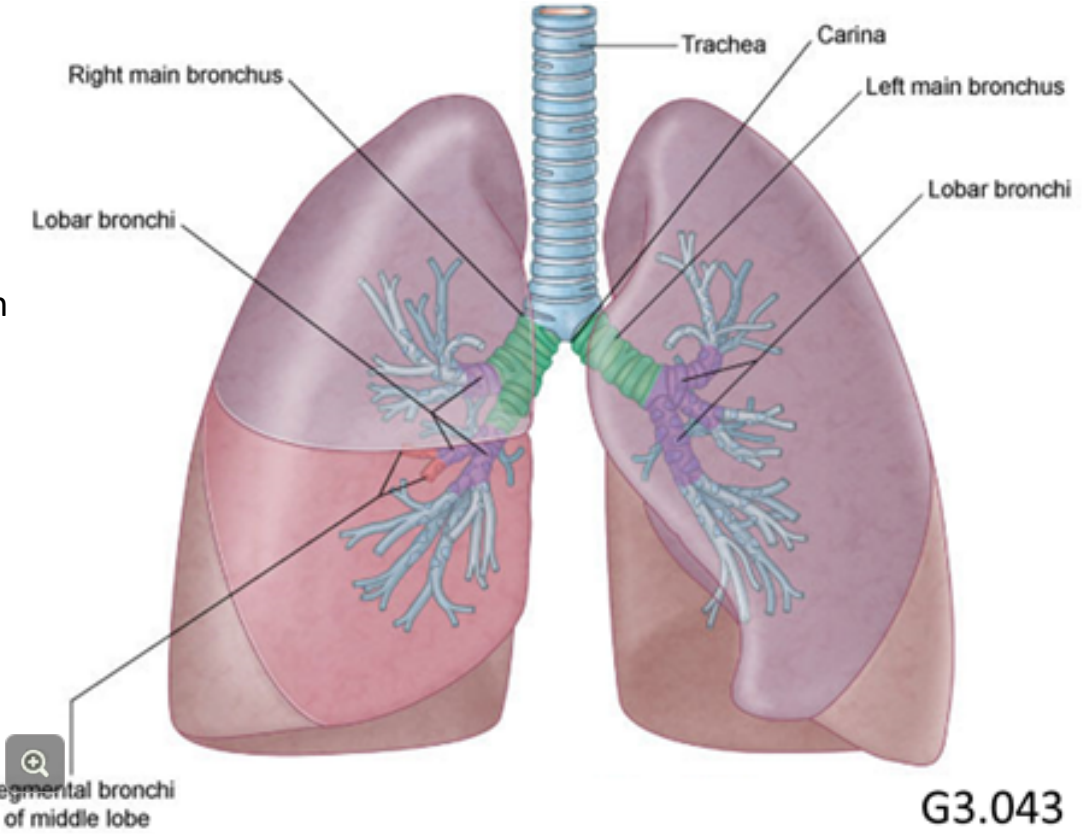
The trachea bifurcates at the level of the sternal angle into the **right and left primary (main) bronchi**, each of which supplies a lung. The **carina** is the cartilage located at the bifurcation of the trachea.

The **left primary bronchus** divides into **two secondary (lobar) bronchi**, one for each of the **two lobes** of the left lung.

The **right primary bronchus** divides into **three secondary (lobar) bronchi**, one for each of the **three lobes** of the right lung.

Branches of the secondary bronchi are the **tertiary (segmental) bronchi**. Each supplies a volume of lung tissue called a **bronchopulmonary segment**.

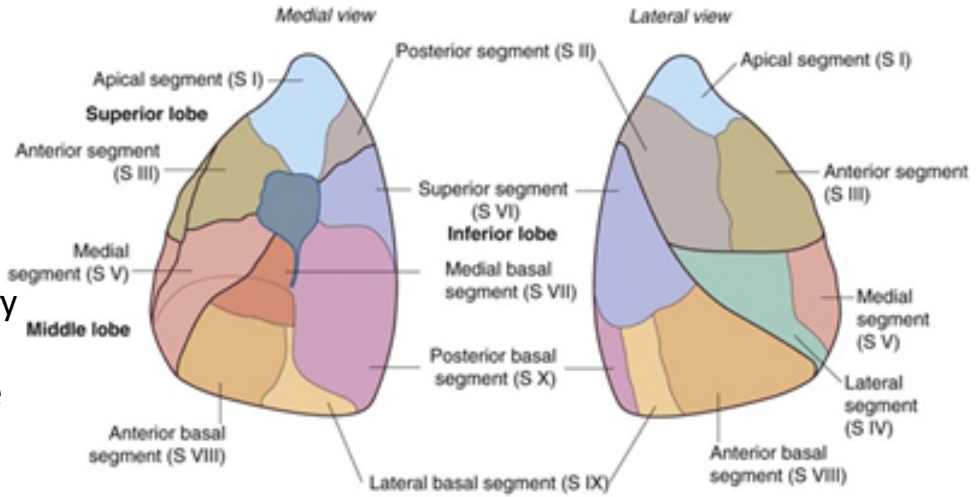
Most commonly, the **right lung has 10 bronchopulmonary segments** (and therefore 10 segmental or tertiary bronchi) and **the left lung has 8 or 9**. This is because, developmentally, there is greater fusion of the left lung than the right.

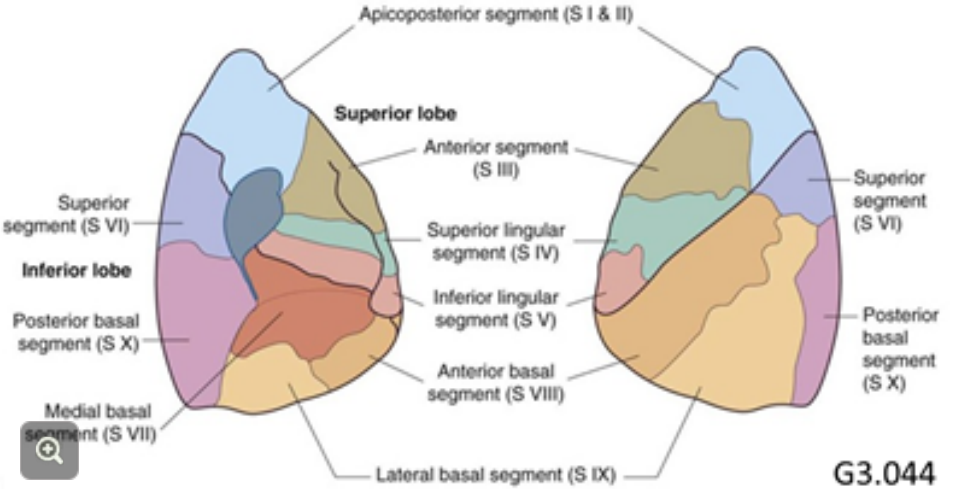


A **bronchopulmonary segment** is the lung tissue supplied by a segmental (tertiary) bronchus. Each segmental bronchus has a companion branch of the **pulmonary artery** that supplies the bronchopulmonary segment with deoxygenated blood. Tributaries of the **pulmonary vein** that drain a bronchopulmonary segment back to the left side of the heart course through the CT between and around the bronchopulmonary segment.

A bronchopulmonary segment is a functionally independent unit of lung tissue. In addition to its own air and blood supply, it has its own nerve supply and lymphatic drainage. **It is the smallest unit of lung tissue that can be removed without affecting adjacent tissue.**

You are responsible only for the knowledge of what a bronchopulmonary segment is. You are not responsible for learning the names or locations of the various bronchopulmonary segments of the lungs.



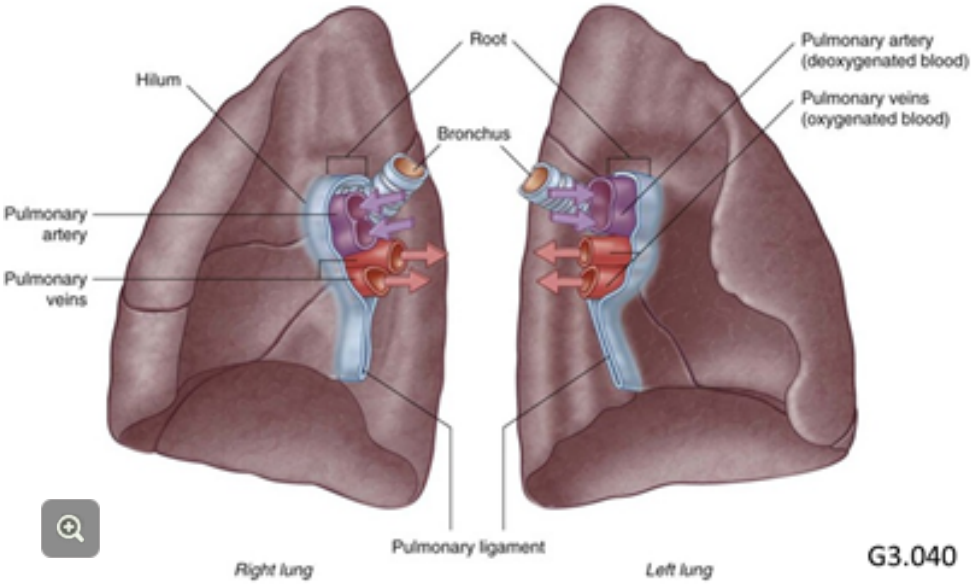


The **main bronchus**, the **pulmonary artery** and the **pulmonary veins** are components of the **root of the lung**, along with its **nerves**, **lymphatic vessels**, **tracheobronchial lymph nodes** and the **bronchial arteries**. These structures that comprise the root of the lung are bound together by CT, and enter / exit the lung at its **hilum**.

Lymph from the deep and superficial (subpleural) lymphatics of the lungs drains into **tracheobronchial lymph nodes**, which are located in the CT around the lobar and primary bronchi, and extend along the trachea and into the posterior mediastinum.

Lymphatic vessels arising from the tracheobronchial lymph nodes unite with those draining the **parasternal nodes** of the anterior chest wall and the **brachiocephalic nodes** located anterior to the brachiocephalic veins, to form the right and left **bronchomediastinal trunks**.

The right and left bronchomediastinal trunks **empty into the right and left venous angles**, respectively.

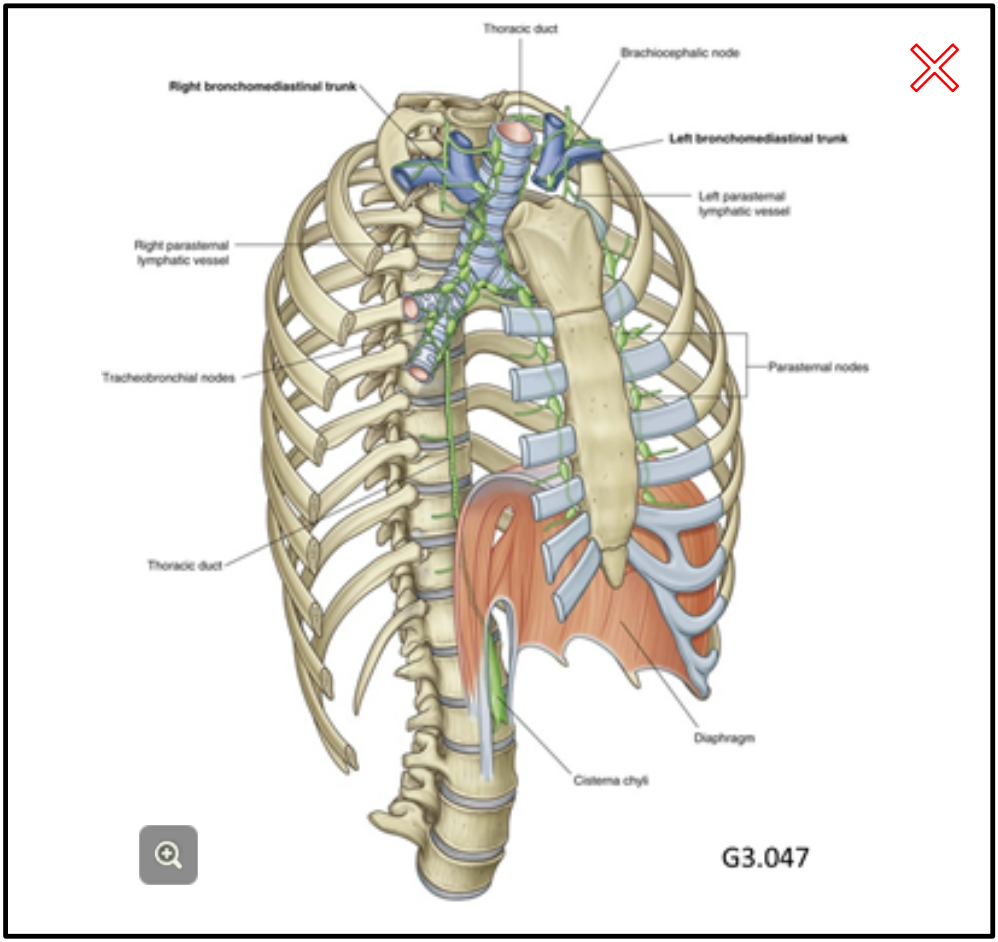


The **main bronchus**, the **pulmonary artery** and the **pulmonary veins** are components of the **root of the lung**, along with its **nerves**, **lymphatic vessels**, **tracheobronchial lymph nodes** and the **bronchial arteries**. These structures that comprise the root of the lung are bound together by CT, and enter / exit the lung at its **hilum**.

Lymph from the deep and superficial (subpleural) lymphatics of the lungs drains into **tracheobronchial lymph nodes**, which are located in the CT around the lobar and primary bronchi, and extend along the trachea and into the posterior mediastinum.

Lymphatic vessels arising from the tracheobronchial lymph nodes unite with those draining the **parasternal nodes** of the anterior chest wall and the **brachiocephalic nodes** located anterior to the brachiocephalic veins, to form the right and left **bronchomediastinal trunks**.

The right and left bronchomediastinal trunks **empty into the right and left venous angles**, respectively.

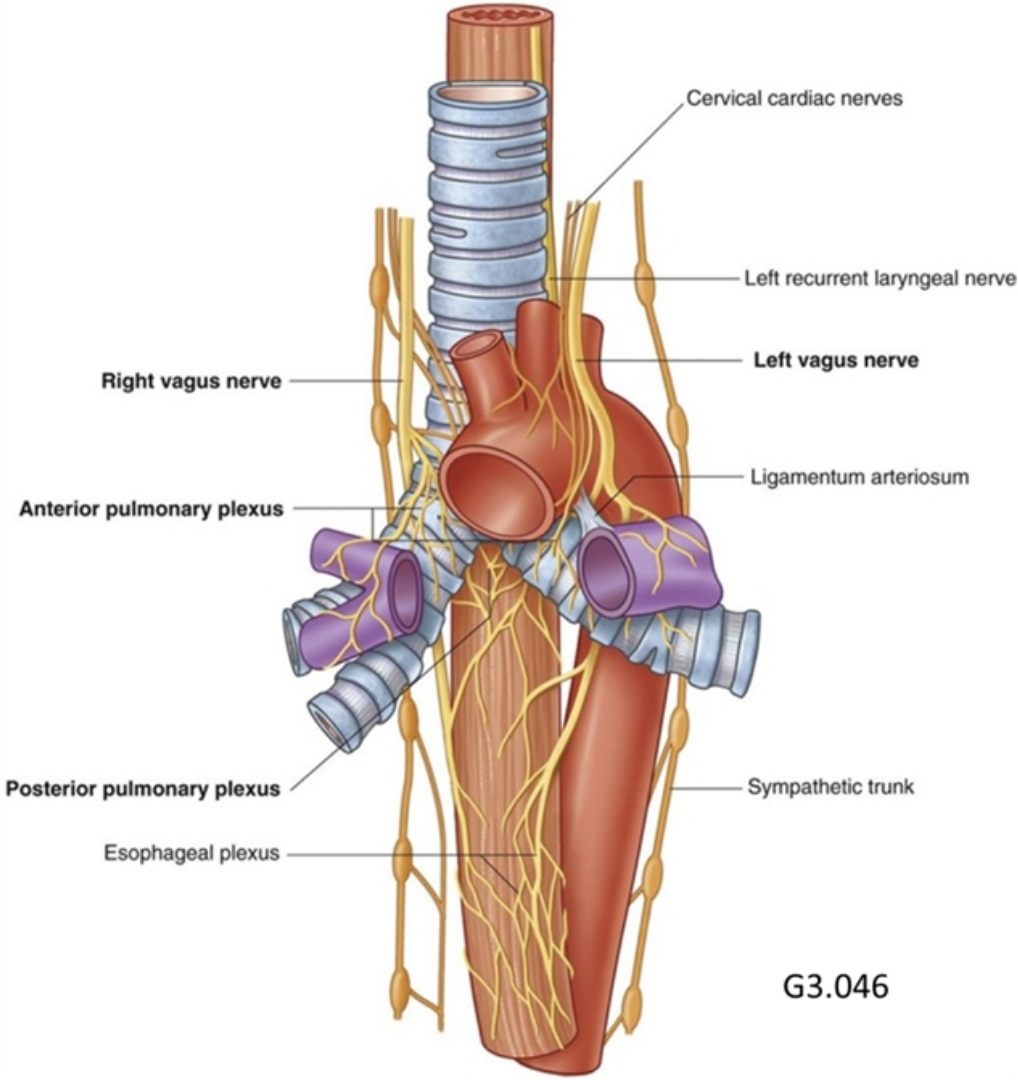


The **anterior and posterior pulmonary plexuses** are located on their respective sides of the tracheal bifurcation and main (primary) bronchi.

They are formed by contributions from the **vagus nerves** (parasympathetic preganglionic) and from **pulmonary** (splanchnic) **nerves** (sympathetic postganglionic), derived from the sympathetic chain. They also include **afferent (sensory) fibres**.

Mixed autonomic nerves derived from these plexuses enter the hilum of the lung along with its airways, blood vessels and lymphatics.

Parasympathetic motor fibres stimulate bronchoconstriction and sympathetic motor fibres stimulate bronchodilation.



The diaphragm originates from the inferior thoracic aperture. The posterior attachment of the diaphragm, like the posterior margin of the inferior thoracic aperture, is **inferior to its anterior attachment**.

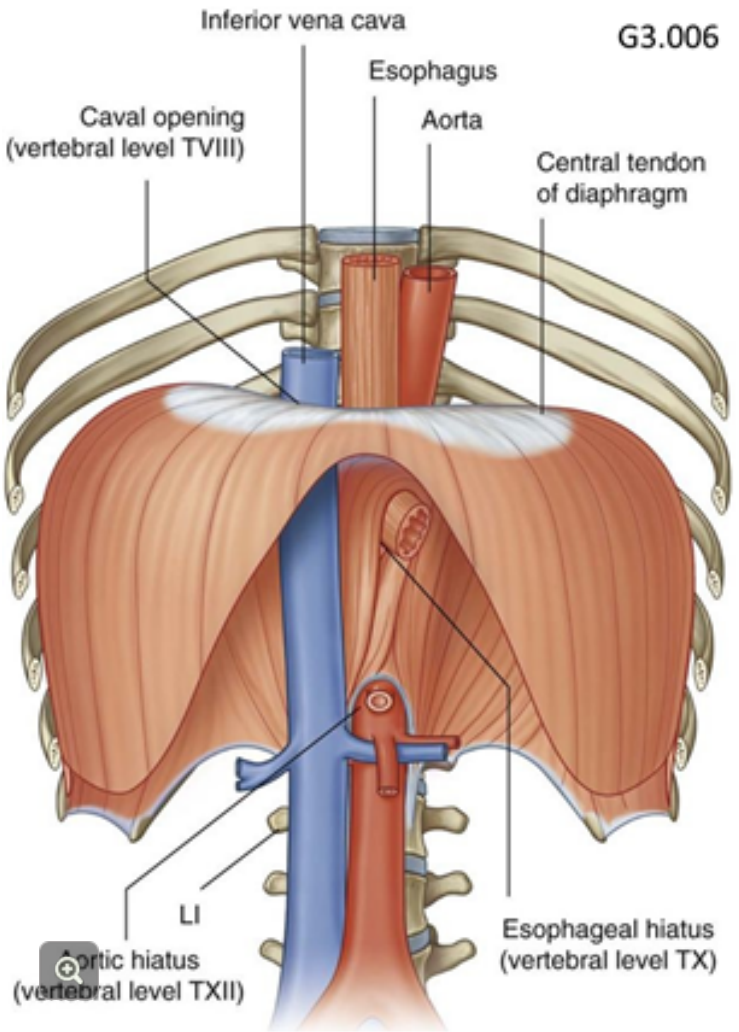
When it is relaxed, the diaphragm domes upward. The right side is higher than the left, owing to the bulk of the liver inferior to it.

The striated muscle fibres of the diaphragm are arranged **radially**, and converge into a large, dense CT **central tendon**. With contraction, the muscle fibres shorten, **pulling the central tendon downward.** Thus, the diaphragm descends and flattens, **increasing the volume of the thorax.**

In the central tendon at the level of the **T8 vertebra** is the **caval opening** through which the IVC passes from the abdomen to the thorax to empty into the right atrium.

The **esophageal hiatus**, at the level of the **T10 vertebra**, is the opening in the central tendon through which the esophagus passes to enter the peritoneal cavity.

At the level of the **T12 vertebra**, the thoracic aorta passes **posterior to** the diaphragm through the **aortic hiatus** to become the abdominal aorta.

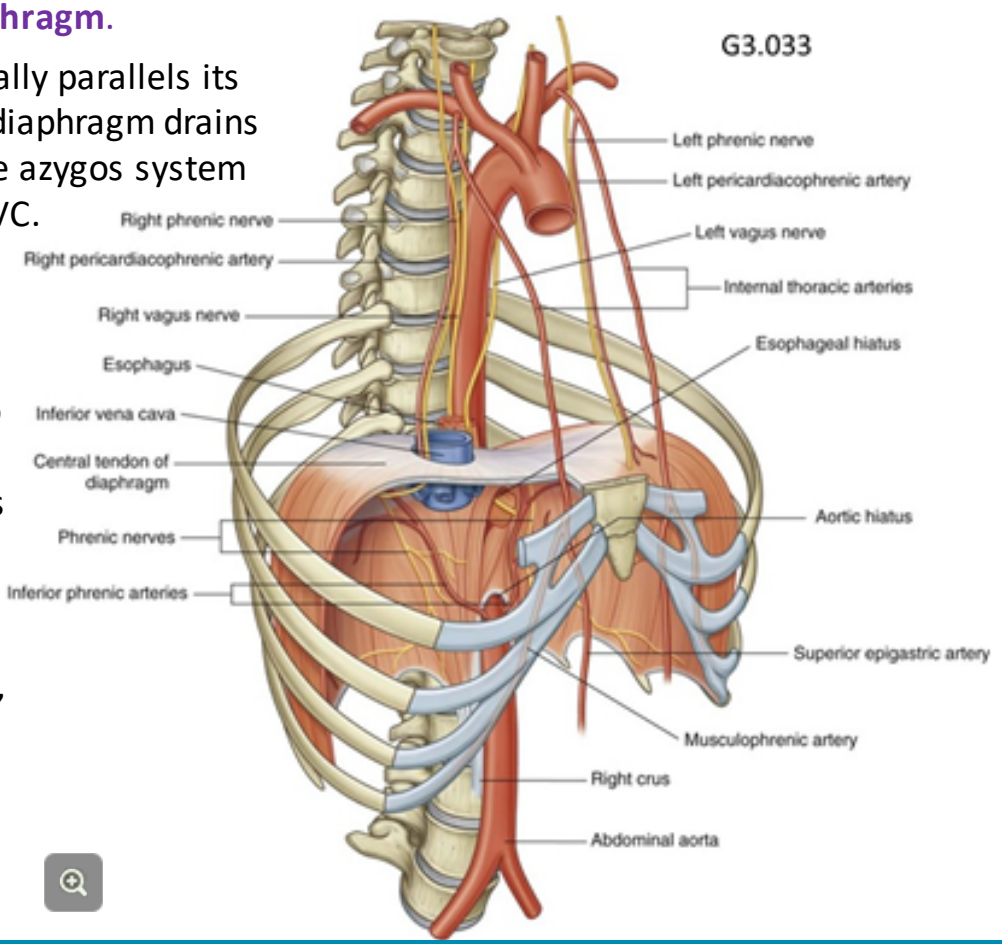


Some of the blood supply to the diaphragm comes from branches of the **internal thoracic arteries**. In addition, the paired **superior phrenic arteries** arise directly from lower parts of the thoracic aorta to supply its superior surface. The **inferior phrenic arteries**, the first branches of the abdominal aorta, **are the primary source of blood supply to the diaphragm**.

The venous drainage of the diaphragm generally parallels its arterial supply. Thus, venous blood from the diaphragm drains into the brachiocephalic veins in the neck, the azygos system of veins and abdominal veins, including the IVC.

Innervation of the diaphragm is provided largely by the **phrenic nerves** (C_3, C_4, C_5). In the thorax, the phrenic nerves are located in the **middle mediastinum**. They lie anterior to the root of the lung, between the mediastinal parietal pleura and the pericardial sac. This is illustrated here for the right phrenic nerve and here for the left phrenic nerve. The phrenic is a **somatic nerve** that carries voluntary motor fibres, general sensory fibres, and sympathetic postganglionic fibres.

Some innervation of the margins of the diaphragm are provided by the **lower intercostal nerves**.

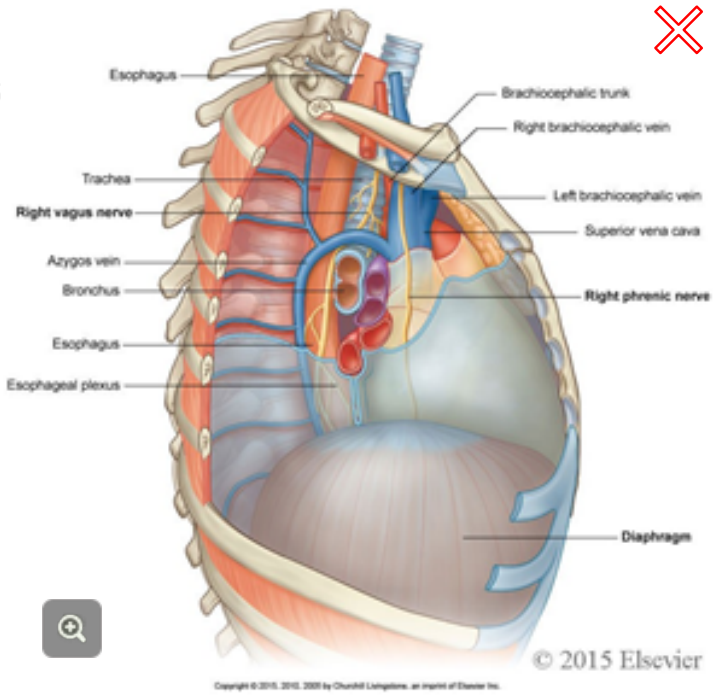


Some of the blood supply to the diaphragm comes from branches of the **internal thoracic arteries**. In addition, the paired **superior phrenic arteries** arise directly from lower parts of the thoracic aorta to supply its superior surface. The **inferior phrenic arteries**, the first branches of the abdominal aorta, **are the primary source of blood supply to the diaphragm**.

The venous drainage of the diaphragm generally parallels its arterial supply. Thus, venous blood from the diaphragm drains into the brachiocephalic veins in the neck, the azygos system of veins and abdominal veins, including the IVC.

Innervation of the diaphragm is provided largely by the **phrenic nerves** (C_3, C_4, C_5). In the thorax, the phrenic nerves are located in the **middle mediastinum**. They lie anterior to the root of the lung, between the mediastinal parietal pleura and the pericardial sac. This is illustrated here for the right phrenic nerve and here for the left phrenic nerve. The phrenic is a **somatic nerve** that carries voluntary motor fibres, general sensory fibres, and sympathetic postganglionic fibres.

Some innervation of the margins of the diaphragm are provided by the **lower intercostal nerves**.



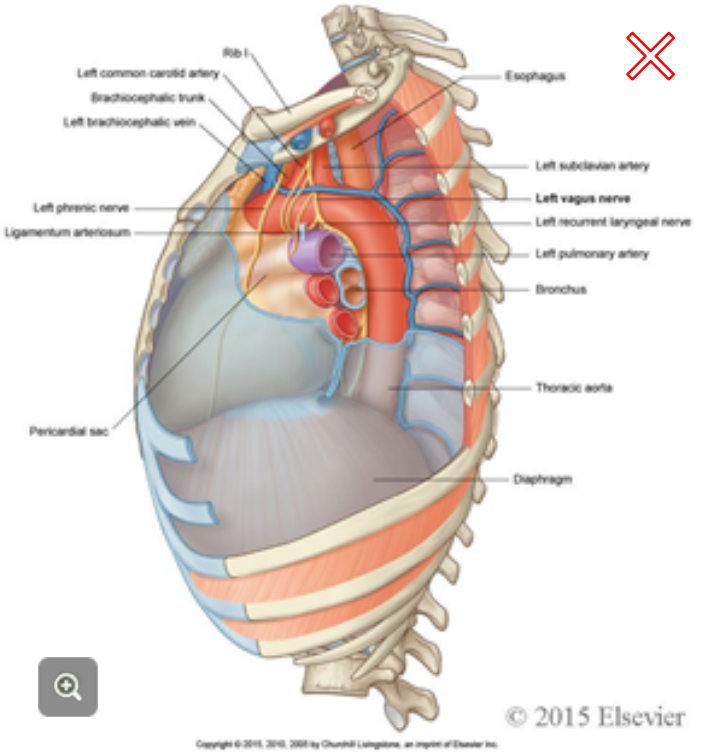
Note that the position of the phrenic nerves, in the middle mediastinum anterior to the roots of the lungs, is in contrast to that of the vagus nerves, which pass posterior to the roots of the lungs and are located in the posterior mediastinum.

Some of the blood supply to the diaphragm comes from branches of the **internal thoracic arteries**. In addition, the paired **superior phrenic arteries** arise directly from lower parts of the thoracic aorta to supply its superior surface. The **inferior phrenic arteries**, the first branches of the abdominal aorta, **are the primary source of blood supply to the diaphragm**.

The venous drainage of the diaphragm generally parallels its arterial supply. Thus, venous blood from the diaphragm drains into the brachiocephalic veins in the neck, the azygos system of veins and abdominal veins, including the IVC.

Innervation of the diaphragm is provided largely by the **phrenic nerves** (C_3, C_4, C_5). In the thorax, the phrenic nerves are located in the **middle mediastinum**. They lie anterior to the root of the lung, between the mediastinal parietal pleura and the pericardial sac. This is illustrated here for the right phrenic nerve and here for the left phrenic nerve. The phrenic is a **somatic nerve** that carries voluntary motor fibres, general sensory fibres, and sympathetic postganglionic fibres.

Some innervation of the margins of the diaphragm are provided by the **lower intercostal nerves**.



Note that the position of the phrenic nerves, in the middle mediastinum anterior to the roots of the lungs, is in contrast to that of the vagus nerves, which pass posterior to the roots of the lungs and are located in the posterior mediastinum.

9.0 Pleural Cavities and Recesses

SPECIMENS

This lab begins with all students at their two cadavers.

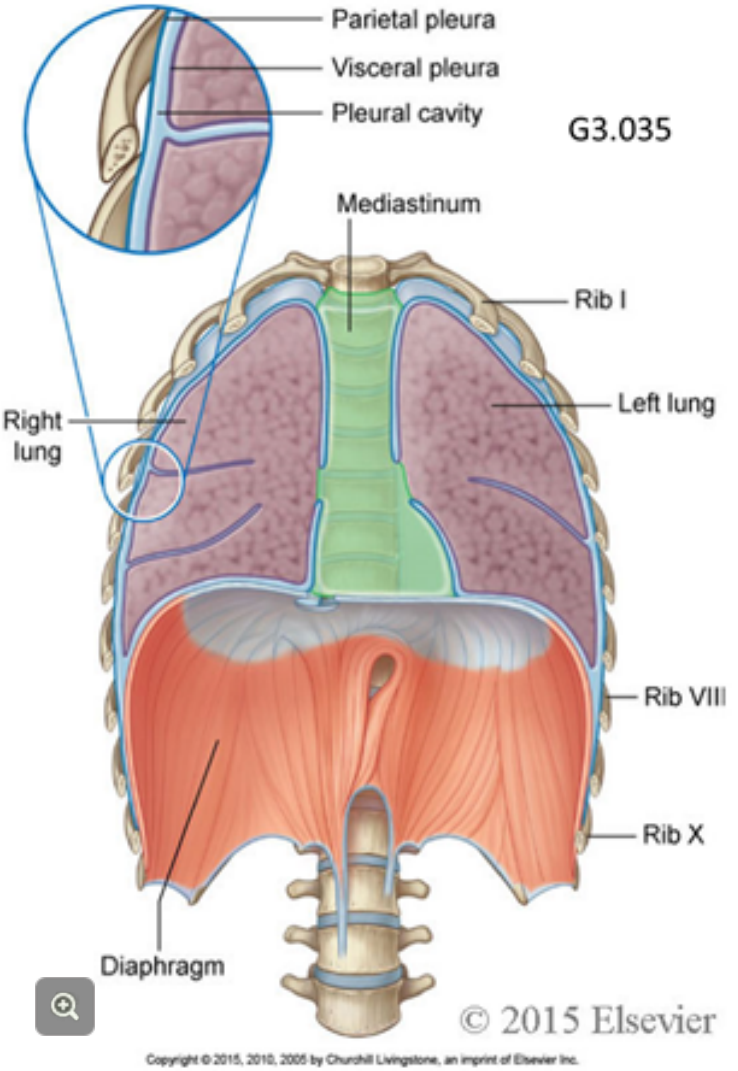
Pairs 1 and 2 will be at their cadaver 1.

Pairs 3 and 4 will be at their cadaver 2.

You will study the pleural cavities and recesses together before embarking on the two exercises included in Lab 9.

When you have learned the material presented in this exercise, you will be able to recognize (in plain x-ray, as appropriate) and / or describe:

- pleura and its various subdivisions – parietal vs. visceral, costal, diaphragmatic, mediastinal and apical (the cupola)
- a pneumothorax, hemothorax, chylothorax and pleural effusion
- the sensory innervation of the various subdivisions of the pleura and where irritation of each will be perceived by the patient
- a line of pleural reflection
- the costodiaphragmatic recesses, the costomediastinal recess and the significance of each



Serous membranes are composed of a simple squamous **mesothelium** and underlying **CT**. The serous membranes associated with the lungs and pleural cavities are the **pleura**.

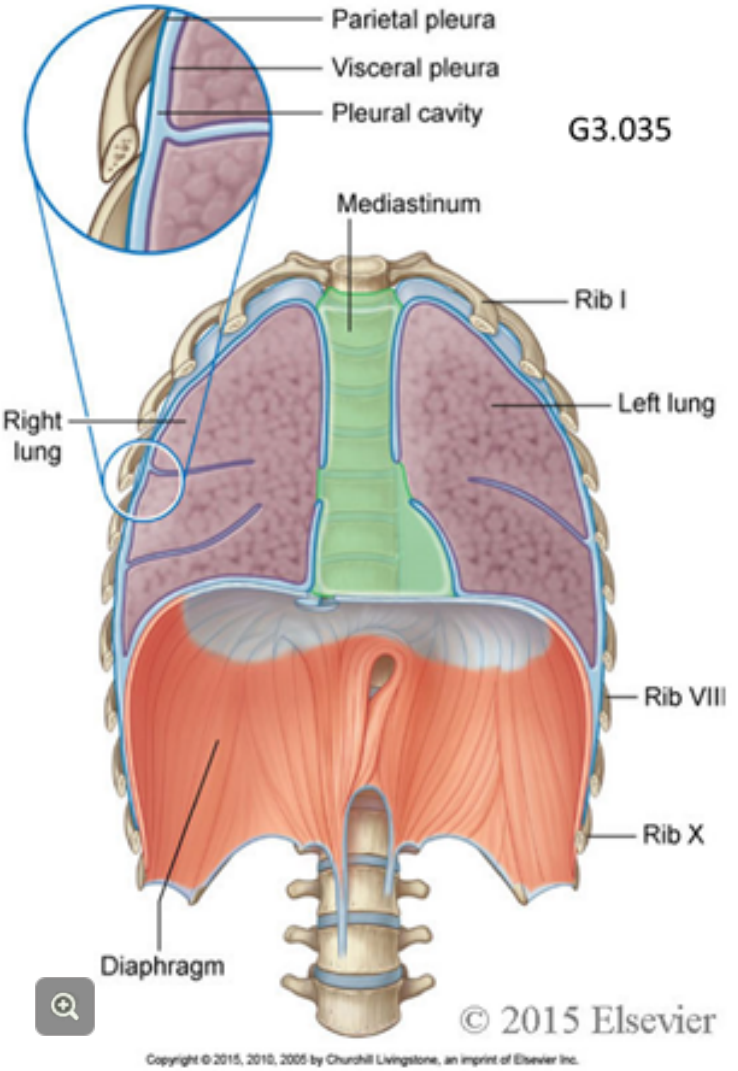
During development, as **the lungs grow out from the mediastinum** to fill the pleural cavities, **they take a covering of pleura**. This is the **visceral pleura**.

The lungs remain attached to the mediastinum by their airways, blood vessels, lymphatics and nerves, which together form **the root of the lung**.

At its root, pleura reflects off the lung and onto the walls of the pleural cavity. This is the **parietal pleura**. It is divided into the **costal, mediastinal and diaphragmatic parietal pleura**.

The **pleural cavity** is a **potential space** that exists between the parietal and visceral pleura; these **two serous membranes are normally in contact with each other.**

The pleural membranes secrete a serous fluid, the **pleural fluid**. This natural lubricant allows the lungs to move relative to the walls of the pleural cavity in a **friction-free manner**.



INFO

Under Pathological Conditions the Pleural Cavity Becomes a Real Space

Under pathological conditions, the visceral and parietal layers of the pleura may be forced apart by the **accumulation of air or fluid in the pleural cavity**. This renders the pleural cavity a **real space**.

In a **pneumothorax**, air gains access to the pleural cavity and, due to its inherent elasticity, the lung collapses against the mediastinum.

Blood or **lymph** may accumulate in the pleural space due to traumatic injury; these are termed **hemothorax** and **chylothorax**, respectively. Accumulation of **serous fluid** in the pleural cavity is called **pleural effusion**.

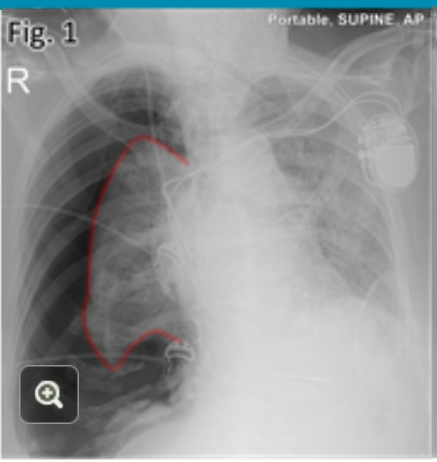
TASK

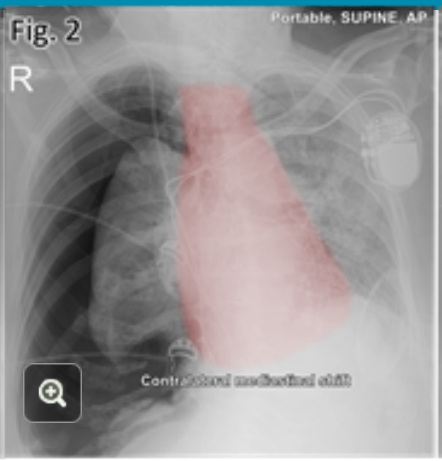
OPEN the body bag, reflect the skin flaps and remove the chest plate & heart.

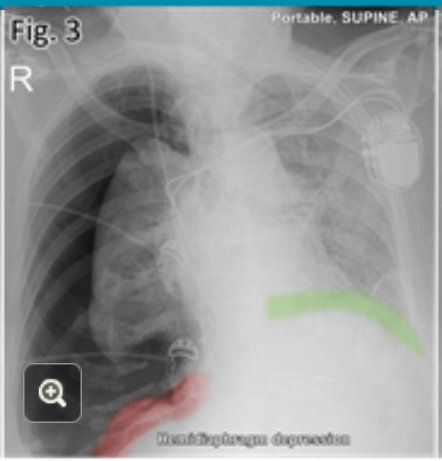
Wrap the heart in moist cloths and set it inside the body bag at the foot of the cadaver. Keep the chest plate handy.

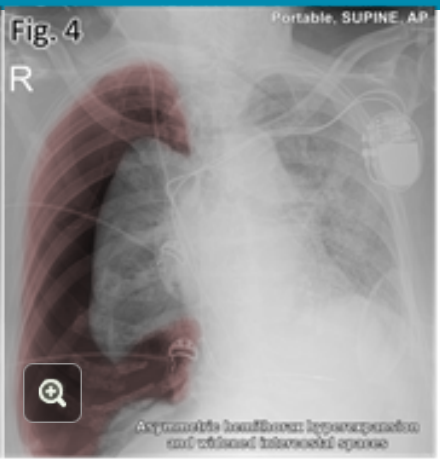
Place the lungs aside; presently, Pair 1 will dissect the lungs from cadaver 1 and pair 3 will dissect the lungs from cadaver 2. Remember to keep track of the lungs and the tissue removed with dissection and return them to the correct cadaver at the end of the lab. If fluid has collected in the pleural cavities, soak it up with the cloths used to cover the cadaver.

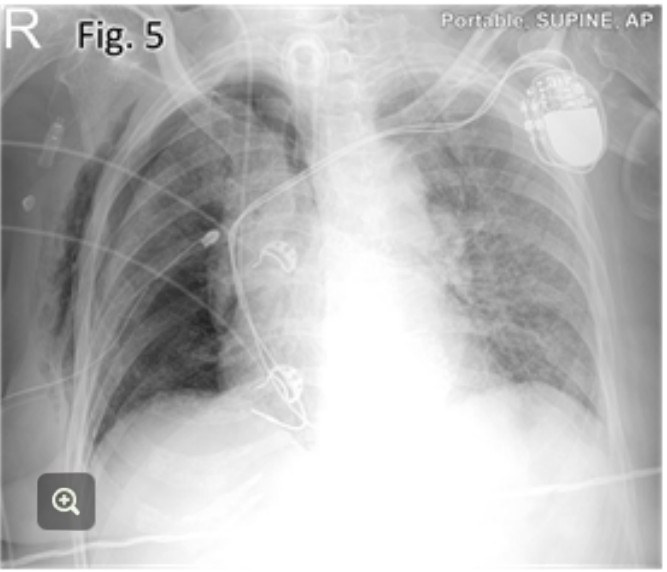
You will start by reviewing the parietal pleura and learning about the pleural recesses and their importance in respiration and disease.











A R-sided **tension pneumothorax**. Accumulated air in the R pleural cavity collapses the R lung against the mediastinum (Fig. 1). Notice the **radiolucent, air-filled pleural cavity** surrounding the collapsed R lung, as compared to the L pleural cavity, which is filled with the intact L lung and is therefore uniformly more radiodense. The accumulated air in the R pleural cavity also causes a L-sided mediastinal shift (Fig. 2), depression of the ipsilateral hemidiaphragm (Fig. 3) and expansion of the ipsilateral intercostal spaces (Fig. 4). All of these signs are caused by the positive pressure of the accumulated air in the plural cavity.

One hour after the insertion of a chest tube to remove accumulated air, all of these signs are attenuated (Fig. 5).

Case courtesy of Dr Balint Botz , Radiopaedia.org, rID: 73040

TASK

On both sides of the cadaver, USE your hands to review the subdivisions of the parietal pleura: costal, mediastinal, diaphragmatic and cervical (the cupola). Insert your fingers into the cupola; Notice that the pleural cavity ascends above the body of the first rib, and that the apex of the lung is therefore in the neck.

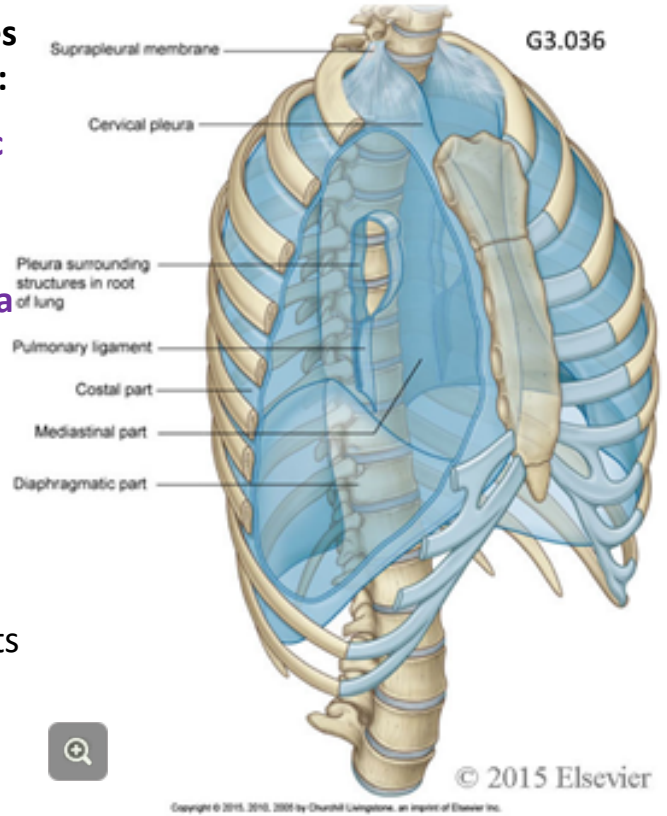
While reviewing these subdivisions, discuss with your colleagues the sensory innervation of the parietal pleura; it is quite logical:

Touch the costal parietal pleura. It, **like all layers of the thoracic wall**, receives sensory fibres from the **intercostal nerves**.

Identify the phrenic nerves. Recall that they course through the **subserous fascia** that lies between the **mediastinal parietal pleura** and the **fibrous pericardium**. The phrenic nerves supply sensory fibres to the **mediastinal parietal pleura and the fibrous pericardium** on their way to innervate the diaphragm.

Run your hands over the diaphragmatic parietal pleura. The full thickness of the diaphragm receives sensory innervation from the phrenic nerves, including the **diaphragmatic parietal pleura** on its superior surface and the **diaphragmatic parietal peritoneum** on its inferior surface.

Remember, pain originating in any tissue innervated by the phrenic nerve will refer to the shoulder.



TASK

Now EXPLORE the extent of the pleural cavities.

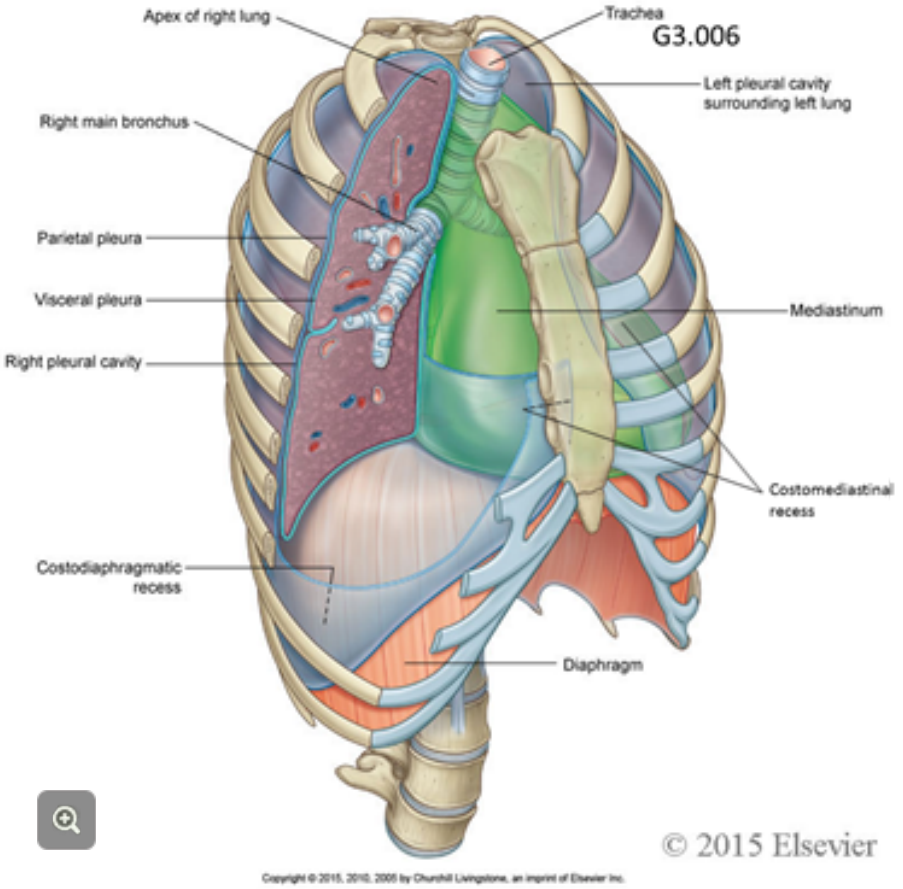
Run your fingers along the margins of the diaphragm from anterior to posterior. This is a line of pleural reflection where costal pleura becomes diaphragmatic pleura. This portion of the pleural cavity is the costodiaphragmatic recess.

Look at the internal surface of the chest plate. Run your fingers superoinferiorly, parallel to the lateral margin of the sternum. Realize that this is the line of pleural reflection where costal pleura becomes mediastinal pleura. Your fingers are outlining the **costomediastinal recess**.

The lung does not completely fill the pleural cavity, particularly on expiration. Thus, along the lines of pleural reflection, **parietal pleura is in contact with parietal pleura**.

It is into these pleural recesses that the lungs expand on inspiration. **Thus, the size of the costodiaphragmatic and costomediastinal recesses changes during the respiratory cycle.**

This is important to understand. If you don't understand it, **ask your TA for help!**



TASK

Now EXPLORE the extent of the pleural cavities.

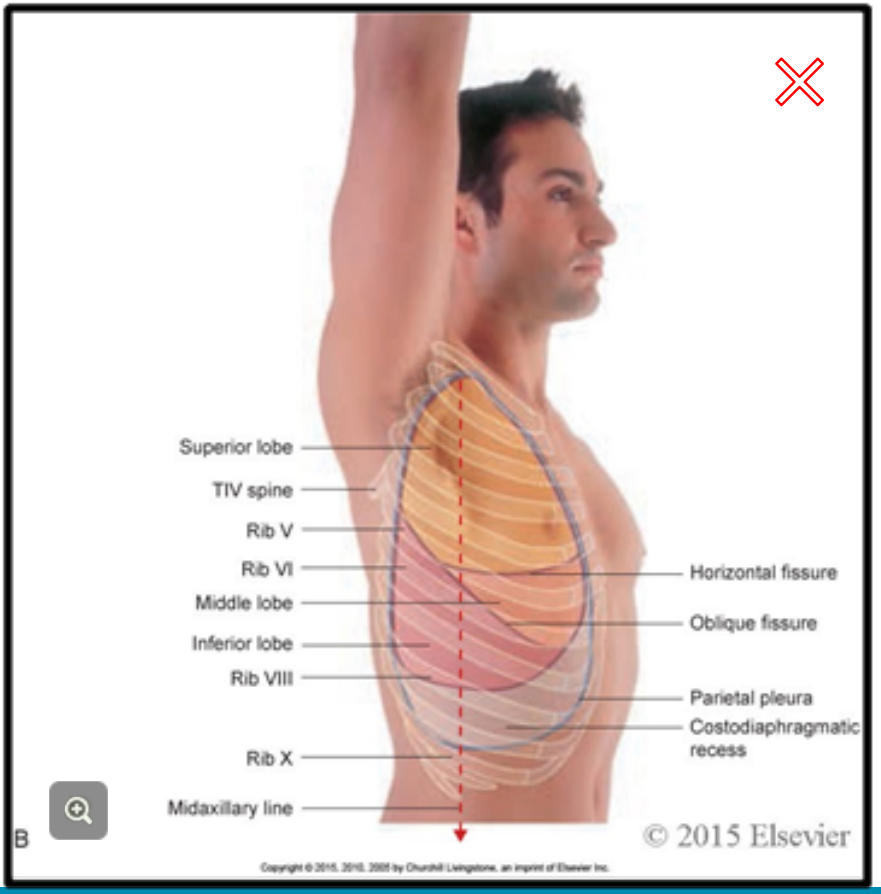
Run your fingers along the margins of the diaphragm from anterior to posterior. This is a line of pleural reflection where costal pleura becomes diaphragmatic pleura. This portion of the pleural cavity is the costodiaphragmatic recess.

Look at the internal surface of the chest plate. Run your fingers superoinferiorly, parallel to the lateral margin of the sternum. Realize that this is the line of pleural reflection where costal pleura becomes mediastinal pleura. Your fingers are outlining the **costomediastinal recess**.

The lung does not completely fill the pleural cavity, particularly on expiration. Thus, along the lines of pleural reflection, **parietal pleura is in contact with parietal pleura**.

It is into these pleural recesses that the lungs expand on inspiration. **Thus, the size of the costodiaphragmatic and costomediastinal recesses changes during the respiratory cycle.**

This is important to understand. If you don't understand it, **ask your TA for help!**



TASK

Now EXPLORE the extent of the pleural cavities.

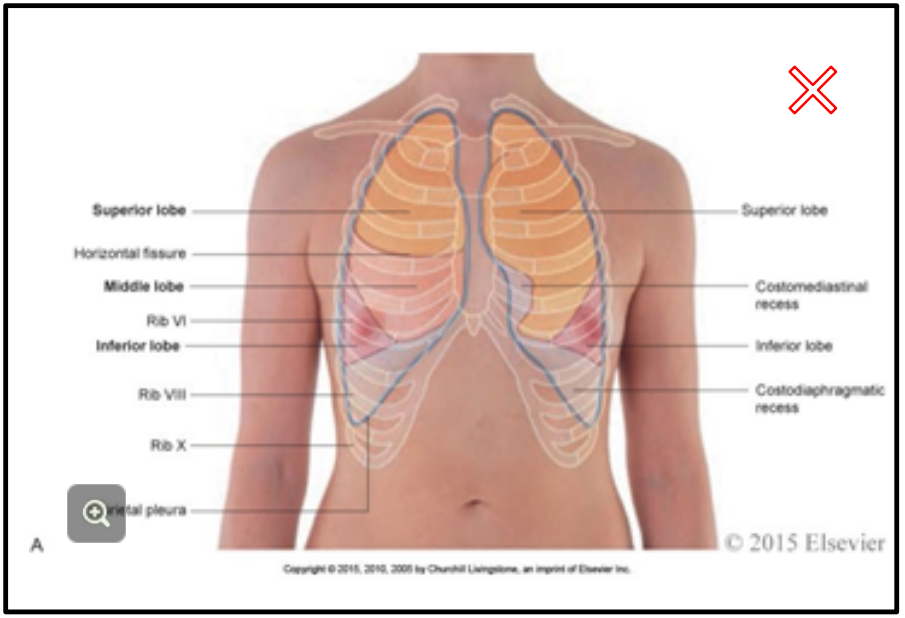
Run your fingers along the margins of the diaphragm from anterior to posterior. This is a line of pleural reflection where costal pleura becomes diaphragmatic pleura. This portion of the pleural cavity is the costodiaphragmatic recess.

Look at the internal surface of the chest plate. Run your fingers superoinferiorly, parallel to the lateral margin of the sternum. Realize that this is the line of pleural reflection where costal pleura becomes mediastinal pleura. Your fingers are outlining the **costomediastinal recess**.

The lung does not completely fill the pleural cavity, particularly on expiration. Thus, along the lines of pleural reflection, **parietal pleura is in contact with parietal pleura**.

It is into these pleural recesses that the lungs expand on inspiration. **Thus, the size of the costodiaphragmatic and costomediastinal recesses changes during the respiratory cycle.**

This is important to understand. If you don't understand it, **ask your TA for help!**



TASK

Now EXPLORE the extent of the pleural cavities.

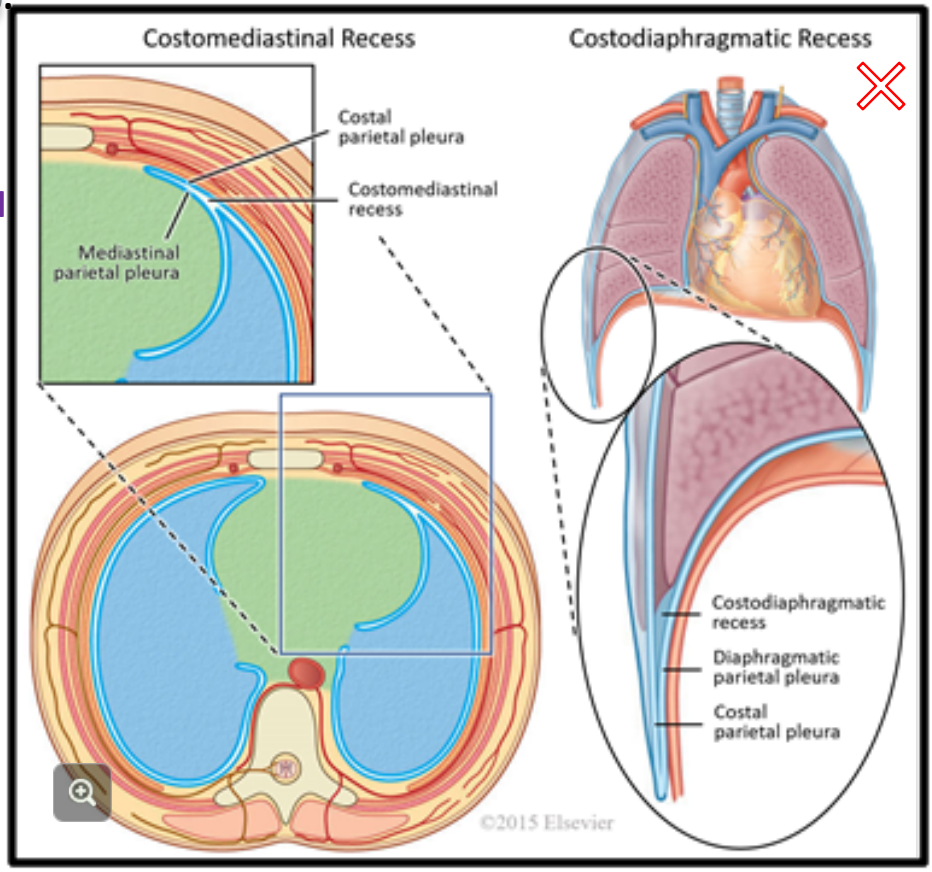
Run your fingers along the margins of the diaphragm from anterior to posterior. This is a line of pleural reflection where costal pleura becomes diaphragmatic pleura. This portion of the pleural cavity is the costodiaphragmatic recess.

Look at the internal surface of the chest plate. Run your fingers superoinferiorly, parallel to the lateral margin of the sternum. Realize that this is the line of pleural reflection where costal pleura becomes mediastinal pleura. Your fingers are outlining the **costomediastinal recess**.

The lung does not completely fill the pleural cavity, particularly on expiration. Thus, along the lines of pleural reflection, **parietal pleura is in contact with parietal pleura**.

It is into these pleural recesses that the lungs expand on inspiration. **Thus, the size of the costodiaphragmatic and costomediastinal recesses changes during the respiratory cycle.**

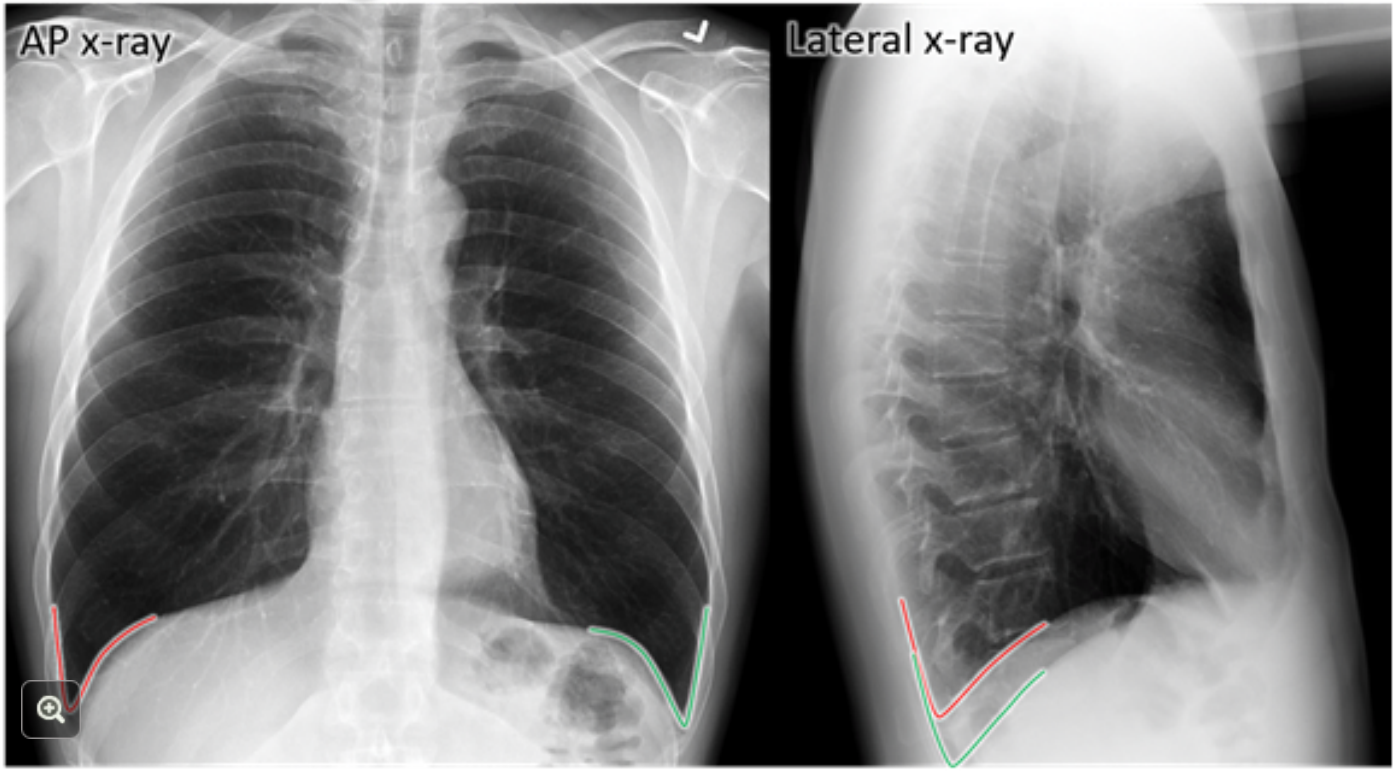
This is important to understand. If you don't understand it, **ask your TA for help!**



TASK

IDENTIFY the right (red) and left (green) costodiaphragmatic recesses in the

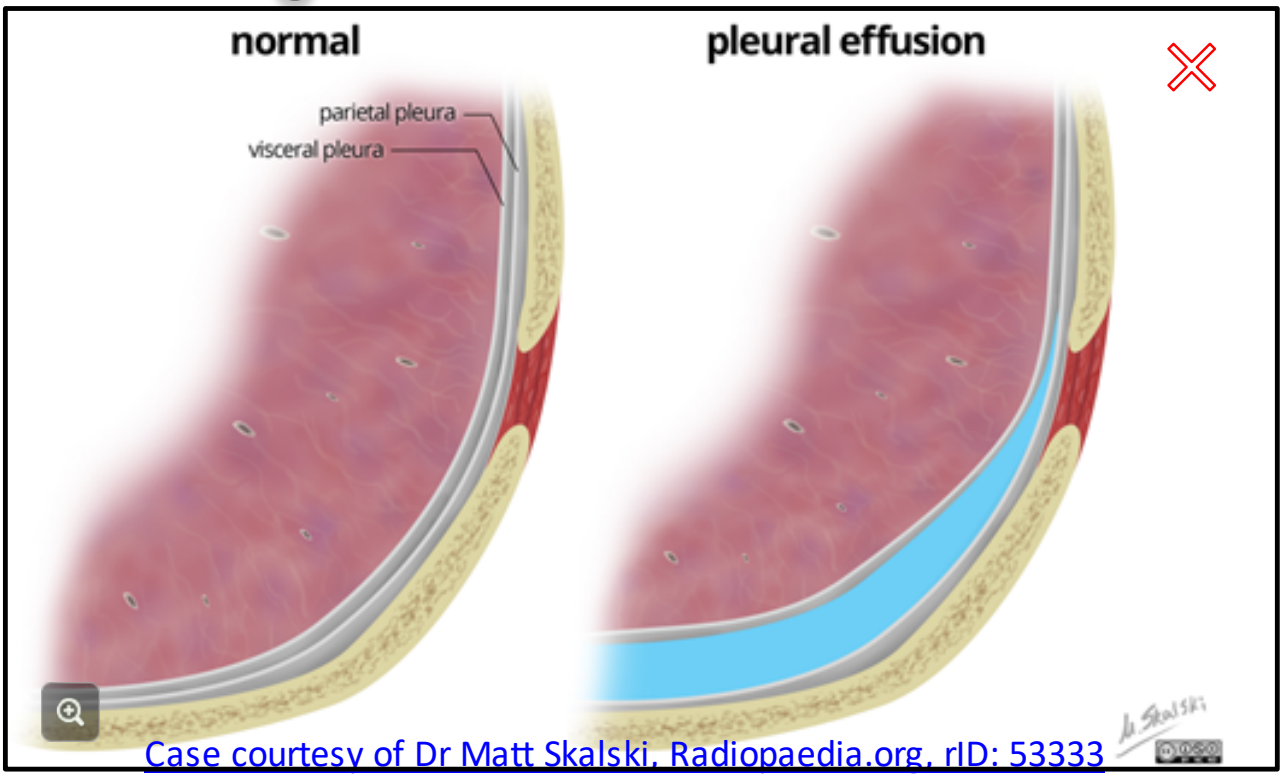
AP and lateral X-rays below. Because the right hemidiaphragm is higher than the left hemidiaphragm, the costodiaphragmatic recesses do not superimpose in the lateral x-ray and can be distinguished by their levels. In **pleural effusion**, pleural fluid accumulates in the pleural cavity. In the upright patient, fluid accumulates in the costodiaphragmatic recess and because it is radio-opaque, this creates a characteristic air-fluid interface.



TASK

IDENTIFY the right (red) and left (green) costodiaphragmatic recesses in the

AP and lateral X-rays below. Because the right hemidiaphragm is higher than the left hemidiaphragm, the costodiaphragmatic recesses do not superimpose in the lateral x-ray and can be distinguished by their levels. In **pleural effusion**, pleural fluid accumulates in the pleural cavity. In the upright patient, fluid accumulates in the costodiaphragmatic recess and because it is radio-opaque, this creates a characteristic air-fluid interface.

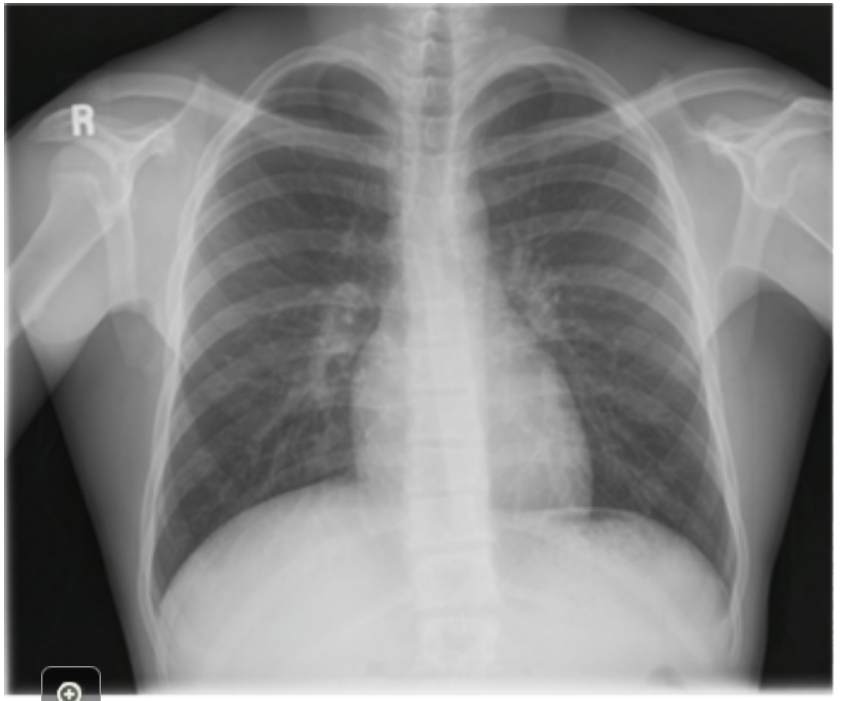


Case courtesy of Dr Matt Skalski, Radiopaedia.org, rID: 53333

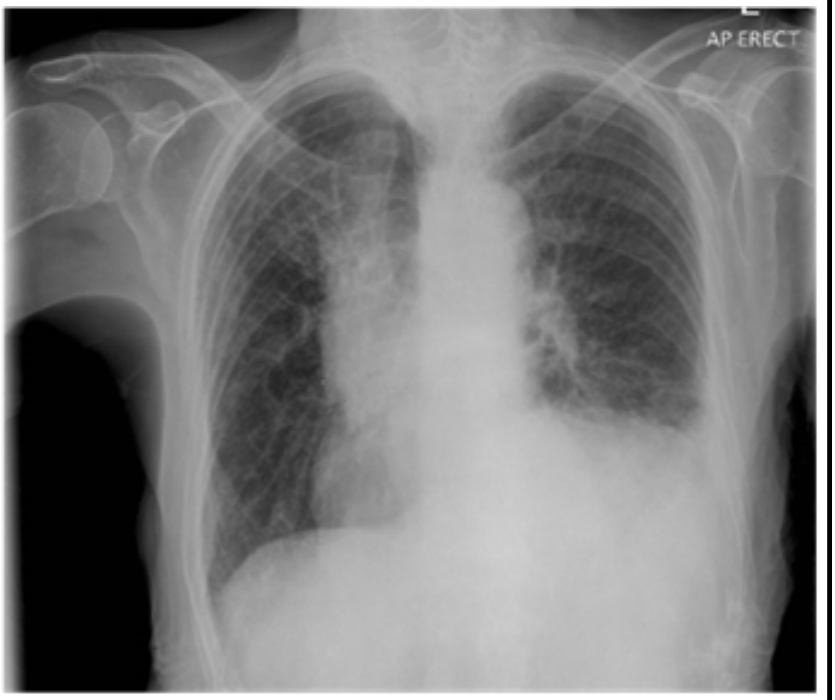
INFO

Pleural Effusion

Because it is a low point in the pleural cavity, excess fluid may collect in the costodiaphragmatic recess in a standing patient. This creates an **air-fluid level** that can be seen in a plain standing X-ray, as in the accompanying image. The fluid can be withdrawn from this space via **thoracentesis**, either for the purposes of analysis or as treatment.



A normal chest X-ray.



A left-sided pleural effusion.

TASK

Pairs 1 will now start 9.1 Lungs and Airways

Exercise 9.1 will be done on the dip tank in front of the big screen in your lab. Pairs 1 will wrap the lungs from cadaver 1 with a moist cloth from the cadaver and carry them to the dip tank. Pairs 4 will work with these lungs when they take over at 10:30. Students must ensure that all tissue removed during dissection is retained, returned to the correct cadaver and placed in the tissue bin underneath its dissection table.

During week 21, when Pairs 3 start with Exercise 9.1 at 9:00 am, they will work with the lungs from cadaver 2. Pairs 2 will work with the lungs from cadaver 2 when they take over at 10:30 and return all dissected tissue to the correct tissue bin.

TASK

Pairs 2 and 4 will now start 9.2 / 9.4 The Posterior Mediastinum

Pairs 2 will work on cadaver 1, and pairs 4 will work on cadaver 2.

TASK

Pairs 3 will now start 9.3 The Diaphragm and Mechanics of Respiration

In MS1162/64 you will find a table labeled with your lab room. You will work at this table using the materials provided. TAs are available there to assist you.

9.1 The Lungs and Airways

What you'll need:

SPECIMENS

Lungs from cadaver 1 and cadaver 2

Teaching models of lungs and bronchi

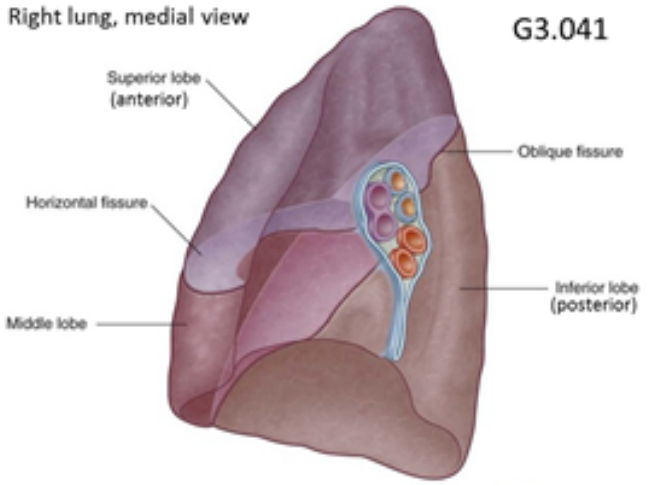
INSTRUCTIONS

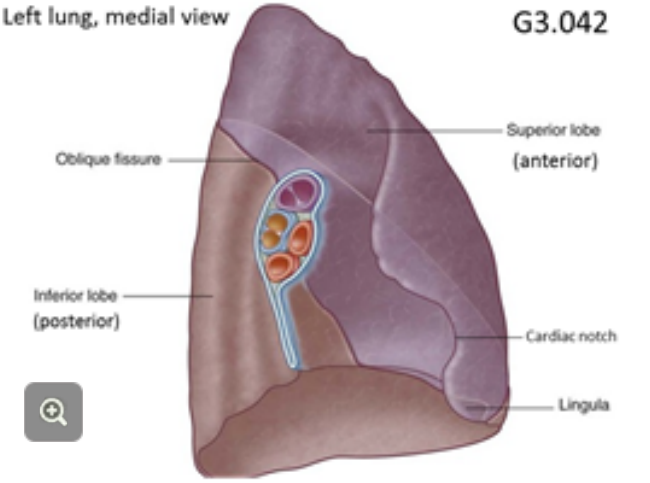
Exercise 9.1 will be done on the dip tank in front of the big screen in your lab. Pairs 1 will wrap the lungs from cadaver 1 with a moist cloth from the cadaver and carry them to the dip tank. Pairs 4 will work with these lungs when they take over at 10:30 AM. Students must ensure that all tissue removed during dissection is retained, returned to the correct cadaver and placed in the tissue bin underneath its dissection table.

During week 21, when Pairs 3 start with Exercise 9.1 at 9:00 am, they will work with the lungs from cadaver 2. Pairs 2 will work with the lungs from cadaver 2 when they take over at 10:30 am and return all dissected tissue to the correct tissue bin.

When you have learned the material presented in this exercise, you will be able to recognize and / or describe:

- the surfaces, borders and lobes of the lung
- the contact impressions on the mediastinal surfaces of the right and left lung
- the branching pattern of the airways of the right and left lungs
- bronchopulmonary segments
- the nerve supply and lymphatic drainage of the lungs





TASK

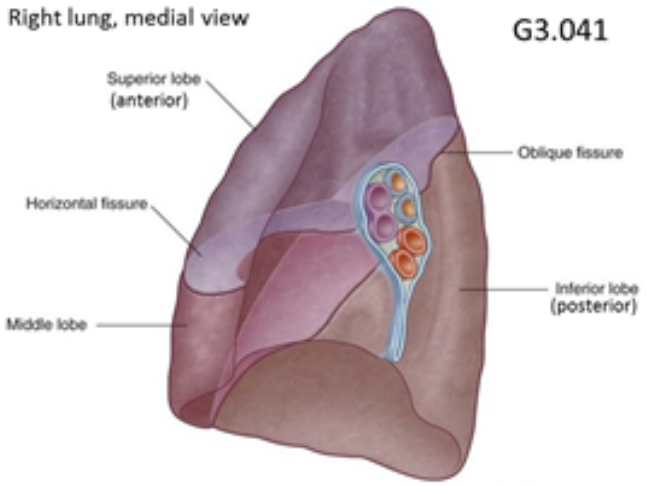
IDENTIFY the lung surfaces as introduced in Lab 2:

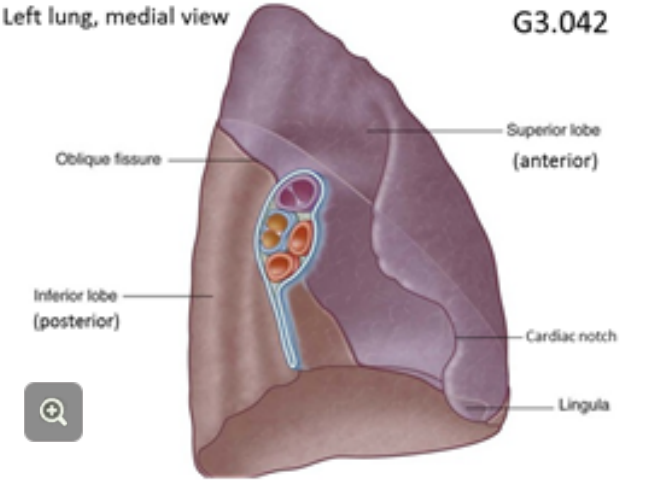
costal, diaphragmatic and mediastinal. Recall that they are covered by a serous membrane, the visceral pleura.

Identify the anterior and posterior borders of each lung. Notice that the anterior border is sharp where it extends into the costomediastinal recess, while the posterior border is round where it abuts against the vertebral column. Identify the inferior border of each lung; it, too, is sharp, as it extends into the costodiaphragmatic recess.

Identify the fissures and lobes of each lung. Start by identifying the oblique fissure of each lung, which divides it into superior and inferior lobes. Notice that the superior lobe is largely anterior and the inferior lobe is largely posterior. Identify the horizontal fissure of the right lung, which separates its middle lobe from its superior lobe.

Identify, on the left lung, the cardiac notch in the anterior border of its superior lobe. Identify the lingula, an inferomedial projection of its superior lobe. The lingula is homologous to the middle lobe of the right lung.





Adjacent mediastinal structures leave **contact impressions** on the mediastinal surfaces of the lungs. By studying these contact impressions, you gain a better understanding of the relative positions of structures within the thorax.

TASK

PICK up the right lung.

Identify, on its mediastinal aspect, impressions left by the:

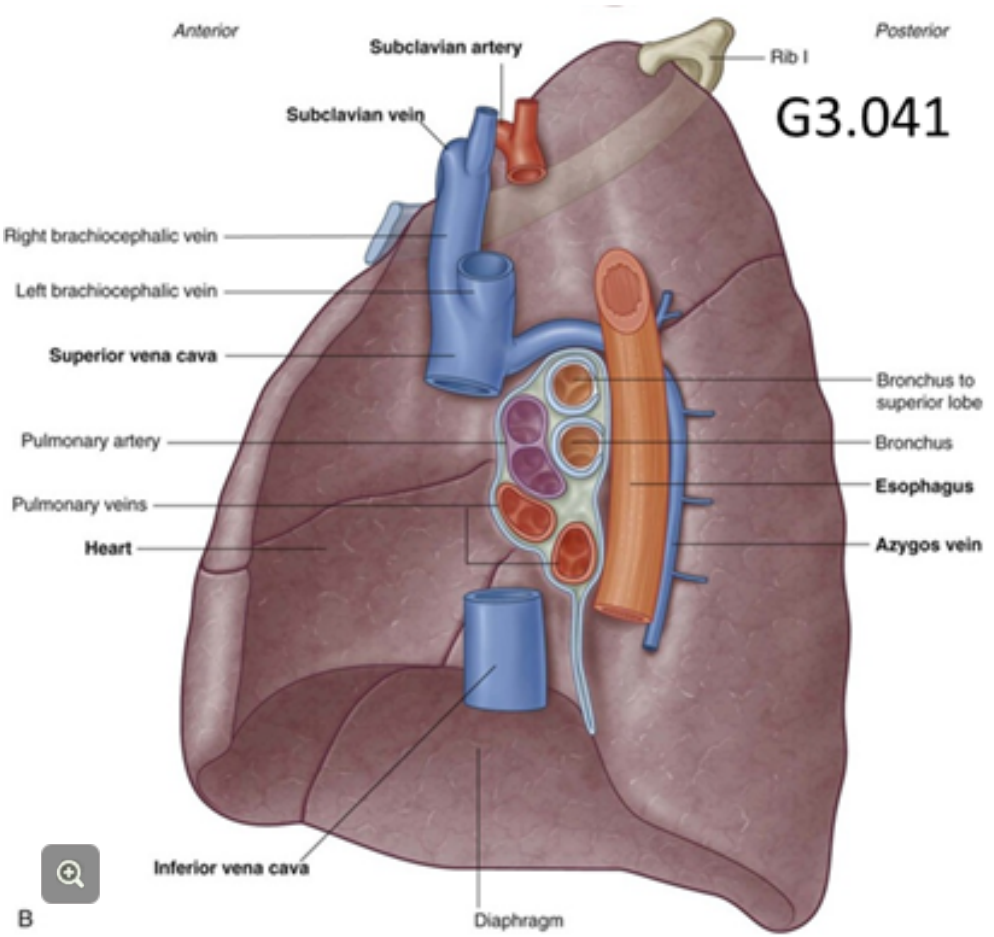
- **heart, the cardiac impression**
- **esophagus, the esophageal impression**
- **azygous vein**
- **SVC**

TASK

PICK up the left lung.

Identify, on its mediastinal aspect, impressions left by the:

- **heart, the cardiac impression**
- **aortic arch**
- **thoracic aorta**



Adjacent mediastinal structures leave **contact impressions** on the mediastinal surfaces of the lungs. By studying these contact impressions, you gain a better understanding of the relative positions of structures within the thorax.

TASK

PICK up the right lung.

Identify, on its mediastinal aspect, impressions left by the:

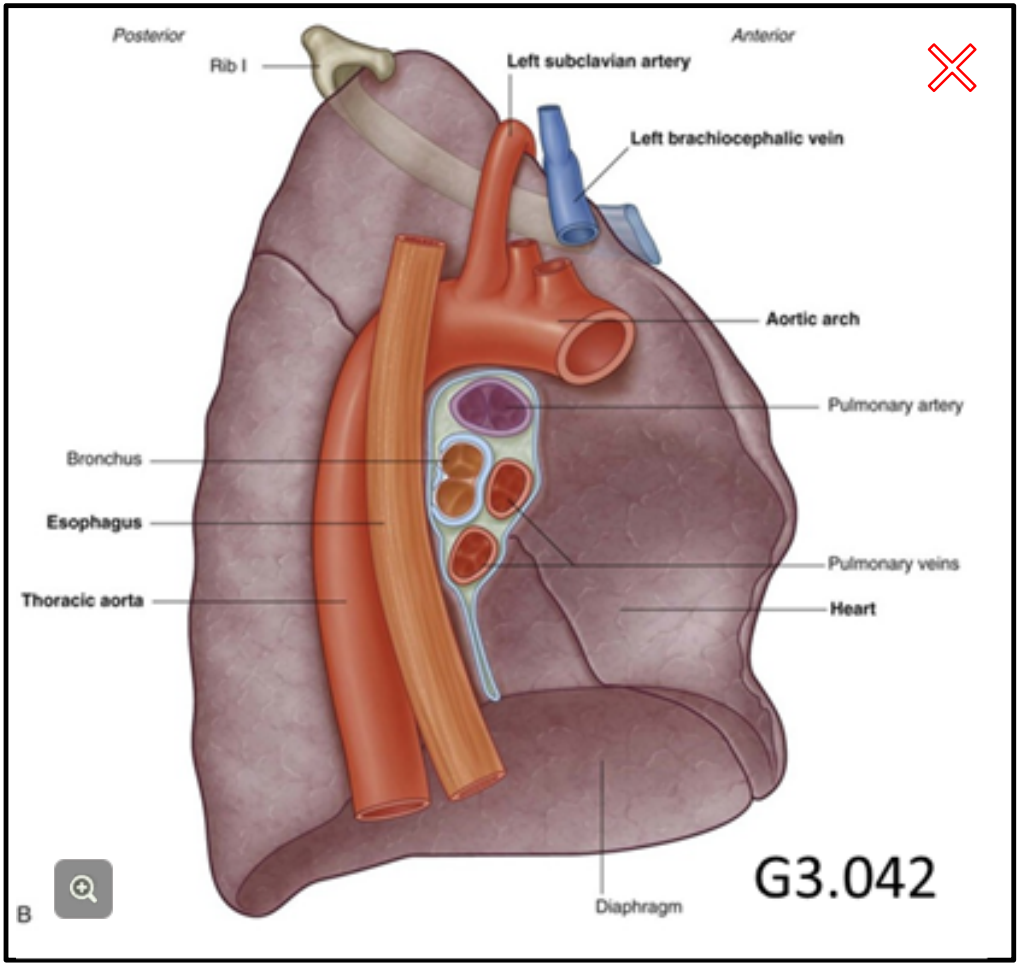
- **heart, the cardiac impression**
- **esophagus, the esophageal impression**
- **azygous vein**
- **SVC**

TASK

PICK up the left lung.

Identify, on its mediastinal aspect, impressions left by the:

- **heart, the cardiac impression**
- **aortic arch**
- **thoracic aorta**



TASK

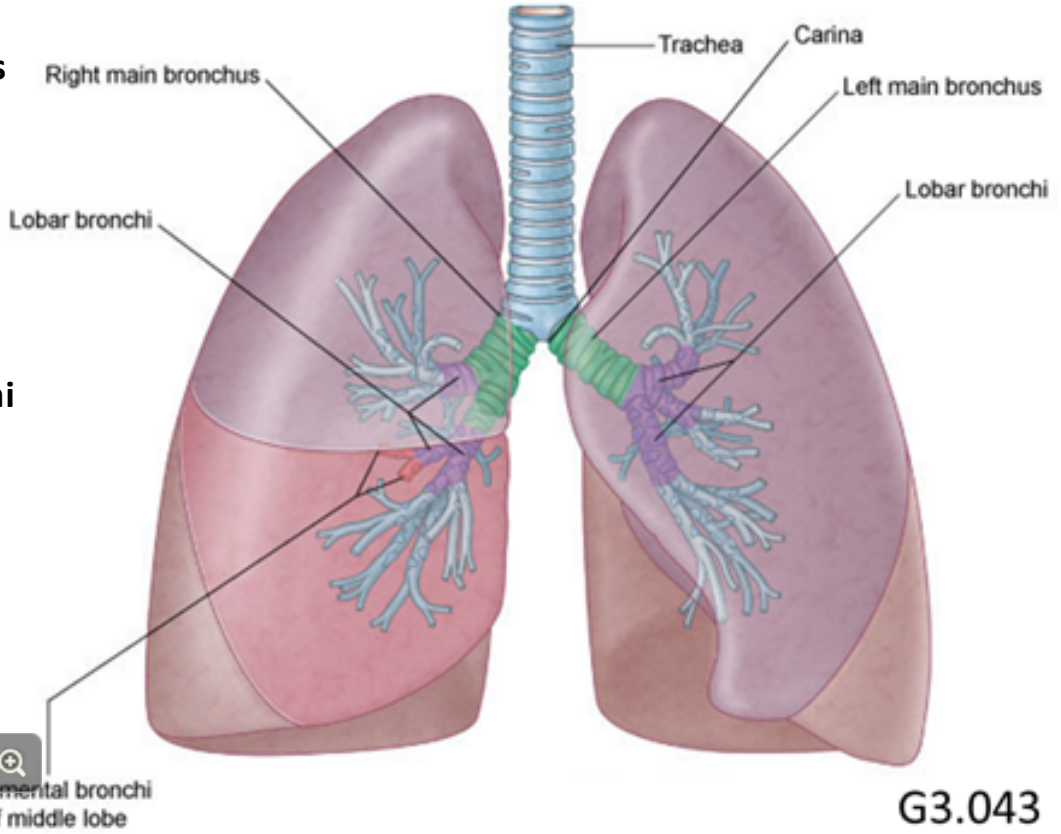
Refer to the model of the lungs and bronchial tree.

On the model, identify the right and left primary bronchi, which branch from the trachea at the carina. The carina is the cartilage located at the bifurcation of the trachea.

Note that the left primary bronchus divides into two secondary (lobar) bronchi, one for each of the two lobes of the left lung.

Note that the right primary bronchus divides into three secondary (lobar) bronchi, one for each of the three lobes of the right lung.

The branches of the secondary bronchi are the tertiary (segmental) bronchi. Each supplies a volume of lung tissue called a bronchopulmonary segment.



G3.043

The **main bronchus**, the **pulmonary artery** and the **pulmonary veins** are components of the root of the lung, along with its **nerves**, **lymphatics**, and the **bronchial arteries**. The relative positions of these structures in the hilum are logical, if you **recall their relative positions in the superior mediastinum.**

Recall from the dissection of the superior mediastinum that the **main bronchus is posterior to the pulmonary vessels**. Recall, also, that the **pulmonary arteries are superior to the pulmonary veins**.

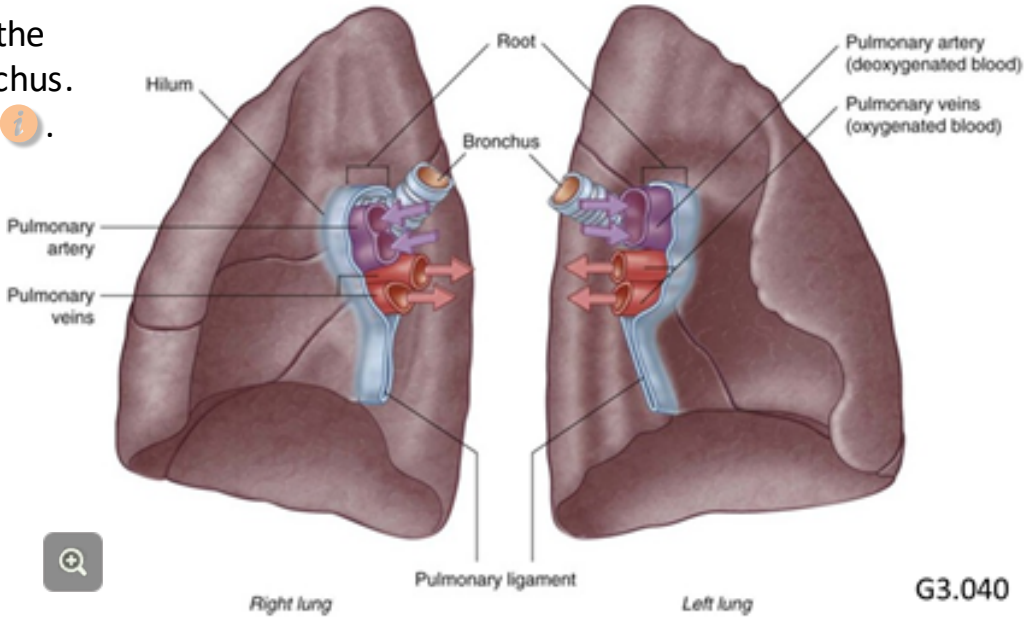
TASK

EXAMINE the hilum of each lung.

Identify, by palpation, airways in the hilum of the lung; you will feel cartilage in their walls.

If the root of the lung was cut farther from the hilum, you might find a single primary bronchus. More likely, you will find secondary bronchi.

It is not easy, **nor necessary,** to definitively differentiate pulmonary arteries from veins, although you should realize from your histology eModule on blood vessels, that pulmonary arteries will have thicker walls, since the contained blood is under higher pressure. Do recognize, however, that the arteries are, in general, superior to the veins.



If you are the 9:30 am group, two pairs will dissect a right lung and two pairs will dissect a left lung. This will leave the 10:30 group with two left and two right lungs intact for study of the surfaces and lobes after you change stations.

Dissect the root of the lung neatly and efficiently. Do not destroy the costal or diaphragmatic surfaces of the lung. Only dissect the mediastinal surface. This will allow you to better understand the relationships of the airways to the blood vessels and lobes.

The 10:30 am groups will dissect their lungs after having studied the surfaces and lobes. In this way, both lungs from both cadavers will be dissected by the end of the second session of Lab 9.

REMEMBER: all tissue dissected from the lungs must be disposed of with the body it came from.

TASK

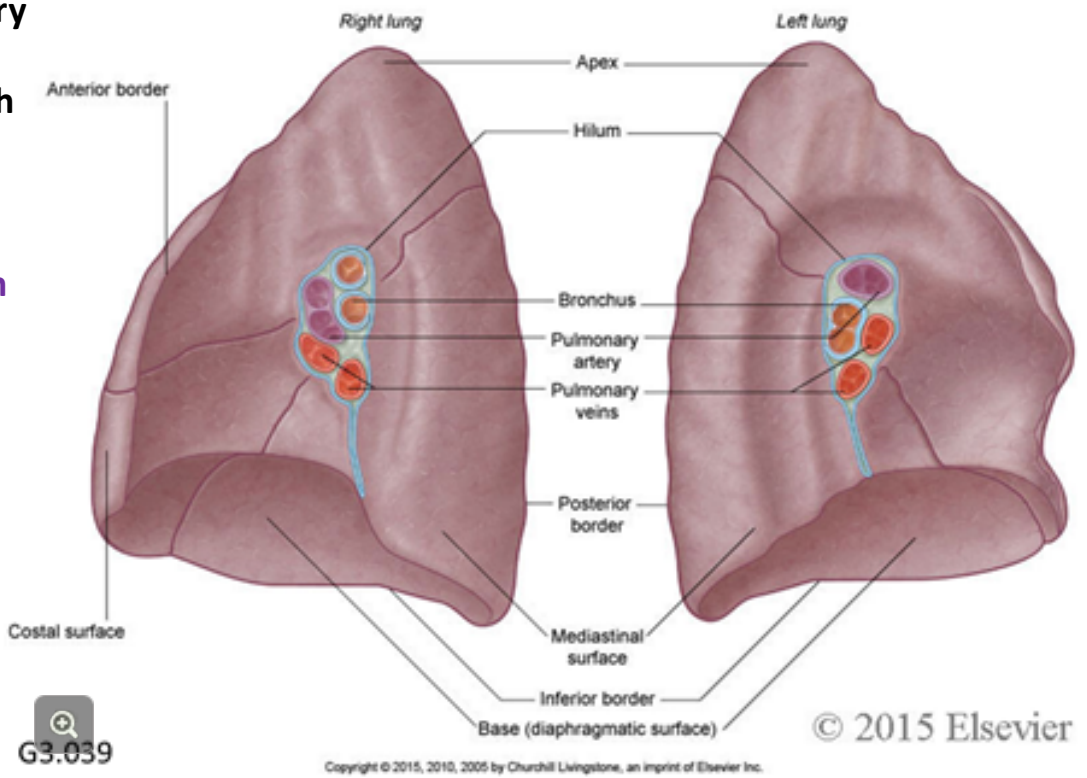
Start by examining the CT in the hilum between the blood vessels and airways.

It is in this CT that nerves and lymphatic vessels are found, as well as **lymph nodes**. You will likely encounter many lymph nodes as you dissect.

Using large forceps, grasp the primary bronchus with your nondominant hand. Using large closed scissors with your dominant hand, push the lung tissue away from the airway, thus cleaning it through blunt dissection. Do not cut away the lung tissue with sharp instruments.

Repeat this with the pulmonary blood vessels. Notice that every time the airway branches, the blood vessels branch as well.

Observe, then remove, lymph nodes as you work. These are the tracheobronchial nodes.



G3.039

TASK

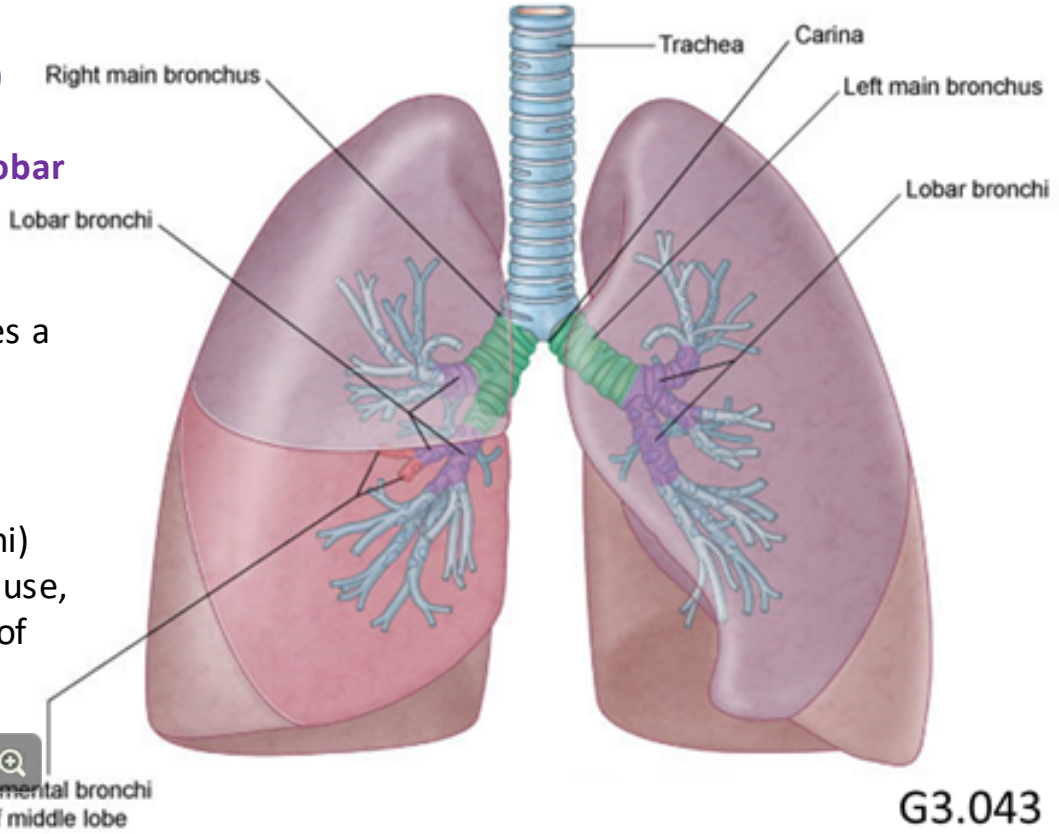
In the left lung, follow the primary bronchus until it bifurcates,

forming a superior and inferior lobar (secondary) bronchus. By definition, a lobar bronchus supplies a lung lobe with air.

In the right lung, follow the primary bronchus until it bifurcates, forming a superior and inferior lobar (secondary) bronchus. Follow the inferior lobar bronchus until it gives off the middle lobar bronchus.

Lobar bronchi branch into **segmental (tertiary) bronchi,** each of which supplies a **bronchopulmonary segment.**

Most commonly, the **right lung has 10 bronchopulmonary segments** (and therefore 10 segmental or tertiary bronchi) and **the left lung has 8 or 9**. This is because, developmentally, there is greater fusion of the left lung than the right.

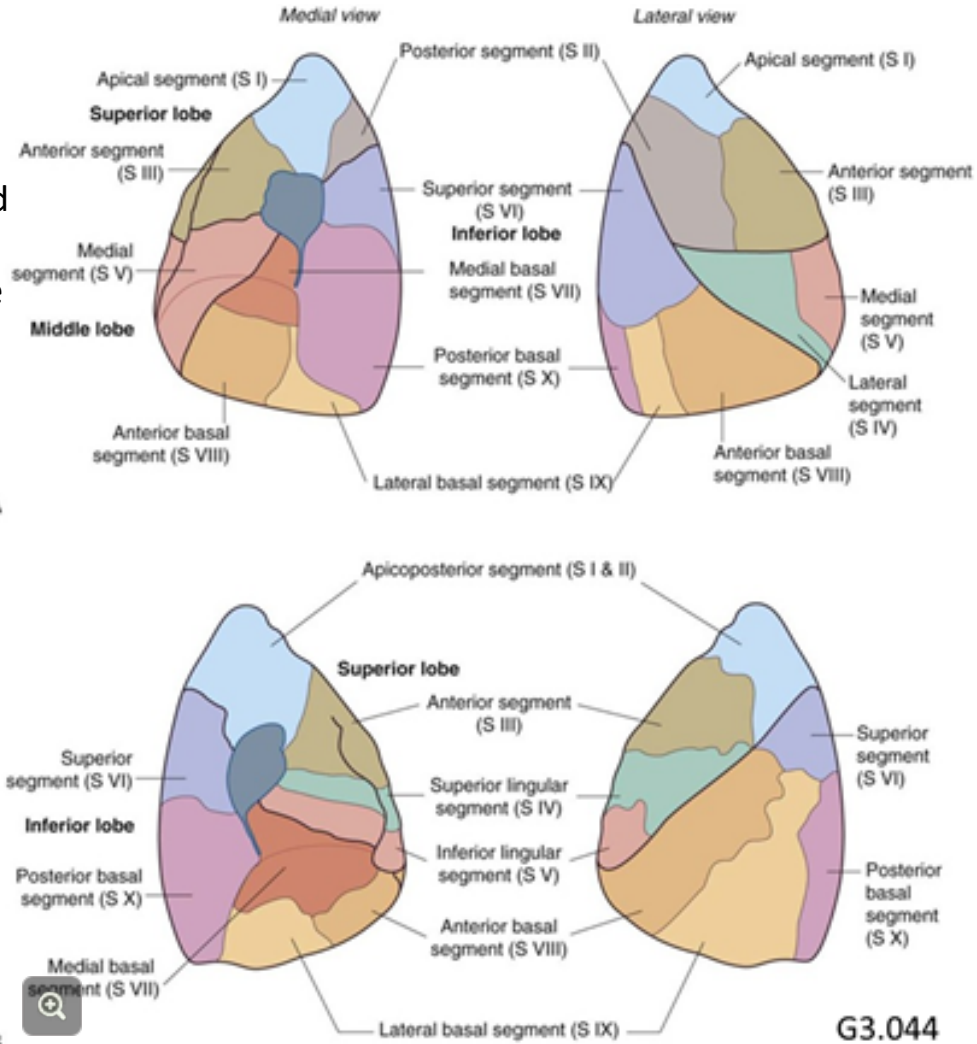


G3.043

A **bronchopulmonary segment** is the lung tissue supplied by a segmental bronchus. Each segmental bronchus has a companion branch of the **pulmonary artery** that supplies the bronchopulmonary segment with deoxygenated blood. Tributaries of the **pulmonary vein** that drain a bronchopulmonary segment back to the left side of the heart course through the CT between and around the bronchopulmonary segment.

A bronchopulmonary segment is a functionally independent unit of lung tissue. In addition to its own air and blood supply, it has its own nerve supply and lymphatic drainage. **It is the smallest unit of lung tissue that can be removed without affecting adjacent tissue.**

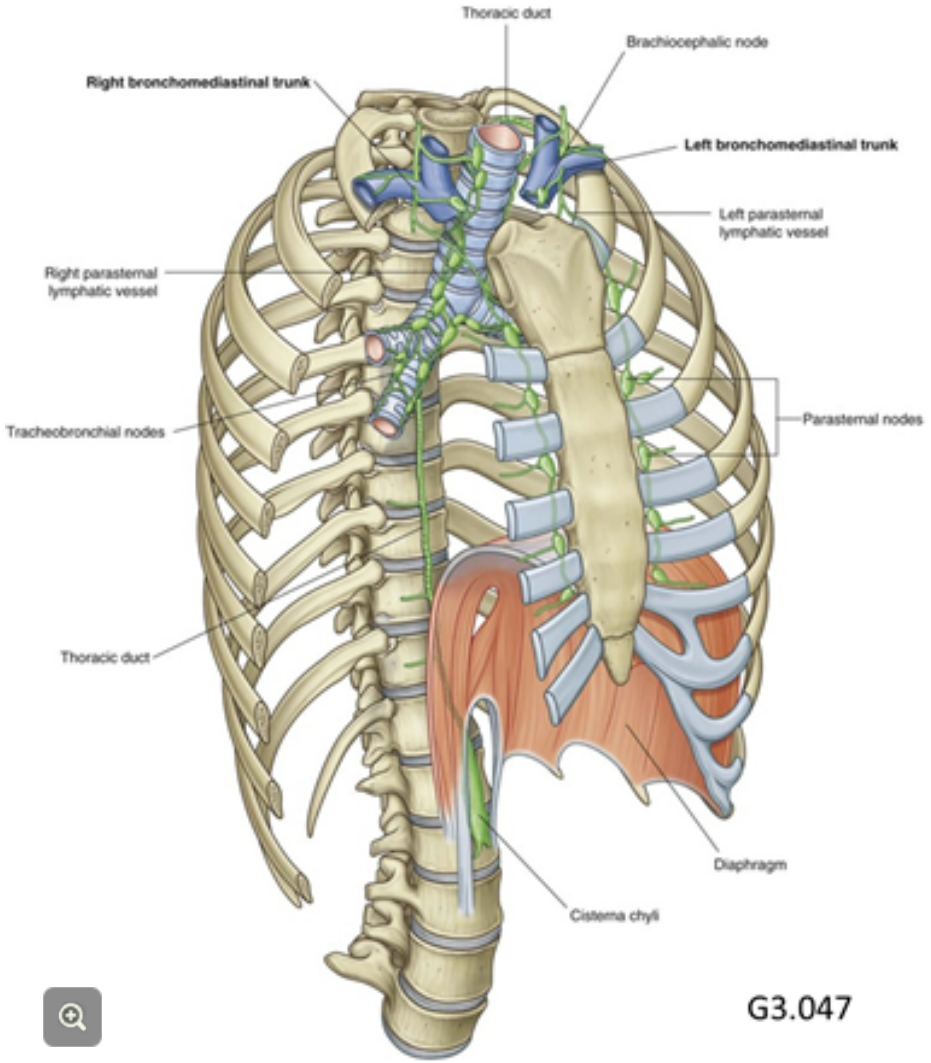
You are responsible only for the knowledge of what a bronchopulmonary segment is. You are not responsible for learning the names or locations of the various bronchopulmonary segments of the lungs.



Lymph from the deep and superficial (subpleural) lymphatics of the lungs drains into **tracheobronchial lymph nodes**, which are located in the CT around the lobar and primary bronchi, and extend along the trachea and into the posterior mediastinum.

Lymphatic vessels arising from the tracheobronchial lymph nodes unite with those draining the **parasternal nodes** of the anterior chest wall and the **brachiocephalic nodes** located anterior to the brachiocephalic veins, to form the right and left **bronchomediastinal trunks**.

The right and left bronchomediastinal trunks **empty into the right and left venous angles**, respectively.

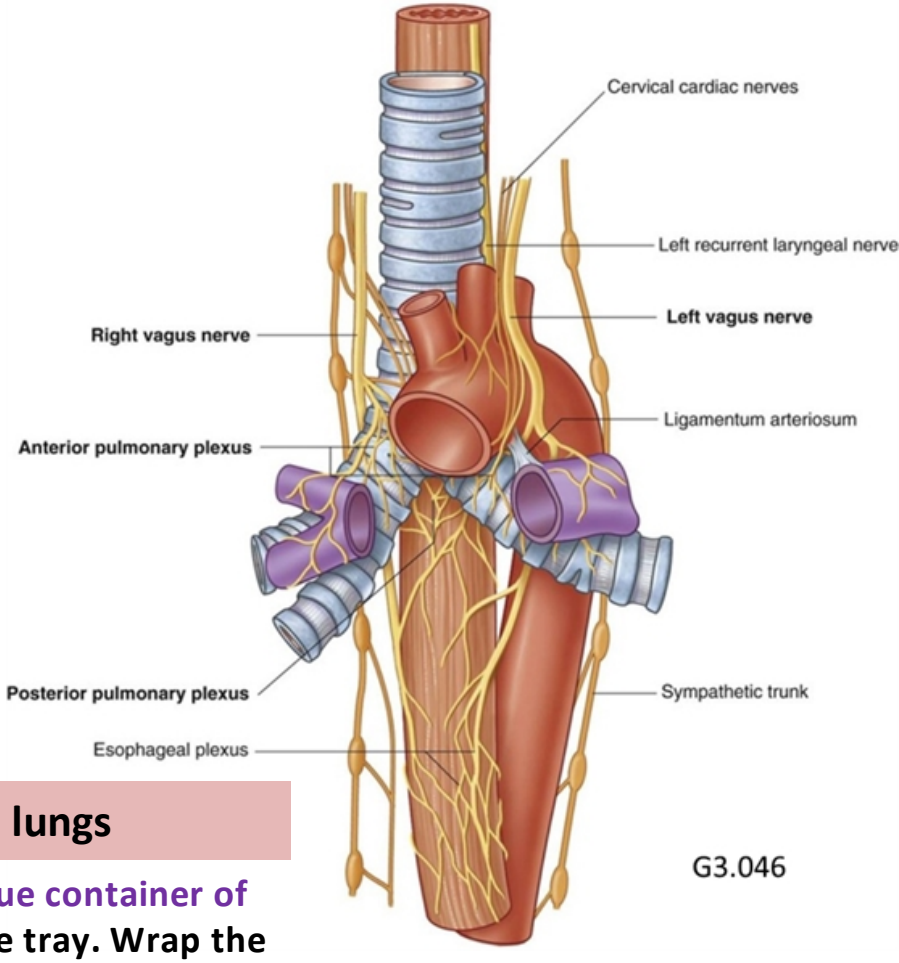


The **anterior and posterior pulmonary plexuses** are located on their respective sides of the tracheal bifurcation and main (primary) bronchi.

They are formed by contributions from the **vagus nerves** (parasympathetic preganglionic) and from **pulmonary nerves** (sympathetic postganglionic), derived from the sympathetic chain. They also include **afferent (sensory) fibres**.

Mixed autonomic nerves derived from these plexuses enter the hilum of the lung along with its airways, blood vessels and lymphatics.

Parasympathetic motor fibres stimulate bronchoconstriction and sympathetic motor fibres stimulate bronchodilation.



T A S K

Any tissue that you removed from the lungs

during dissection, must be placed in the tissue container of the correct cadaver. For now, leave it on the tray. Wrap the lungs in moist cloths for the time being. At the end of the lab, the lungs will be stored within the pleural cavity of the cadaver.

Since embarking on this exercise, you have **identified** the following structures and learned the **answers to the following questions**:

- Identify the lung surfaces, borders, fissures, lobes, the cardiac notch and lingula. What is the lingula of the left lung analogous to in the right lung?
- Identify the contact impressions on the mediastinal surfaces of the two lungs and state what structure forms each.
- Define primary, secondary and tertiary bronchi. What is a bronchopulmonary segment?
- List the structures that comprise the root of the lung. Explain the difference between the root of the lung and the hilum of the lung.
- Describe the lymphatic drainage of the lung, starting from the deep and superficial (subpleural) lymphatics. What group of lymph nodes is located along the lobar and primary bronchi, and trachea? Lymph from these nodes unites with that arising from two other groups of nodes to form the bronchomediastinal trunks. Name these two other groups of nodes. Where do the bronchomediastinal trunks terminate?
- Where are the pulmonary plexuses located relative to the airways? What nerves feed into the pulmonary plexuses and what functional fibre types do they contain? What effect does parasympathetic and sympathetic input have on airway smooth muscle?

Pause here to assess your learning. Quiz each other thoroughly. If you are satisfied with your **ability to identify these structures** and **answer these questions**, move on to the next stage of the exercise.

9.2/9.4 The Posterior Mediastinum

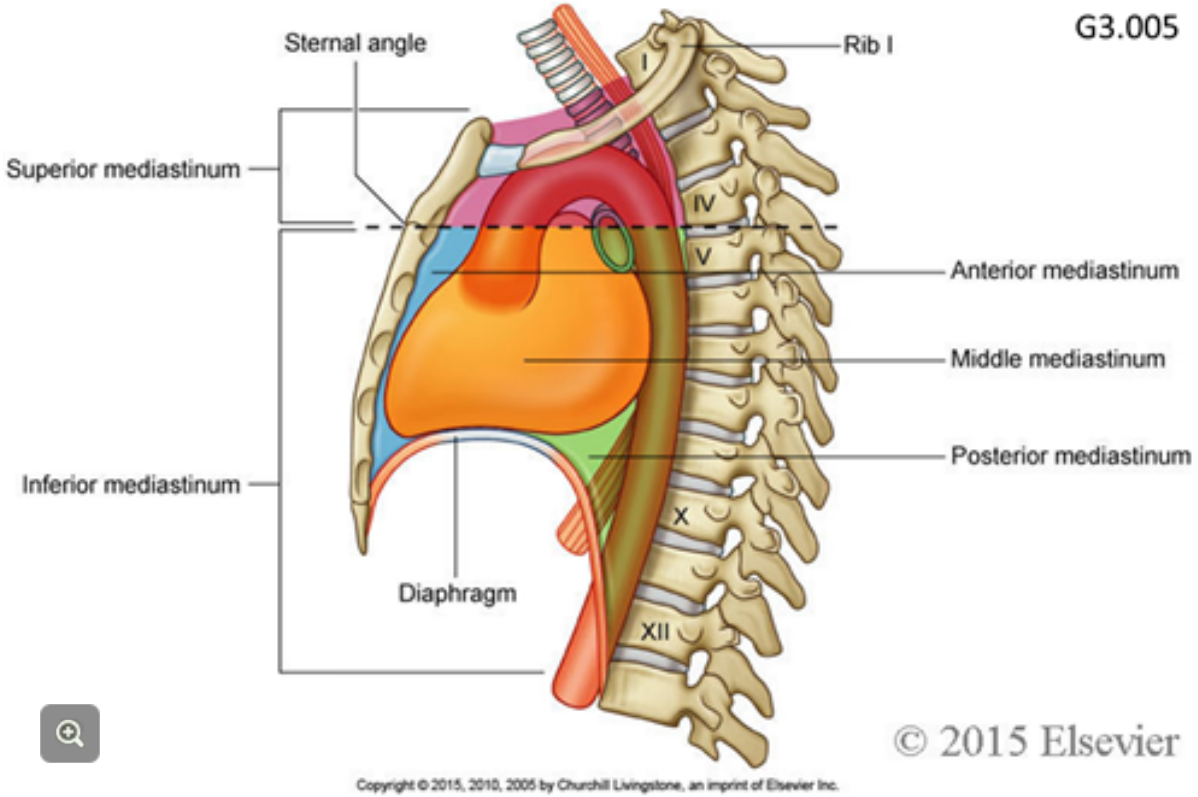
What you'll need:

SPECIMENS

- Cadaver 1 and 2

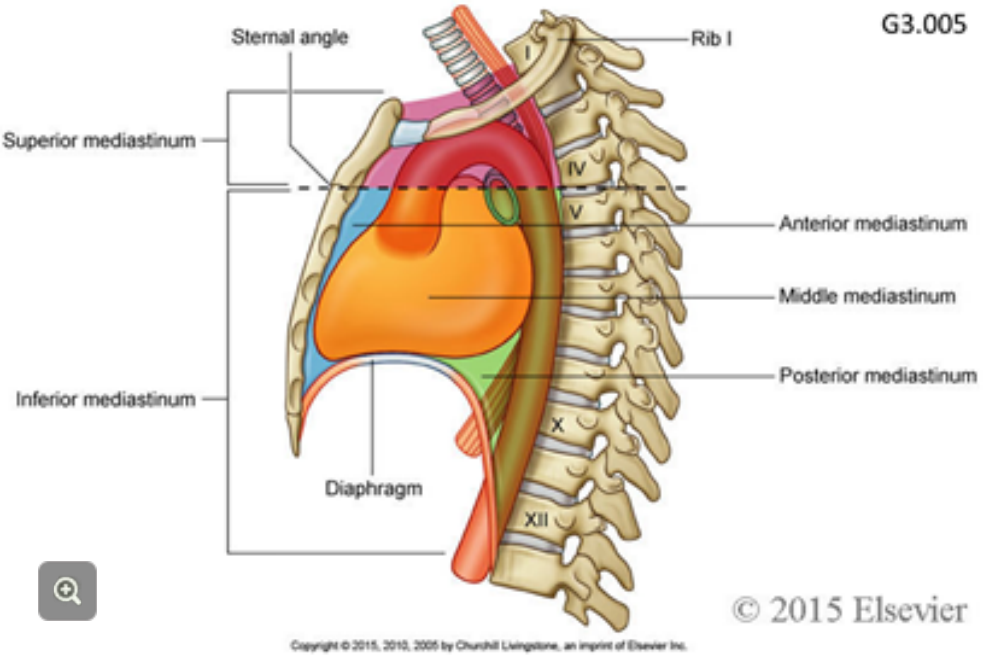
When you have learned the material presented in this exercise, you will be able to recognize and / or describe the:

- boundaries of the posterior mediastinum
- viscera, vessels, nerves and lymphatics of the posterior mediastinum, their relationships to each other and to structures of adjacent regions



As illustrated in the accompanying diagram, the **borders** of the posterior mediastinum are as follows:

- **anteriorly**, the pericardial sac and diaphragm
- **posteriorly**, the bodies of the mid- to lower thoracic vertebrae
- **superiorly**, a horizontal plane passing through the sternal angle and intervertebral disc between vertebrae T4 and T5
- **inferiorly**, the attachment of the diaphragm to the vertebral column
- **laterally**, the mediastinal parietal pleura



In Exercise 9.2 / 9.4 you will dissect and study the following structures:

- the esophagus and its associated nerve plexus
- the thoracic aorta and its branches
- the azygos system of veins
- the thoracic duct and associated lymph nodes
- the sympathetic trunks and the thoracic splanchnic nerves.

Just one piece of advice, before you get started:

From the right side of the cadaver,

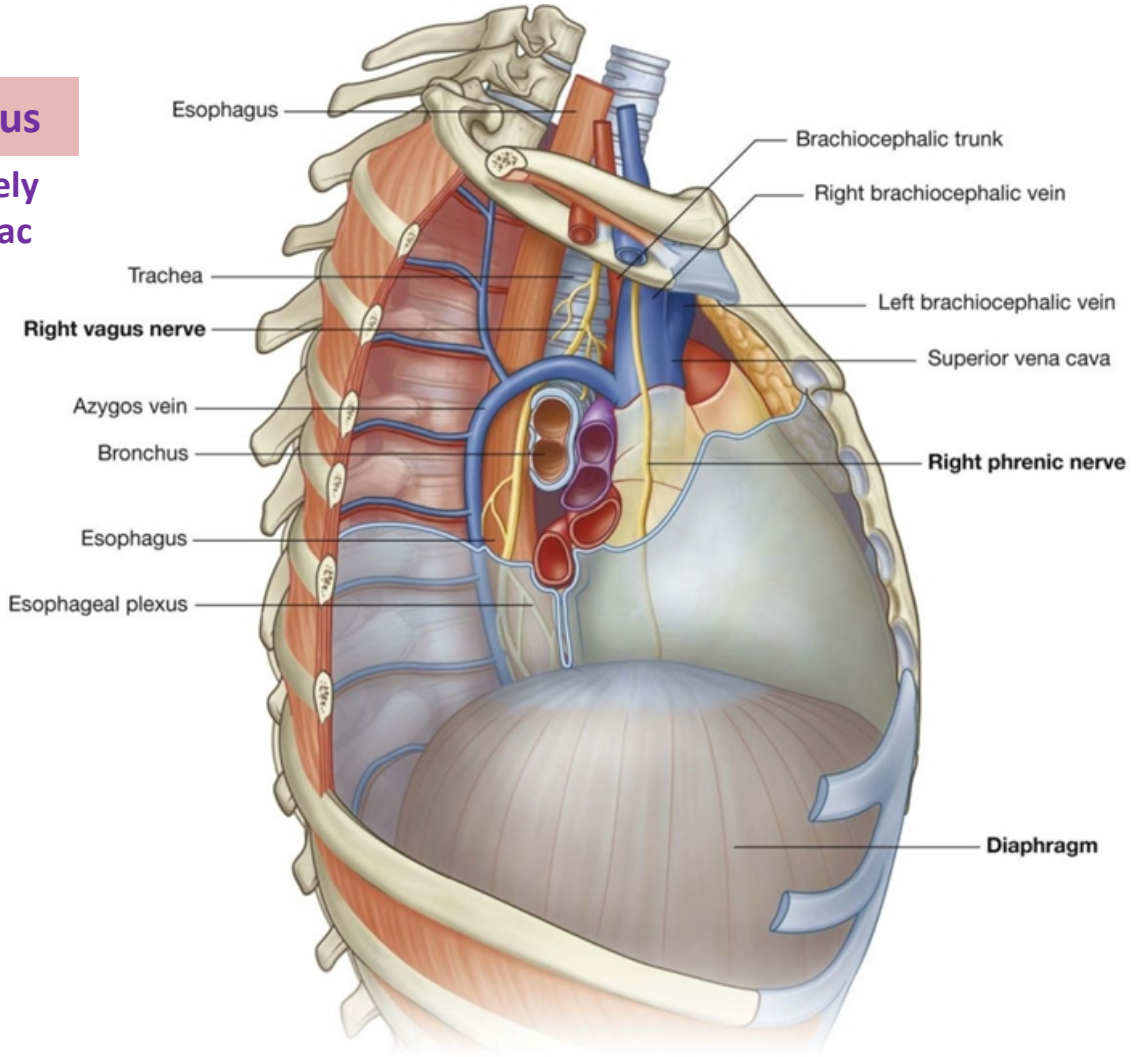
TASK

NOTICE that the esophagus lies in the midline, immediately posterior to the pericardial sac and heart.

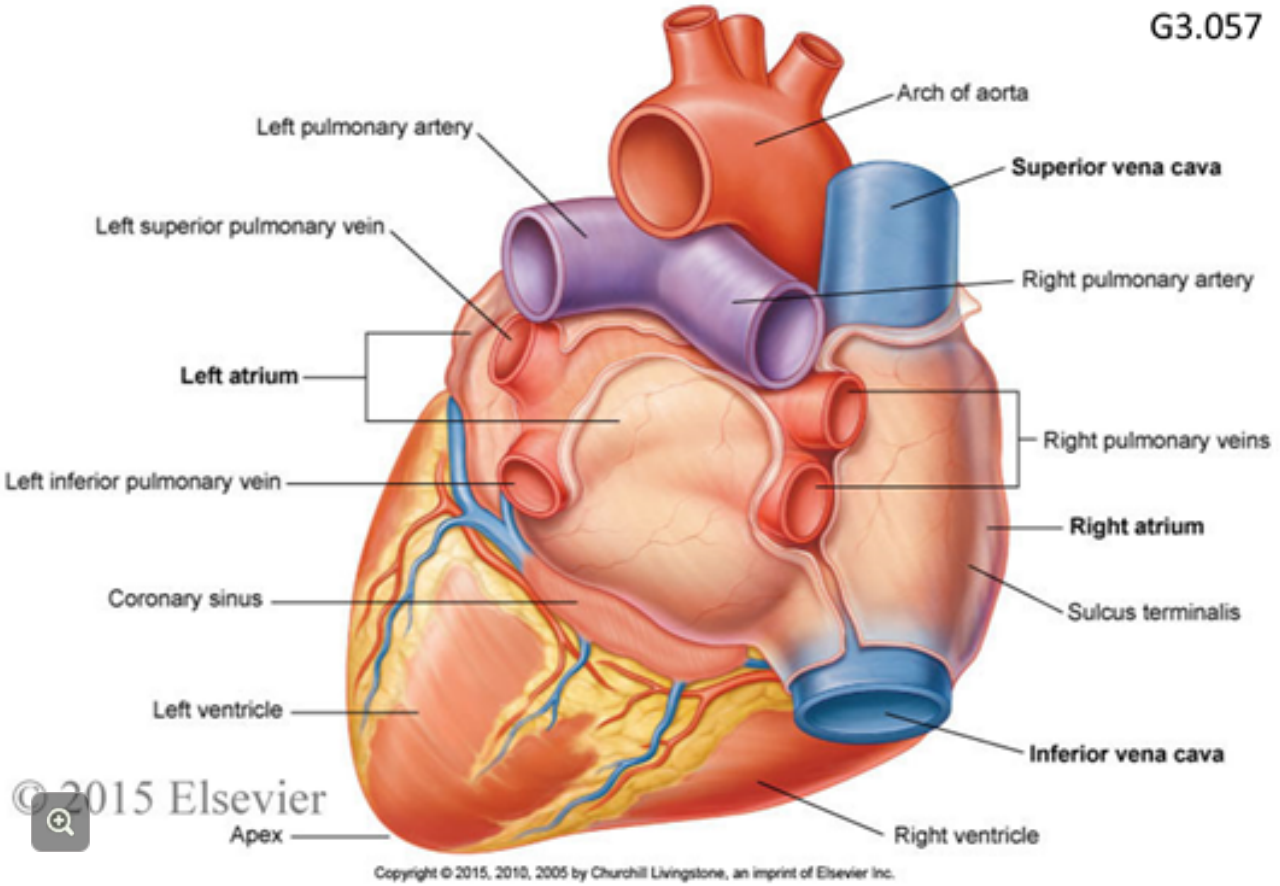
Which chamber of the heart is most closely associated with the esophagus?

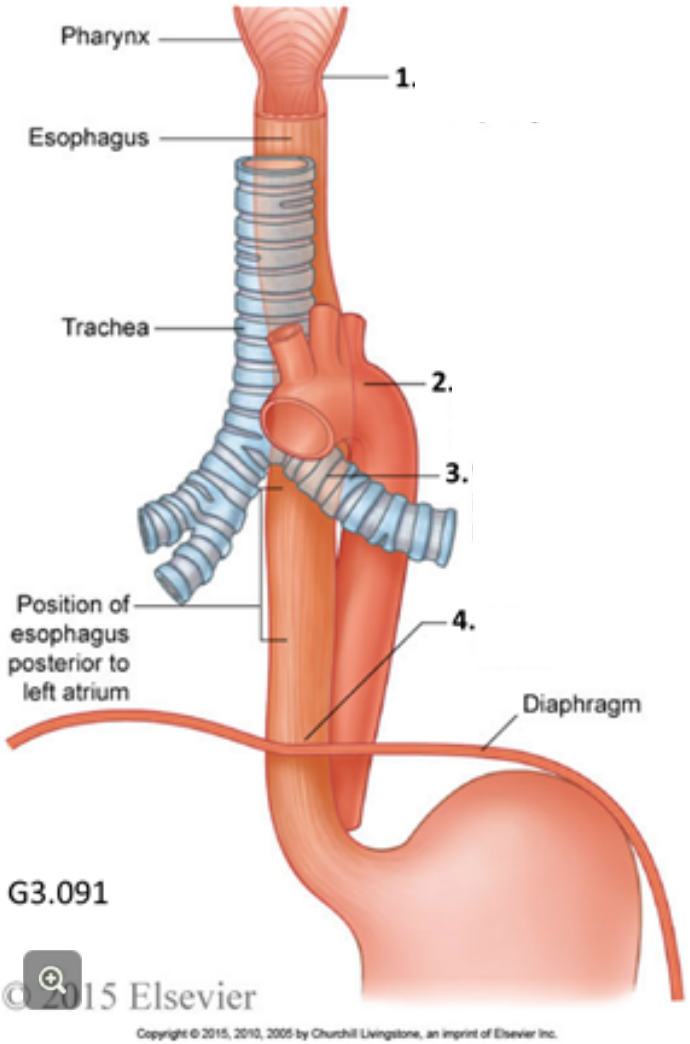
Hint: it is the chamber of the heart that largely forms its base.

Another hint: Identify the vessels located between the esophagus and heart in this figure. With which chamber are they associated?



The base of the heart is formed largely by the **left atrium**. In the posterior mediastinum, from superior to inferior, the **esophagus** is located **posterior to the left atrium** and then posterior to the **diaphragm.** It passes through the **esophageal hiatus** at the level of the **T_{10} vertebra**.



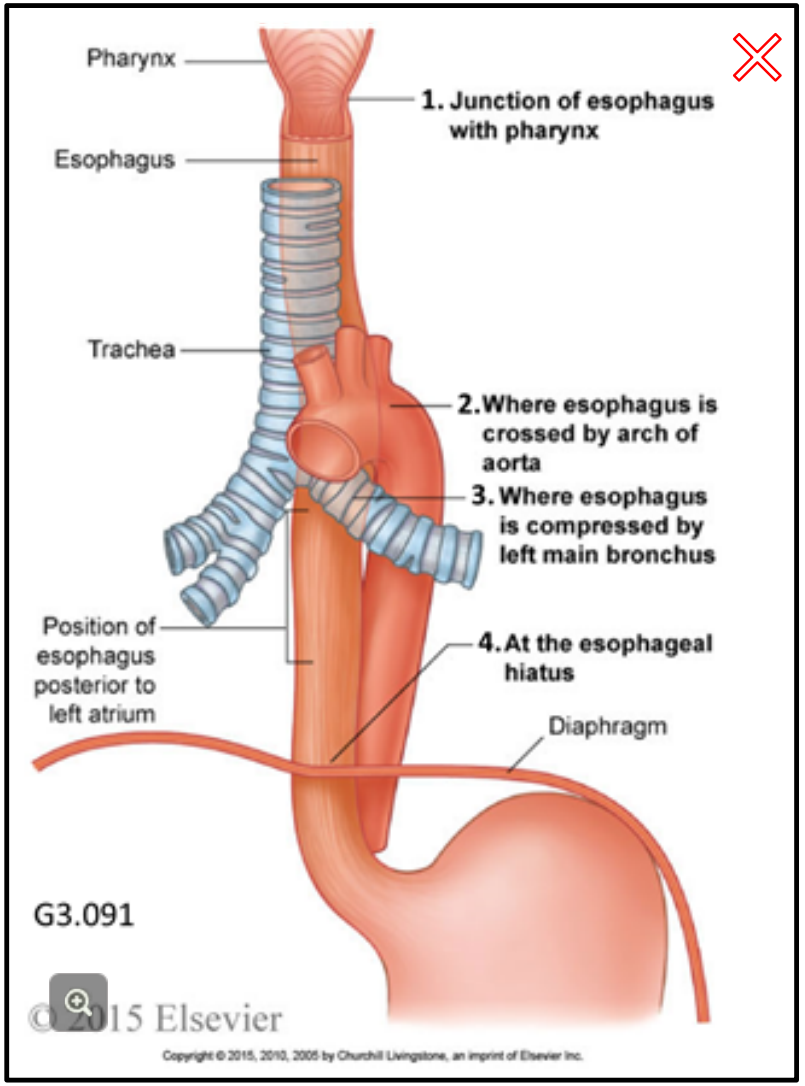


Fill-in-the-blank:

The esophagus is a muscular tube, ___ cm in length and ___ cm in diameter. It begins at the ___ sphincter, which is made up of the ___ muscle, a component of the ___ and is located at the level of the ___ vertebra. It passes through the diaphragm via an opening called the ___ at the level of the ___ vertebra. It ends at the ___ sphincter (also known as the ___ sphincter of the stomach) at the level of the ___ vertebra.

As illustrated in the accompanying diagram, the esophagus is narrowed, or may become compressed, at **four locations** along its length. Do you know what they are? Think first and then click here to reveal the answers. **Make note of these locations.**

Clinically, these are the more likely places where certain problems may arise. Work with your group to come up with all three of these problems, and then click here to reveal the answers:



Fill-in-the-blank:

The esophagus is a muscular tube, 25 cm in length and 2 cm in diameter. It begins at the upper esophageal sphincter, which is made up of the cricopharyngeus muscle, a component of the inferior pharyngeal constrictor and is located at the level of the C6 vertebra. It passes through the diaphragm via an opening called the esophageal hiatus at the level of the T10 vertebra. It ends at the lower esophageal sphincter (also known as the cardiac sphincter of the stomach) at the level of the T11 vertebra.

As illustrated in the accompanying diagram, the esophagus is narrowed, or may become compressed, at **four locations** along its length. Do you know what they are? Think first and then click here to reveal the answers. **Make note of these locations.**

Clinically, these are the more likely places where certain problems may arise. Work with your group to come up with all three of these problems, and then click here to reveal the answers:

i. a swallowed object may become lodged, or
ii. where more damage can be done by a swallowed corrosive substance, the passage of which is slowed at these sites, or
iii. where the passage of instruments may be more problematic.

When you removed the heart in Lab 7, you left the posterior wall of the pericardial sac intact, as illustrated in the accompanying figure.

T A S K

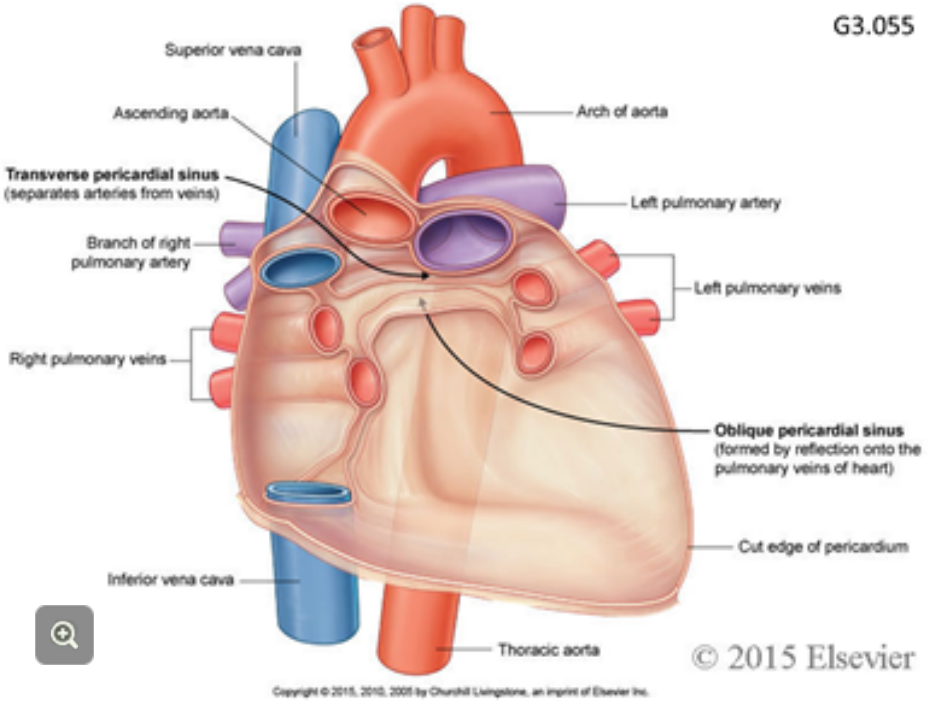
REMOVE the heart from the cadaver's chest.

Wrap it in moist cloths for the duration of the lab.
Keep it handy for study, however, as needed.

Using blunt dissection (large forceps and large closed scissors), remove the remnants of the posterior wall of the pericardial sac to expose the esophagus and thoracic aorta. Leave intact the portion of the pericardial sac that adheres to the superior surface of the diaphragm by cutting its margin with the large scissors.

Identify the esophagus as a midline muscular tube. To the left of the midline, and posterior to the esophagus, identify the thoracic aorta.

Using blunt dissection, clean the esophagus. Take care to leave intact on its surface the esophageal plexus, which innervates the distal portion of the esophagus.



When you removed the heart in Lab 7, you left the posterior wall of the pericardial sac intact, as illustrated in the accompanying figure.

TASK

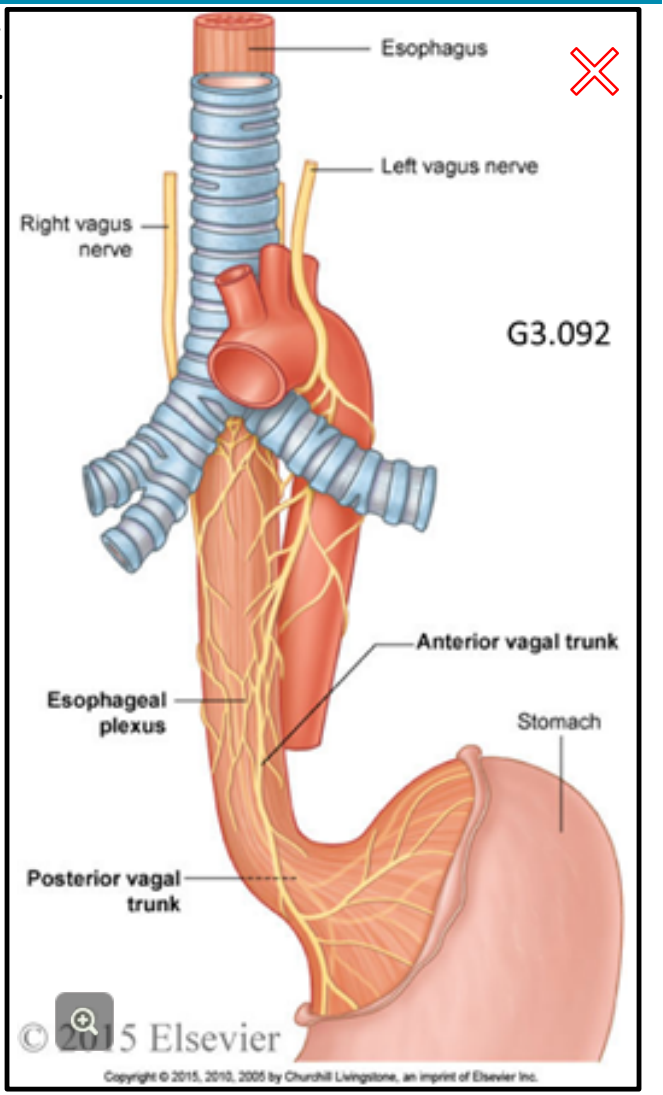
REMOVE the heart from the cadaver's chest.

Wrap it in moist cloths for the duration of the lab. Keep it handy for study, however, as needed.

Using blunt dissection (large forceps and large closed scissors), remove the remnants of the posterior wall of the pericardial sac to expose the esophagus and thoracic aorta. Leave intact the portion of the pericardial sac that adheres to the superior surface of the diaphragm by cutting its margin with the large scissors.

Identify the esophagus as a midline muscular tube. To the left of the midline, and posterior to the esophagus, identify the thoracic aorta.

Using blunt dissection, clean the esophagus. Take care to leave intact on its surface the esophageal plexus, which innervates the distal portion of the esophagus.



TASK

On the right side of the cadaver, TRACE

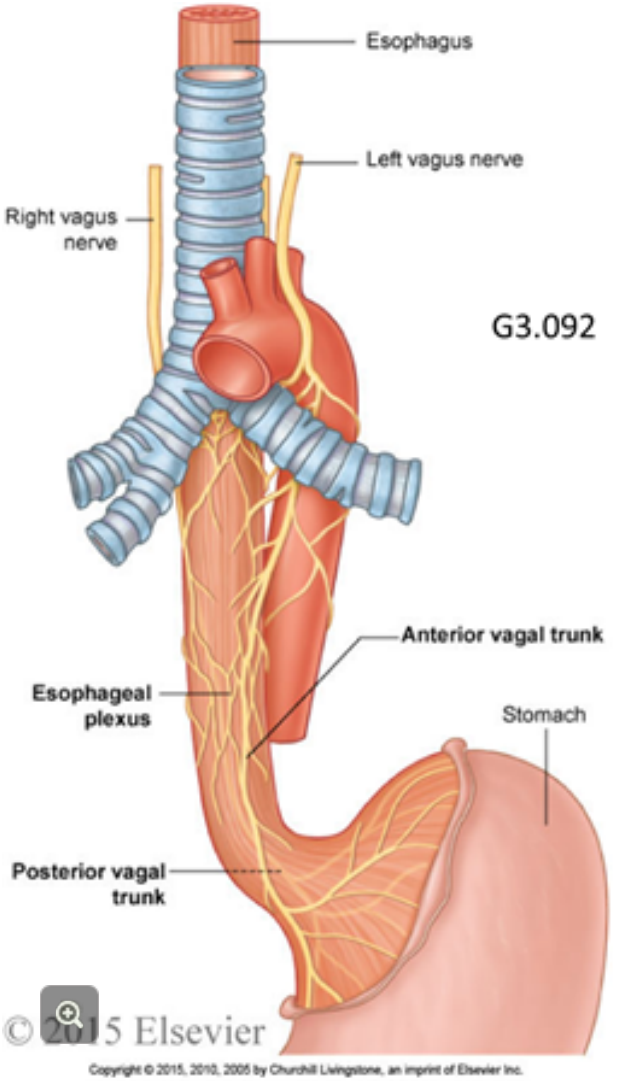
the right vagus nerve across the anterior surface of the right subclavian artery, posterior to the root of the right lung to the esophagus. Note that its fibres spread out over the esophagus, contributing to the esophageal plexus.

On the left side of the cadaver, trace the left vagus nerve across the left lateral aspect of the arch of the aorta, posterior to the root of the left lung to the esophagus and its plexus.

The esophageal plexus receives sympathetic postganglionic contributions from the upper thoracic levels via the sympathetic chain ganglia and the esophageal nerves.

Due to the curve of the diaphragm and the bulk of the liver antero-inferior to it, you may or may not be able, at this point, to trace the esophageal plexus distally to the diaphragm, where it forms the anterior and posterior vagal trunks.

The anterior vagal trunk is largely formed from the left vagus nerve, and the posterior vagal trunk is formed largely from the right vagus nerve. The anterior and posterior vagal trunks accompany the esophagus through the diaphragm to the abdominal cavity, where the vagi innervate much of the digestive tract.



The azygous system of veins is a clinically significant anastomotic route by which blood can return to the right side of the heart if the IVC is occluded. In Lab 8, you left the azygous vein intact where it empties into the SVC.

From the right side of the cadaver,

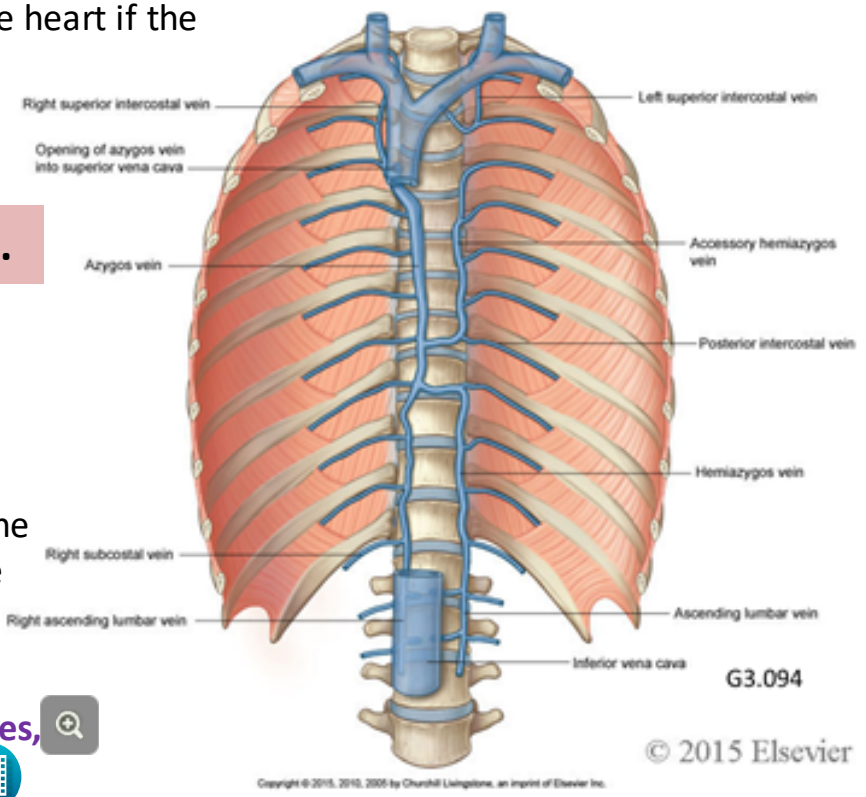
TASK

REVIEW the course of the azygous vein.

It begins in the abdomen at the level of the L1 or L2 vertebra, and passes through the diaphragm via either the aortic hiatus or the right crus of the diaphragm.

It ascends through the thorax to the right of the midline and at the level of the sternal angle it arches over the root of the right lung to empty into the SVC.

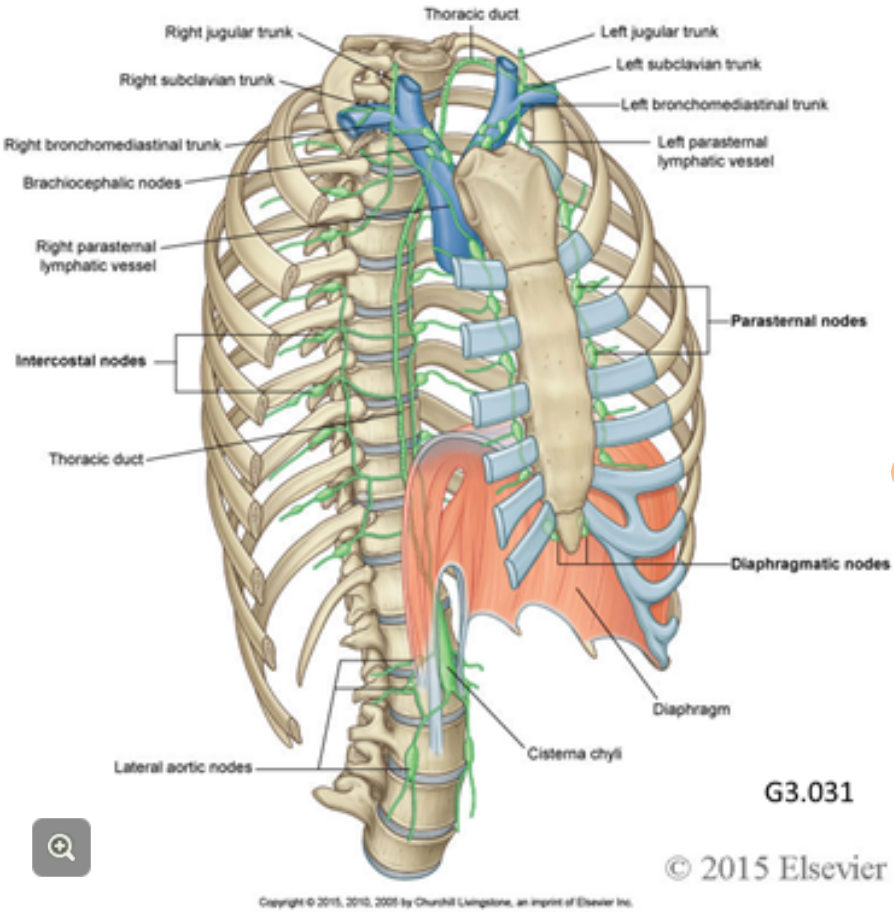
Now, clean the azygous vein thoroughly along its entire length. Take care not to damage its tributaries, the right posterior intercostal veins. see video 1



TASK

From the left side of the cadaver, IDENTIFY left posterior intercostal veins

and trace them to where they empty into either the hemiazygous vein or the accessory hemiazygous vein. Do not trace these latter veins across the midline at this point; do so after you have identified the thoracic duct. see video 2



Fill-in-the-blank:

The thoracic duct **conveys most of the lymph from the body to the venous system**.

Lymph trunks in the abdomen, carrying lymph derived from the lower limbs, pelvis, perineum, abdominal walls and abdominal organs converge to form the which is located at the level of the vertebra. The cisterna chyli continues superiorly as the and enters the thorax by passing through the **hiatus** of the diaphragm posterior to the .

In the thorax, the thoracic duct ascends to the of the midline, **between the thoracic aorta and the** and posterior to the . On entering the superior mediastinum, the thoracic duct moves to the left and enters the neck.

The thoracic duct is joined by the and trunks and empties into the left venous angle. The trunk empties into the left venous angle independently.

In the thorax, the thoracic duct receives lymph from the lower six intercostal spaces, bilaterally, and the upper five intercostal spaces on the left. It also receives lymph from ducts draining the posterior mediastinal and posterior diaphragmatic nodes.

TASK

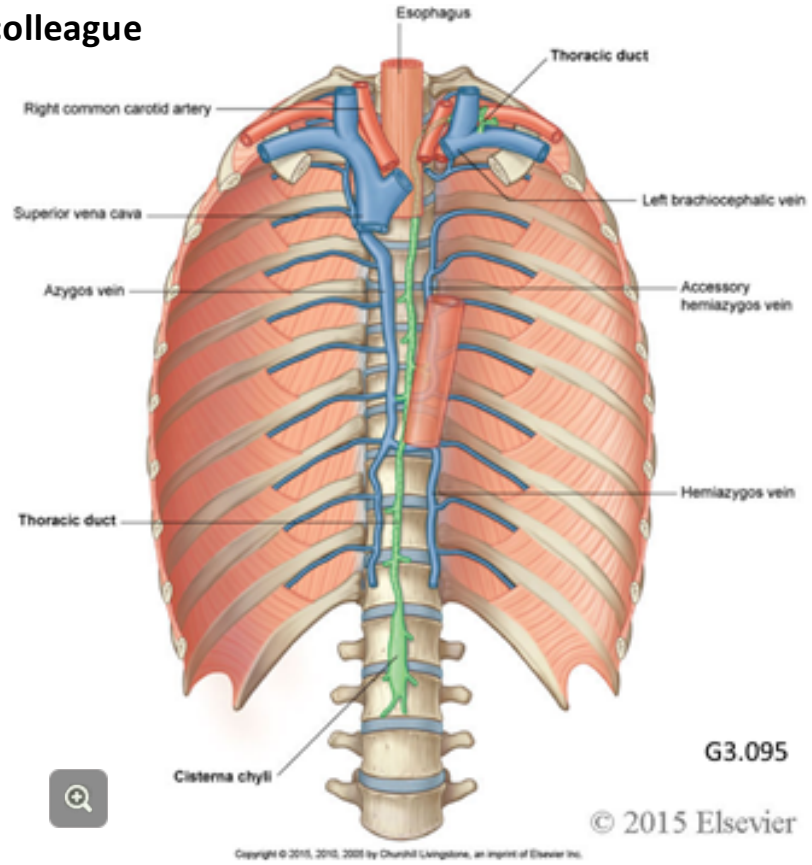
Between the azygous vein and the thoracic aorta, IDENTIFY:

the thoracic duct. Because the thoracic duct is posterior to the esophagus, it might be helpful to have a colleague retract the esophagus to the left.

The thoracic duct is roughly the size of a probe tip. **Carefully clean the thoracic duct along its length to where it passes behind the diaphragm with the thoracic aorta; it is thin-walled and easily torn.**

Notice that it has many small swellings along its length, making it look like a small vein. Indeed, these swellings are formed by the numerous **valves** located along its length, that ensure the movement of lymph superiorly, toward the terminus of the thoracic duct at the left venous angle.

Make note of the relationship of the thoracic duct to the right posterior intercostal arteries, arising from the thoracic aorta, and the hemiazygous and accessory hemiazygous veins: the thoracic duct runs anterior to these structures.



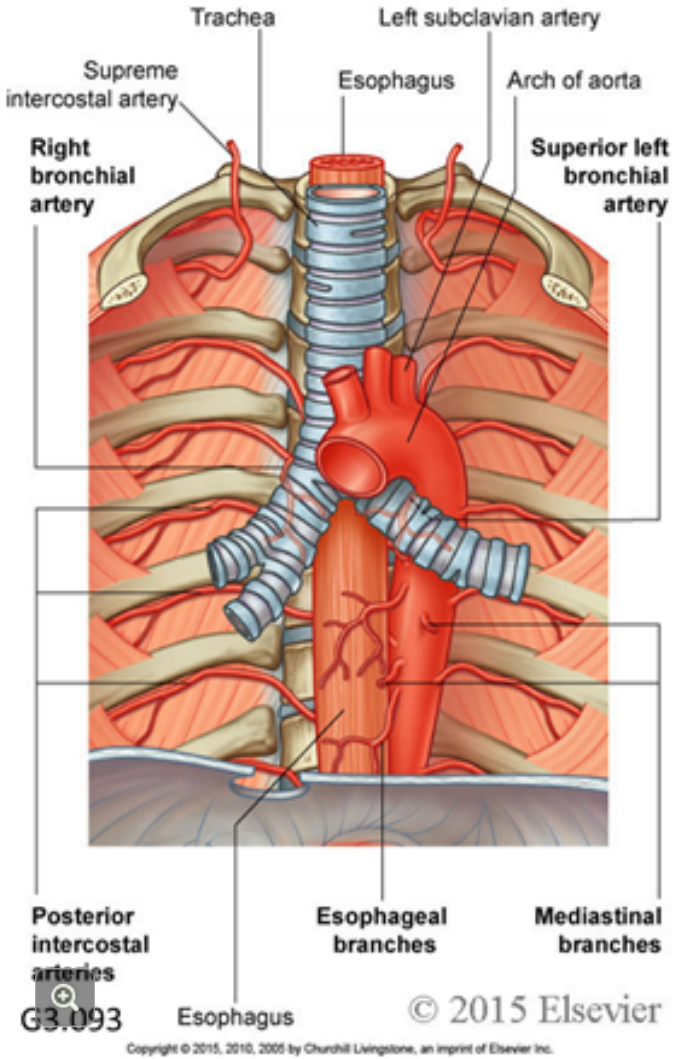
The **thoracic aorta** begins at the sternal angle (the level of the disc between the T4 and T5 vertebra) and ends at the disc between the T12 and L1 vertebra, where it passes **behind the diaphragm** through the **aortic hiatus** to enter the abdominal cavity. There it becomes the **abdominal aorta**.

TASK

LOOK at the position of the thoracic aorta within the posterior mediastinum. Notice that it begins, superiorly, to the left of the vertebral column. Follow it inferiorly and note that as it descends, it shifts toward the midline, and takes up a position posterior to the esophagus.

Observe that the aorta ultimately passes through the aortic hiatus in the midline, anterior to the T12 vertebral body.

Look for the visceral branches of the thoracic aorta, the bronchial and esophageal arteries. Identify them by their targets. The bronchial arteries supply the conducting portions of the respiratory system; that is, they supply the system of airways that conduct air toward and away from the gas-exchange surfaces of the lungs. The esophageal arteries supply the middle third of this organ with blood.

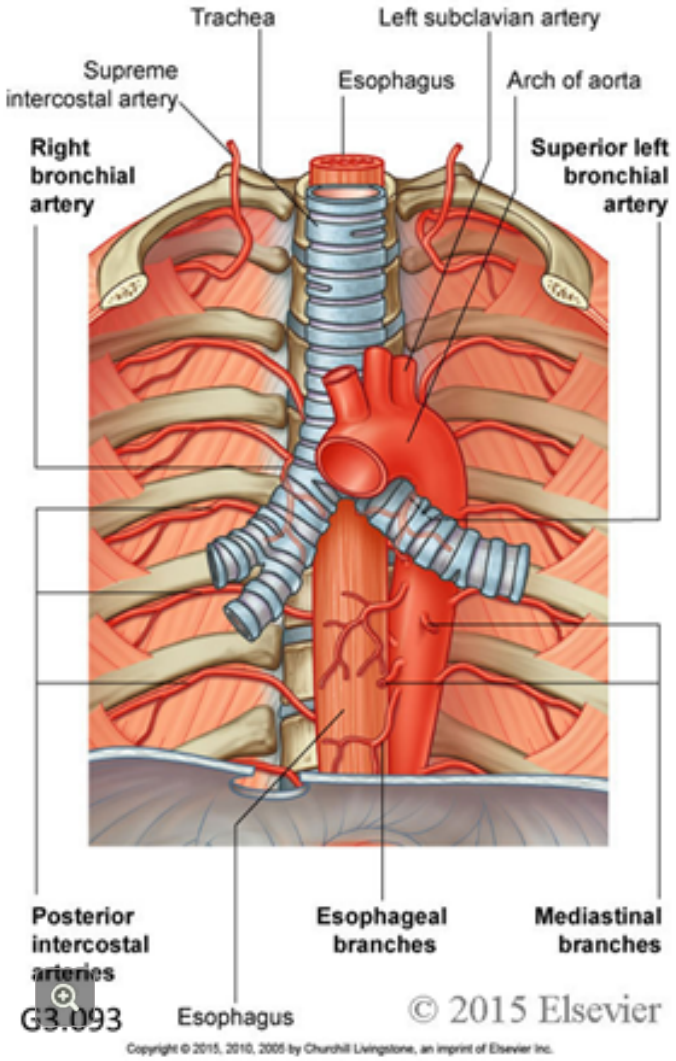


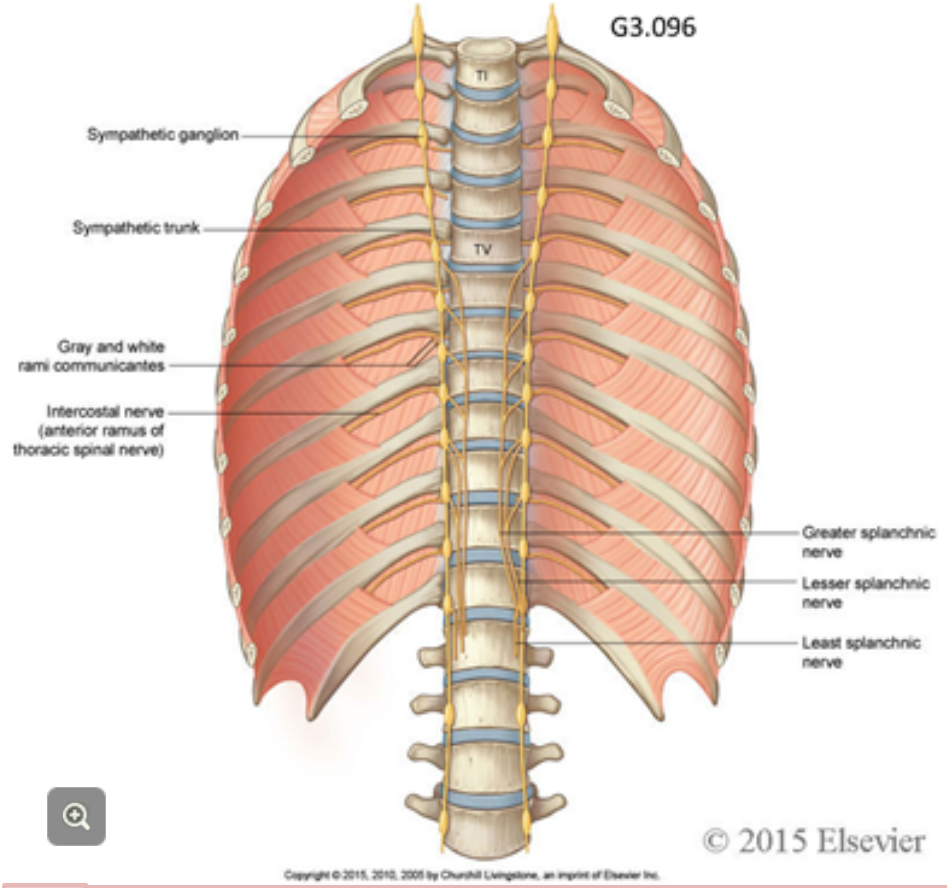
TASK

Now, turn your attention to the parietal branches of the thoracic aorta. Working on both sides of the cadaver simultaneously, clean one right and one left posterior intercostal artery from where they arise from the aorta to the intercostal space where they join their companion vein, lymphatic and nerve. Notice that the right posterior intercostal arteries cross the anterior aspect of the thoracic vertebral bodies, and that they pass posterior to all other structures: venous, lymphatic and nervous. Clean the posterior intercostal artery, vein and intercostal nerve within this one intercostal space until they disappear posterior to the innermost intercostal muscle.

Each pair that rotates to the cadaver should clean one right and one left intercostal space, tracing all structures back to their origin; in doing so, the team will create a complete dissection of the posterior thoracic wall.

Notice that the intercostal vein, artery and nerve pass between the internal and innermost intercostal muscles. You can use this fact to identify these muscle layers.





TASK

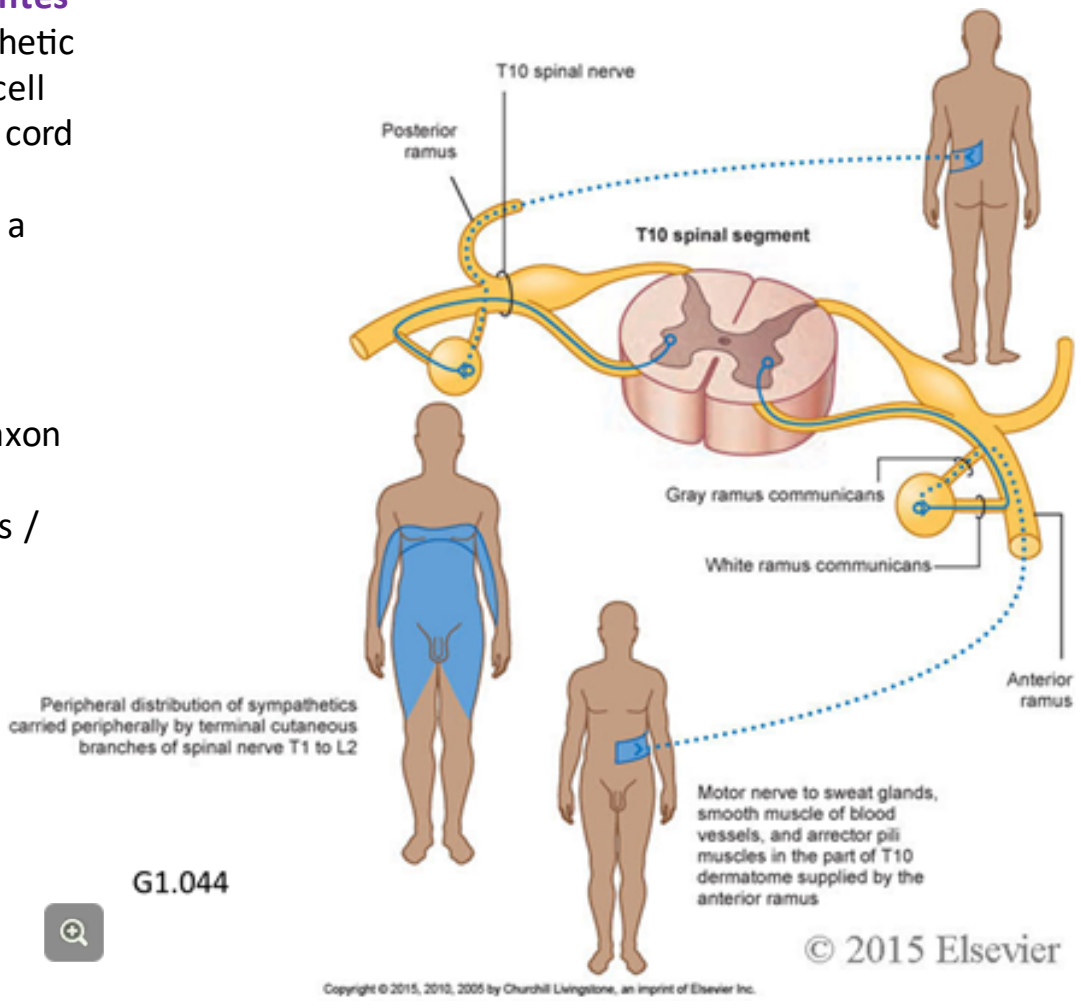
IDENTIFY the right and left sympathetic chains. Trace the sympathetic chains inferiorly, along the length of the thoracic cavity. Observe that the sympathetic chains gradually move medially, starting at the necks of the first ribs, then, more inferiorly, crossing the heads of the ribs, and finally at the lower thoracic levels, lying more anteriorly, on the lateral aspect of the T10 - T12 vertebral bodies. Notice that there is one sympathetic ganglion corresponding to each intercostal space. This is **unlike in the cervical region**, where there are three ganglion, superior (stellate), middle and inferior.

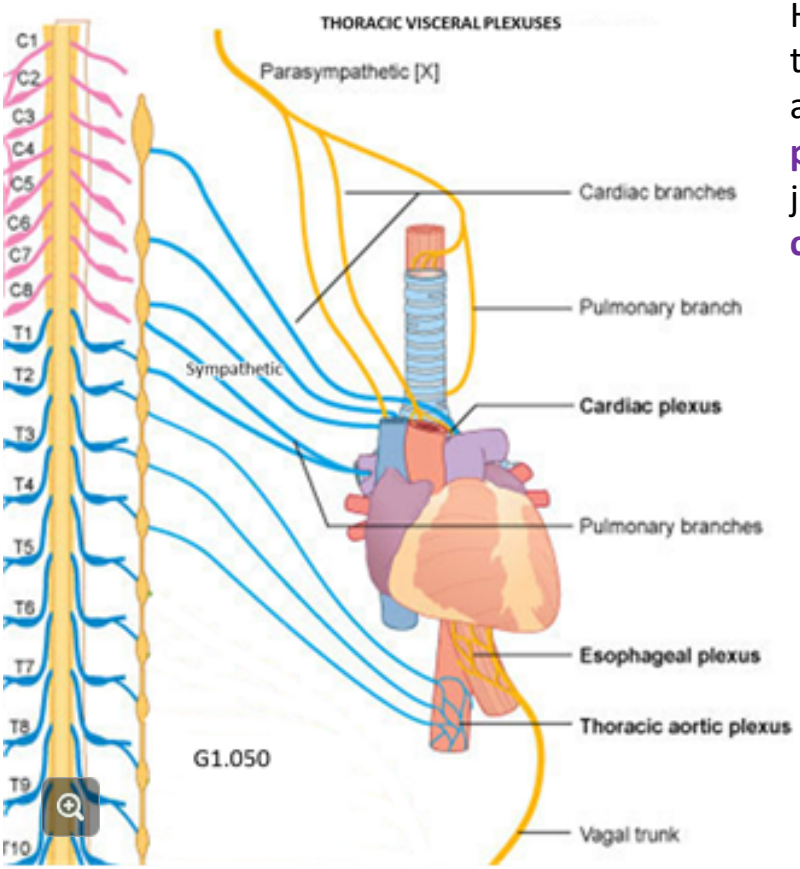
TASK

IDENTIFY, connecting each intercostal nerve with its corresponding ganglion, the white and grey rami communicantes. They can be differentiated on the basis of the fact that the white rami are lateral to the grey rami.

Recall that the **white rami communicantes** carry myelinated **preganglionic** sympathetic fibres from the intermediolateral (IML) cell column (lateral horn cells) of the spinal cord to the cell bodies of the **sympathetic postganglionic neurons** located within a **sympathetic chain ganglion**.

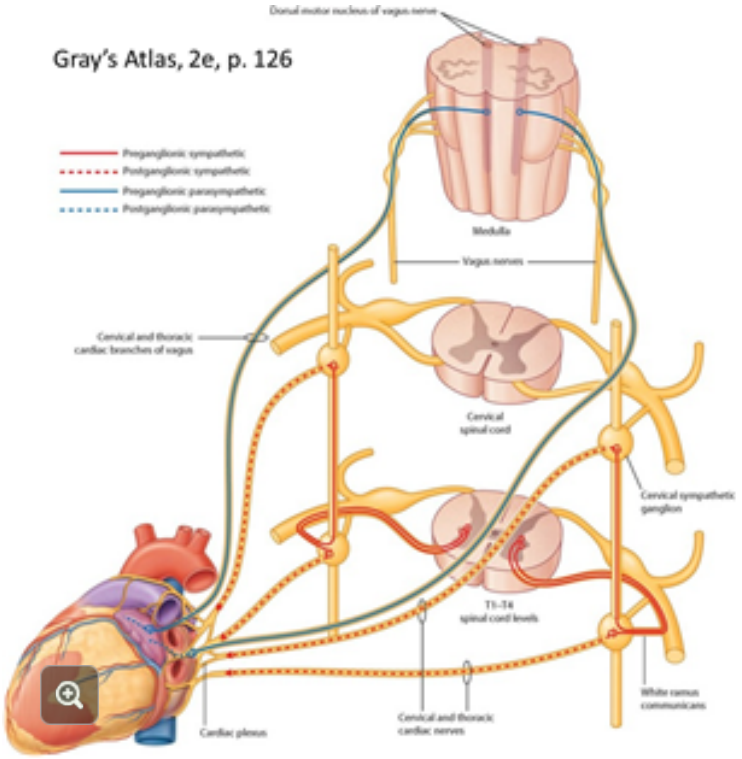
Recall also, that if the sympathetic postganglionic neuron in the chain is to innervate targets in the **body wall**, its axon will pass through the **grey ramus communicans** back to the ventral ramus / intercostal nerve or the dorsal ramus.





In these plexuses, the sympathetic postganglionic fibres first meet with the parasympathetic preganglionic fibres delivered by the vagus nerves.

HOWEVER, if the sympathetic postganglionic neuron in the chain is to innervate thoracic visceral targets such as the heart, lungs or esophagus, **its axon does not pass through the grey ramus**, but it forms nerves that join the plexuses associated with these organs, the **cardiac, pulmonary** and **esophageal plexuses**.

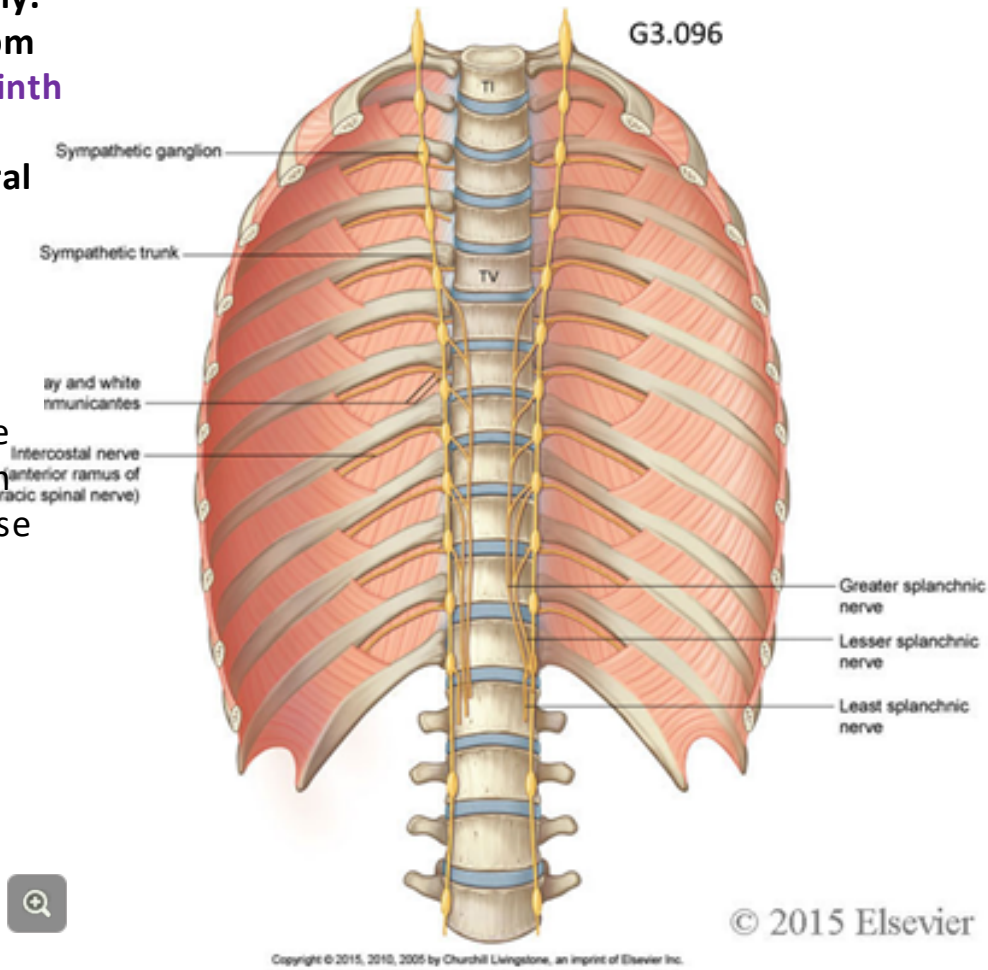


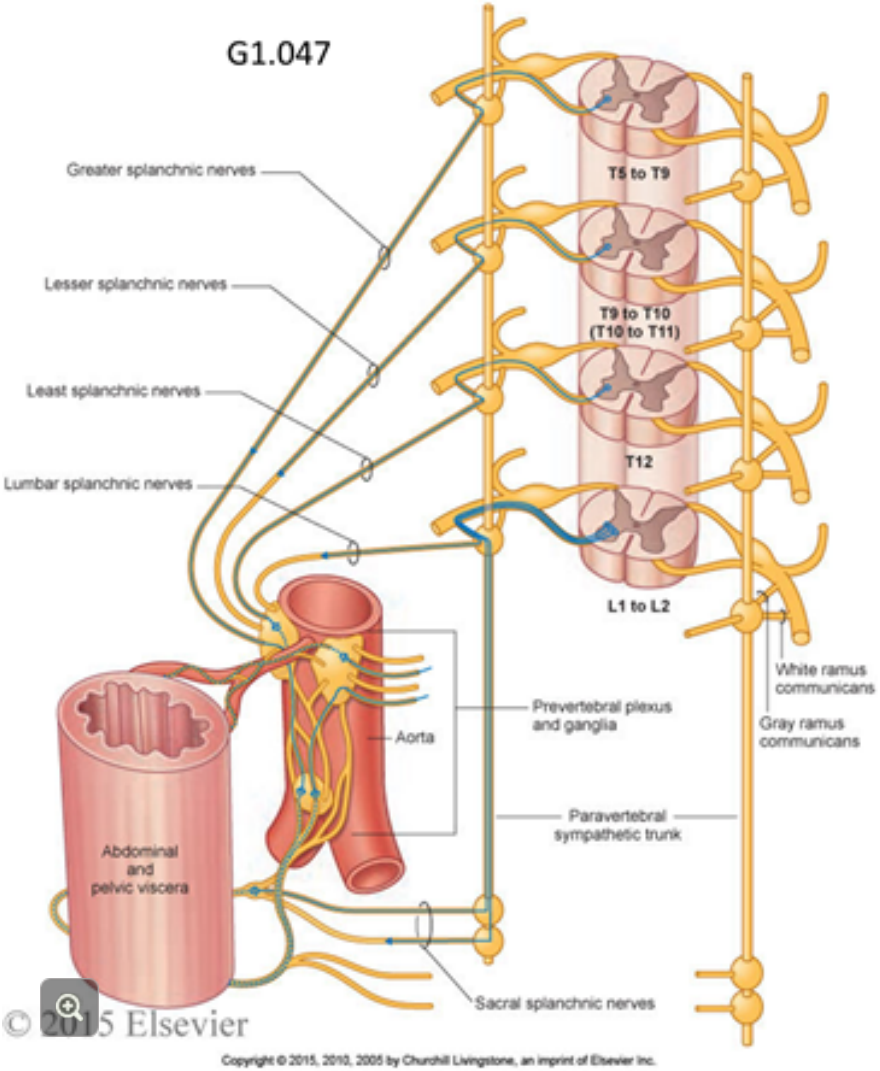
TASK

IDENTIFY and CLEAN

the greater splanchnic nerves bilaterally. The greater splanchnic nerves arise from contributions from the fifth through ninth ganglia. You will find them located on the lateral aspects of the lower thoracic vertebral bodies, anterior to the sympathetic chains.

You will be unable to see the lesser and least splanchnic nerves in the cadaver at this time because they are obscured by the dome of the diaphragm. The **lesser splanchnic nerves** arise from contributions from the tenth and eleventh ganglia, while the **least splanchnic nerves** arise from the twelfth ganglia.





Sympathetic preganglionic fibres arising from T5-T9 lateral horn cells (greater splanchnic nerve), T10-T11 lateral horn cells (lesser splanchnic nerve) and from the T12 lateral horn cells (least splanchnic nerve) **that are destined to innervate abdominal viscera pass through the sympathetic chain ganglia without synapsing**. The greater, lesser and least splanchnic nerves pass behind the diaphragm with the aorta to enter the abdominal cavity. There, along with the lumbar and sacral splanchnic nerves, they enter pre-aortic ganglia which contain the cell bodies of postganglionic sympathetic neurons. The details of the innervation of abdominopelvic viscera will be covered in Unit 4 with the digestive and genitourinary systems.

All tissue removed as you dissected should be in the tissue container associated with your cadaver. Moisten all exposed surfaces with the moistening fluid provided. Replace the heart, lung and chest plate. Cover the cadaver with moist cloths such that no air can access the openings in the body wall. Close the body bag, and wipe its superior surface with cleaning fluid and paper towel.

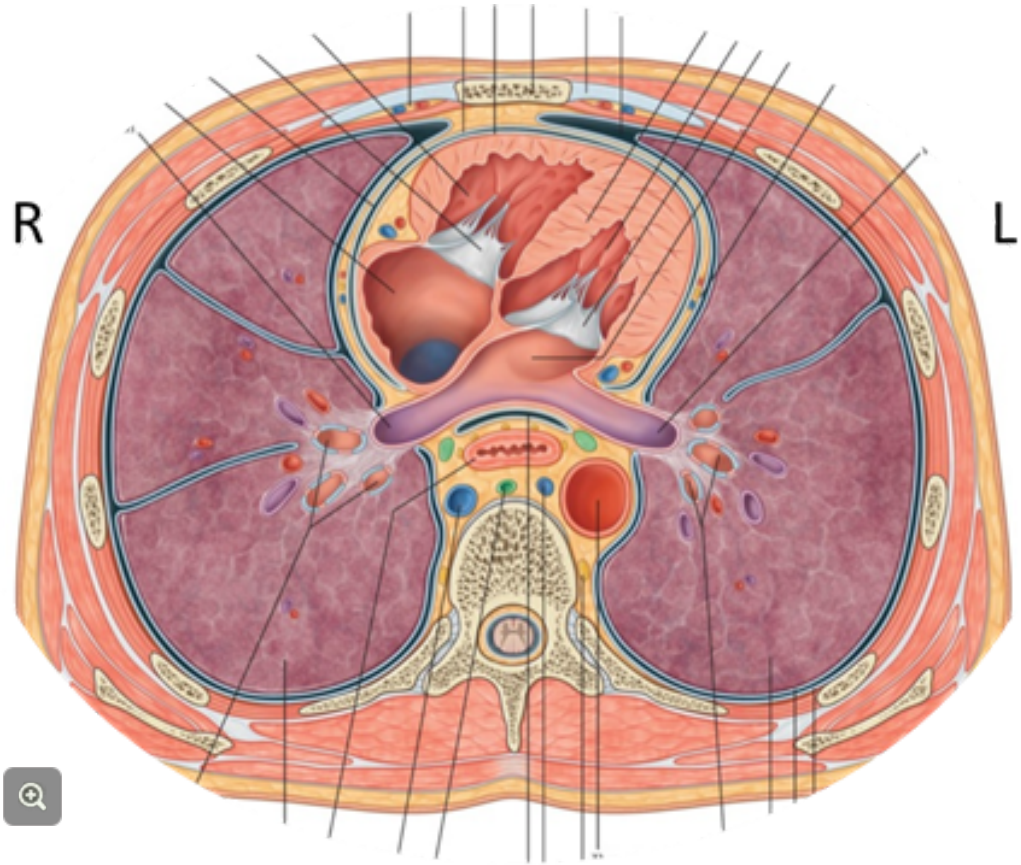
Now, I know how you're feeling right now: 

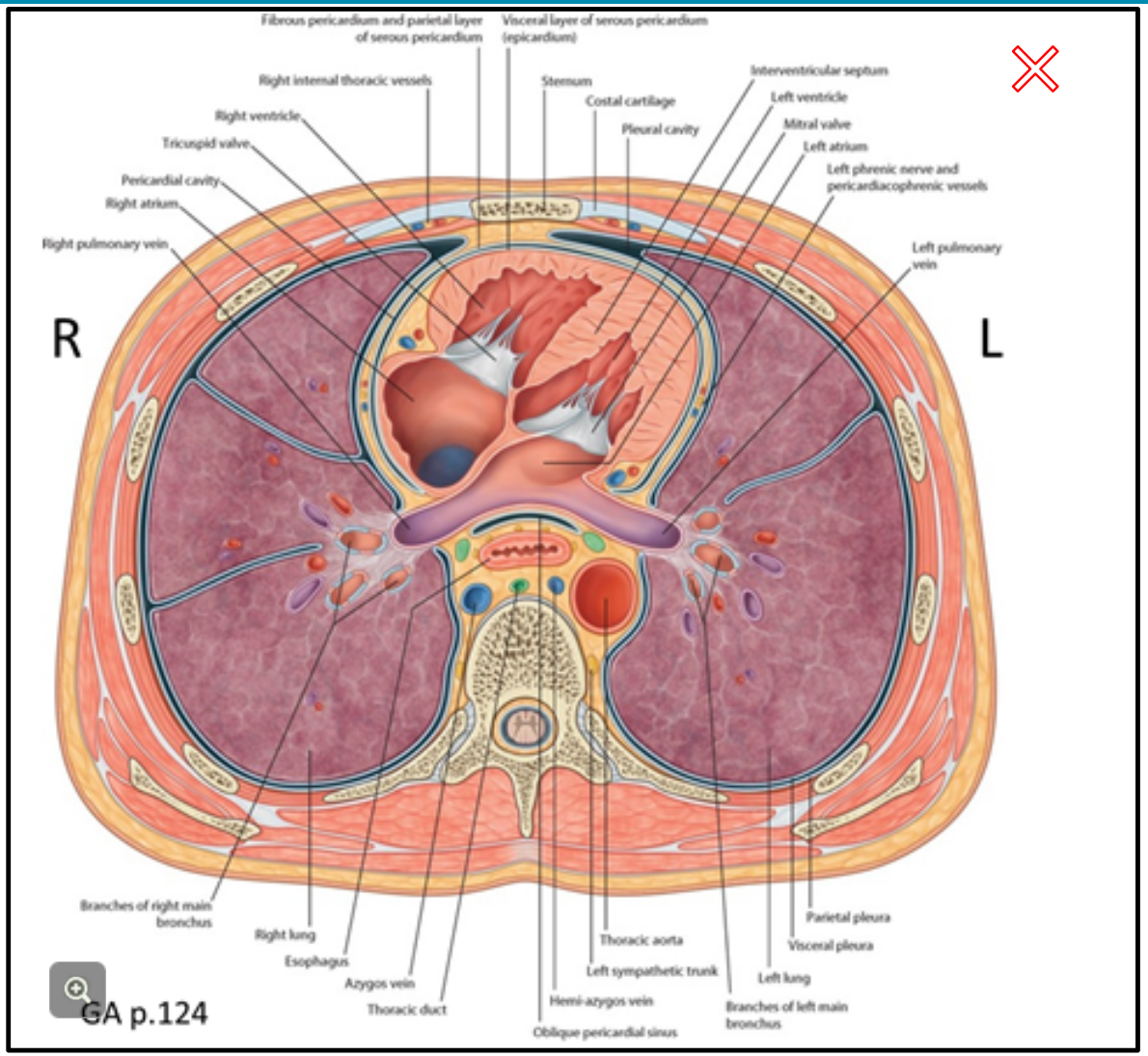
but first do your Progress Check.

Since embarking on this exercise, you have **identified** the following structures and learned the **answers to the following questions**:

- Which heart chamber is most closely associated with the esophagus?
- State four locations along its length that the esophagus is compressed by adjacent structures. Why is this of clinical importance?
- Identify the remnants of the pericardial sac on the superior surface of the diaphragm. Identify the esophagus, esophageal plexus, thoracic aorta, left and right vagus nerves. What are the anterior and posterior vagal trunks? Through which opening in the diaphragm do they pass?
- Identify the azygous, hemiazygous, accessory hemiazygous and posterior intercostal veins. Identify the thoracic duct and describe its origin and terminus. Describe its position relative to the thoracic aorta, azygous vein and esophagus. What portions of the posterior thoracic wall drain to the thoracic duct?
- Identify the thoracic aorta. At what landmarks does it begin and end? Identify the bronchial, esophageal and posterior intercostal arteries. What portion of the esophagus does the esophageal arteries supply?
- Identify the left and right sympathetic chains, the ganglia, intercostal nerves, white and grey rami communicantes and greater splanchnic nerves. Describe the sympathetic innervation of the body wall and of thoracic viscera.
- What are the greater, lesser and least splanchnic nerves? What fibre types do they contain and where are their target organs located?
- Identify the internal and innermost intercostal muscles.

If you are satisfied with your **ability to identify these structures** and **answer these questions**, call your TA over for confirmation and for **permission to move on**.


R
L


Fibrous pericardium and parietal layer of serous pericardium
Visceral layer of serous pericardium (epicardium)
Right internal thoracic vessels
Sternum
Costal cartilage
Pleural cavity
Interventricular septum
Left ventricle
Mitral valve
Left atrium
Left phrenic nerve and pericardiacophrenic vessels
Right ventricle
Tricuspid valve
Pericardial cavity
Right atrium
Right pulmonary vein
Left pulmonary vein
R
L
Branches of right main bronchus
Right lung
Esophagus
Azygos vein
Thoracic duct
Oblique pericardial sinus
Hemi-azygos vein
Thoracic aorta
Left sympathetic trunk
Parietal pleura
Visceral pleura
Left lung
Branches of left main bronchus
GA p.124

9.3 The Diaphragm and Mechanics of Respiration

What you'll need:

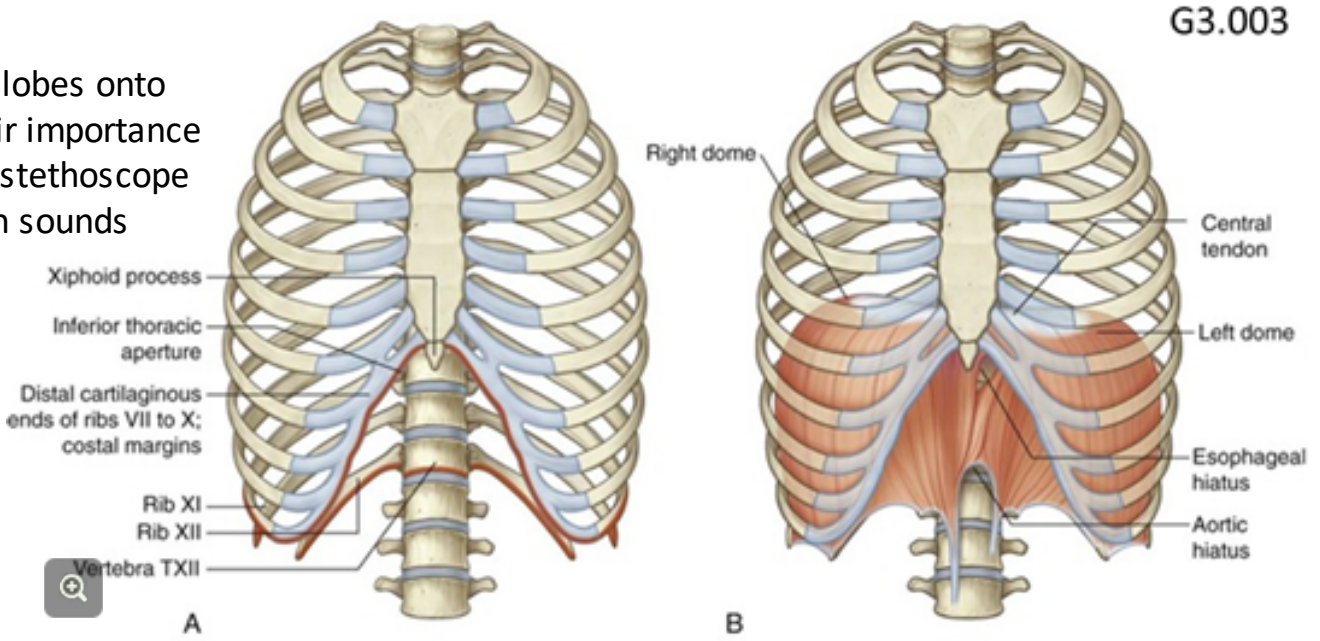
SPECIMENS

Hanging skeleton or articulated bony thorax

Cardiovascular Teaching Bin Each specimen is wrapped in a moist cloth and tied into a bag with the **CORRECT TAG ON THE BAG**. **This is how the bin must be left when you are done studying the contained specimens.**

When you have learned the material presented in this exercise, you will be able to recognize and / or describe:

- the anatomy of the diaphragm, its hiatuses, blood and nerve supply and its role in determining thoracic volume during respiratory movements.
- the role that the movement of the ribs and sternum play in determining thoracic volume during respiratory movements.
- the lines of pleural and pulmonary reflection on the body wall, their relationship to the costodiaphragmatic and costomediastinal recesses, and their importance in thoracentesis and pericardiocentesis.
- the projection of lung lobes onto the body wall and their importance in the placement of a stethoscope for listening for breath sounds



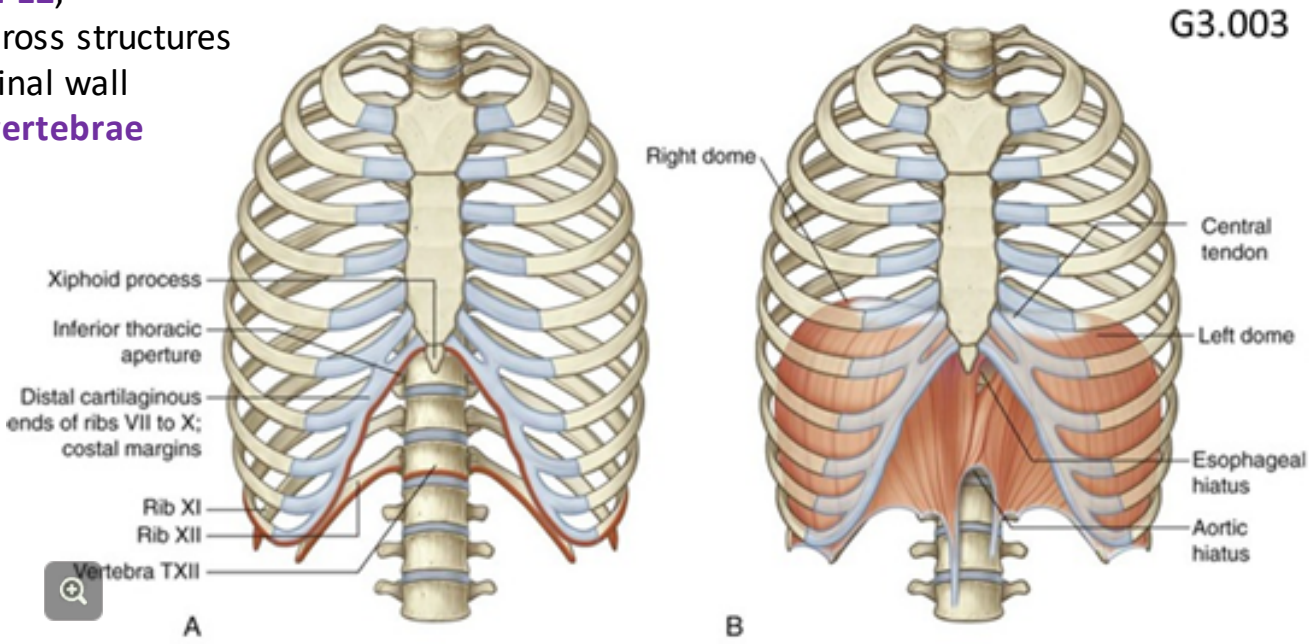
TASK

RETRIEVE the specimen marked, "diaphragm wedge" from the cardiorespiratory teaching bin. Unwrap the specimen, noting how it was wrapped and bagged so that you can re-wrap it properly when you are finished studying it.

Run your finger around the margins of the diaphragm to learn the details of its peripheral attachments to:

- the **xiphoid process** of the sternum,
- the **costal margin** of the thoracic wall,
- the ends of **ribs 11 and 12**,
- **ligaments** that span across structures of the posterior abdominal wall
- the bodies of **lumbar vertebrae**

Appreciate that the diaphragm encloses the inferior thoracic aperture and thus separates the thoracic cavity from the abdominal cavity.



TASK

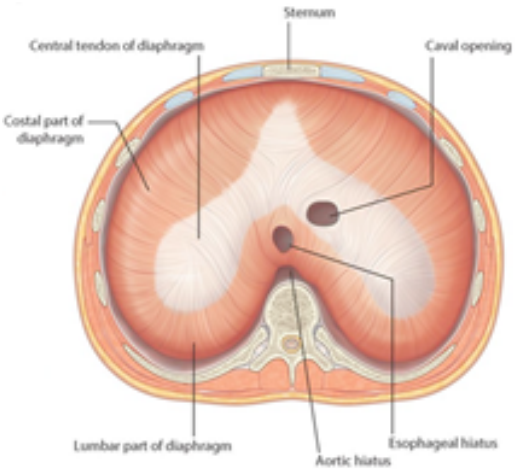
NOTE the direction of the muscle fibers

of the diaphragm; they are arranged radially, like the spokes of a bicycle wheel, and converge into a large, dense CT central tendon. The pericardial sac is attached to the superior surface of the central tendon. Look for remnants of the pericardial sac on the superior surface of the central tendon.

Observe that the posterior attachment of the diaphragm, like the posterior margin of the inferior thoracic aperture, is inferior to its anterior attachment.

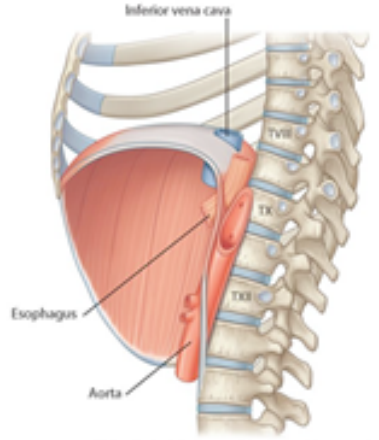
When it is relaxed, the diaphragm is not flat; rather, it domes upward; the right side is higher than the left, owing to the bulk of the liver inferior to it.

With contraction, the muscle fibres shorten, pulling the central tendon downward. As such, the diaphragm descends and flattens, increasing the volume of the thorax.



Diaphragm (superior view)

Gray's Atlas, 3e, p. 73



Major structures that pass through the diaphragm

TASK

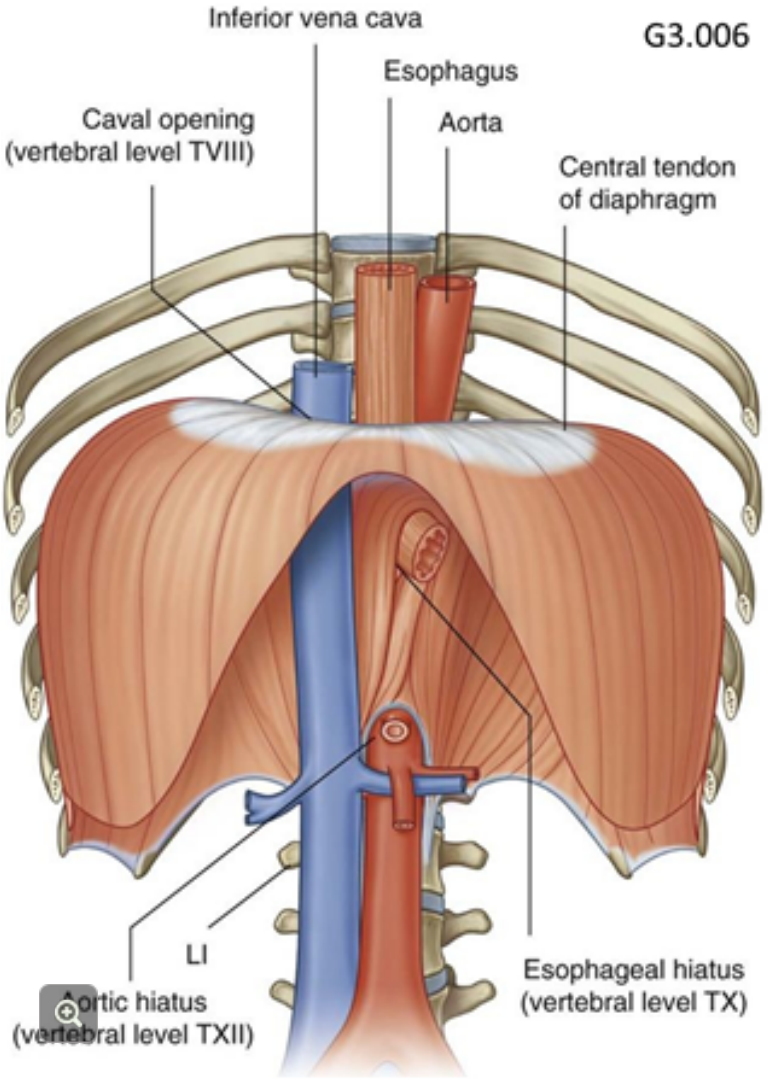
IDENTIFY the openings in the diaphragm

through which major structures pass between the thorax and the abdomen.

In the central tendon, identify the caval opening through which the IVC passes from the abdomen to the thorax, where it empties into the right atrium. It is at the level of the **T8 vertebra**.

Next, identify the esophageal hiatus, through which the esophagus passes to enter the peritoneal cavity and empty into the stomach. It is at the level of the **T10 vertebra**.

The thoracic aorta passes posterior to the diaphragm through the aortic hiatus to become the abdominal aorta. Identify the aortic hiatus. It is at the level of the **T12 vertebra.**



TASK

LOOK FOR remnants of the phrenic nerves on the superior and / or inferior

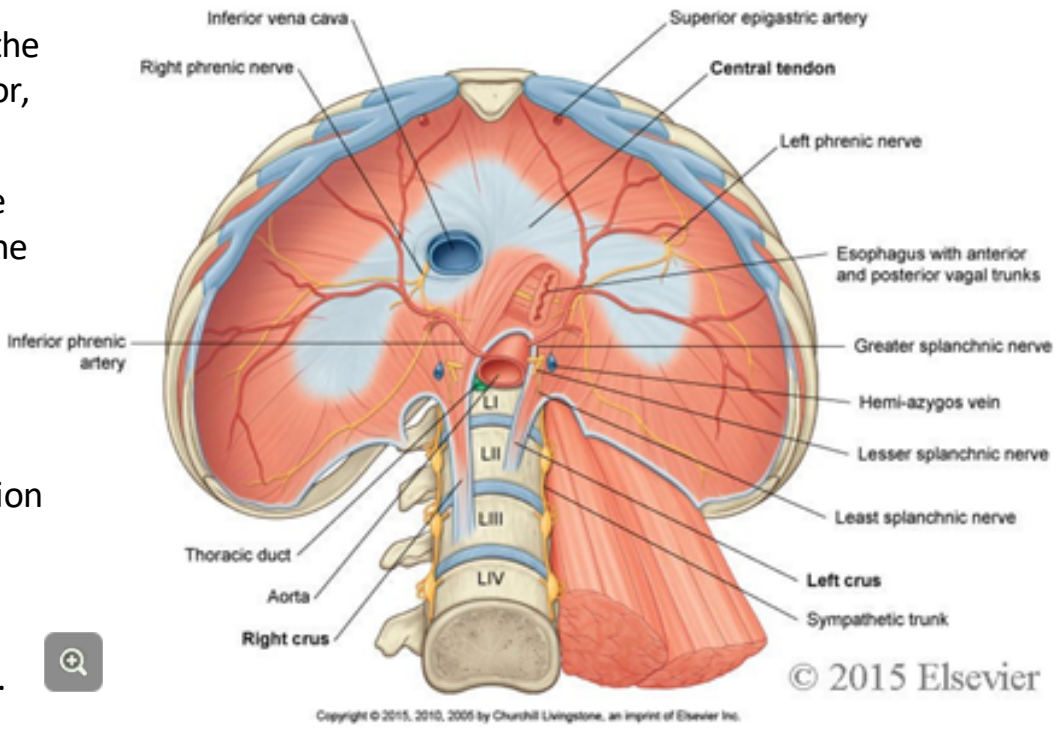
surfaces of the diaphragm. Since the central portion of each hemidiaphragm is innervated by the ipsilateral phrenic nerve, **lesion of a phrenic nerve causes paralysis of the ipsilateral hemidiaphragm**. The accompanying figure shows an inferior view of the diaphragm and its associated phrenic nerves.

Run your finger along the margin of the diaphragm, where it originates from the lower ribs and costal margin. Recall that the margins of the diaphragm are innervated by adjacent intercostal nerves.

The phrenic and intercostal nerves carry the same complement of fibres: somatic motor, sensory and sympathetic postganglionic.

Recall that nerves to the diaphragm serve its entire thickness: its skeletal muscle, the diaphragmatic parietal pleura covering of its superior surface, and the parietal peritoneum covering its inferior surface.

Note that while irritation of the **central diaphragm** refers to the **shoulder**, irritation of the **periphery** of the diaphragm is experienced in the **overlying body wall**. This is as expected, once you understand the sensory innervation of the diaphragm.

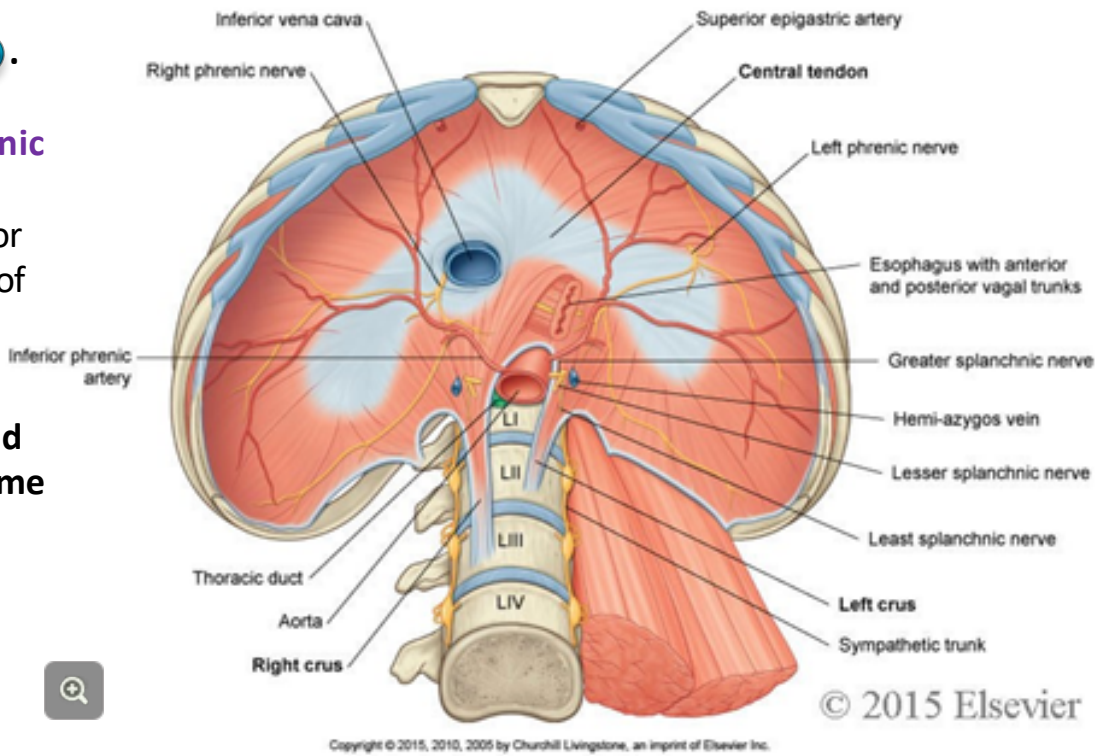


TASK

LOOK FOR remnants of the inferior phrenic arteries on the inferior surface of the diaphragm. These are the first branches of the abdominal aorta and **are the primary source of blood supply to the diaphragm**.

Look for remnants of arteries on the superior surface of the diaphragm. These are branches of the **internal thoracic arteries** (the **pericardiophrenic** or **musculophrenic** As) or of the **superior phrenic arteries**. The superior phrenic arteries are the last branches of the thoracic aorta before it passes through the aortic hiatus.

Moisten the diaphragm specimen and drape it with a damp cloth for the time being.

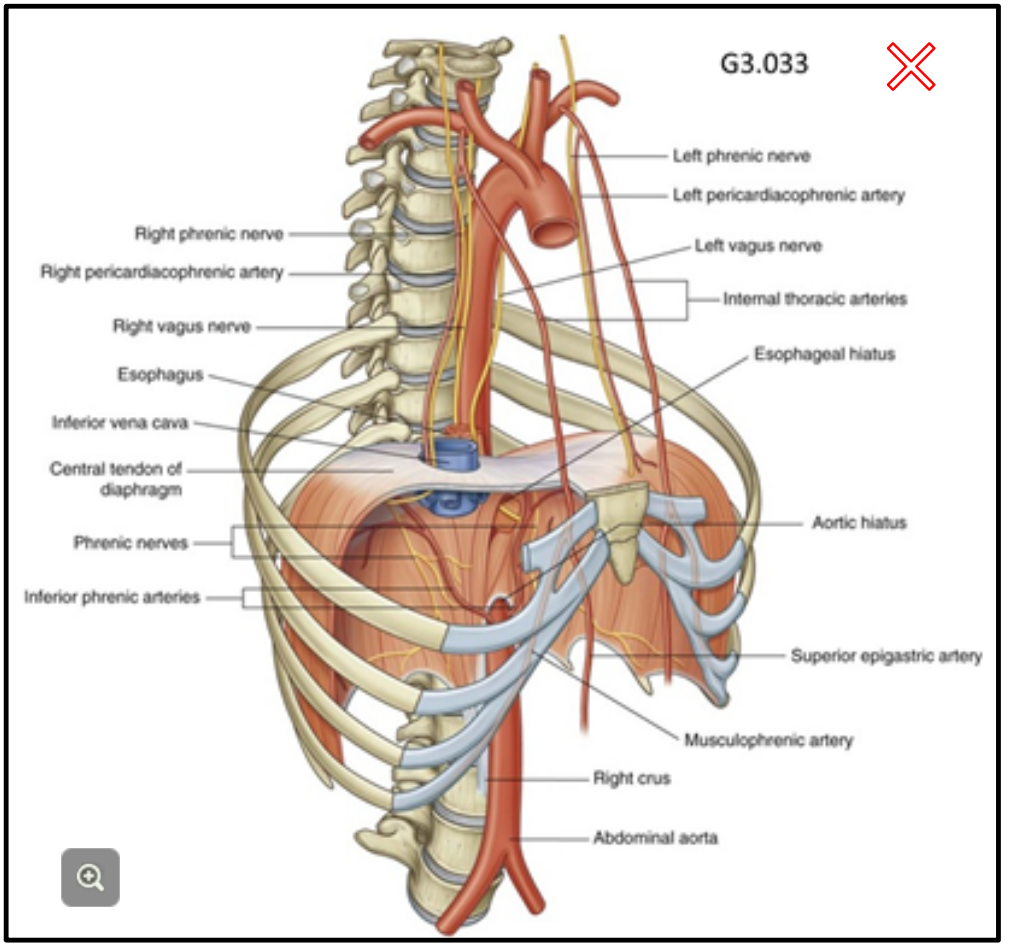


TASK

LOOK FOR remnants of the inferior phrenic arteries on the inferior surface of the diaphragm. These are the first branches of the abdominal aorta and **are the primary source of blood supply to the diaphragm**.

Look for remnants of arteries on the superior surface of the diaphragm. These are branches of the **internal thoracic arteries** (the **pericardiophrenic** or **musculophrenic** As) or of the **superior phrenic arteries**. The superior phrenic arteries are the last branches of the thoracic aorta before it passes through the aortic hiatus.

Moisten the diaphragm specimen and drape it with a damp cloth for the time being.



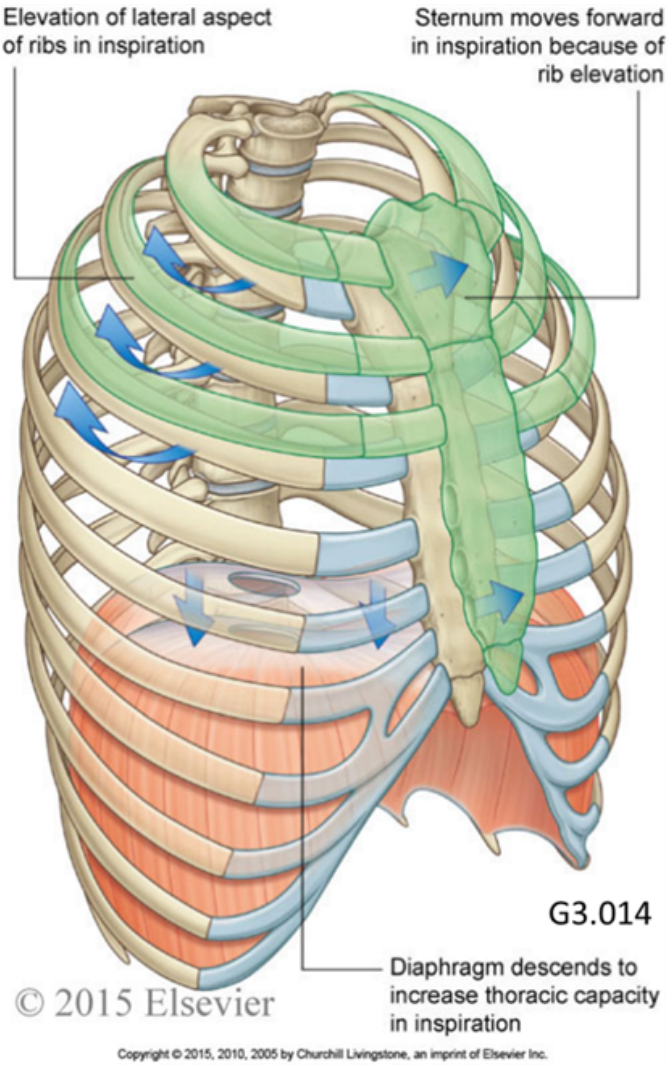
Since embarking on this exercise, you have **identified** the following structures and learned the **answers to the following questions**:

- Identify and describe the attachments of the diaphragm. Identify its central tendon. Describe how contraction of the diaphragm changes its shape and position and affects thoracic dimensions.
- Identify and state the vertebral level of the caval, esophageal and aortic hiatuses. What other structures pass through these hiatuses?
- What is the primary source of blood to the diaphragm? Describe the innervation of the diaphragm by the phrenic and intercostal nerves.

Pause here to assess your learning. Quiz each other thoroughly. If you are satisfied with your **ability to identify these structures** and **answer these questions**, move on to the next stage of the exercise.

During respiration, movement of the thoracic wall and diaphragm alters all dimensions of the thorax: **vertical, lateral** and **anteroposterior**. This changes the volume of the thorax and moves air in and out of the lungs.

You've already learned how **contraction of the diaphragm** pulls downward on its central tendon, and thus **increases the vertical dimension** of the thoracic cavity. Relaxation of the diaphragm causes it to dome upward, decreasing the vertical dimension of the thoracic cavity.



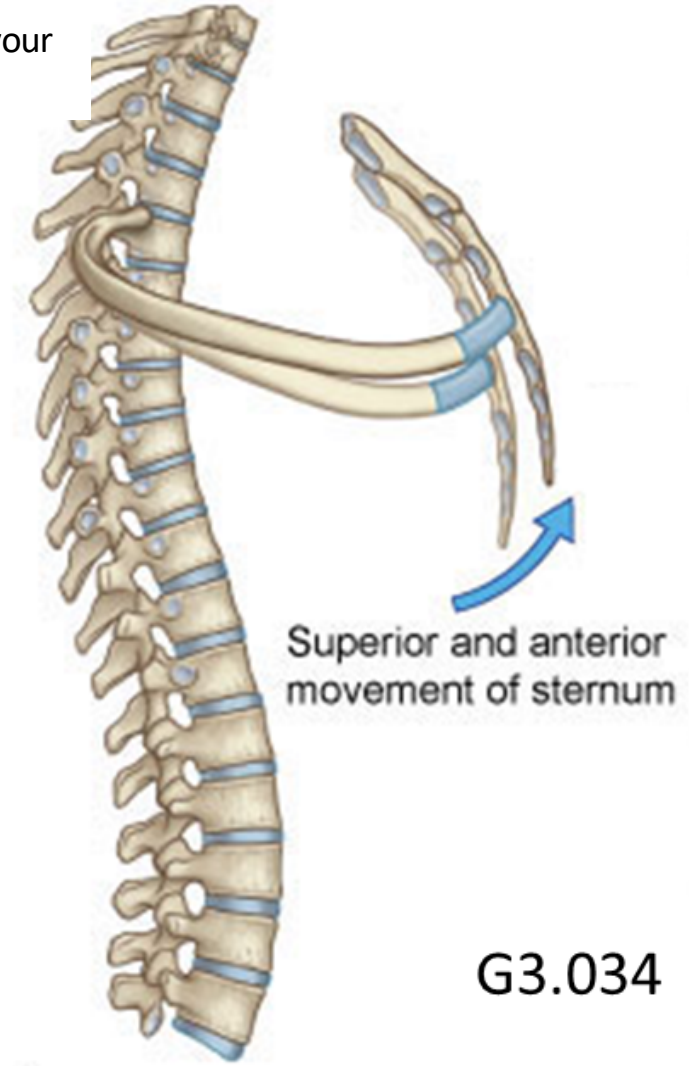
Go to either the articulated skeleton hanging in the lab, or turn your attention to the bony thorax with which you have been provided.

TASK

Notice that ribs do not run horizontally around the thorax. Notice that they run downward, such that the anterior tip of any given rib is inferior to its head, whether the rib is articulating directly or indirectly with the sternum.

Realize that, as illustrated in the accompanying diagram, any muscle that pulls up on the ribs will also pull up on the sternum, moving it upward and outward. Notice that this will increase the anteroposterior dimension of the thorax. Any muscle that pulls downward on the ribs will reverse this process, moving the sternum downward and inward.

These are the actions of the **muscles of inspiration** and **expiration**, respectively. The primary muscles of inspiration are the **external intercostal muscles**. While expiration is normally passive, it can be assisted in **forced expiration** by the **internal** and **innermost intercostal muscles**.



G3.034

TASK

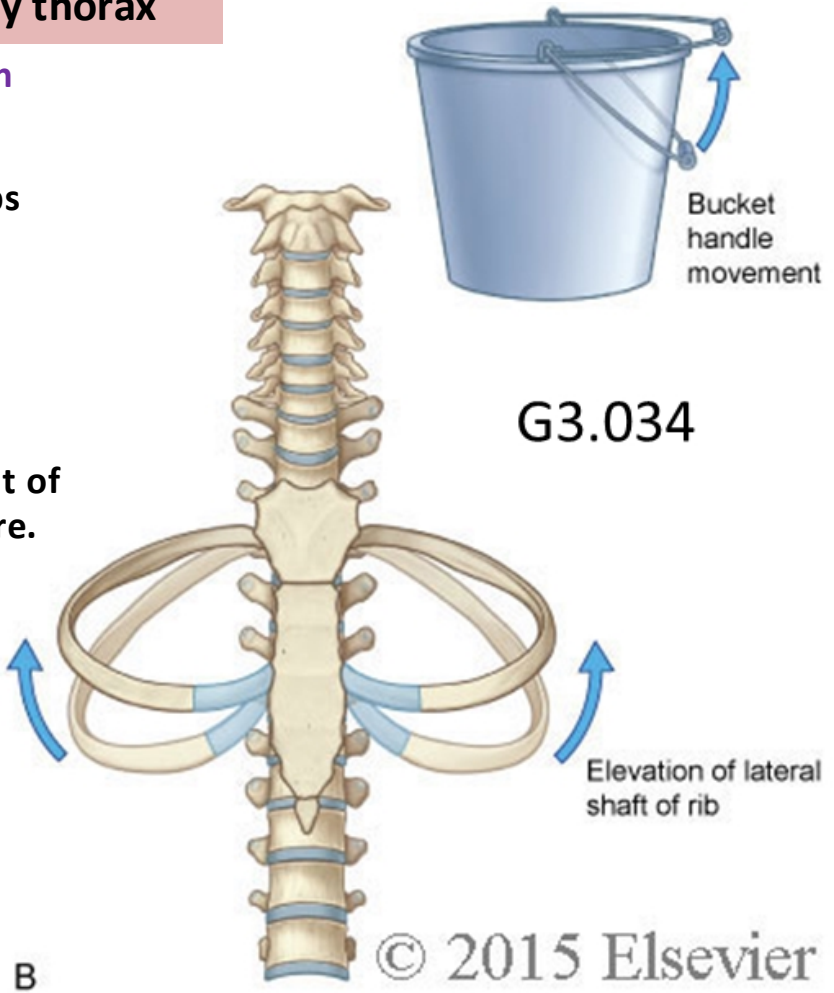
Look at a given rib in the skeleton or bony thorax

and notice that its lateral extreme is lower than either of its two ends.

Realize that any muscle that pulls upward on the ribs will increase the lateral dimension of the thorax.

Conversely, any muscle that pulls downward on the ribs will reverse this process, decreasing the lateral dimension of the thorax.

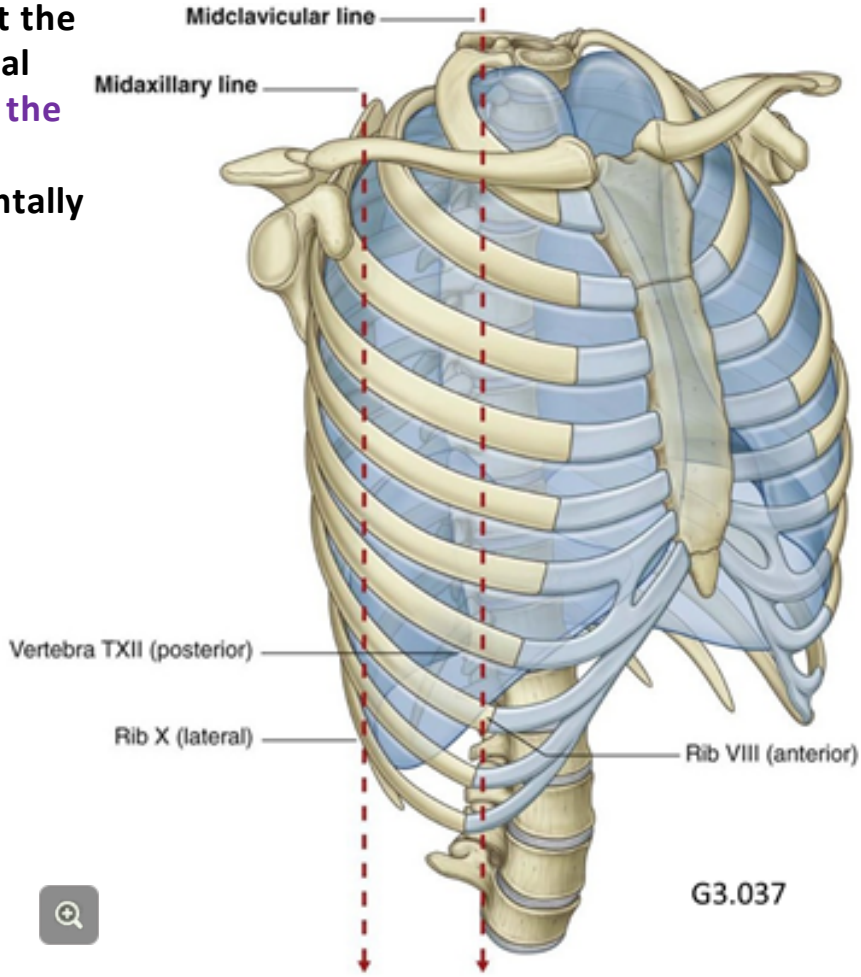
The analogy often used is to compare this movement of the ribs to that of a bucket handle, as illustrated here.



TASK

With reference to the bony thorax,

and as illustrated here, note that the costodiaphragmatic line of pleural reflection crosses the 8th rib in the midclavicular line, the 10th rib in the midaxillary line, and then runs horizontally across the back at the level of the 12th vertebral body.



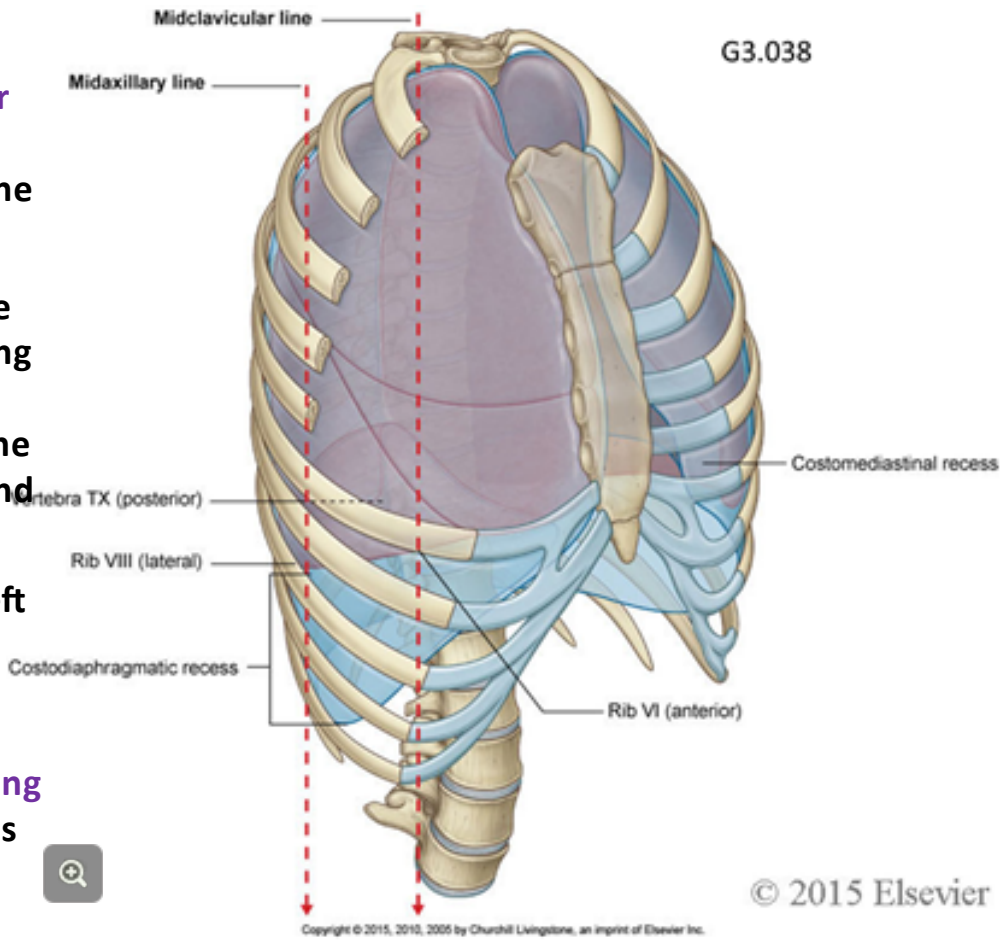
TASK

With reference to the bony thorax,

and as illustrated in this figure, note that the inferior border of the lung crosses the 6th rib in the midclavicular line, the 8th rib in the midaxillary line, and then runs horizontally across the back at the level of the 10th vertebral body.

Notice that the difference between the line of pleural reflection and the base of the lung is two ribs, and corresponds to the costodiaphragmatic recess. This provides the clinician with access to the pleural space and pleural fluid in thoracentesis.

Also notice that the cardiac notch of the left lung enlarges the costomediastinal recess over the pericardial sac. This provides the clinician with needle access to fluid in the pericardial space without threat of damaging the lungs. This is pericardiocentesis which is performed for instance in cases of cardiac tamponade.



TASK

With reference to the bony thorax,

and as illustrated in this figure, note that the inferior border of the lung crosses the 6th rib in the midclavicular line, the 8th rib in the midaxillary line, and then runs horizontally across the back at the level of the 10th vertebral body.

Notice that the difference between the line of pleural reflection and the base of the lung is two ribs, and corresponds to the costodiaphragmatic recess. This provides the clinician with access to the pleural space and pleural fluid in thoracentesis.

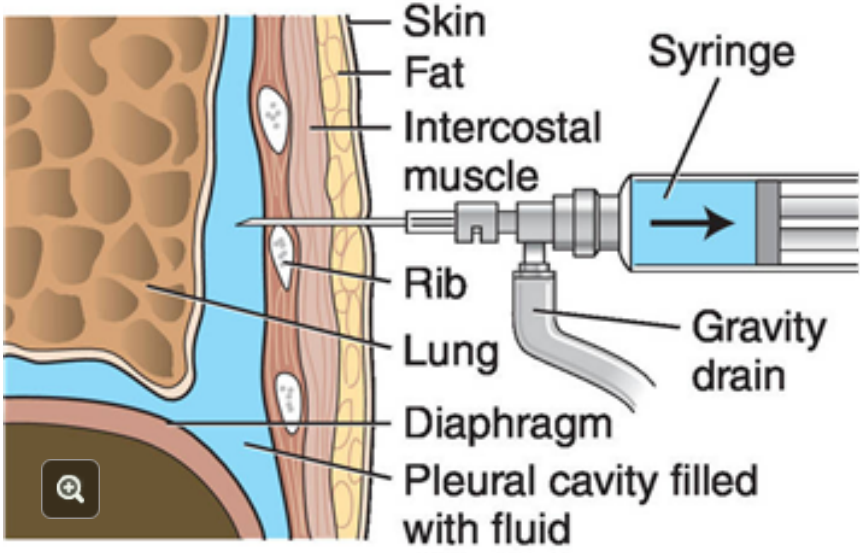
Also notice that the cardiac notch of the left lung enlarges the costomediastinal recess over the pericardial sac. This provides the clinician with needle access to fluid in the pericardial space without threat of damaging the lungs. This is pericardiocentesis which is performed for instance in cases of cardiac tamponade.

INFO

Thoracentesis

In **thoracentesis**, excess fluid is drained from the pleural space by a needle inserted above a rib.

This positioning of the needle avoids damaging the intercostal neurovascular bundle, which is located immediately inferior to the rib in the **costal groove**. For therapeutic or diagnostic purposes, thoracentesis is also known as a **pleural tap** or **chest tap**.



TASK

With reference to the bony thorax,

and as illustrated in this figure, note that the inferior border of the lung crosses the 6th rib in the midclavicular line, the 8th rib in the midaxillary line, and then runs horizontally across the back at the level of the 10th vertebral body.

Notice that the difference between the line of pleural reflection and the base of the lung is two ribs, and corresponds to the costodiaphragmatic recess. This provides the clinician with access to the pleural space and pleural fluid in thoracentesis.

Also notice that the cardiac notch of the left lung enlarges the costomediastinal recess over the pericardial sac. This provides the clinician with needle access to fluid in the pericardial space without threat of damaging the lungs. This is pericardiocentesis which is performed for instance in cases of cardiac tamponade.

INFO

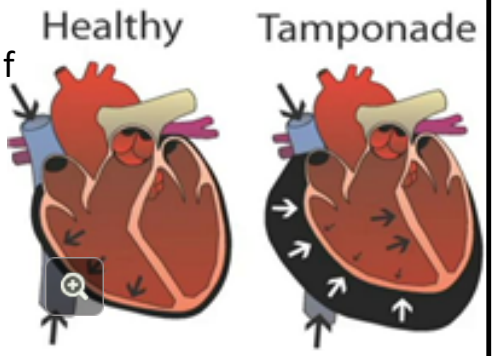
Cardiac Tamponade

Normally, the pericardial space is a **potential space**, and the visceral and parietal layers of the serous pericardium are in contact with each other.

In **cardiac tamponade**, fluid, usually blood, accumulates in the pericardial space and it becomes a "real" space. Because the fibrous pericardium is inextensible, the accumulated fluid puts pressure on the heart and prevents it from filling properly. Cardiac output falls with this decreased filling of the heart, resulting in hypotension. Cardiac tamponade may result from a stab wound to the chest or from rupture of the heart wall following acute myocardial infarction.

Cardiac tamponade is an emergent situation that, if left untreated, will result in a cardiac arrest.

In **pericardiocentesis**, a needle is used to withdraw fluid from the pericardial space.



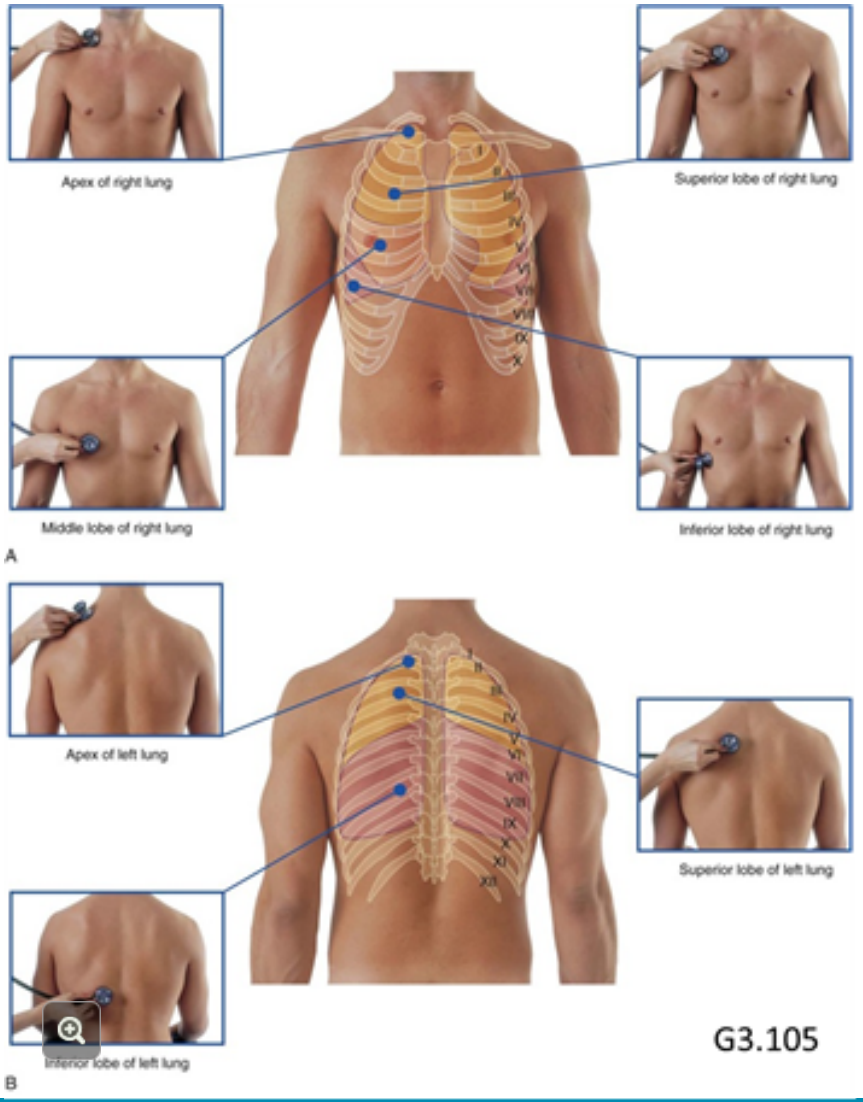
INFO

Surface Projections of the Lung Lobes and Lung Sounds

In the accompanying figures, you can see the projection of the lung lobes onto the surface features of the chest.

These relationships allow the clinician to know the correct placement of a stethoscope to hear the breath sounds in the different lung lobes.

After your pro, wrap it and put it back in the bag it came from and tie the bag with the correct tag. Place it back in the cardiopulmonary teaching bin and close the lid.



If you have time to spare after completing this exercise, study the other specimens in the cardiopulmonary teaching bin. It contains, in addition to the diaphragm wedge, the following:

- L & R lungs
- a pluck
- a closed heart with arch
- a closed heart without arch
- an open heart

Review the anatomy of the superior and middle mediastinum with the pluck.

Review the anatomy of the open and closed hearts with the relevant specimens.

Review the anatomy of the lungs.

You will see specimens such as these during the Anatomy Assessment in Week 22.

Since embarking on this exercise, you have **identified** the following structures and learned the **answers to the following questions**:

- How do the ribs and sternum move during inspiration and expiration? How does this affect the lateral and AP dimensions of the thorax?
- Name the primary muscles of inspiration and the muscles that act in forced expiration.
- Describe the surface projections of the line of pleural reflection and of the lungs. Why do they differ? What spaces intervene and what are their clinical importance?
- What are the thoracentesis, pericardiocentesis and cardiac tamponade? Describe the anatomical considerations involved in needle placement in thoracentesis and pericardiocentesis.
- Where is a stethoscope placed to listen to the lobes and apices of each lung?

If you are satisfied with your **ability to identify these structures** and **answer these questions**, call your TA over for confirmation and for **permission to move on**.

After your progress check, wrap up all wet specimens and put them back in the bag from which they came. Close the bag with the correct tag. Place it back in the cardiopulmonary teaching bin and close the lid.