ANATOMY OF THE RESPIRATORY SYSTEM

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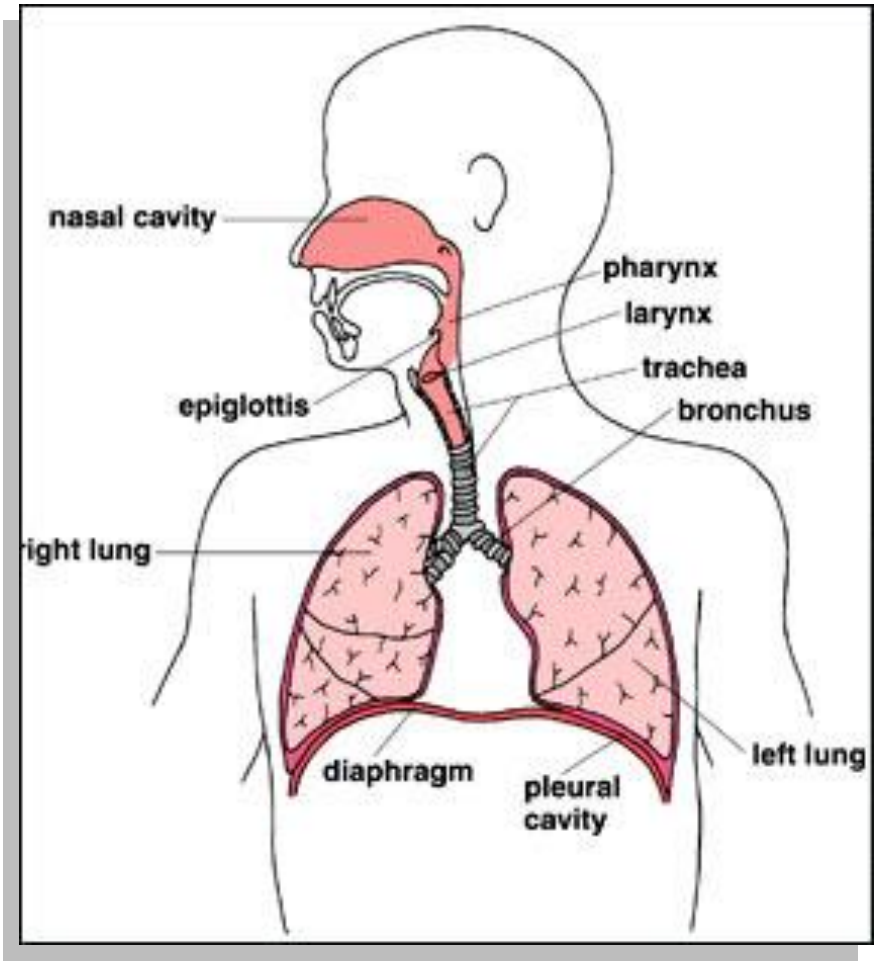

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A TOTAL 41 OF FIGURES INSERTED IN THE TEXT

DERSİ SAYFA SAYFA TÜRKÇE DİNLEYİN!

READABILITY SCORE

43 %

1. NOSE & NASAL CAVITIES

The nose is divided into two parts. External nose & Nasal cavities

1.1. EXTERNAL NOSE

The **external nose** extends the nasal cavities onto the front of the face. It has pyramidal shape. Its apex is anterior in position. The external nose has five parts. **Dorsum nasi** is formed by the superior surfaces of the right and left noses. It extends from the root of the nose superiorly, to the **apex nasi** (tip of the nose) inferiorly. The inferior aspect of the external nose is pierced by two oval apertures. They are the nares (nostrils, anterior nasal apertures). They are bounded laterally by the wings of the nose: **alae nasi.**
The **nares** are continuously open. They can be widened further by the action of the related muscles of facial expression. External nose has bony and cartilaginous parts.
The skeleton of the bone is made by bones and cartilages.
Bones contributing to the structure of the external nose:

- Nasal bones
- Frontal process of maxilla
- Nasal part of frontal bone

Cartilages contributing to the structure of the external nose:

- Greater and lesser alar cartilages (paired)
- Septal [nasal] cartilage (single)

The septal cartilage [**Cartilago septi nasi]** is a T-shaped cartilage formed by two plates. The vertical plate is the cartilaginous part of septum nasi. The greater alar cartilages form the skeleton of the alae nasi.

1.2. NASAL CAVITIES

The two **nasal cavities** are the uppermost parts of the respiratory tract. They contain the olfactory receptors. The nasal cavities are separated from each other by the nasal septum in the midline. The hard palate is between the nasal cavities and the oral cavity. The nasal cavities are separated from the cranial cavity above by parts of the frontal, ethmoid, and sphenoid bones.
Lateral to the nasal cavities are the orbits. Posteriorly, each nasal cavity communicates with the nasopharynx via two openings. They are called **choana [e]**.
Each nasal cavity consists of three general regions.
1) Nasal vestibule: is a small dilated space internal to naris. It is lined by skin and contains hair follicles.
2) Respiratory region: is the largest part of the nasal cavity. It has a rich neurovascular supply. It is lined by respiratory epithelium. It is composed mainly of ciliated and mucous cells.
3) Olfactory region: is small. It is at the apex of each nasal cavity. It is lined by olfactory epithelium. It contains the olfactory receptors.
The lateral wall of the nasal cavity is characterized by three curved shelves of bone. These projections are called conchae. They are one above the other. They project medially and inferiorly across the nasal cavity.

- Inferior nasal meatus is between the inferior concha and the nasal floor.
- Middle nasal meatus is between the inferior and middle concha.
- Superior nasal meatus is between the middle and superior concha.
- Spheno-ethmoidal recess is between the superior concha and the sphenoid bone.

These conchae increase the surface area of contact between tissues of the lateral wall and the respired air.
The openings of the paranasal sinuses are extensions of the nasal cavity. They erode into the surrounding bones during childhood and early adulthood. They are located on the lateral wall and roof of the nasal cavities.
The lateral wall also contains the opening of the nasolacrimal duct. It drains tears from the eye into the nasal cavity. It opens onto the lateral wall of the inferior nasal meatus.
The **inferior nasal concha** is the biggest of all. It starts from the posterior border of nasal vestibule. Posteriorly it ends 1 cm anterior to **choanae.**

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The middle nasal concha is a medium-sized concha. As you see the conchae get larger while going down. **Superior nasal concha:** is the smallest one. The superior nasal meatus lies under this concha. Posterior ethmoid air cells open here. The opening between the superior nasal concha and sphenoidal body is the spheno-ethmoidal recess [Recessus sphenoethmoidalis (1) (2)]. Sphenoidal sinus drains here.

NASAL SEPTUM

Medial wall of the nasal cavity is formed by the **nasal septum**.

1.3. FUNCTIONS OF THE NOSE AND THE NASAL CAVITIES

1) Olfaction (sense of smell)
2) Respiration
3) Filtration of the dust in the inspired air
4) Humidification and warming of the inspired air (cooling the internal carotid artery for brain)
5) Reception of the secretions from the paranasal sinuses and nasolacrimal ducts

2. PARANASAL SINUSES

Paranasal sinuses are air filled spaces lying within the bones around the nasal cavity. The paranasal sinuses develop as outgrowths from the nasal cavities and erode into the surrounding bones. All are:

- lined by respiratory mucosa.
- open into the nasal cavities.
- innervated by branches of the trigeminal nerve [V].

Sinuses are named according to the bones they are located in.

2.1. FRONTAL SINUS

The frontal sinuses are one on each side. They are variable in size. The frontal sinuses are the most superior of the sinuses. The frontal sinus lies within the inner and outer plates of the frontal bone.
Each frontal sinus drains onto the lateral wall of the middle meatus.

2.2. ETHMOID SINUSES

Several ethmoid air cells (3-15) collectively are called the ethmoid sinuses.
Ethmoid air cells form three groups:
Anterior group ------opens into the middle meatus
Middle group --------opens into the middle meatus
Posterior group --------opens into the superior meatus

2.3. SPHENOID SINUS

The sphenoid sinus is situated within the body of the sphenoid bone. Sinuses of each side are seperated by a bony septum. The only paranasal sinus that does not drain onto the lateral wall of the nasal cavity is the sphenoidal sinus. It usually opens onto the sloping posterior roof of the nasal cavity.

2.4. MAXILLARY SINUS (CAVUM HIGMORE)

The maxillary sinuses are one on each side. The maxillary sinuses are the largest of the paranasal sinuses. They completely fill the bodies of the maxillae. Each is pyramidal in shape. The apex is directed laterally. The base is deep to the lateral wall of the adjacent nasal cavity. It drains into middle nasal meatus.
The air respired in travels from the nasal cavities into the nasopharynx (nasal part of the pharynx) then into the laryngeal cavity. The nasopharynx will be covered in the digestive system under “pharynx”.

3. LARYNX

Larnynx is the organ of phonation (vocalization). It is formed of cartilage, muscles and connective tissue. The cavity of the larynx is continuous below with the trachea. Superiorly it opens into the pharynx immediately posterior and slightly inferior to the tongue. The larynx lies between the C3-C6 vertebrae.

3.1. CARTILAGES OF THE LARYNX

Skeleton of larynx is formed of 3 unpaired and 3 paired cartilages.

Unpaired cartilages
- Thyroid cartilage (biggest)
- Cricoid cartilage
- Epiglottic cartilage

Paired cartilages
- Arytenoid
- Corniculate
- Cuneiform

LARYNX KIKIRDAKLARI LAB-VIDEO

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Thyroid cartilage is the largest cartilage of the larynx. It is formed of two laminae. They fuse anteriorly at the **thyroid angle.** They form the **laryngeal prominence** (**Adam's apple**). The angle between the two laminae is more acute in men (90°) than in women (120°). As a result, the laryngeal prominence is more apparent in men than women.

Cricoid cartilage is a ring shaped cartilage.

Arytenoid cartilages are pyramidal in shape. An arytenoid cartilage has three processes:

- Apex is the superior process.
- Vocal process is the anterior one. The vocal ligament attaches here.
- Muscular processes lie laterally.

The anterolateral surface has two depressions. They are separated by a ridge, for muscle (vocalis) and ligament (vestibular ligament) attachment. The anterior angle of the base is elongated into a **vocal process.** The vocal ligament is attached here.

Epiglottic cartilage (**Epiglottis**) is a leaf-shaped cartilage. It is attached by its stem to the posterior aspect of the thyroid cartilage at the angle. It projects posterosuperiorly over the thyroid cartilage.

Corniculate and cuneiform cartilages are two small conical cartilages. Their bases articulate with the apices of the arytenoid cartilages. The **cuneiform cartilages** are small cartilages. They lie anterior to the corniculate cartilages. They are suspended in the part of the fibro-elastic membrane of the larynx.

3.2. LIGAMENTS OF THE LARYNX

3.2.1. Extrinsic ligaments

Thyrohyoid membrane, hyo-epiglottic ligament and cricotracheal ligament. These extrinsic ligaments are formed by connective tissue. They lie between the thyroid cartilage and hyoid bone, hyoid bone and epiglottic cartilage, and cricoid cartilage and trachea, respectively.

3.2.2. Intrinsic ligaments- Fibroelastic membrane of the larynx

The fibroeleastic membrane of the larynx lies under the mucosa of the larynx. It links the laryngeal cartilages together. It completes the architectural framework of the laryngeal cavity. It has thickenings at certain regions. By this way it forms some of the ligaments between the cartilages.

The fibroeleastic membrane of the larynx is composed of two parts. These parts are; a lower **conus elasticus** and an upper **quadrangular membrane**.

Conus elesticus **(cricothyroid ligament, cricovocal membrane, cricothyroid membrane):** Its free upper margin thickens to form the **vocal ligament**. This ligament is covered by mucosa to form the **vocal fold**. The opening between the two vocal folds is called **rima glottidis**. Each vocal ligament starts anteriorly. It attaches to the anterior part of the inner surface of the thyroid cartilage (thyroid angle). Posteriorly they individually attach to the vocal processes of the arytenoid cartilages.

Rima glottis widens during inspiration. The two vocal folds are approximated during phonation. Various changes of the vocal folds determine the color, pitch and the tones of sound. Pitch increases with tensing, decreases by relaxation. Intensity of expiration determines the loudness of sound.

3.3. LARYNGEAL CAVITY

The cavity of the larynx is tubular. Its architectural support is provided by the fibro-elastic membrane of the larynx and by the laryngeal cartilages to which it is attached.

The superior aperture of the cavity (**laryngeal inlet**) opens into the anterior aspect of the pharynx just below and posterior to the tongue. It is bounded by the upper border of epiglotttis, aryepiglottic folds and interarytenoid notch.

The inferior opening of the laryngeal cavity is continuous with the lumen of the trachea. It is completely encircled by the cricoid cartilage. It is horizontal in position unlike the laryngeal inlet. The laryngeal inlet is oblique and points posterosuperiorly into the pharynx. In addition, the inferior opening is continuously open. The laryngeal inlet can be closed by downward movement of the epiglottis.

Division into three major regions: Two pairs of mucosal folds, the vestibular and vocal folds, project medially from the lateral walls of the laryngeal cavity. They constrict it. They divide it into three major regions. These regions are the vestibule, a middle chamber, and the infraglottic cavity.

The **vestibule** is the upper chamber of the laryngeal cavity between the laryngeal inlet and the vestibular folds. The vestibular folds enclose the vestibular ligaments and associated soft tissues.

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The **middle part of the laryngeal cavity** is very thin. It is between the vestibular folds above and the vocal folds below.

The **infraglottic space** is the most inferior chamber of the laryngeal cavity. It is between the vocal folds and the inferior opening of the larynx.

3.4. LARNYGEAL MUSCLES

The laryngeal muscles are divided into extrinsic and intrinsic groups.

Extrinsic laryngeal muscles move the larynx as a whole. The infrahyoid muscles are depressors of the hyoid and larynx, whereas the suprahyoid muscles are elevators of the hyoid and larynx.

Intrinsic laryngeal muscles move the laryngeal components, altering the length and tension of the vocal folds and the size and shape of the rima glottidis. All but one of the intrinsic muscles of the larynx are supplied by the **recurrent laryngeal nerve**. It is a branch of vagus nerve (CN X). The cricothyroid is supplied by the the superior laryngeal nerve.

Adductors and abductors: These muscles move the vocal folds to open and close the rima glottidis. The principal adductors are the **lateral crico-arytenoid muscles.** They pull the vocal processes medially. When this action is combined with that of the **transverse and oblique arytenoid muscles**, which pull the arytenoid cartilages together, air pushed through the rima glottidis causes vibrations of the vocal ligaments (phonation). The sole abductors are the **posterior crico-arytenoid muscles** which rotate the vocal processes laterally and thus widening the rima glottidis.

Sphincters: The combined actions of most of the muscles of the laryngeal inlet result in a sphincteric action. They close the laryngeal inlet as a protective mechanism during swallowing. Contraction of the **lateral crico-arytenoids**, **transverse and oblique arytenoids**, and **ary-epiglottic muscles** pull the arytenoid cartilages toward the epiglottis. This action occurs reflexively in response to the presence of liquid or particles approaching or within the laryngeal vestibule. It is perhaps our strongest reflex, diminishing only after loss of consciousness, as in drowning.

Tensors: The principal tensors are the **cricothyroid muscles**, which tilt the prominence or angle of the thyroid cartilage anteriorly and inferiorly. This increases the distance between the thyroid prominence and the arytenoid cartilages. Because the anterior ends of the vocal ligaments attach to the posterior aspect of the prominence, the vocal ligaments elongate and tighten, *raising the pitch of the voice*.

Relaxers: The principal muscles in this group are the **thyro-arytenoid muscles**, which pull the arytenoid cartilages anteriorly, toward the thyroid angle (prominence), thereby relaxing the vocal ligaments to lower the pitch of the voice.

Table. Instrinsic laryngeal muscles and their main actions

Muscle	Main action(s)
Cricothyroid	Stretches and tenses vocal ligament
Thyro-arytenoid[a]	Relaxes vocal ligament
Posterior crico-arytenoid	Abducts vocal folds
Lateral cricoarytenoid	Adducts vocal folds
Transverse and oblique arytenoids[b]	Adduct arytenoid cartilages (adducting intercartilaginous portion of vocal folds, closing posterior rima glottidis)
Vocalis[c]	Relaxes posterior vocal ligament while maintaining (or increasing) tension of anterior part

[a] Superior fibers of the thyro-arytenoid muscles pass into the ary-epiglottic fold, and some of them reach the epiglottic cartilage. These fibers constitute the thyro-epiglottic muscle, which widens the laryngeal inlet.
[b] Some fibers of the oblique arytenoid muscles continue as ary-epiglottic muscles .
[c] This slender muscle slip lies medial to and is composed of fibers finer than those of the thyro-arytenoid muscle.

The vocalis muscles lie medial to the thyro-arytenoid muscles and lateral to the vocal ligaments within the vocal folds. The vocalis muscles produce minute adjustments of the vocal ligaments, selectively tensing and relaxing the anterior and posterior parts, respectively, of the vocal folds during animated speech and singing.

The (superior and inferior) laryngeal arteries, branches of the superior thyroid artery (a branch of the external carotid artery) and inferior thyroid arteries (coming from the subclavian artery) supply the larynx.

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http://www.youtube.com/yeditepeanatomy

3.5. FUNCTIONAL ANATOMY OF THE LARYNX

Respiration: During quiet respiration, the laryngeal inlet, vestibule, rima vestibuli, and rima glottidis are open. The arytenoid cartilages are abducted. The rima glottidis is triangular shaped. During forced inspiration, the arytenoid cartilages are rotated laterally. This occurs mainly by the action of the posterior crico-arytenoid muscles. As a result, the vocal folds are abducted, and the rima glottidis widens into a rhomboid shape. These effectively increase the diameter of the laryngeal airway.

Phonation: When phonating, the arytenoid cartilages and vocal folds are adducted. The air is forced through the closed rima glottidis. This action causes the vocal folds to vibrate against each other. This produces sounds. This can then be modified by the upper parts of the airway and oral cavity. Tension in the vocal folds can be adjusted by the vocalis and cricothyroid muscles.

Effort closure: Effort closure of the larynx occurs when air is retained in the thoracic cavity to stabilize the trunk. This occurs, for example during heavy lifting, or as part of the mechanism for increasing intra-abdominal pressure. During effort closure, the rima glottidis is completely closed. The rima vestibuli and lower parts of the vestibule close also. The result is to completely and forcefully shut the airway.

Swallowing: During swallowing, the rima glottidis, the rima vestibuli, and vestibule are closed and the laryngeal inlet is narrowed. In addition, the larynx moves up and forward. This action causes the epiglottis to swing downward toward the arytenoid cartilages. So it effectively narrows or closes the laryngeal inlet. The up and forward movement of the larynx also opens the esophagus. This organ is attached to the posterior aspect of the lamina of cricoid cartilage. All these actions together prevent solids and liquids from entry into the airway.

4. TRACHEA

The **trachea** extends from the inferior end of larynx to the level of superior part of T5 vertebra. It terminates by dividing into right and left main bronchi at the sternal angle (@ the manubriosternal joint). Right main bronchus is wider, shorter, runs more vertically. The main bronchi give branches inside the lungs that form the bronchial tree. Trachea is formed of tracheal rings which are incomplete posteriorly.

5. PLEURA

Each pulmonary cavity (right and left) is lined by a pleural membrane (pleura) that also reflects onto and covers the external surface of the lungs occupying the cavities. Each lung is invested by and enclosed in a serous pleural sac that consists of two continuous membranes: the visceral pleura, which invests all surfaces of the lungs forming their outer surface, and the parietal pleura, which lines the pulmonary cavities. The parietal pleaura also lines the inner surface of the thorax.

The **pleural cavity**—the potential space between the layers of pleura—contains a capillary layer of serous pleural fluid, which lubricates the pleural surfaces and allows the layers of pleura to slide smoothly over each other during respiration.

6. LUNGS

The two lungs are organs of respiration and lie on either side of the mediastinum surrounded by the right and left pleural cavities. Air enters and leaves the lungs via main bronchi, which are branches of the trachea. Their main function is to oxygenate the blood by bringing the inspired air into close relation with the venous blood in the pulmonary capillaries. *The pulmonary arteries deliver deoxygenated blood to the lungs from the right ventricle of the heart. Oxygenated blood returns to the left atrium via the pulmonary veins.*

Right lung is 2.5 cm. shorter than the left lung because of the presence of the liver. On the other hand, the right lung is wider with a much more total capacity and weight than those of the left lung.

Each lung bears the following features:

- Apex (upper pole)
- Three surfaces (costal, mediastinal and diaphragmatic).
- Root of the lung is formed by the structures entering and leaving the lung through its hilum.

- There are two lobes (superior lobe & inferior lobe) in the left lung seperated by the oblique fissure.

There are three lobes (superior lobe, middle lobe, inferior lobe) in the right lung seperated by horizontal and oblique fissures. The middle lobe is between these two fissures.

TRACHEOBRONCHIAL TREE

Beginning at the larynx, the walls of the airway are supported by horseshoe- or C-shaped rings of hyaline cartilage. The sublaryngeal airway constitutes the tracheobronchial tree. The trachea, located within the superior mediastinum, constitutes the trunk of the tree. It bifurcates at the level of the transverse thoracic plane (or sternal angle) into main (principal) bronchi, one to each lung. Each main bronchus passes inferolaterally to enter the lungs at the hila (singular = hilum). Within the lungs, the bronchi branch in a constant fashion to form the branches of the tracheobronchial tree. Each main (primary) bronchus divides into secondary (lobar) bronchi. There are two secondary bronchi on the left and three on the right. Each of them supplies a lobe of the lung. Each lobar bronchus divides into several tertiary (segmental) bronchi. They supply the bronchopulmonary segments.

The bronchopulmonary segments are:

- The largest subdivisions of a lobe.
- Pyramidal-shaped segments of the lung, with their apices facing the root of the lung.
- Supplied independently by a segmental bronchus and a tertiary branch of the pulmonary artery.
- Named according to the segmental bronchi supplying them.
- There are 10 bronchopulmonary segments in each lung. Some of them are fused in the left lung.
- Surgically resectable.

Beyond the tertiary (segmental bronchi), there are generations of branching conducting bronchioles. The conducting bronchioles eventually end as terminal bronchioles. Terminal bronchioles are the smallest conducting bronchioles. Bronchioles lack cartilage in their walls. Each terminal bronchiole gives rise to several respiratory bronchioles. They are characterized by scattered, thin-walled outpocketings (alveoli) that extend from their lumens. The pulmonary alveolus is the basic structural unit of gas exchange in the lung.

Branching of the tracheobronchial tree:

1. Trachea
2. Principal bronchus
3. Lobar bronchi (secondary bronchi)
4. Segmental bronchi (tertiary bronchi)
5. Conducting brochiole
6. Terminal bronchiole
7. Respiratory bronchiole
8. Alveolar duct
9. Alveolar sac
10. Alveolus

The mediastinal pleura reflects off the mediastinum as a tubular, sleeve-like covering for structures (i.e., airway, vessels, nerves, lymphatics) that pass between the lung and mediastinum. This sleeve-like covering, and the structures it contains, forms the **root of the lung**. The root joins the medial surface of the lung at an area referred to as the **hilum of lung**. Here, the mediastinal pleura is continuous with the visceral pleura.

VASCULATURE OF THE PLEAURA AND THE LUNGS

Each lung has a pulmonary artery (carries venous blood) and two pulmonary veins (carries arterial blood). Each lobe and segment has its own artery. Branching of the arteries follow the bronchial tree and terminate as capillaries around the alveoli. Intersegmental part of the pulmonary veins run within the septa and drain the segments. Pulmonary veins also drain the visceral pleura. Veins of the parietal pleura drain into the systemic veins mainly through the intercostal veins.

Bronchial arteries and veins make the “nutritive” vascular system of the pulmonary tissue. They supply and drain the bronchial walls and glands, walls of large vessels, and visceral pleura.

Bronchial arteries: Left bronchial arteries (from thoracic aorta) are paired and the right bronchial artery is one single artery. Parietal pleura is supplied by arteries of the thoracic wall.
Bronchial veins: drain into pulmonary veins, azygos vein on the right, or hemiazygos vein on the left.

NERVES OF THE LUNGS AND PLEURA

Lungs are innervated by pulmonary plexuses, which contain both sympathetic and parasympathetic nerves. The vagus nerve supplies parasympathetic innervation (bronchoconstrictor, vasodilator to the lung vessels, secretomotor to the glands). The sympathetic innervation comes from the sympathetic trunk (bronchodilator, vasoconstrictor to the lung vessels, inhibitor to the glands). Innervation of the parietal pleura is by intercostal and phrenic nerves.

MEDIASTINUM (Interpleaural space)

The thoracic cavity is divided into three major spaces: the central compartment or mediastinum. It houses the thoracic viscera except for the lungs and, on each side. The right and left pulmonary cavities house the lungs.
The mediastinum means middle septum. It is occupied by the mass of tissue between the two pulmonary cavities. It is the central compartment of the thoracic cavity. It is covered on each side by mediastinal pleura. Mediastinum contains all the thoracic viscera and structures except the lungs.
It extends from superior thoracic aperture superiorly. It extends to the diaphragm inferiorly. The sternum and costal cartilages lie anteriorly. The bodies of the thoracic vertebrae lie posteriorly.
The loose connective tissue and the elasticity of the lungs and parietal pleura on each side of the mediastinum enable it to accommodate movement. It also is adaptable to volume and pressure changes in the thoracic cavity. These changes result from movements of the diaphragm, thoracic wall, and tracheobronchial tree. They occur during respiration, contraction (beating) of the heart and pulsations of the great arteries. The passage of ingested substances through the esophagus also results in changes.
The mediastinum is divided into superior and inferior parts for purposes of description.
The sternal angle is the angle formed between the manubrium sterni and body of sternum at the manubriosternal joint. It is also called as the angle of Louis. It corresponds to the 2nd costal cartilage. Posteriorly it corresponds to the level of the intervertebral disc between the fourth and fifth thoracic vertebrae. By a plane between the sternal angle and this vertebral level, the mediastinum is divided into superior mediastinum and inferior mediastinum.

Superior mediastinum Superior to sternal angle

Some important structures here are; trachea, esophagus, thymus, vagus nerve, phrenic nerve and great vessels such as arch of aorta, brachiocephalic vein.

Inferior mediastinum Inferior to sternal angle

- **Anterior mediastinum** (the major structure here is part of the thymus)

–Between the anterior surface of pericardium and posterior surface of the sternum.

- **Middle mediastinum**

–Pericardium, heart and beginings of the great vessels emerging from the heart lie here.

- **Posterior mediastinum** (some important structures here; thoracic aorta, esophagus)

–Lies posterior to the pericardium and diaphragm.

Some structures, such as the esophagus, pass vertically through the mediastinum and therefore lie in more than one mediastinal compartment. The trachea is anterior to the esophagus, in the **superior mediastinum**. The thoracic duct which drains ¾ of the lymph in the body is in the superior mediastinum as well as in the posterior mediastinunm. The thoracic aorta is an important structure in this area.

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