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***FUNCTIONAL ANATOMY OF THE
RESPIRATORY SYSTEM***

***Educational and methodical textbook for students of Medical
Faculty***

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FUNCTIONAL ANATOMY OF THE RESPIRATORY SYSTEM.

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The textbook is designed for students 1 – 2 courses specialty "Medicine". In connection with reform of medicine and change of direction of preparation of doctors and increase the proportion of independent work in the structure of learning, there is a need revision of the work plan for the study of human anatomy. The modern stage professional medical training within the credit-module system characterized by a significant increase in volume, complexity and pace assimilation of educational material. As a result, the role and requirements for the quality of preparation and competent conduct of practical classes, which should meet educational and methodological requirements. The ultimate goals are the basis for building the content of the discipline and are established on the basis of the educational and professional program of preparation of the doctor by profession according to its block. Most of the terminological apparatus and methods of exposure is based on the achievements of dermatology, physiotherapy, restorative medicine, cosmetic chemistry, and in recent years and achievements orthopedics. The textbook is based on modern methodological approaches to the organization of the educational process, preparation of materials for methodological support and professional algorithms. The presented manual has a practical orientation, it is generalized experience of the teaching staff of the Department of Human Anatomy, Uzhhorod National University.

The major organs of the respiratory system function primarily to provide oxygen to body tissues for cellular respiration, remove the waste product carbon dioxide, and help to maintain acid-base balance. Portions of the respiratory system are also used for non-vital functions, such as sensing odors, speech production, and for straining, such as during childbirth or coughing (**Figure 1**). The major respiratory structures span the nasal cavity to the diaphragm.

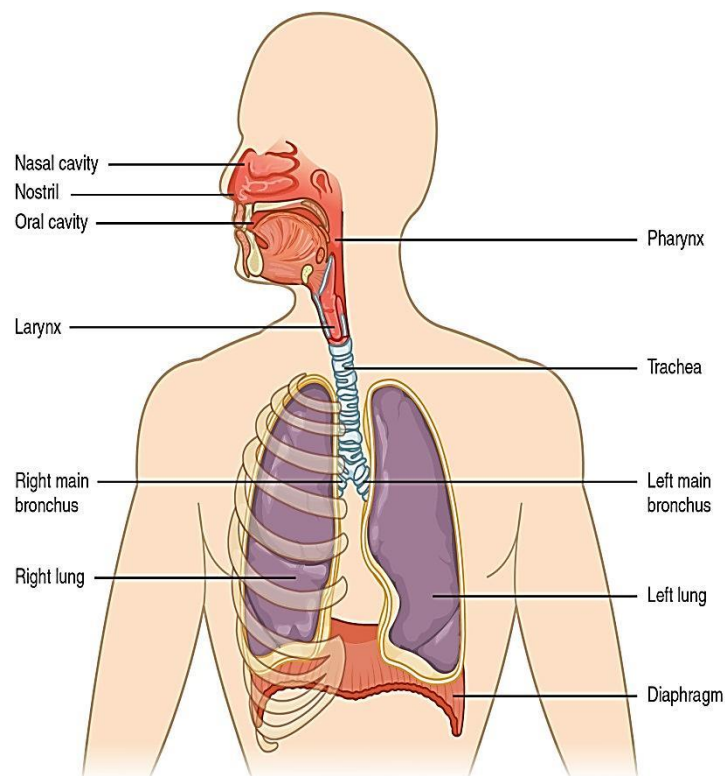


Figure 1. Major Respiratory Structures.

Functionally, the respiratory system can be divided into a conducting zone and a respiratory zone. The **conducting zone** of the respiratory system includes the organs and structures not directly involved in gas exchange. The gas exchange occurs in the **respiratory zone**.

Conducting Zone

The major functions of the conducting zone are to provide a route for incoming and outgoing air, remove debris and pathogens from the incoming air, and warm and humidify the incoming air. Several structures within the conducting zone perform other functions as well. The epithelium of the nasal passages, for example, is essential to sensing odors, and the bronchial epithelium that lines the lungs can metabolize some airborne carcinogens.

The Nose and its Adjacent Structures

The major entrance and exit for the respiratory system is through the nose. When discussing the nose, it is helpful to divide it into two major sections: the external nose, *nasus externus* and the *nasal cavity* or internal nose.

The **external nose** consists of the surface and skeletal structures that result in the outward appearance of the nose and contribute to its numerous functions (Figure 2). The **root**, *radix nasi* is the region of the nose located between the eyebrows. The **bridge** is the part of the nose that connects the root to the rest of the nose. The **dorsum nasi** is the length of the nose. The **apex nasi** is the tip of the nose. On either side of the apex, the nostrils are formed by the *alae* (singular = ala). An **ala**, *alae nasi* is a cartilaginous structure that forms the lateral side of each *naris*, *nares* (plural = nares), or nostril opening. The **philtrum** is the concave surface that connects the apex of the nose to the upper lip.

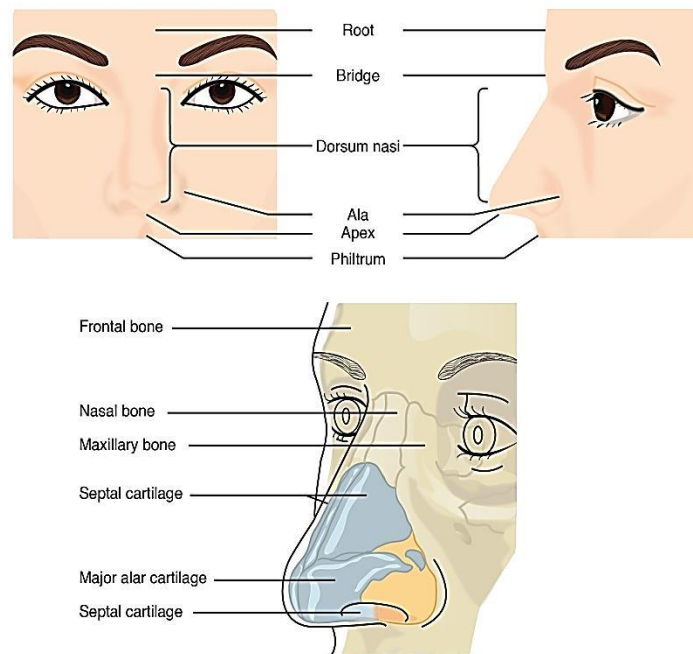


Figure 2. Nose. This illustration shows features of the external nose (top) and skeletal features of the nose (bottom).

Underneath the thin skin of the nose are its skeletal features (see Figure 2, lower illustration). While the root and bridge of the nose consist of bone, the protruding portion of the nose is composed of cartilage. As a result, when looking at a skull, the nose is missing. The **nasal bone** is one of a pair of bones that lies under the root and bridge of the nose. The nasal bone articulates superiorly with the frontal bone and laterally with the maxillary bones. Septal cartilage is flexible hyaline cartilage connected to the nasal bone, forming the dorsum nasi. The **alar cartilage** consists of the apex of the nose; it surrounds the naris.

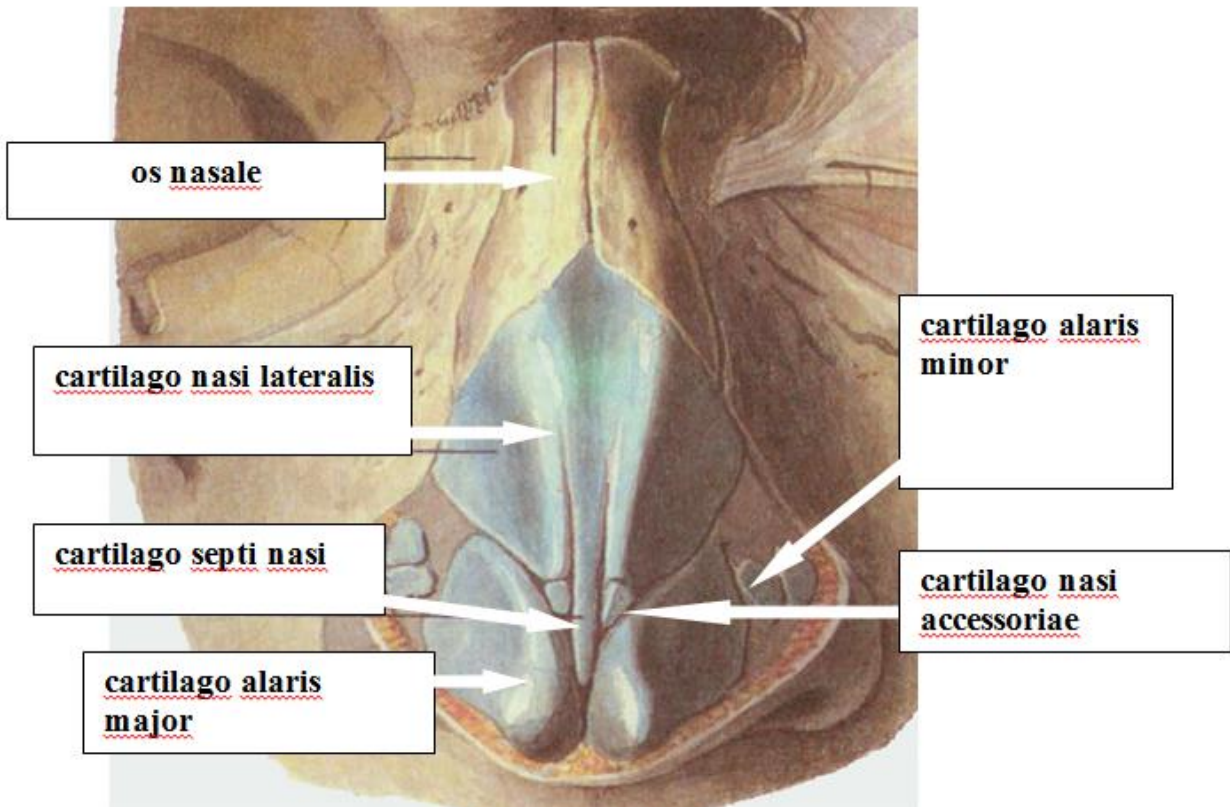


Figure 3. Nose. Cartilage

The nares open into the nasal cavity, which is separated into left and right sections by the nasal septum, *septum nasi*, and have 4 walls - *paries inferior* is formed by the *processus palatinus* os maxilla and *lamina horisontalis* os palatinum; *paries superior* - *ossa nasale* and *lamina cribrosa* of the ethmoid bone; *paries mediales* - *lamina perpendicularis* of the ethmoid bone and *vomer*; *paries lateralis* - *procesus frontalis* os maxilla, *os lacrimale*, *facies nasalis* of the body of os maxilla, *concha nasalis inferior*, *labyrinthus ethmoidalis*, *lamina perpendicularis* os palatinum and *lamina medialis procesus pterigoideus os sphenoadale*. Each lateral wall of the nasal cavity has three bony projections, called the *superior, middle, and inferior nasal conchae* (Figure 4). The inferior conchae are separate bones, whereas the superior and middle conchae are portions of the ethmoid bone. Conchae serve to increase the surface area of the nasal cavity and to disrupt the flow of air as it enters the nose, causing air to bounce along the epithelium, where it is cleaned and warmed. The *conchae* and *meatuses* also conserve water and prevent dehydration of the nasal epithelium by trapping water during exhalation. The floor of the nasal cavity is composed of the palate. The hard palate at the anterior region of the nasal cavity is composed of bone. The soft palate at the posterior portion of the nasal cavity consists of muscle tissue. Air exits the nasal cavities via the internal nares and moves into the pharynx.

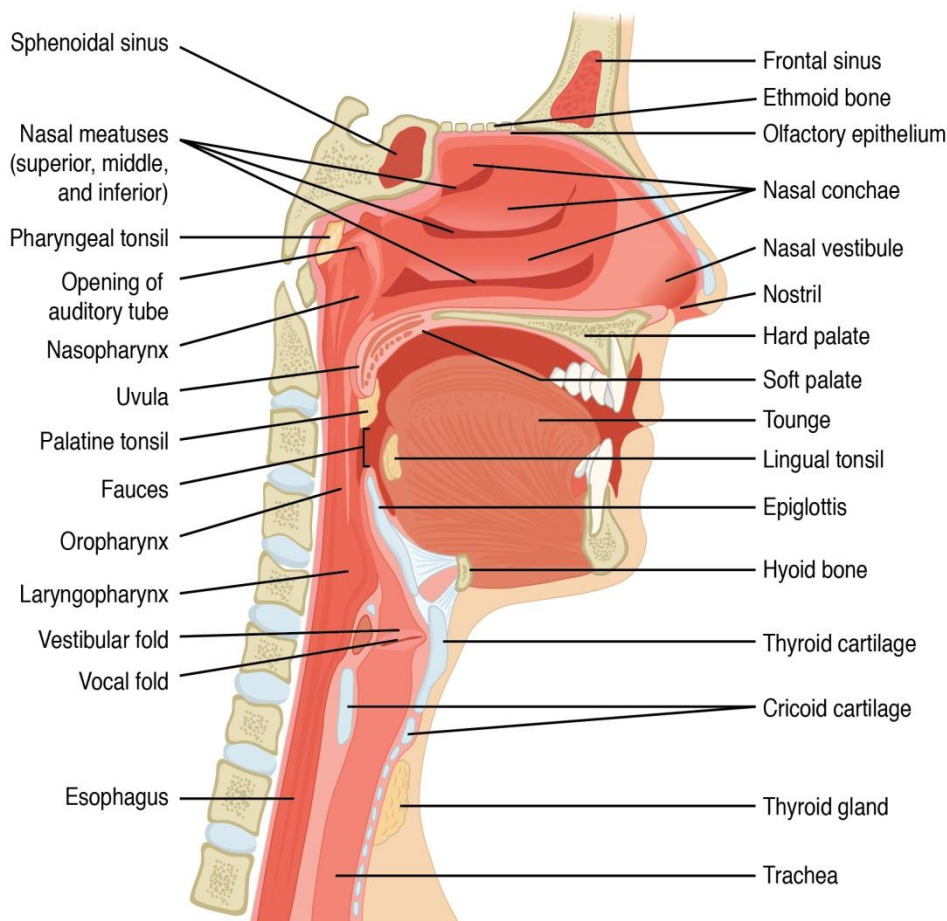


Figure 4. The nasal cavity.

Several bones that help form the walls of the nasal cavity have air-containing spaces called the *paranasal sinuses*, which serve to warm and humidify incoming air. Sinuses are lined with a mucosa. Each **paranasal sinus** is named for its associated bone: **frontal sinus**, **maxillary sinus**, **sphenoidal sinus**, and **ethmoidal sinus**. The sinuses produce mucus and lighten the weight of the skull.

The nares and anterior portion of the nasal cavities are lined with mucous membranes, containing sebaceous glands and hair follicles that serve to prevent the passage of large debris, such as dirt, through the nasal cavity. An olfactory epithelium used to detect odors is found deeper in the nasal cavity.

The conchae, meatuses, and paranasal sinuses are lined by **respiratory epithelium** composed of pseudostratified ciliated columnar epithelium. The epithelium contains goblet cells, one of the specialized, columnar epithelial cells that produce mucus to trap debris. The cilia of the respiratory epithelium help remove the mucus and debris from the nasal cavity with a constant beating motion, sweeping materials towards the throat to be swallowed. Interestingly, cold air slows the movement of the cilia, resulting in accumulation of mucus that may in turn lead to a runny nose during cold weather. This moist epithelium functions to warm and humidify incoming air. Capillaries located just beneath the nasal epithelium warm the air by convection. Serous and mucus-producing cells also secrete the lysozyme enzyme and proteins called defensins, which have antibacterial properties. Immune

cells that patrol the connective tissue deep to the respiratory epithelium provide additional protection.

Larynx

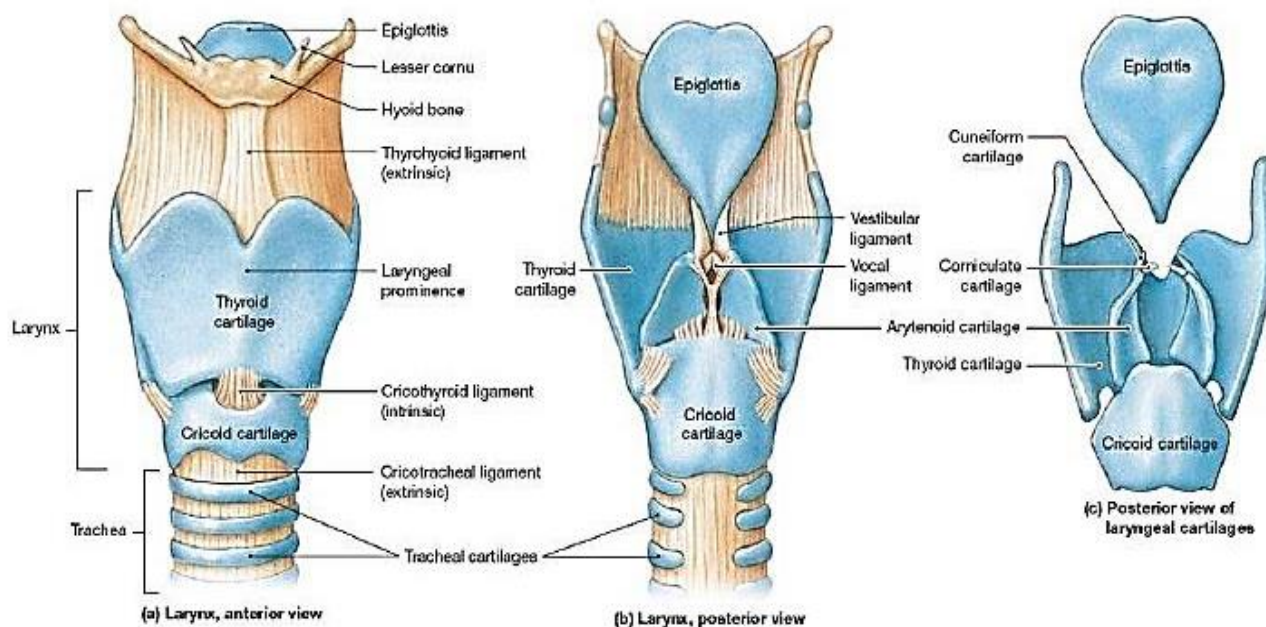


Figure 5. The cartilages of the larynx.

The larynx is located within the anterior aspect of the neck, anterior to the inferior portion of the pharynx and superior to the trachea. Its primary function is to protect the lower airway by closing abruptly upon mechanical stimulation, thereby halting respiration and preventing the entry of foreign matter into the airway. Other functions of the larynx include the production of sound (phonation), coughing, and control of ventilation, and acting as a sensory organ.

The **Cartilages of the Larynx, *cartilagine laryngis*** (Fig.5). The larynx is composed of 3 large, unpaired cartilages - cricoid, thyroid, epiglottis; and 3 pairs of smaller paired cartilages - arytenoids, corniculate, cuneiform. (Fig.6). The hyoid bone, while technically not part of the larynx, provides muscular attachments from above that aid in laryngeal motion.

The **Thyroid Cartilage, *cartilago thyreoidea***, - is the largest cartilage of the larynx. It consists of two laminae the anterior borders of which are fused with each other at an acute angle in the middle line of the neck, and form a subcutaneous projection named the **laryngeal prominence (*pomum Adami*)**. This prominence is most distinct at its upper part, and is larger in the male than in the female. Immediately above it the laminae are separated by a V-shaped notch, the **superior**

thyroid notch. The laminæ are irregularly quadrilateral in shape, and their posterior angles are prolonged into processes termed the **superior** and **inferior cornua**.

The **outer surface** of each lamina presents an **oblique line** which runs downward and forward from the superior thyroid tubercle situated near the root of the superior cornu, to the inferior thyroid tubercle on the lower border. This line gives attachment to the Sternothyreoides, Thyreohyoideus, and Constrictor pharyngis inferior.

The **inner surface** is smooth; above and behind, it is slightly concave and covered by mucous membrane. In front, in the angle formed by the junction of the laminæ, are attached the stem of the epiglottis, the ventricular and vocal ligaments, the Thyreoarytænoidei, Thyreoepiglottici and Vocales muscles, and the thyroepiglottic ligament.

The **upper border** is concave behind and convex in front; it gives attachment to the corresponding half of the hyothyroid membrane.

The **lower border** is concave behind, and nearly straight in front, the two parts being separated by the inferior thyroid tubercle. A small part of it in and near the middle line is connected to the cricoid cartilage by the middle cricothyroid ligament.

The **posterior border**, thick and rounded, receives the insertions of the Stylopharyngeus and Pharyngopalatinus. It ends above, in the superior cornu, and below, in the inferior cornu. The **superior cornu** is long and narrow, directed upward, backward, and medialward, and ends in a conical extremity, which gives attachment to the lateral hyothyroid ligament. The **inferior cornu** is short and thick; it is directed downward, with a slight inclination forward and medialward, and presents, on the medial side of its tip, a small oval articular facet for articulation with the side of the cricoid cartilage.

The **Cricoid Cartilage** (*cartilago cricoidea*) is smaller, but thicker and stronger than the thyroid, and forms the lower and posterior parts of the wall of the larynx. It consists of two parts: a **posterior quadrate lamina**, and a narrow **anterior arch**, one-fourth or one-fifth of the depth of the lamina.

The **lamina** (*lamina cartilaginis cricoideæ; posterior portion*) is deep and broad, and measures from above downward about 2 or 3 cm.; on its posterior surface, in the middle line, is a vertical ridge to the lower part of which are attached the longitudinal fibers of the esophagus; and on either side of this a broad depression for the Cricoarytænoideus posterior.

The **arch** (*arcus cartilaginis cricoideæ; anterior portion*) is narrow and convex, and measures vertically from 5 to 7 mm.; it affords attachment externally in front and at the sides to the Cricothyreidei, and behind, to part of the Constrictor pharyngis inferior.

On either side, at the junction of the lamina with the arch, is a small round articular surface, for articulation with the inferior cornu of the thyroid cartilage.

The **lower border** of the cricoid cartilage is horizontal, and connected to the highest ring of the trachea by the cricotracheal ligament.

The **upper border** runs obliquely upward and backward, owing to the great depth of the lamina. It gives attachment, in front, to the middle cricothyroid

ligament; at the side, to the conus elasticus and the Cricoarytænoidei laterales; behind, it presents, in the middle, a shallow notch, and on either side of this is a smooth, oval, convex surface, directed upward and lateralward, for articulation with the base of an arytenoid cartilage.

The **inner surface** of the cricoid cartilage is smooth, and lined by mucous membrane.

The **Arytenoid Cartilages**, *cartilagine arytenoideæ*, - are two in number, and situated at the upper border of the lamina of the cricoid cartilage, at the back of the larynx. Each is pyramidal in form, and has three surfaces, a base, and an apex.

The **posterior surface** is a triangular, smooth, concave, and gives attachment to the Arytænoidei obliquus and transversus.

The **antero-lateral surface** is somewhat convex and rough. On it, near the apex of the cartilage, is a rounded elevation, **colliculus**, from which a ridge **crista arcuata** curves at first backward and then downward and forward to the vocal process. The lower part of this crest intervenes between two depressions or **foveæ**, an upper, triangular, and a lower oblong in shape; the latter gives attachment to the Vocalis muscle.

The **medial surface** is narrow, smooth, and flattened, covered by mucous membrane, and forms the lateral boundary of the intercartilaginous part of the rima glottidis.

The **base** of each cartilage is broad, and on it is a concave smooth surface, for articulation with the cricoid cartilage. Its lateral angle is short, rounded, and prominent; it projects backward and lateralward, and is termed the **muscular process**; it gives insertion to the Cricoarytænoideus posterior behind, and to the Cricoarytænoideus lateralis in front. Its anterior angle, also prominent, but more pointed, projects horizontally forward; it gives attachment to the vocal ligament, and is called the **vocal process**.

The **apex** of each cartilage is pointed, curved backward and medialward, and surmounted by a small conical, cartilaginous nodule, the **corniculate cartilage**.

The **Corniculate Cartilages**, *cartilagine corniculatæ; cartilages of Santorini*, - are two small conical nodules consisting of yellow elastic cartilage, which articulate with the summits of the arytenoid cartilages and serve to prolong them backward and medialward. They are situated in the posterior parts of the aryepiglottic folds of mucous membrane, and are sometimes fused with the arytenoid cartilages.

The **Cuneiform Cartilages**, *cartilagine cuneiformes; cartilages of Wrisberg*, - are two small, elongated pieces of yellow elastic cartilage, placed one on either side, in the aryepiglottic fold, where they give rise to small whitish elevations on the surface of the mucous membrane, just in front of the arytenoid cartilages.

CARTILAGES

Paired

- Arytenoid
- Corniculate
- Cuneiform
- Cartilago triticea

Unpaired

- Thyroid
- Cricoid
- Epiglottis

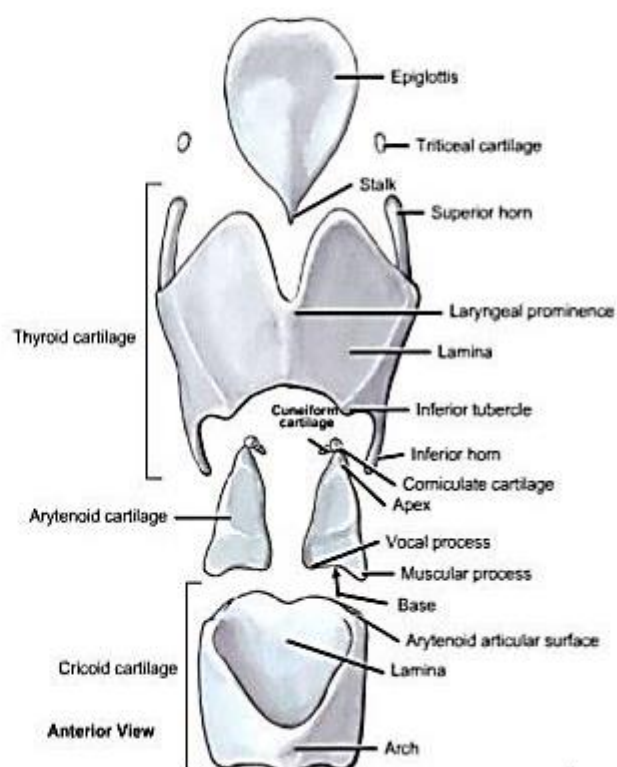


Figure 6. The cartilages of the larynx.

The **Epiglottis**, *cartilago epiglottica*, - is a thin lamella of fibrocartilage of a yellowish color, shaped like a leaf, and projecting obliquely upward behind the root of the tongue, in front of the entrance to the larynx(Fig.6). The free extremity is broad and rounded; the attached part or stem is long, narrow, and connected by the **thyroepiglottic ligament** to the angle formed by the two laminae of the thyroid cartilage, a short distance below the superior thyroid notch. The lower part of its anterior surface is connected to the upper border of the body of the hyoid bone by an elastic ligamentous band, the **hyoepiglottic ligament**.

The **anterior** or **lingual surface** is curved forward, and covered on its upper, free part by mucous membrane which is reflected on to the sides and root of the tongue, forming a median and two lateral **glossoepiglottic folds**; the lateral folds are partly attached to the wall of the pharynx. The depressions between the epiglottis and the root of the tongue, on either side of the median fold, are named the **valleculæ**. The lower part of the anterior surface lies behind the hyoid bone, the thyrohyoid membrane, and upper part of the thyroid cartilage, but is separated from these structures by a mass of fatty tissue.

The **posterior** or **laryngeal surface** is smooth, concave from side to side, concavo-convex from above downward; its lower part projects backward as an elevation, the **tubercle** or **cushion**. When the mucous membrane is removed, the surface of the cartilage is seen to be indented by a number of small pits, in which mucous glands are lodged. To its sides the aryepiglottic folds are attached.

Ligaments

The ligaments of the larynx (Fig.7) are **extrinsic**, *i. e.*, those connecting the thyroid cartilage and epiglottis with the hyoid bone, and the cricoid cartilage with the trachea; and **intrinsic**(Fig.7), those which connect the several cartilages of the larynx to each other.

Extrinsic Ligaments. The ligaments connecting the thyroid cartilage with the hyoid bone are the thyrohyoid membrane, and a middle and two lateral thyrohyoid ligaments.

EXTRINSIC

- Thyrohyoid
- Cricothyroid
- Cricotracheal

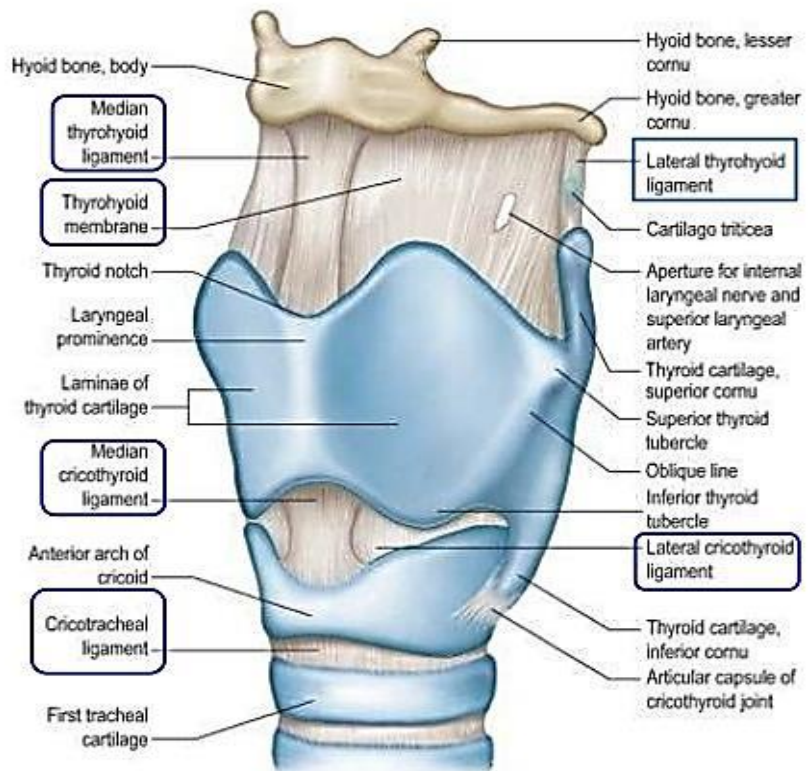
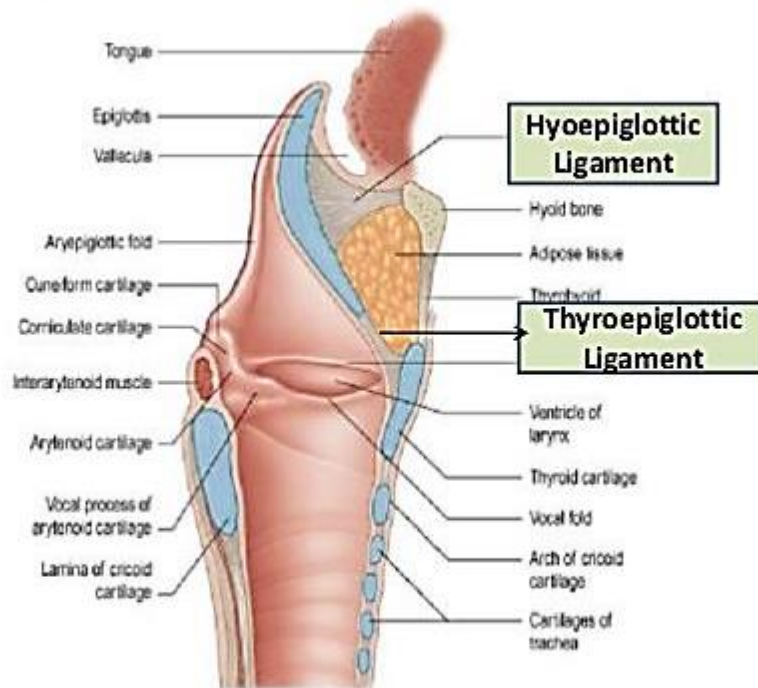


Figure 7. Ligaments of the larynx.

EXTRINSIC



Sagittal section showing interior of left half of larynx

Figure 8. Ligaments of the larynx.

The **Hyothyroid Membrane**, *membrana hyothyroidea*; *thyrohyoid membrane*, - is a broad, fibro-elastic layer, attached below to the upper border of the thyroid cartilage and to the front of its superior cornu, and above to the upper margin of the posterior surface of the body and greater cornua of the hyoid bone, thus passing behind the posterior surface of the body of the hyoid, and being separated from it by a mucous bursa, which facilitates the upward movement of the larynx during deglutition. Its middle thicker part is termed the **middle hyothyroid ligament**, *ligamentum hyothyroideum medium*; *middle thyrohyoid ligament*, its lateral thinner portions are pierced by the superior laryngeal vessels and the internal branch of the superior laryngeal nerve. Its anterior surface is in relation with the Thyrohyoideus, Sternohyoideus, and Omohyoideus, and with the body of the hyoid bone.

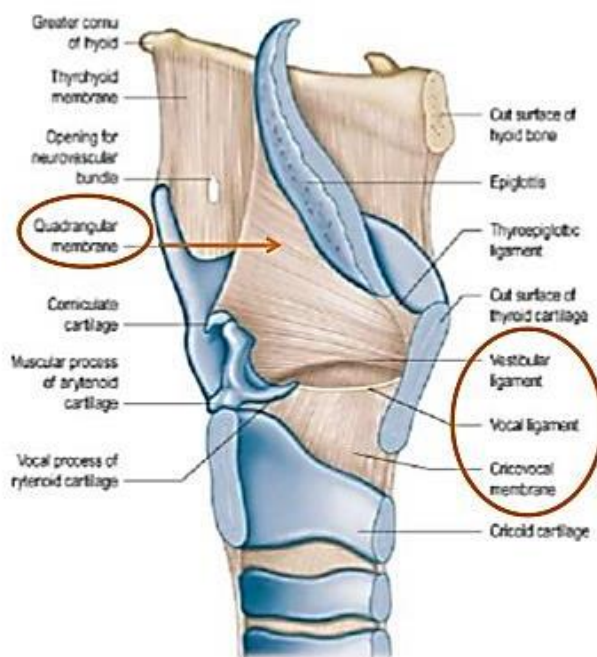
The **Lateral Hyothyroid Ligament**, *ligamentum hyothyroideum laterale*; *lateral thyrohyoid ligament*, - is a round elastic cord, which forms the posterior border of the hyothyroid membrane and passes between the tip of the superior cornu of the thyroid cartilage and the extremity of the greater cornu of the hyoid bone. A small cartilaginous nodule *cartilago triticea*, sometimes bony, is frequently found in it.

The **Epiglottis** is connected with the hyoid bone by an elastic band, the **hyoepiglottic ligament**, *ligamentum hyoepiglotticum*, which extends from the anterior surface of the epiglottis to the upper border of the body of the hyoid bone.

The **Cricotracheal Ligament**, *ligamentum cricotracheale*, - connects the cricoid cartilage with the first ring of the trachea. It resembles the fibrous membrane which connects the cartilaginous rings of the trachea to each other.

Intrinsic Ligaments. Beneath the mucous membrane of the larynx is a broad sheet of fibrous tissue containing many elastic fibers, and termed the **elastic membrane of the larynx** (Fig.7). It is subdivided on either side by the interval between the ventricular and vocal ligaments, the upper portion extends between the arytenoid cartilage and the epiglottis and is often poorly defined; the lower part is a well-marked membrane forming, with its fellow of the opposite side, the conus elasticus which connects the thyroid, cricoid, and arytenoid cartilages to one another. In addition the joints between the individual cartilages are provided with ligaments.

INTRINSIC



Sagittal section of left side of larynx showing laryngeal membranes

Figure 9. Ligaments of the larynx.

The **Conus Elasticus**, *cricothyroid membrane*, - is composed mainly of yellow elastic tissue. It consists of an anterior and two lateral portions. The **anterior part** or **middle cricothyroid ligament**, *ligamentum cricothyroideum medium*; *central part of cricothyroid membrane*, - is thick and strong, narrow above and broad below. It connects together the front parts of the contiguous margins of the thyroid and cricoid cartilages. It is overlapped on either side by the Cricothyroideus, but between these is subcutaneous; it is crossed horizontally by a small anastomotic arterial arch, formed by the junction of the two cricothyroid arteries, branches of which pierce it. The **lateral portions** are thinner and lie close under the mucous membrane of the larynx; they extend from the superior border of the cricoid cartilage to the inferior margin of the vocal ligaments, with which they are continuous. These ligaments may therefore be regarded as the free borders of the lateral portions of the

conus elasticus, and extend from the vocal processes of the arytenoid cartilages to the angle of the thyroid cartilage about midway between its upper and lower borders.

An **articular capsule**, strengthened posteriorly by a well-marked fibrous band, encloses the articulation of the inferior cornu of the thyroid with the cricoid cartilage on either side.

Each arytenoid cartilage is connected to the cricoid by a capsule and a posterior cricoarytenoid ligament. The **capsule**, *capsula articularis cricoarytenoidea* - is thin and loose, and is attached to the margins of the articular surfaces. The **posterior cricoarytenoid ligament**, *ligamentum cricoarytenoideum posterius*, extends from the cricoid to the medial and back part of the base of the arytenoid.

The **thyroepiglottic ligament**, *ligamentum thyroepiglotticum*, - is a long, slender, elastic cord which connects the stem of the epiglottis with the angle of the thyroid cartilage, immediately beneath the superior thyroid notch, above the attachment of the ventricular ligaments.

The **cavity of the larynx**, *cavum laryngis* extends from the laryngeal entrance to the lower border of the cricoid cartilage where it is continuous with that of the trachea. It is divided into two parts by the projection of the vocal folds, between which is a narrow triangular fissure or chink, the **rima glottidis**. The portion of the cavity of the larynx above the vocal folds is called the **vestibule**; it is wide and triangular in shape, its base or anterior wall presenting, however, about its center the backward projection of the tubercle of the epiglottis. It contains the ventricular folds, and between these and the vocal folds are the **ventricles of the larynx**. The portion below the vocal folds is at first of an elliptical form, but lower down it widens out, assumes a circular form, and is continuous with the tube of the trachea.

The **entrance of the larynx** (Fig.10) is a triangular opening, wide in front, narrow behind, and sloping obliquely downward and backward. It is bounded, in front, by the epiglottis; behind, by the apices of the arytenoid cartilages, the corniculate cartilages, and the interarytenoid notch; and on either side, by a fold of mucous membrane, enclosing ligamentous and muscular fibers, stretched between the side of the epiglottis and the apex of the arytenoid cartilage; this is the **aryepiglottic fold**, on the posterior part of the margin of which the cuneiform cartilage forms a more or less distinct whitish prominence, the **cuneiform tubercle**.

SUBDIVISIONS OF LARYNGEAL CAVITY

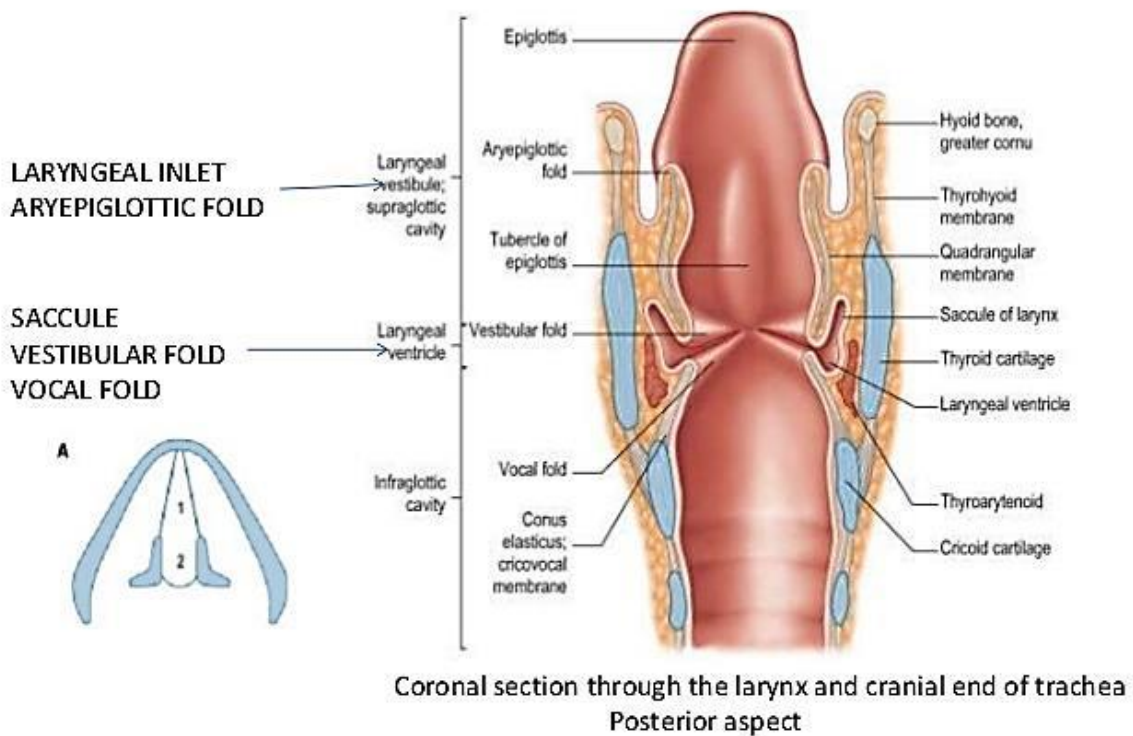
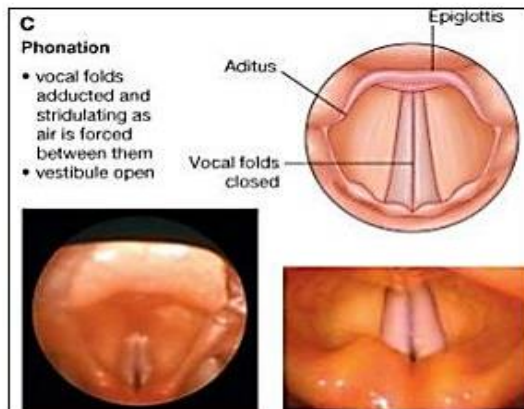


Figure 10. Coronal section of the larynx and upper part of the trachea.

The **Ventricular Folds**, *pllicæ ventriculares*; *superior or false vocal cords*, - are two thick folds of mucous membrane, each enclosing a narrow band of fibrous tissue, the **ventricular ligament** which is attached in front to the angle of the thyroid cartilage immediately below the attachment of the epiglottis, and behind to the antero-lateral surface of the arytenoid cartilage, a short distance above the vocal process. The lower border of this ligament, enclosed in mucous membrane, forms a free crescentic margin, which constitutes the upper boundary of the ventricle of the larynx(Fig.11).

The **Vocal Folds**, *pllicæ vocale*; *inferior or true vocal cords*, - are concerned in the production of sound, and enclose two strong bands, named the **vocal ligaments**, *ligamenta vocales*; *inferior thyroarytenoid*. Each ligament consists of a band of yellow elastic tissue, attached in front to the angle of the thyroid cartilage, and behind to the vocal process of the arytenoid. Its lower border is continuous with the thin lateral part of the conus elasticus. Its upper border forms the lower boundary of the ventricle of the larynx. Laterally, the Vocalis muscle lies parallel with it. It is covered medially by mucous membrane, which is extremely thin and closely adherent to its surface (Fig.11).

DURING PHONATION



DURING WHISPERING

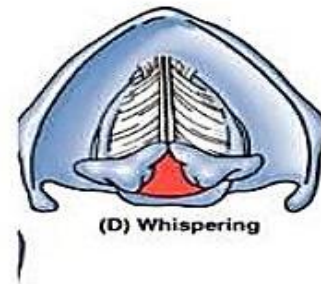


Figure 11. Vocal Folds.

The **Ventricle of the Larynx**, *ventriculus laryngis* [Morgagnii]; *laryngeal sinus*, - is a fusiform fossa, situated between the ventricular and vocal folds on either side, and extending nearly their entire length. The fossa is bounded, *above*, by the free crescentic edge of the ventricular fold; *below*, by the straight margin of the vocal fold; *laterally*, by the mucous membrane covering the corresponding Thyreoarytænoideus. The anterior part of the ventricle leads up by a narrow opening into a cecal pouch of mucous membrane of variable size called the **appendix**.

The **appendix of the laryngeal ventricle**, *appendix ventriculi laryngis*; *laryngeal saccule*, - is a membranous sac, placed between the ventricular fold and the inner surface of the thyroid cartilage, occasionally extending as far as its upper border or even higher; it is conical in form, and curved slightly backward. On the surface of its mucous membrane are the openings of sixty or seventy mucous glands, which are lodged in the submucous areolar tissue. This sac is enclosed in a fibrous capsule, continuous below with the ventricular ligament. Its medial surface is covered by a few delicate muscular fasciculi, which *arise* from the apex of the arytenoid cartilage and become lost in the aryepiglottic fold of mucous membrane; laterally it is separated from the thyroid cartilage by the Thyreoepiglotticus. These muscles compress the sac, and express the secretion it contains upon the vocal folds to lubricate their surfaces.

The **Rima Glottidis** (Fig.12) is the elongated fissure or chink between the vocal folds in front, and the bases and vocal processes of the arytenoid cartilages behind. It is therefore subdivided into a larger anterior intramembranous part (*glottis vocalis*), which measures about three-fifths of the length of the entire aperture, and a posterior intercartilaginous part (*glottis respiratoria*). Posteriorly it is limited by the mucous membrane passing between the arytenoid cartilages. The rima glottidis is the narrowest part of the cavity of the larynx, and its level corresponds with the bases of the arytenoid cartilages. Its length, in the male, is about 23 mm.; in the female from 17 to 18 mm. The width and shape of the rima glottidis vary with the movements of

the vocal folds and arytenoid cartilages during respiration and phonation. In the condition of rest, *i. e.*, when these structures are uninfluenced by muscular action, as in quiet respiration, the intramembranous part is triangular, with its apex in front and its base behind—the latter being represented by a line, about 8 mm. long, connecting the anterior ends of the vocal processes, while the medial surfaces of the arytenoids are parallel to each other, and hence the intercartilaginous part is rectangular. During extreme adduction of the vocal folds, as in the emission of a high note, the intramembranous part is reduced to a linear slit by the apposition of the vocal folds, while the intercartilaginous part is triangular, its apex corresponding to the anterior ends of the vocal processes of the arytenoids, which are approximated by the medial rotation of the cartilages. Conversely in extreme abduction of the vocal folds, as in forced inspiration, the arytenoids and their vocal processes are rotated lateralward, and the intercartilaginous part is triangular in shape but with its apex directed backward. In this condition the entire glottis is somewhat lozenge-shaped, the sides of the intramembranous part diverging from before backward, those of the intercartilaginous part diverging from behind forward—the widest part of the aperture corresponding with the attachments of the vocal folds to the vocal processes.

SHAPE OF RIMA GLOTTIDIS DURING DIFFERENT MOVEMENTS
OF VOCAL CORDS

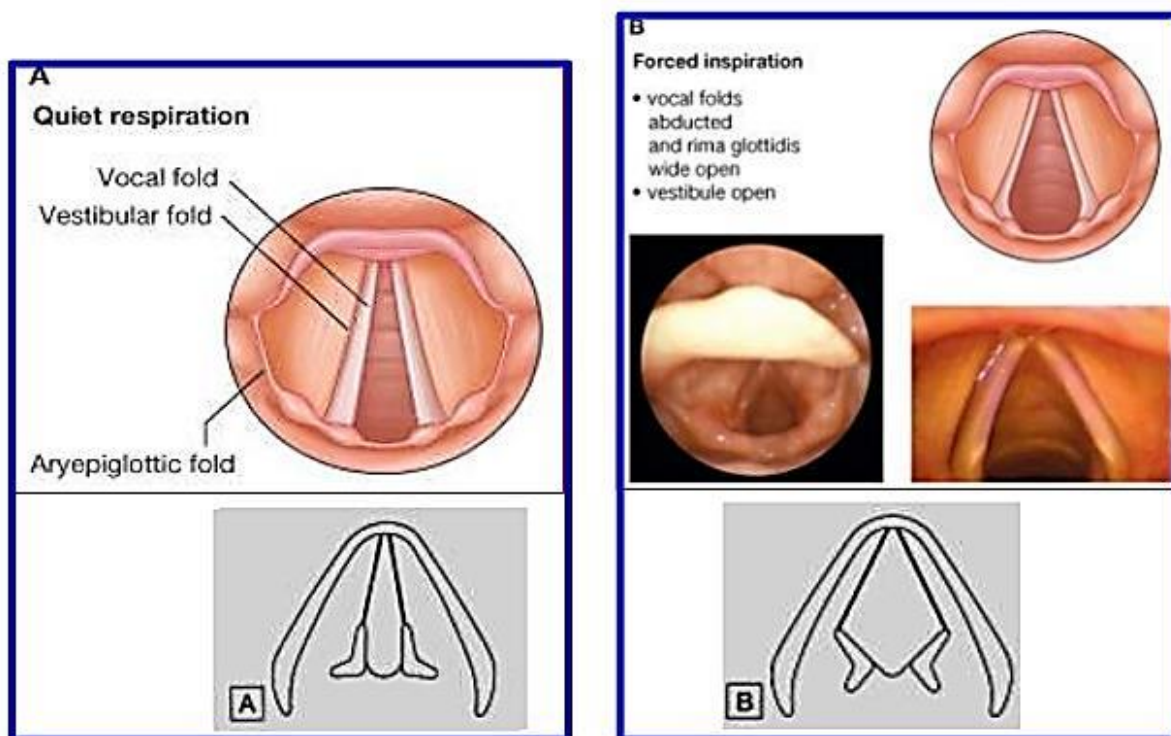


Figure 12. Laryngoscopic view of interior of larynx.

Muscles

The muscles of the larynx are *extrinsic* (Fig.13, 14), passing between the larynx and parts around—these have been described in the section on Myology; and *intrinsic*, confined entirely to the larynx.

EXTRINSIC MUSCLES

Extrinsic attached to hyoid

(Depressors)

- Sternothyroid
- Sternohyoid
- Thyrohyoid

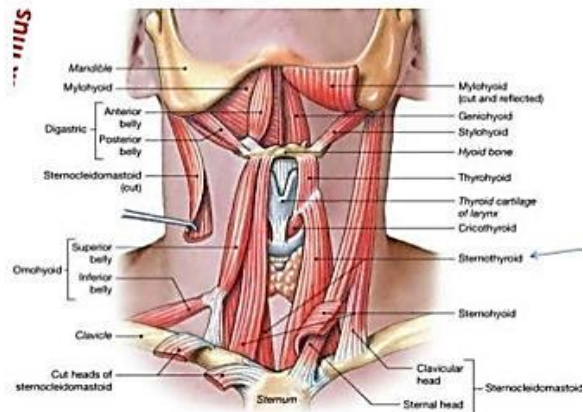


Figure 13. Extrinsic muscles.

Extrinsic attached to thyroid

(Elevators)

- Palatopharyngeus
- stylopharyngeus

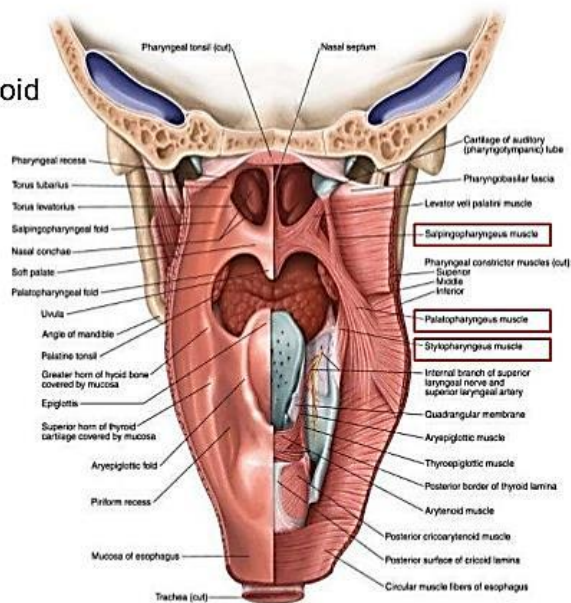


Figure 14. Extrinsic muscles of larynx. Posterior view.

The **Cricothyroideus**, *Cricothyroid muscle* (Fig. 15), triangular in form, arises from the front and lateral part of the cricoid cartilage; its fibers diverge, and are arranged in two groups. The lower fibers constitute a **pars obliqua** and slant backward and lateralward to the anterior border of the inferior cornu; the anterior

fibers, forming a **pars recta**, run upward, backward, and lateralward to the posterior part of the lower border of the lamina of the thyroid cartilage.

The medial borders of the two muscles are separated by a triangular interval, occupied by the middle cricothyroid ligament.

CRICOTHYROID MUSCLE

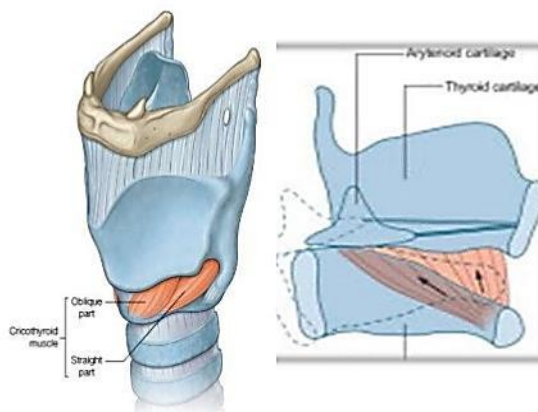


Figure 15. Cricothyroid muscle.

The **Cricoaerytaenoideus posterior**, *posterior cricoarytenoid muscle* (Fig. 16), - arises from the broad depression on the corresponding half of the posterior surface of the lamina of the cricoid cartilage; its fibers run upward and lateralward, and converge to be *inserted* into the back of the muscular process of the arytenoid cartilage. The uppermost fibers are nearly horizontal, the middle oblique, and the lowest almost vertical.

POSTERIOR CRICOARYTENOID MUSCLE

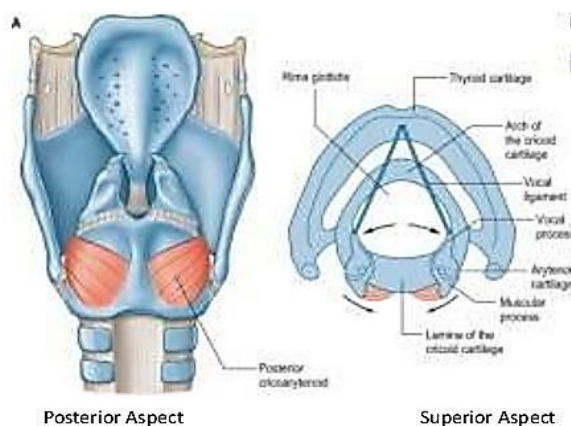


Figure 16. Posterior cricoarytenoid muscle.

The **Cricoaerytaenoideus lateralis**, *lateral cricoarytenoid muscle* (Fig. 17) is smaller than the preceding, and of an oblong form. It *arises* from the upper border of the arch of the cricoid cartilage, and, passing obliquely upward and backward, is inserted into the front of the muscular process of the arytenoid cartilage.

LATERAL CRICOARYTENOID MUSCLE

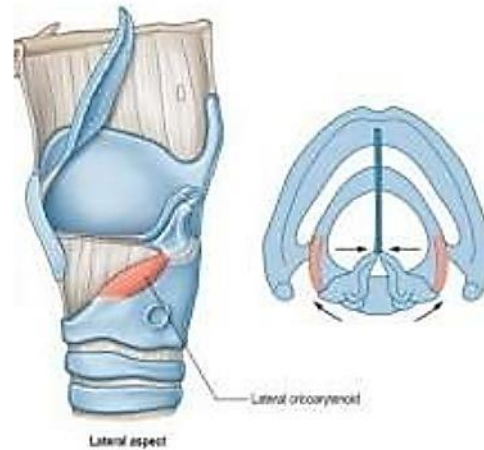


Figure 17. Lateral cricoarytenoid muscle.

The **Arytaenoideus muscle** (Fig. 18, 19) is a single muscle, filling up the posterior concave surfaces of the arytenoid cartilages. It *arises* from the posterior surface and lateral border of one arytenoid cartilage, and is inserted into the corresponding parts of the opposite cartilage. It consists of oblique and transverse parts. The **Arytaenoideus obliquus** (Fig. 18), the more superficial, forms two fasciculi, which pass from the base of one cartilage to the apex of the opposite one, and therefore cross each other like the limbs of the letter X; a few fibers are continued around the lateral margin of the cartilage, and are prolonged into the aryepiglottic fold; they are sometimes described as a separate muscle, the **Aryepiglotticus**. The **Arytaenoideus transversus** (Fig.19) crosses transversely between the two cartilages.

OBLIQUE ARYTENOID MUSCLE and ARYEPIGLOTTICUS

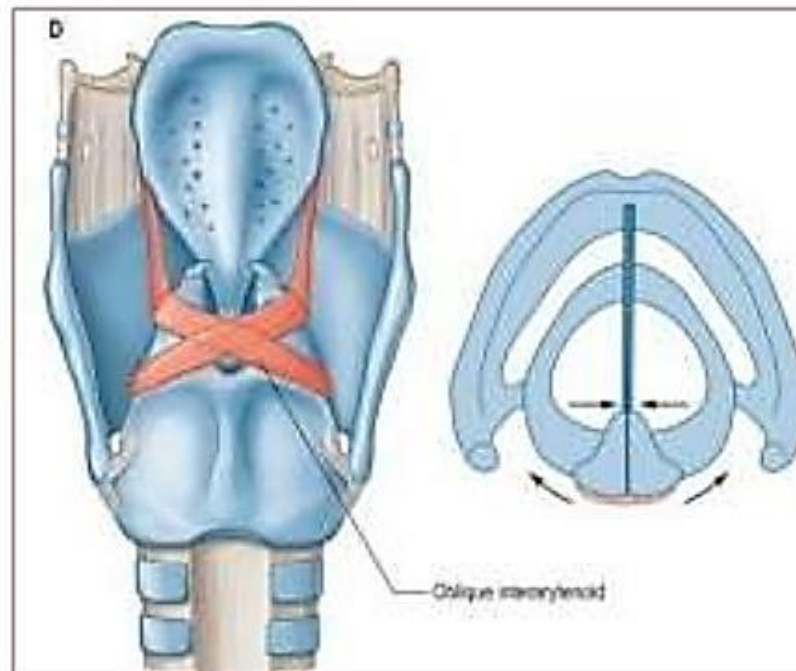


Figure 18. Arytaenoideus obliquus muscle.

TRANSVERSE ARYTENOID MUSCLE

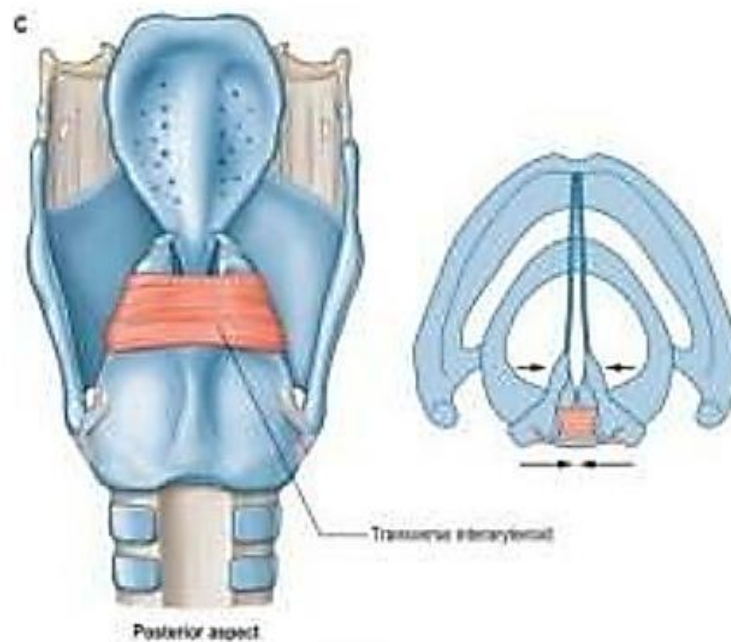


Figure 19. Arytænoideus transversus muscle.

The **Thyroarytaenoideus**, *Thyroarytenoid muscle* (Fig.20) is a broad, thin, muscle which lies parallel with and lateral to the vocal fold, and supports the wall of the ventricle and its appendix. It *arises in front* from the lower half of the angle of the thyroid cartilage, and from the middle cricothyroid ligament. Its fibers pass backward and lateralward, to be *inserted* into the base and anterior surface of the arytenoid cartilage. The lower and deeper fibers of the muscle can be differentiated as a triangular band which is inserted into the vocal process of the arytenoid cartilage, and into the adjacent portion of its anterior surface; it is termed the **Vocalis**, and lies parallel with the vocal ligament, to which it is adherent.

THYROARYTENOID and VOCALIS MUSCLE

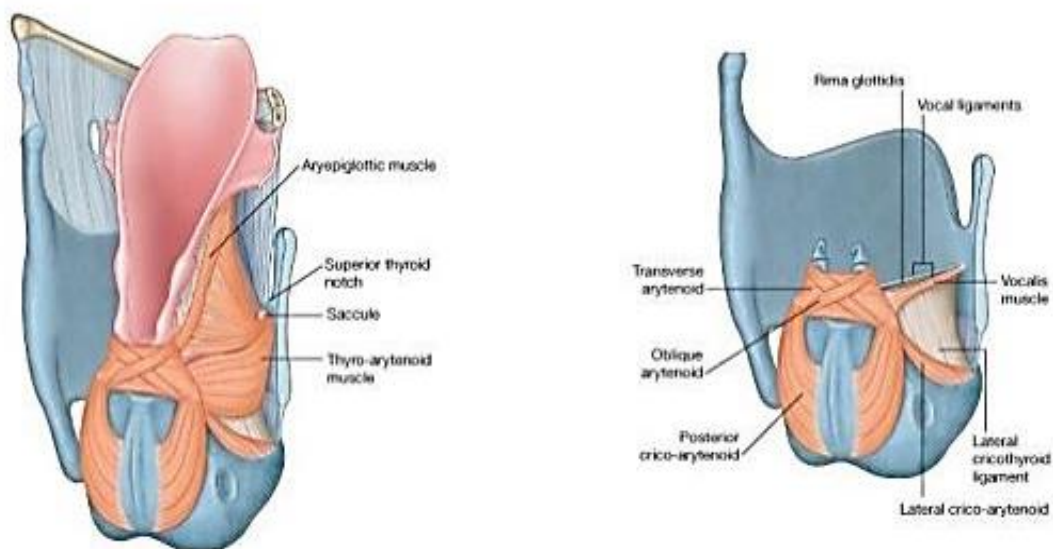


Figure 20. Thyroarytenoid muscle.

Trachea

The Trachea is a tube, which consists of 16-20 *semicircular cartilages*, joint each other by *annular ligaments*(Fig.21). Last built by connective tissue with smooth muscular fibres. Behind semi-rings communicate by each other by *membranous tracheal wall*. Trachea (windpipe) extends from VI cervical to V thoracic vertebra, where it ramifies on two *principal bronchi*. This place is *tracheal bifurcation*. Trachea has cervical part and thoracic part. *Cervical part* at the front covered by infrahyoid muscles and isthmus of thyroid gland that accords to the second-third tracheal ring. Esophagus (gullet) passes behind the trachea. *Thoracic part* of trachea is situated in superior mediastinum.

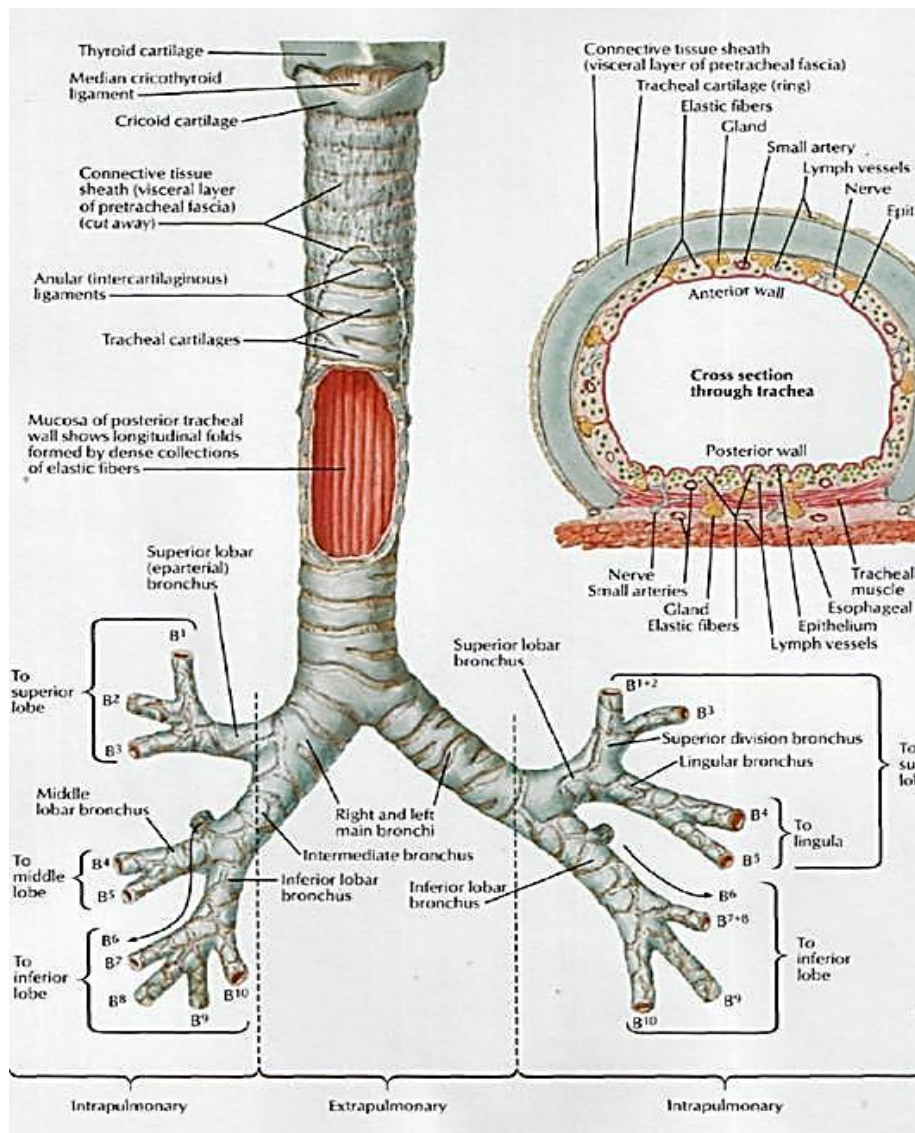


Figure 21. The Trachea. Right and Left principal bronchus.

PRINCIPAL BRONCHI are generated from the bifurcation of trachea and have similar structure as trachea. *Right principal bronchus* is wider than left and it is continuation of trachea by its direction. It consists of 6-8 cartilaginous semirings. *Left principal bronchus* is longer and narrower and passes with angle from trachea than right. It consists of 9-12 cartilaginous semi-ring. The principal bronchi are the bronchi of first order, the bronchial tree starts from them. The extraneous things, especially in children, more frequently get into right principal bronchus(Fig.21).

Lungs

The LUNGS (Fig.22), are the pair parenchymatic organs, which occupy larger part of thoracic cavity. Each lung has a pulmonic *base* and *apex*; *costal surface*, *diaphragmatic surface*, *interlobar surface* and *medial surface*. Medial surface

subdivides into posterior (vertebral) surface and anterior (mediastinal) surface. They distinguish *anterior margin* and *inferior margin* on lungs. There is *pulmonal hilus* on mediastinal surface through which pulmonary artery, bronchi and nerves, enter into the lung, lymphatic vessels and pulmonary veins leave the lungs. All these elements, which enter and exit from lungs gates, form a *pulmonary root*. Arrangement of vessels and bronchus in left pulmonary root: from above downwards: pulmonary artery, bronchus and vein (ABV). Arrangement of vessels and bronchus in right pulmonary root (from above downwards): bronchus, pulmonary artery, and vein (BAV). On lateral surface of lungs *oblique fissura* passes, which subdivides each lung into **superior** lobe and **inferior** lobe.

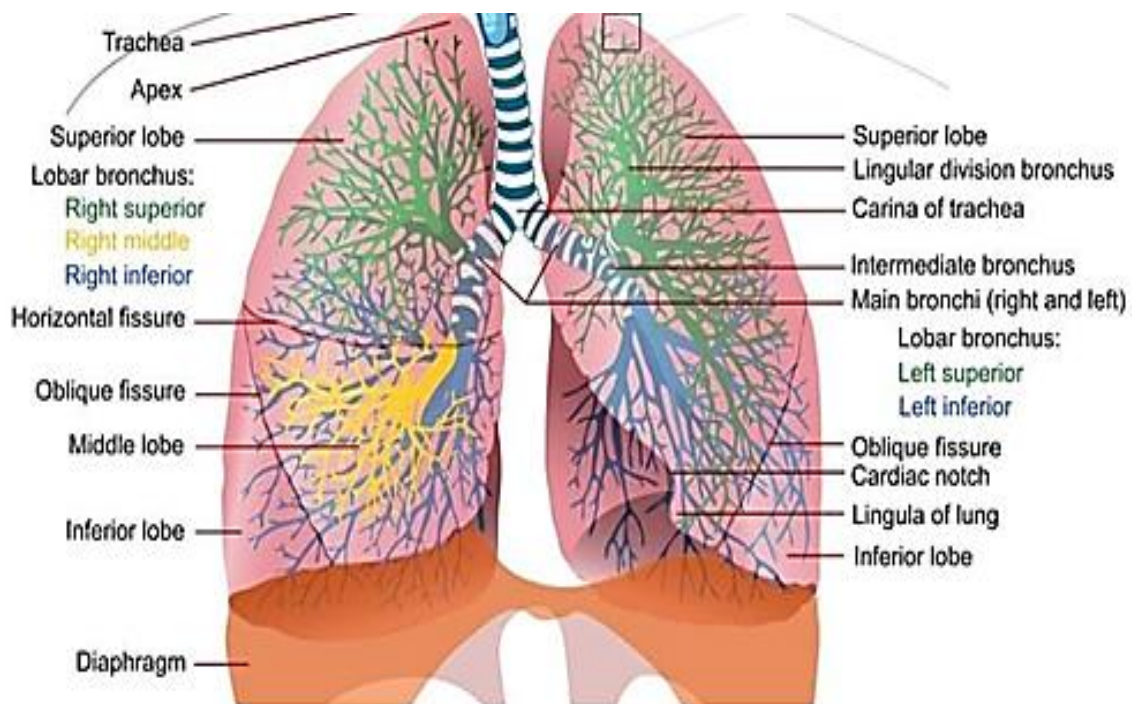


Figure 22. The Lungs.

Right lungs, except oblique fissure, has a *horizontal fissure* passes on level of the IV ribs, which separates **middle** and **inferior** lobes of the right lung. Left lung is more narrow and longer than right one and in area of anterior margin it has cardiac notch of left lung, limited from below by *uvula*.

The principal bronchi, turning into lung gates, subdivide into bronchi of second order, which ventilate lung lobes (lobar bronchi).

There are 2 lobar bronchi in left lung, and 3 - in right lung. The lobar bronchi subdivide into bronchi of third order, which ventilate lung area, dissociated from neighboring by stratum of connective tissue, which is called as lung *segment*. That's why these bronchi are called as by segmental bronchi.

According to San Paulo nomenclature in superior lobe of **right lung** situated 3 segments, in middle - 2, and in inferior 5 segments; in right lung they count 10 segments. In superior lobe of **left lung** count 4 (or 5) segments, and in inferior lobe - 6 (or 5) segments. So, in left lung counts also 10 segments(Fig.23).

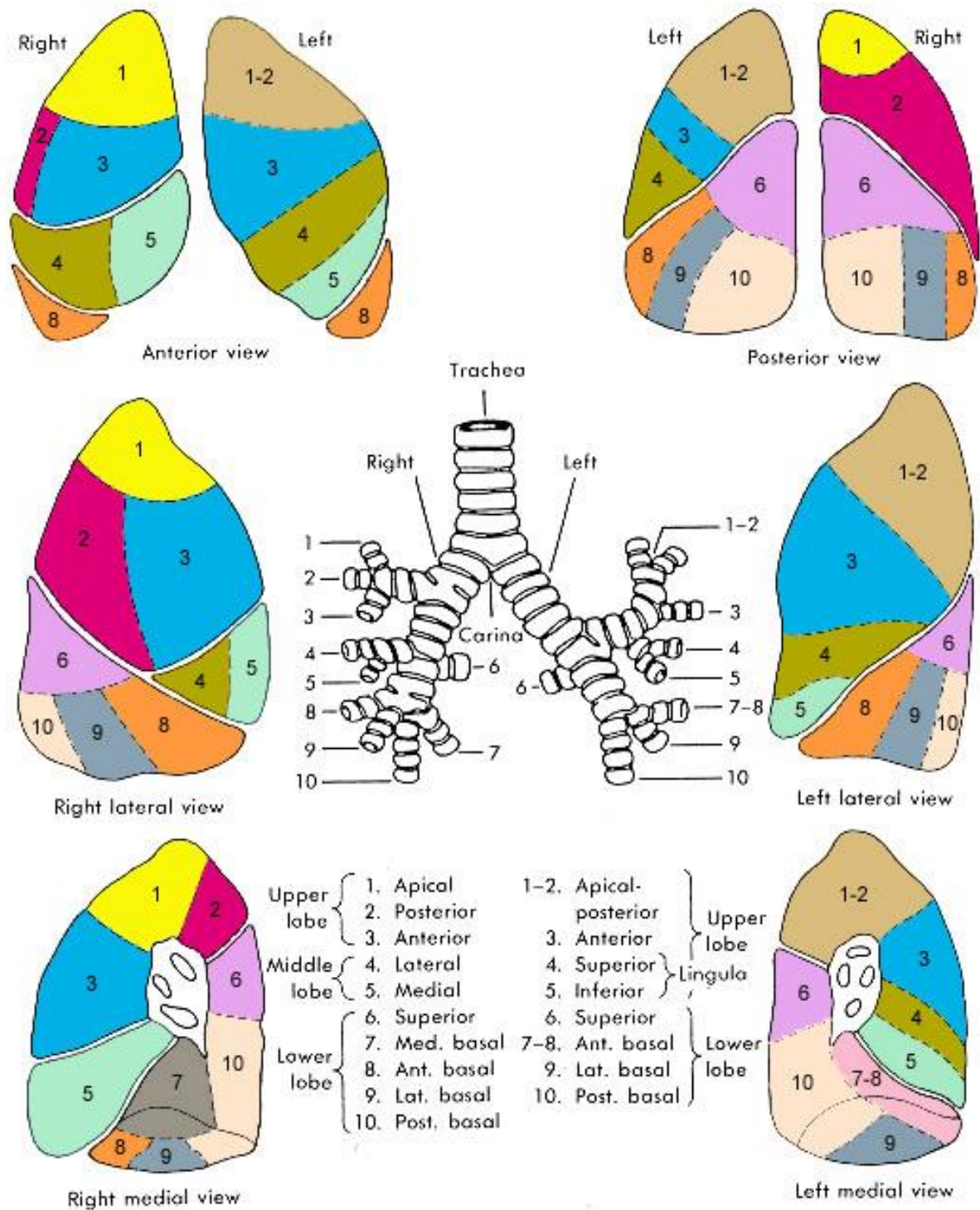


Figure 23. Lungs segments.

Segmental bronchi dichotomically (each on two) divides by bronchi of following orders, while do not pass as far as bronchi, which ventilate lung area, that has a volume 1MM^3 . This area is called by **pulmonary lobule** and bronchi, which ventilate it, are called lobular bronchi.

Lesser bronchi contain more connective tissue in their wall and less cartilaginous tissue. From each lobular bronchus 16-18 terminal bronchiole start, their wall does not contain cartilaginous tissue.

Bronchial tree includes branching of the bronchi starting from the principal bronchi and finishing by terminal bronchioli. Next branching of the bronchial tubes they call **acynus** – morpho-functional lung unit(Fig.24).

Acynus contains 14-16 respiratory bronchioli, which are ramification of one terminal bronchioli and they have *alveoli* in the wall. Each respiratory bronchi forms to 1500 *alveolar ductuli*, which terminate in *alveolar saccule*(Fig.24).

One pulmonary lobule contains 16-18 acynuses. The acynus is covered by network of vessels. Gas-exchange between external environment and blood takes place here. Disease of organs of the respiratory system (Fig.25).

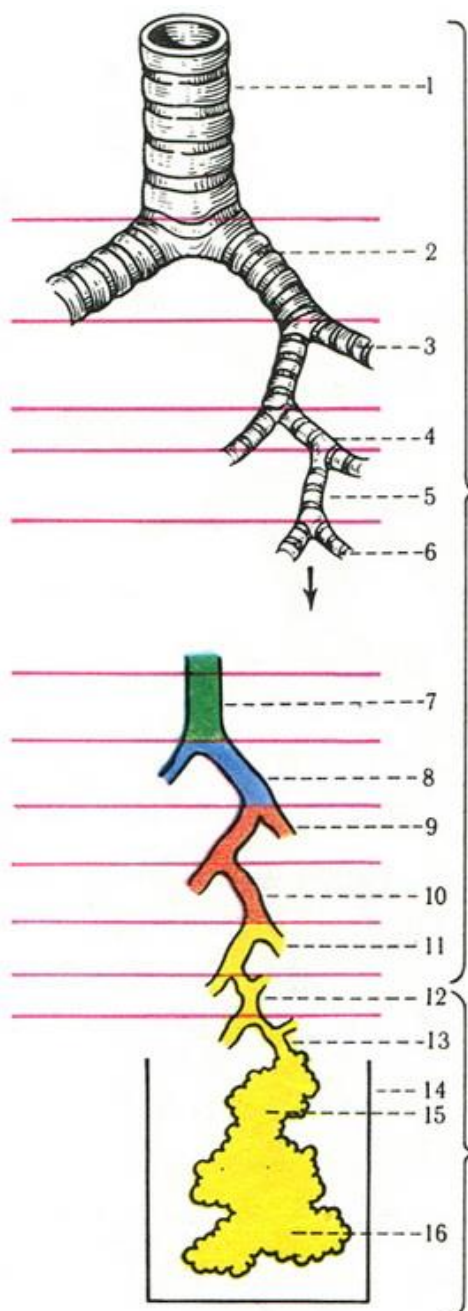


Figure 23. Segmental bronchi:
 1 - trachea;
 2 - bronchus principalis;
 3 - bronchus lobaris;
 4 - bronchus segmentalis;
 5, 6 - проміжні бронхи;
 7 - bronchus interlobularis;
 8 - bronchus terminalis;
 9 - bronchioli I;
 10 - bronchioli II;
 11-13 bronchioli respiratorii I, II, III;
 14 - *alveolar ductuli* ;
 15 – transition zone;
 16 – respiratory zone.

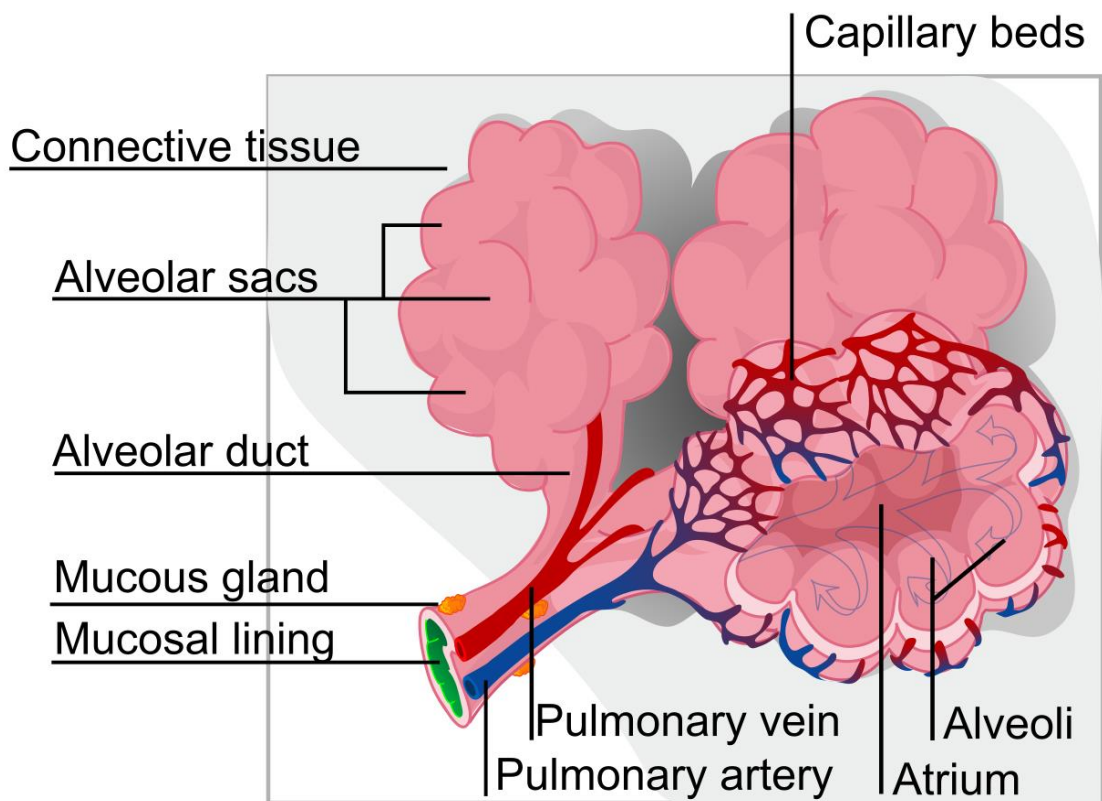


Figure 24. Acynus.

Pneumonia
Alveoli fill with a thick fluid, making gas exchange difficult.

Bronchitis
Airways are influenced due to infection (acute) or due to an irritant (chronic). Coughing brings up mucus.

Asthma
Airways are inflamed due to irritation, and bronchioles constrict due to muscle spasms.

Emphysema
Alveoli burst and fuse into enlarged air spaces. Surface area for gas exchange is reduced.

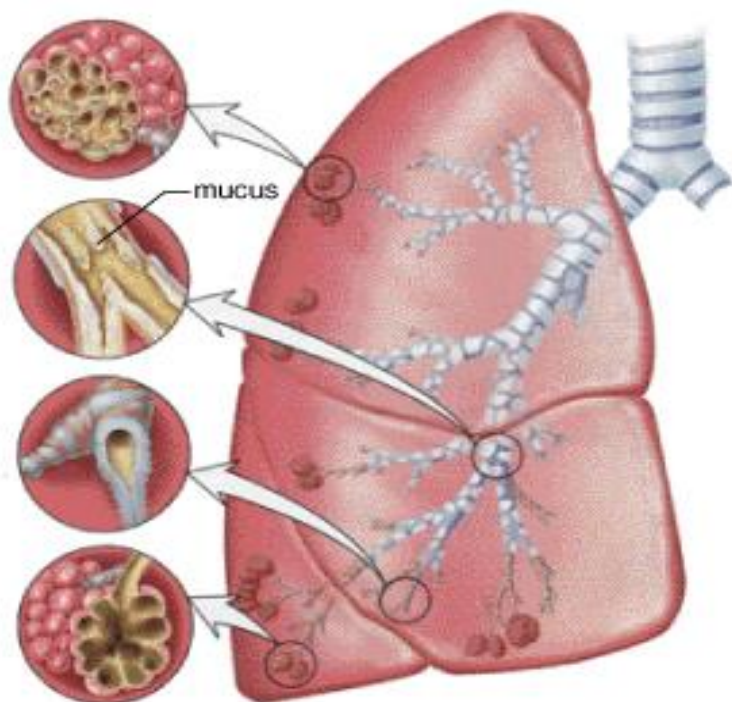


Figure 25. Disease of organs of the respiratory system.

Parenchyma of the lungs and walls of thoracic cavity covered by serous membrane named *pleura*. Sheet of pleurae which covers the lung called *visceral*, and one which covers inner walls of thoracic cavity named *parietal*. Parietal pleura pass into visceral one in place of *pulmonal ligament* which lies in frontal plane. Parietal pleura divided into some portions: *costal* portion, *diaphragmatic*, *mediastinal* portion and has a *cupola* of pleurae.

Boundaries of LUNGS and PLEURAE

The *superior border* of lung and pleura (pleura cupola) coincide and situated on 2-3 cm above from clavicle, or on 4-5 cm above from first rib. *Posterior lung boundary* path coincides with posterior pleural border, it passes along paravertebral line from I to XI thoracic vertebrae (Fig.26, 27).

Anterior lung boundary path also coincides with by anterior pleural border. It passes from top of the lung to sternoclavicular joint, passes over middle the manubrium sterni, sternal body from II to IV costal cartilage. Anterior boundary of left lung deviates here to the left, passes on parasternal line till VI rib, where continues into inferior border. Anterior boundary path of right lung passes along the border of left lung, but gradually deviates to the right and on level of the VI costal cartilage on right parasternal line continues into inferior border. Inferior boundary path of right lung is situated 1-2 cm above from inferior border of suitable pleura and passes :

- on medioclavicular line - at level of the VI ribs,
- on anterior axillar line - on level of the VII ribs,
- on middle axillar line - on level of the VIII ribs,
- on posterior axillar line - on level of the IX ribs,
- on scapular line - on level of the X ribs,
- on paravertebral line - on level of the XI heads of rib.

Inferior border of right pleura lies 1 cm beneath from lung border. Note that a left lung and pleura inferior boundary path is situated 1-2 cm beneath, than right.

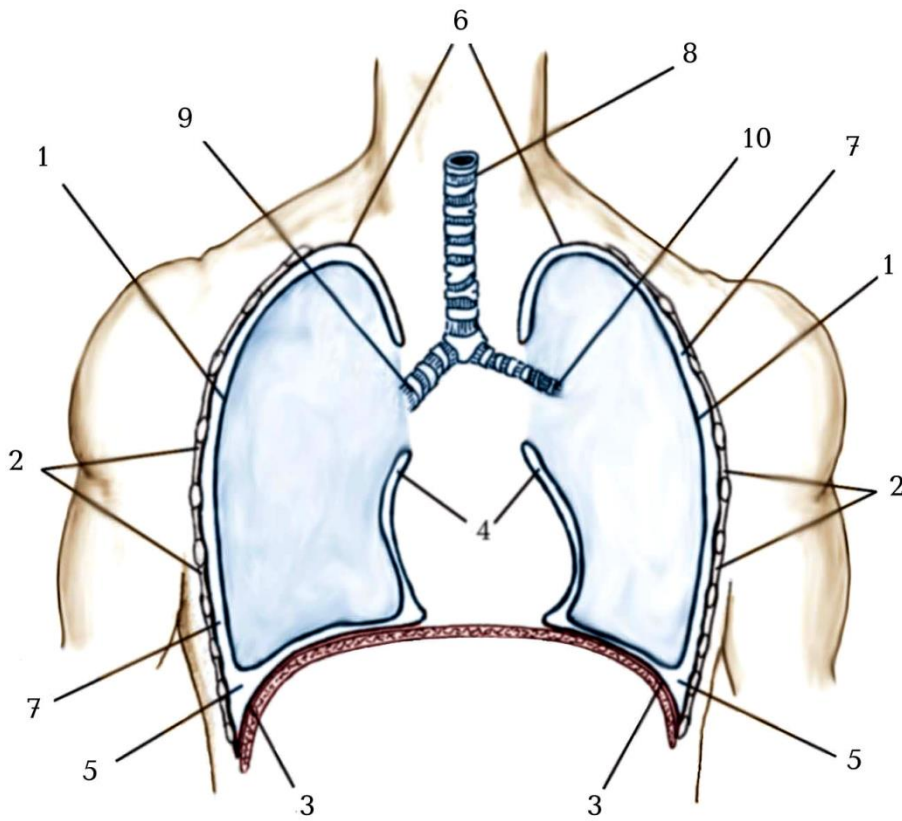


Figure 26. Frontal section of thorax. Pleura(chart) :

1. pleura visceralis (dextra et sinistra);
2. pleura costalis (dextra et sinistra);
3. pleura diaphragmatica (dextra et sinistra);
4. pleura mediastinalis (dextra et sinistra);
5. recessus costodiaphragmaticus (dexter et sinister);
6. cupula pleurae (dextra et sinistra);
7. cavitas pleuralis (dextrum et sinistrum);
8. trachea;
9. bronchus principalis dexter;
10. bronchus principalis sinister.

Topography of Lungs

Anterior View

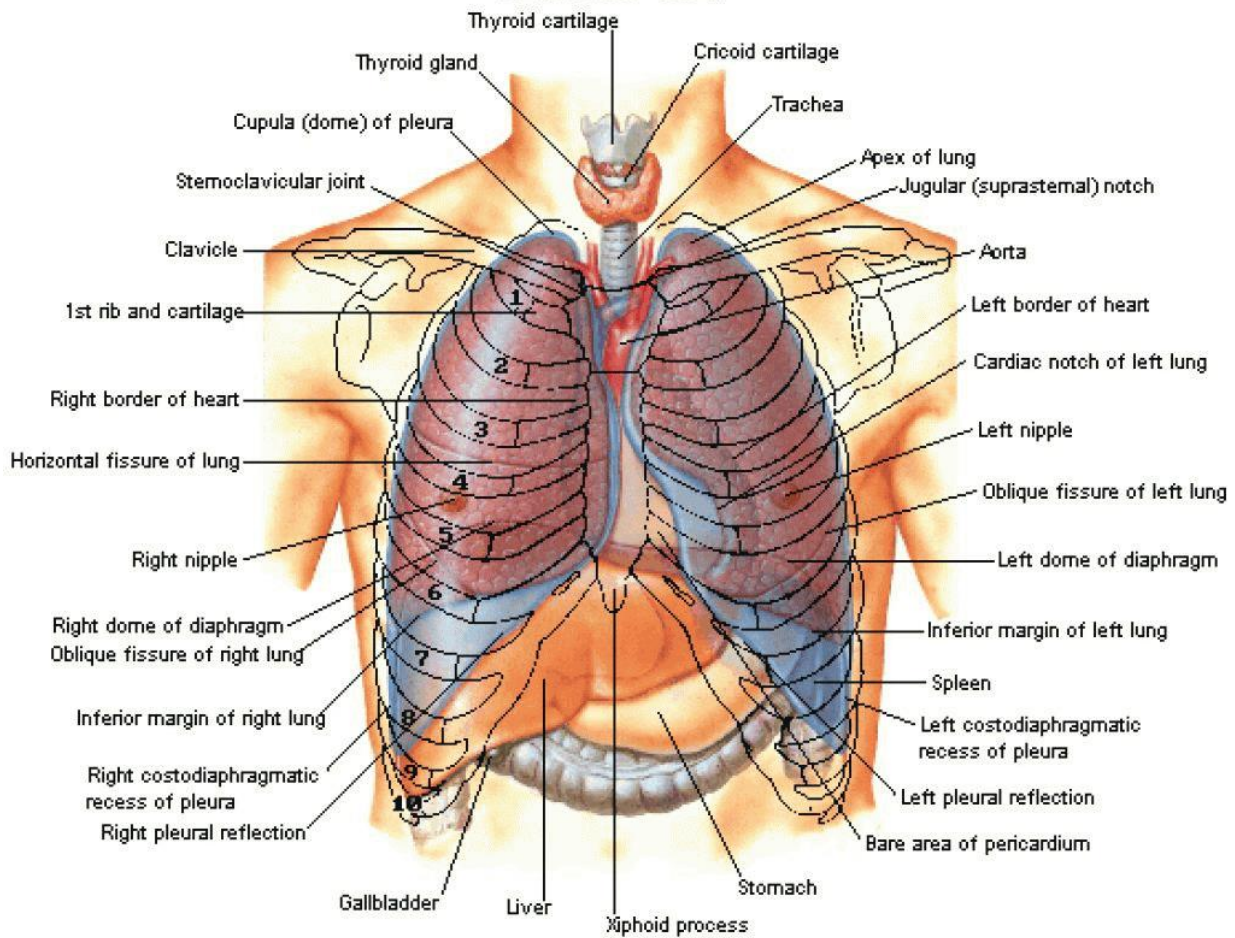


Figure 26. Topography of lungs.

Mediastinum

The mediastinum is complex of organs, which is situated between two pleural sacs. Mediastinum is limited - at front by sternum, behind by thoracic part of backbone, from sides - by right and left mediastinal pleurae. Its superior boundary is superior foramen of thoracic cavity, and inferior - diaphragm. Conventionally horizontal plane, carrying out from joint of manubrium sterni and corpus sterni to cartilage between IV-V thoracic vertebrae, divides mediastinum into *superior mediastinum* and *inferior mediastinum* (**Fig 27**).

In *superior mediastinum* thymus gland, superior cava vein, aortal arch, part of trachea, superior part of thoracic esophageal portion, suitable parts of thoracic lymphatic duct, sympathetic trunks, vagus and phrenic nerves are situated.

Inferior mediastinum into its turn subdivides into anterior mediastinum, middle mediastinum and posterior mediastinum. Anterior mediastinum is situated between body by sternum and anterior wall of pericardium. Internal thoracic arteries and veins, lymphatic nodes and vessels are situated here. On middle mediastinum heart, covered by pericardium, phrenic nerves and inner pericardial portions of big vessels are located. Posterior mediastinum is situated between posterior pericardial wall and backbone. Thoracic part of aorta, azygos and hemiazygos veins, sympathetic trunks, splanchnic nerves, vagus nerves, esophagus, thoracic duct, lymphatic nodes passes here.

In surgery mediastinum is subdivided by frontal plane, carrying out through trachea and lung root, into anterior mediastinum and posterior mediastinum. In anterior mediastinum heart, ascending aorta, aortal arch, superior vena cava, trachea, lung root elements, phrenic nerves and thymus gland are placed. In posterior mediastinum esophagus, descending aorta, inferior vena cava, azygos and hemiazygos veins, splanchnic nerves, sympathetic trunk, thoracic lymphatic duct and vagus nerves are situated.

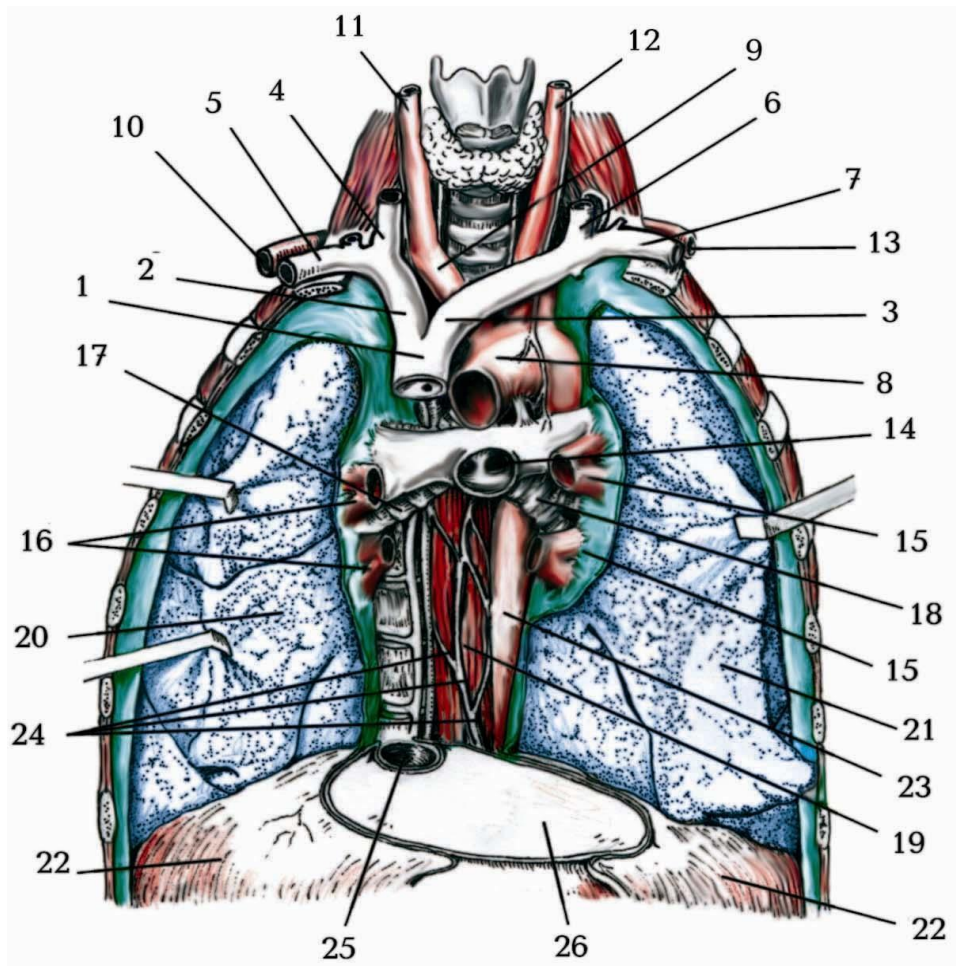


Figure 27. Mediastinum. A front pectoral wall is remote.

- | | |
|---------------------------------------|---|
| 1. v. cava superior; | 19. oesophagus; |
| 2. v. brachiocephalica dextra; | 20. pulmo dexter; |
| 3. v. brachiocephalica sinistra; | 21. pulmo sinister; |
| 4. v. jugularis interna dextra; | 22. diaphragma; |
| 5. v. subclavia dextra; | 23. pars thoracica; |
| 6. v. jugularis interna sinistra; | 24. plexus oesophageus anterior
(n. vagus) |
| 7. v. subclavia sinistra; | 25. v. cava inferior; |
| 8. arcus aortae; | 26. pericardium |
| 9. truncus brachiocephalicus; | |
| 10. a. subclavia dextra; | |
| 11. a. carotis communis dextra; | |
| 12. a. carotis communis
sinistra; | |
| 13. a. subclavia sinistra; | |
| 14. truncus pulmonalis; | |
| 15. vv. pulmonales sinistrae; | |
| 16. vv. pulmonales dextrae; | |
| 17. bronchus principalis dexter; | |
| 18. bronchus principalis
sinister; | |

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Для нотаток

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Educational and methodical textbook
for students of Medical Faculty

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