

The respiratory system



The respiratory system

Functions:

- **external respiration:** exchange of respiratory gases (CO_2 , O_2) between external environment and the blood, (**internal respiration** between the blood and the tissues)
- Nasal cavity contains olfactory cells - regio olfactoria
- In larynx: generating of the voice
- Inner opening of Eustachian tube into the nasopharynx

The upper respiratory tract (head part)

Cavum nasi

Pharynx

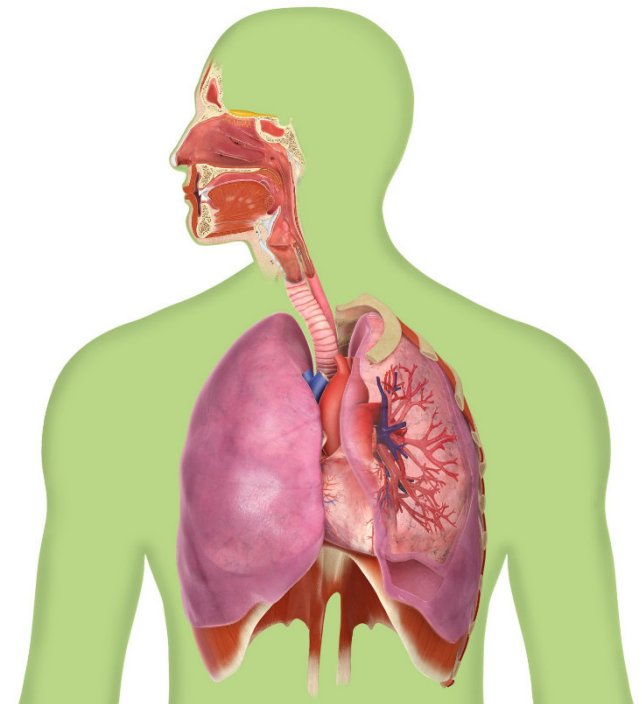
The lower respiratory tract (neck and chest part)

The larynx

The trachea (the windpipe)

The bronchi

The lungs



1. The upper respiratory tract

The external nose (nasus externus)

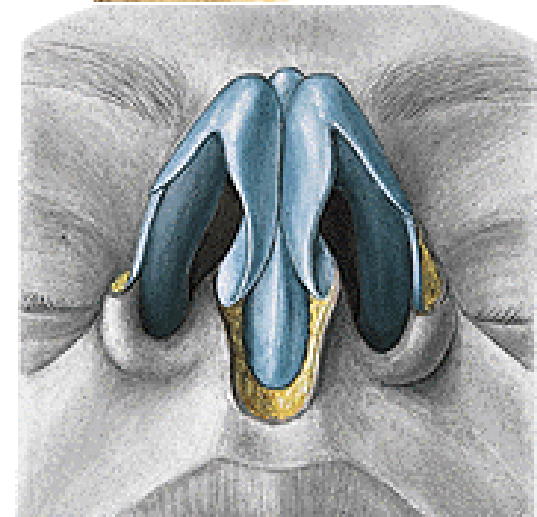
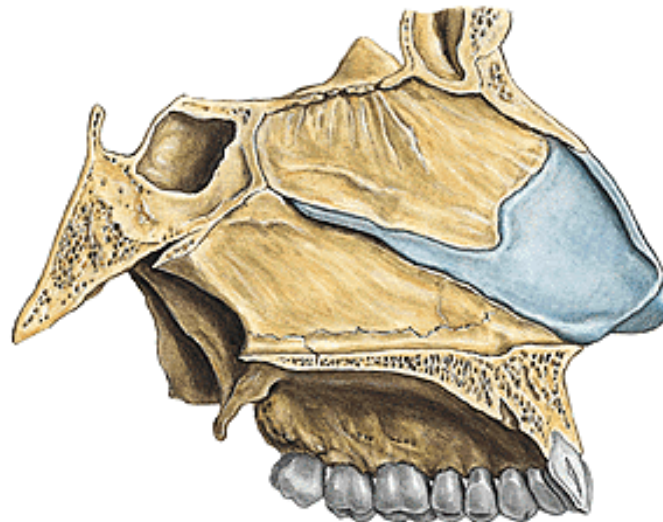
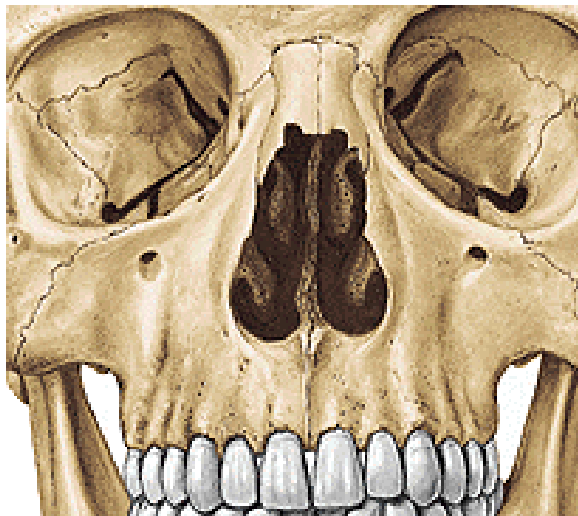
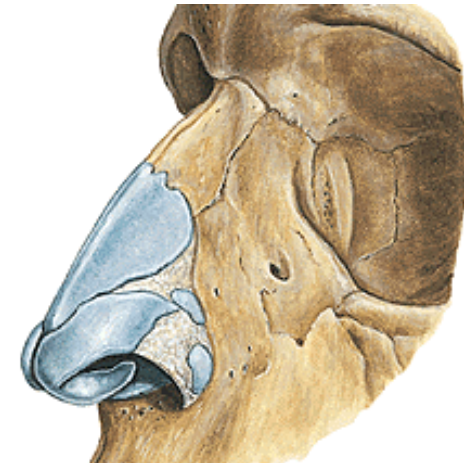
radix nasi
dorsum nasi
apex nasi
alae nasi, nares
septum nasi

Bony skeleton

ossa nasalia
maxillae
(apertura piriformis)

Cartilagineous skeleton

cartilago septi nasi
cartilago nasi lateralis
cartilago alaris major
cartilagineae alares minores



Cavum nasi

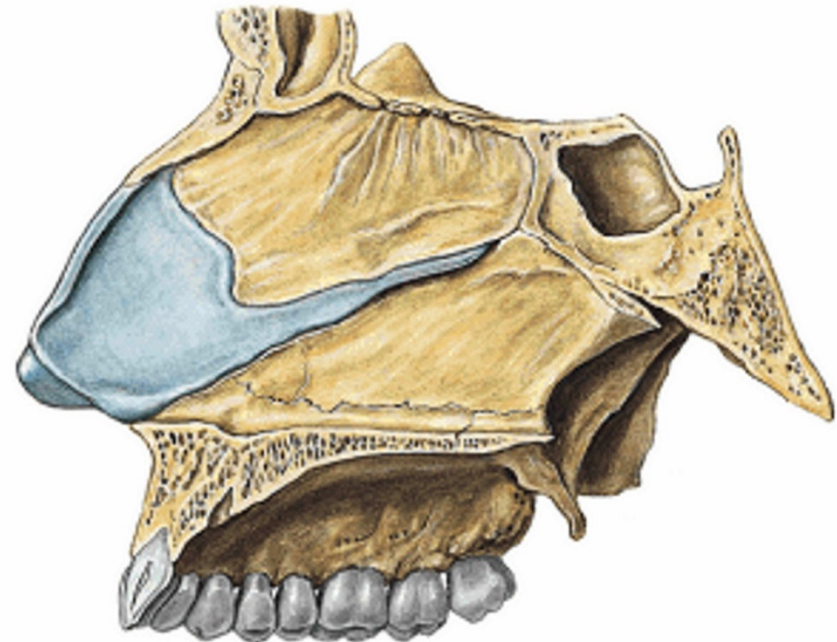
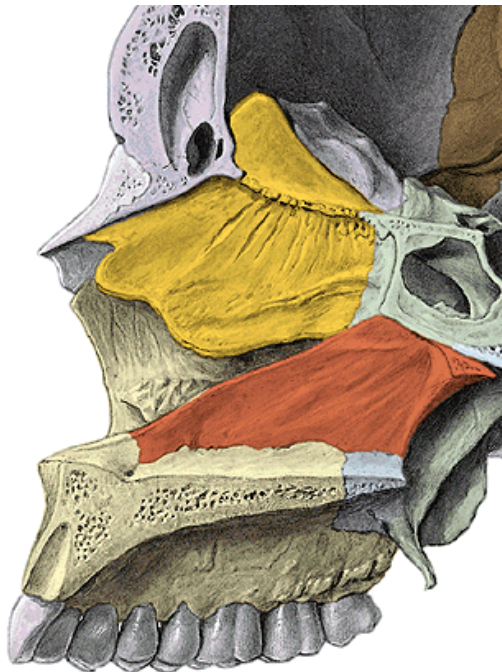
Nares - vestibulum nasi - cavitas nasi propria – choanae

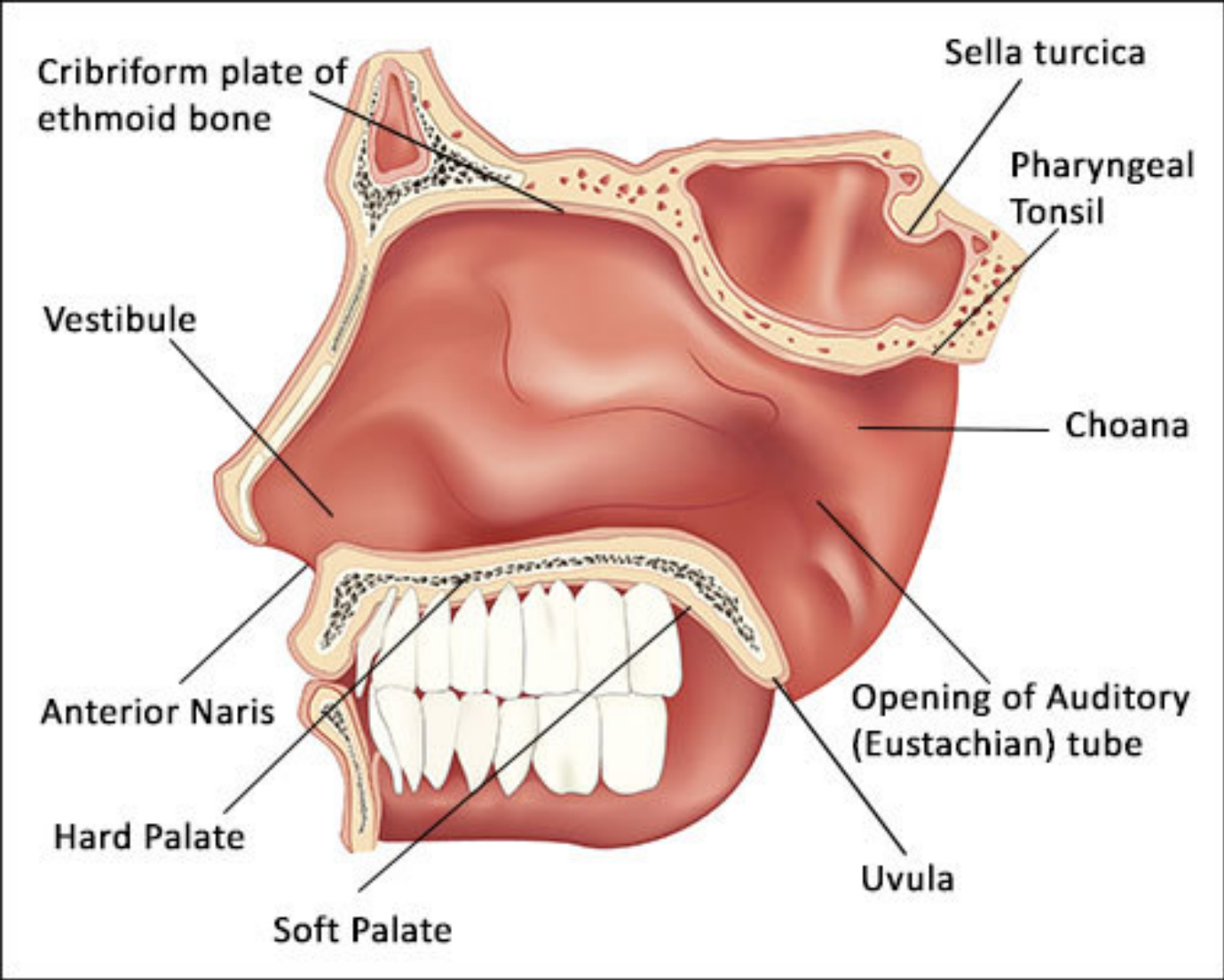
Septum nasi

**Bony part- lamina perpendicularis ossis ethmoidalis,
vomer (bone)**

Cartilagineous part – cartilago septi nasi (cartilage)

Membranous part (skin)

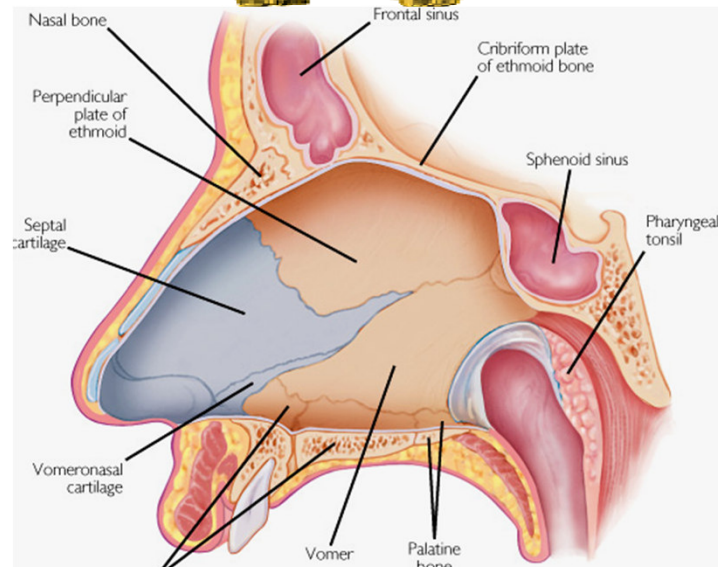






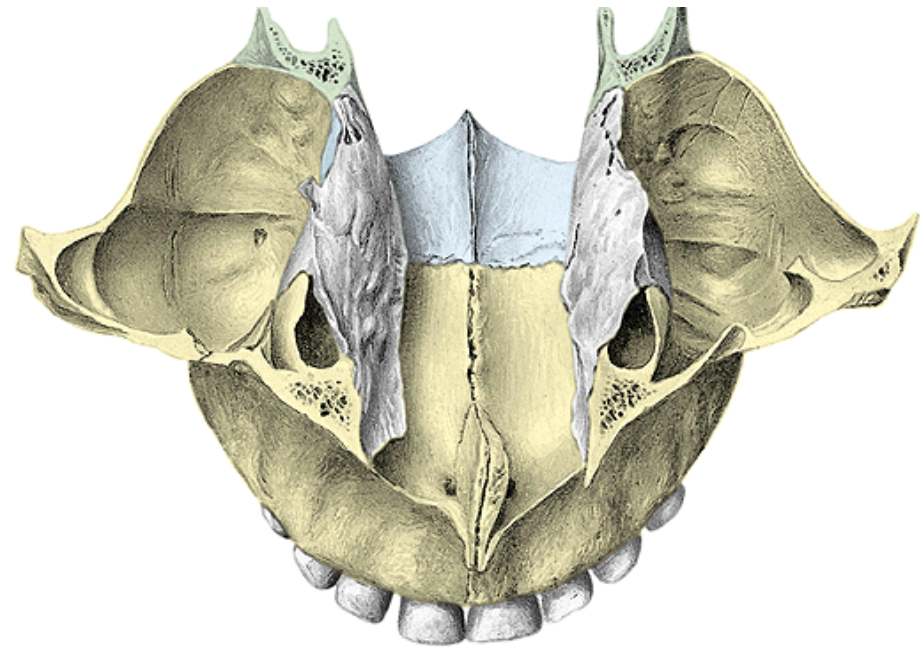
The roof of the nasal cavity

- ossa nasalia, os frontale
- lamina cribrosa ossis ethmoidalis
- corpus ossis sphenoidalis



The bottom of the nasal cavity

- lamina horizontalis ossis palatini
- processus palatinus maxillae

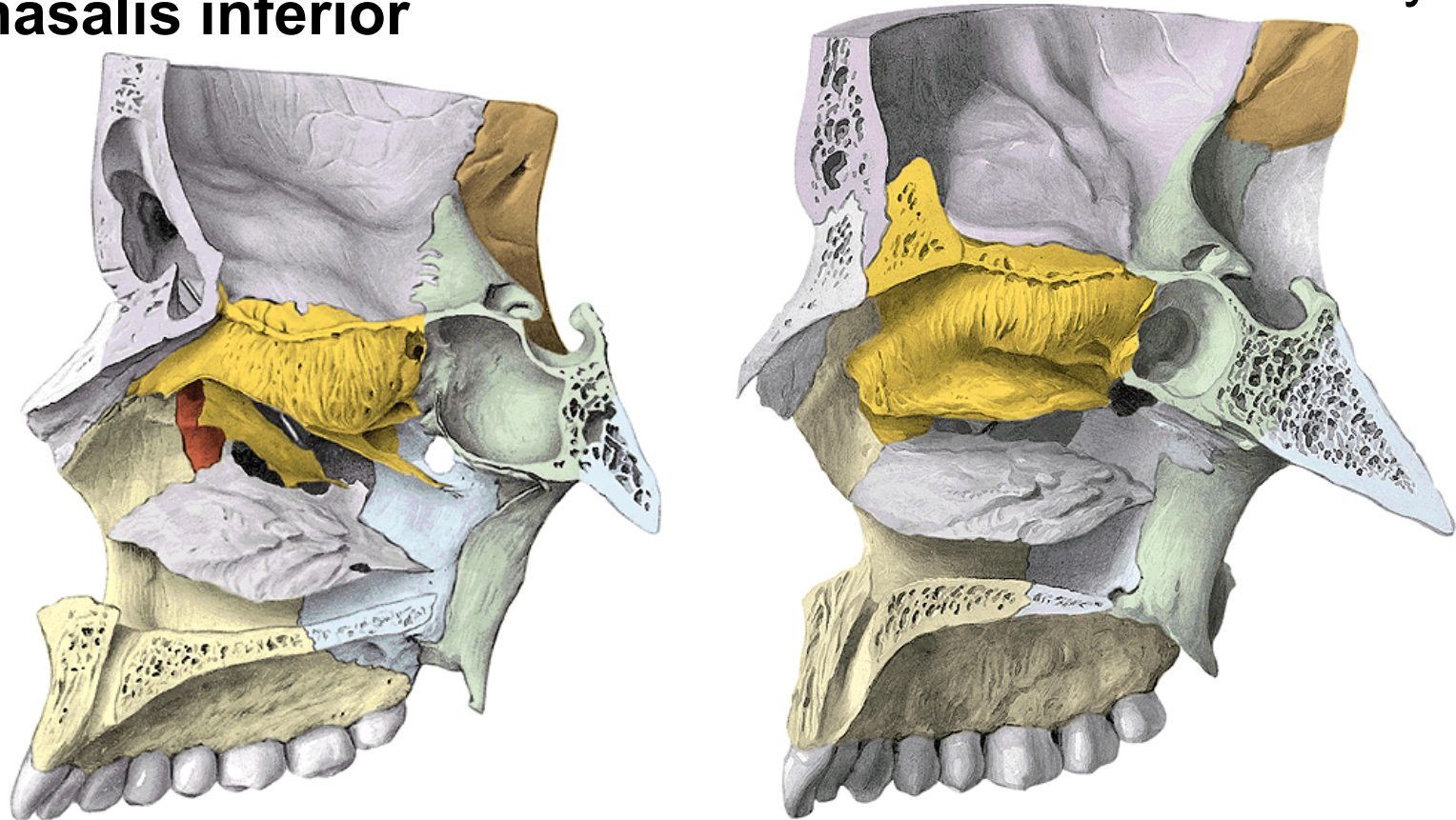


The lateral wall of the nasal cavity

proc. frontalis maxillae, facies nasalis corporis maxillae, os lacrimale, os ethmoidale, lamina perpendicularis ossis palatini

**Concha nasalis superior (os ethmoidale)
Concha nasalis media (os ethmoidale)
Concha nasalis inferior**

} They enlarge the surface of the nasal cavity



The nasal cavity

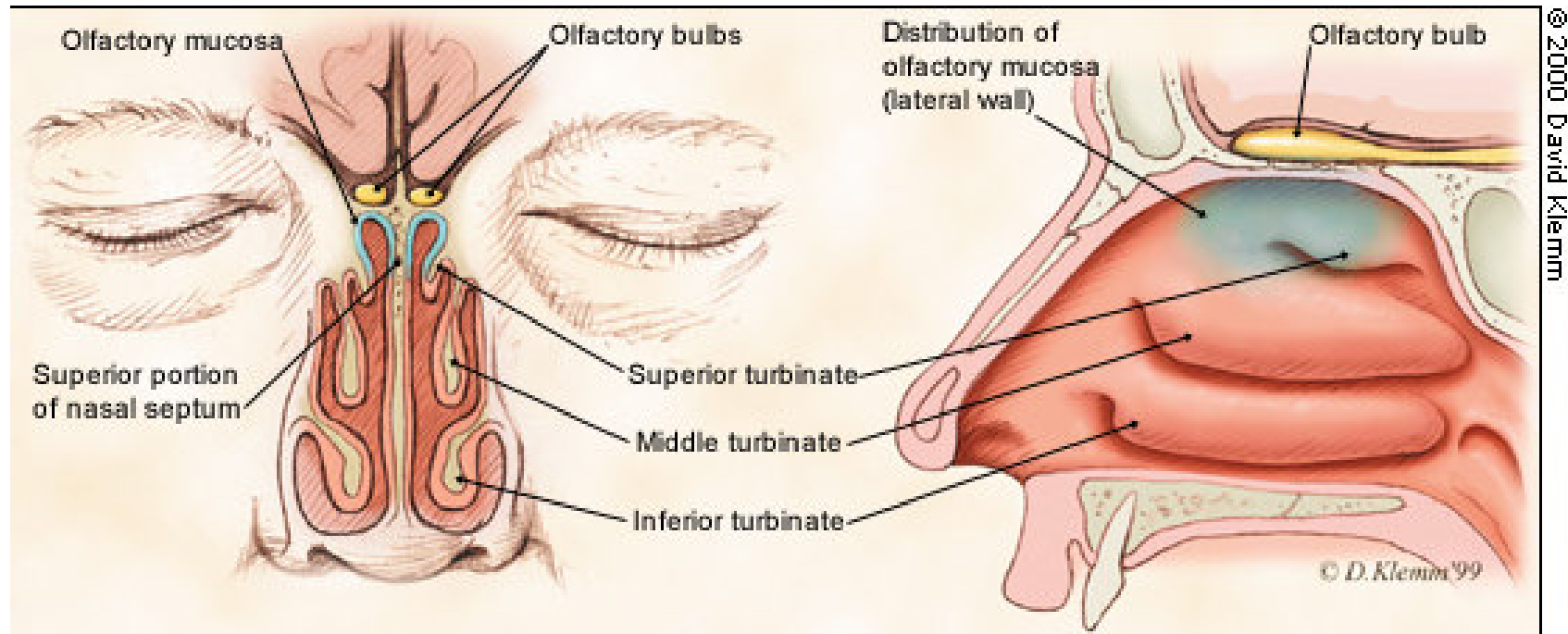
meatus nasi (superior, medius, inferior) – are bordered by conchae, in elongation of the meatus inf. lies ***ostium pharyngeum tubae auditivae***

choanae – openings of the nasal cavity to the nasopharynx

The mucosa

Regio olfactoria – on the roof, yellowish colour, olfactory cells (large as a coin)

Regio respiratoria – grey-pink colour, ciliated epithelium, rich vascular plexus (plexus cavernosi concharum) - easily bleeds– epistaxis



The paranasal sinuses: open out into the nasal cavity, form during the embryonic development

Function: resonance chamber

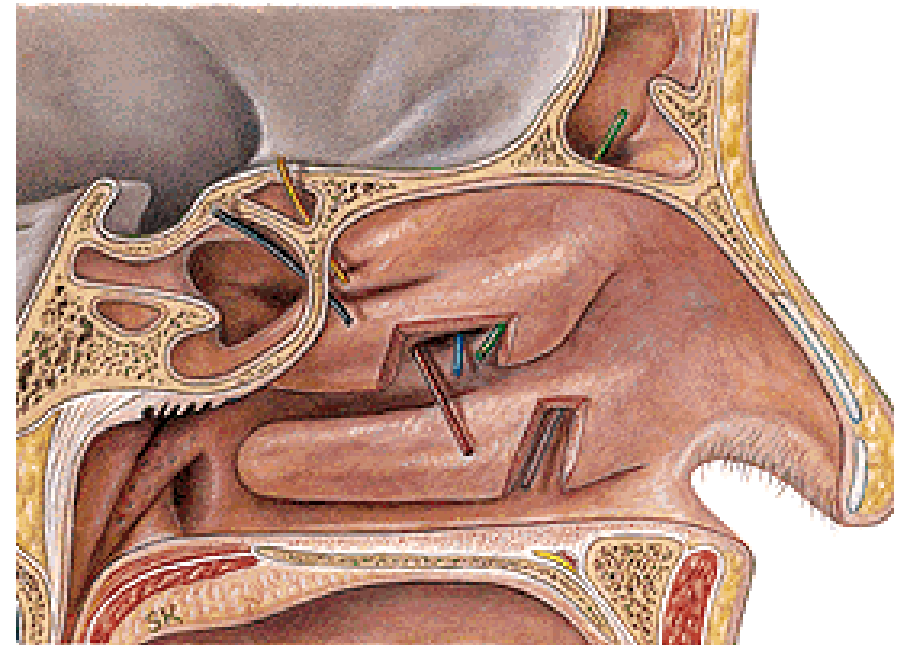
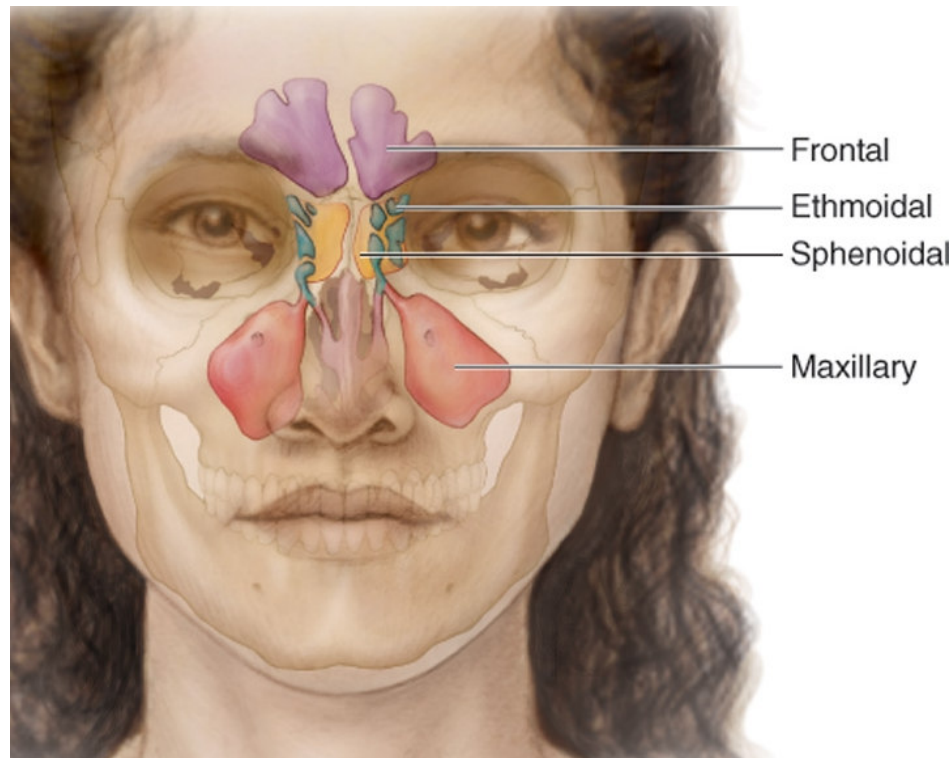
Sinus maxillaris – meatus nasi medius

Sinus frontalis – meatus nasi medius

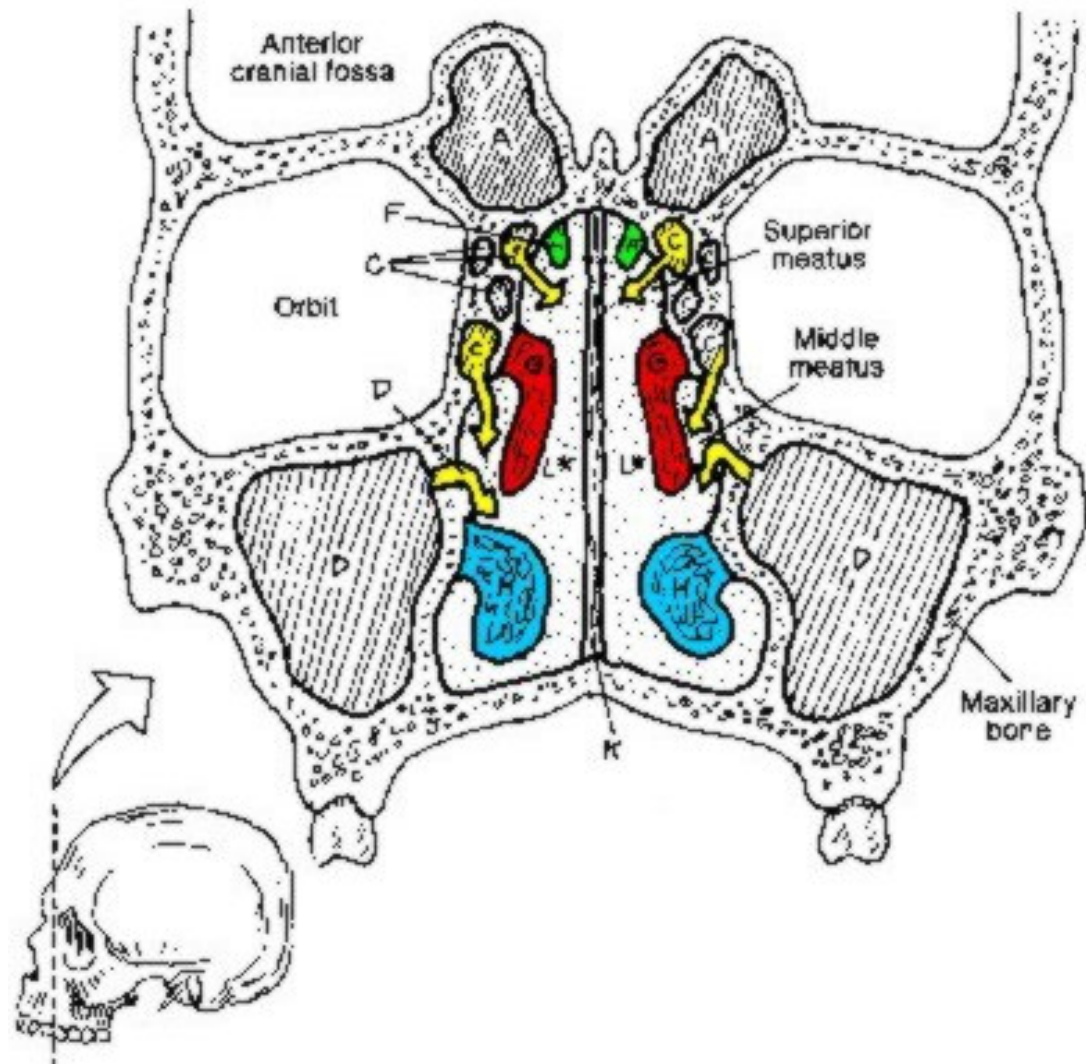
Sinus ethmoidalis – meatus nasi medius et superior

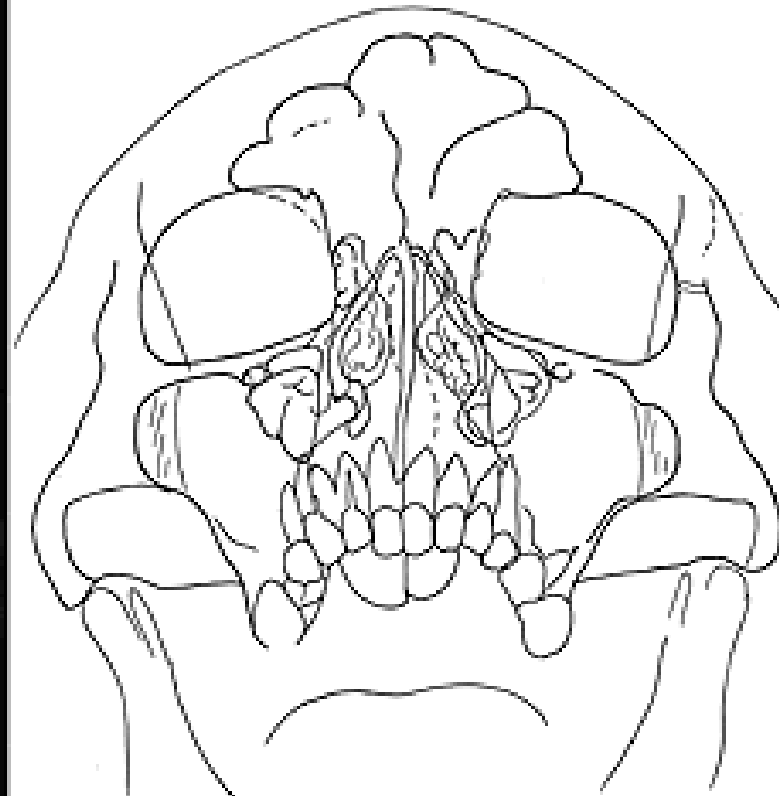
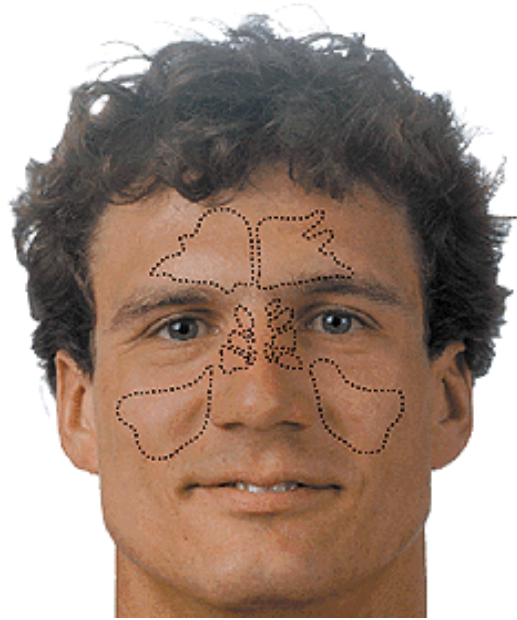
Sinus sphenoidalis – meatus nasi superior

Ductus nasolacrimalis – meatus nasi inferior



Sinus paranasales have clinical importance– inflammations





Pharynx (the gullet) crossing of the respiratory and digestive tract



Nasopharynx

From the base of skull till the soft palate (tuba auditiva, tonsilla pharyngea)

Oropharynx (C2-4)

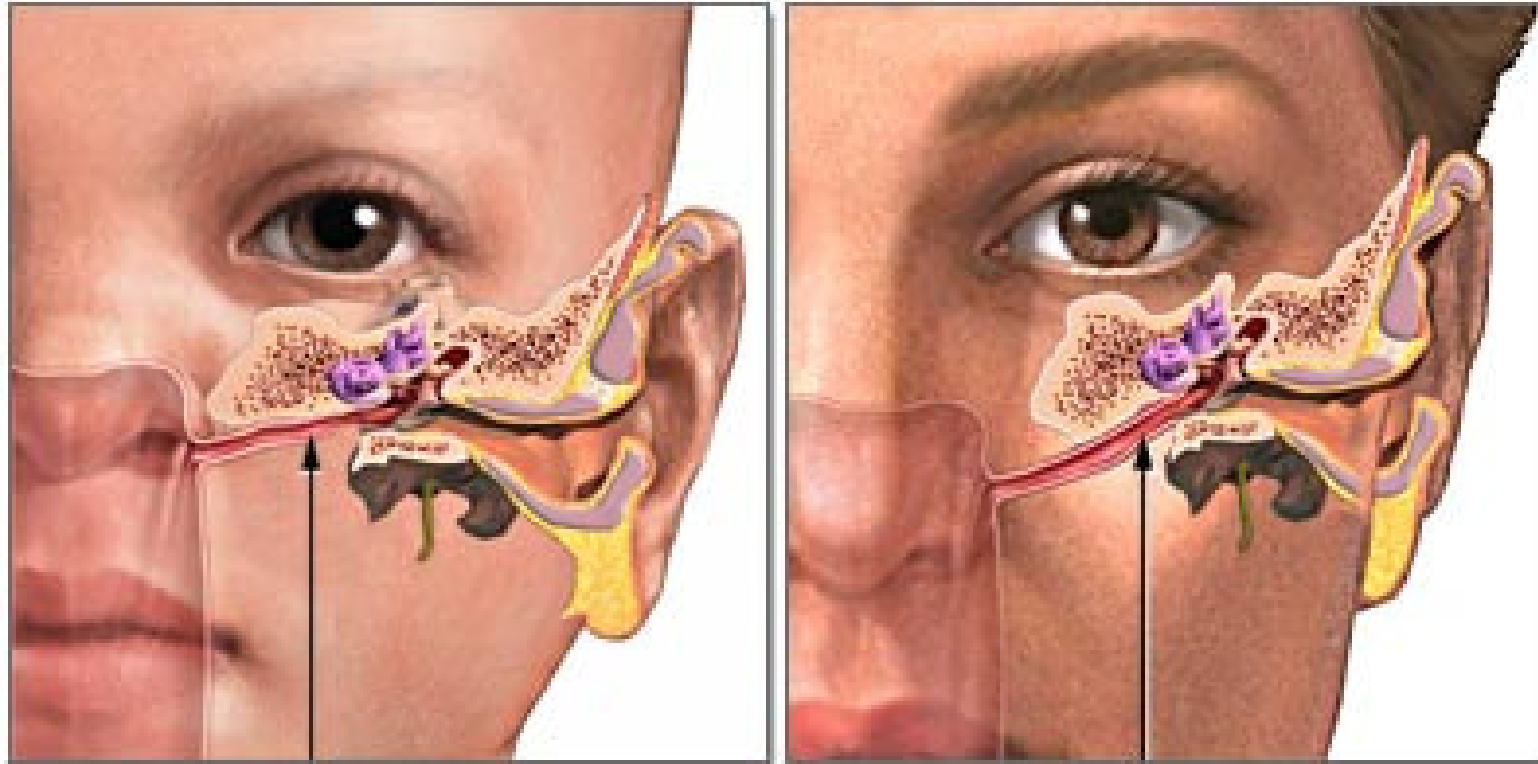
communication with oral cavity (Waldeyer's lymphoepitelial circle)

Pars laryngea pharyngis

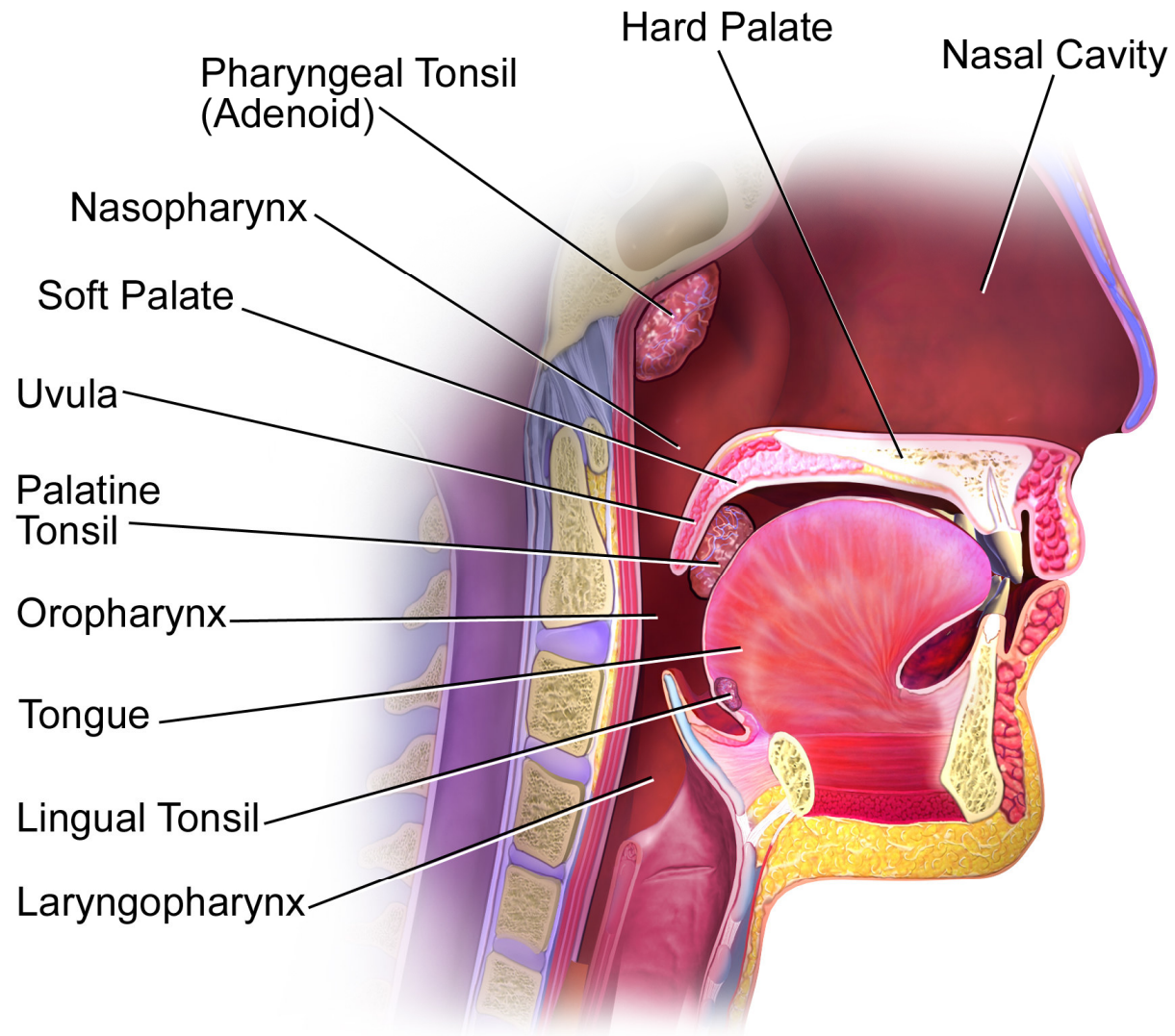
(at the level of C6 transition to oesophagus) aditus laryngis in its anterior wall

Infant

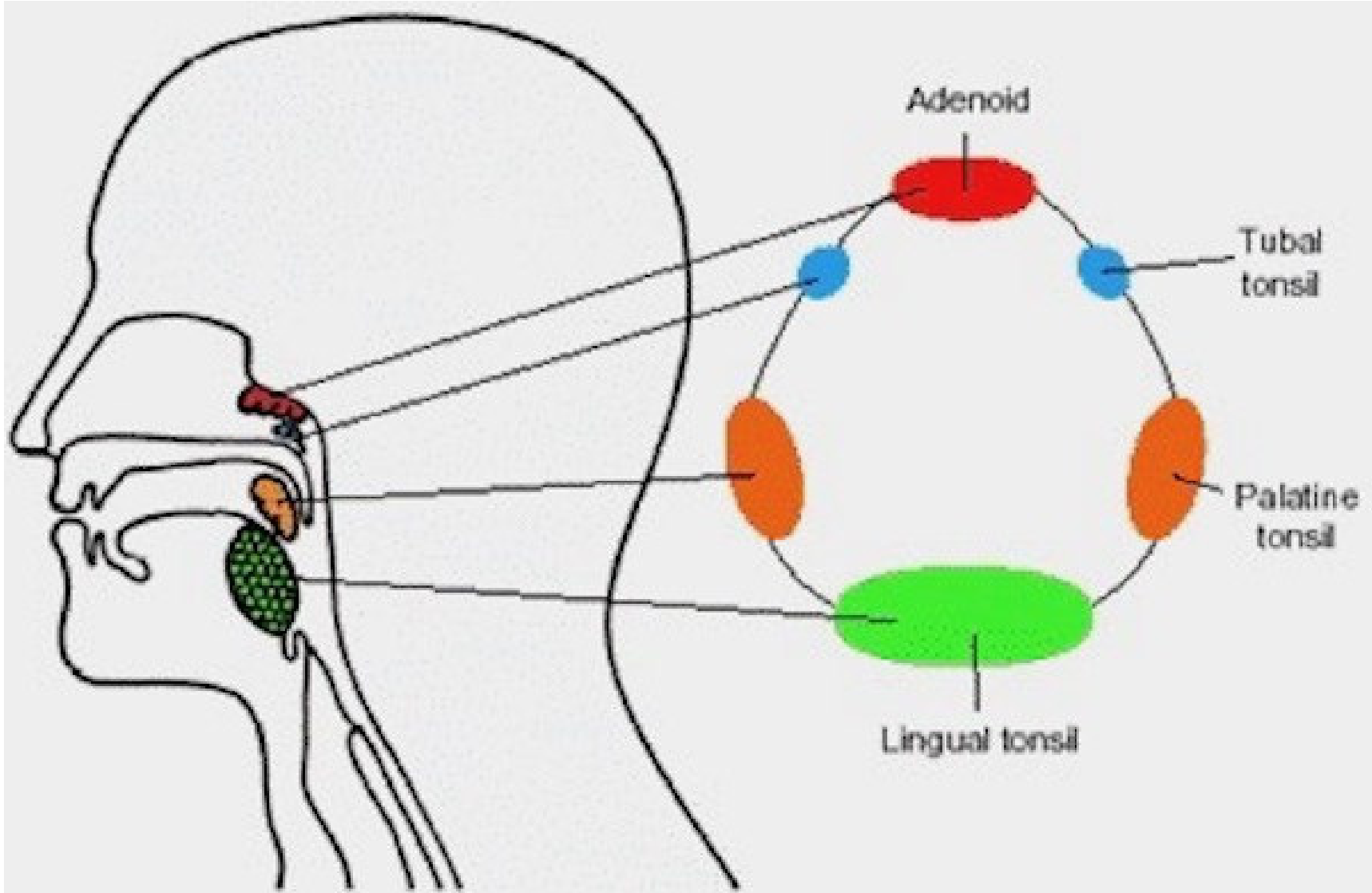
Adult



Eustachian tube

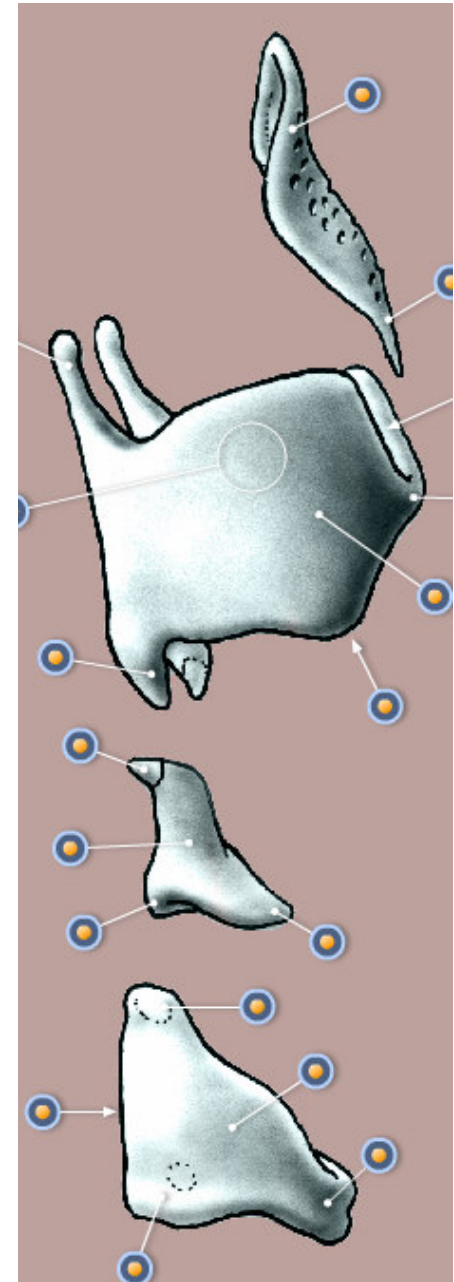
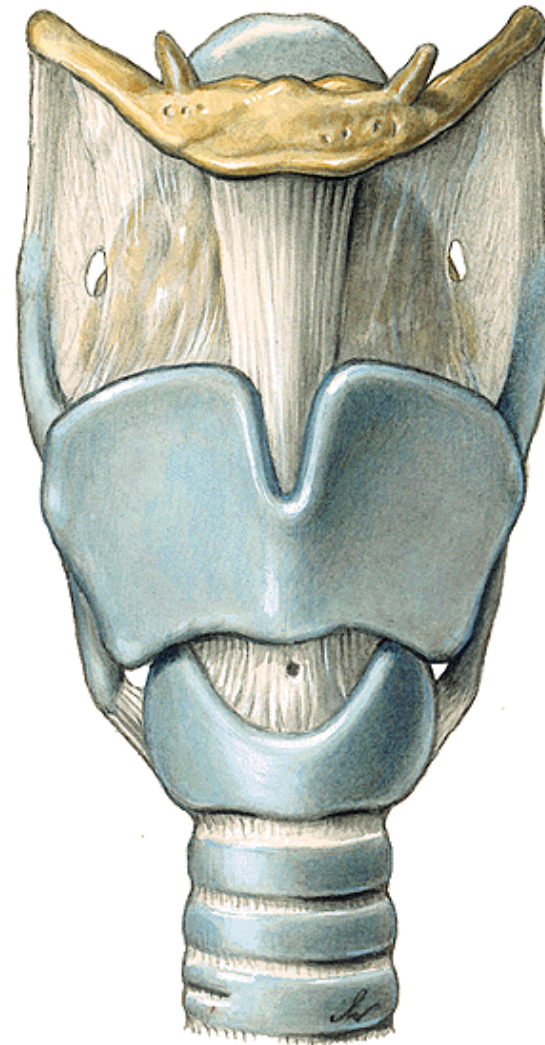
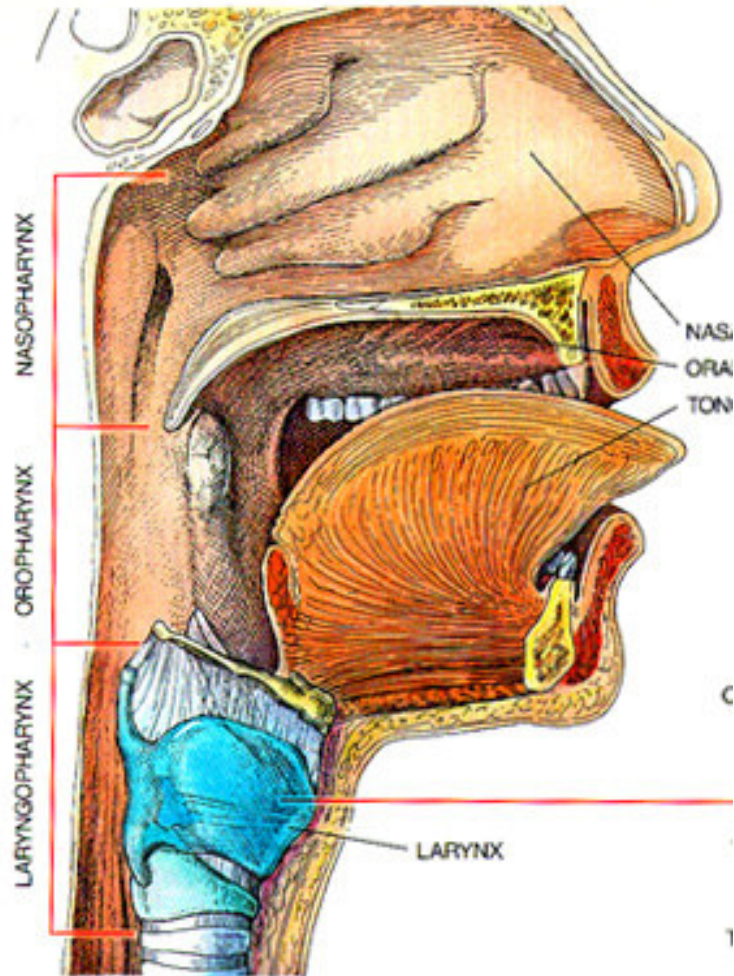


Tonsils and Throat



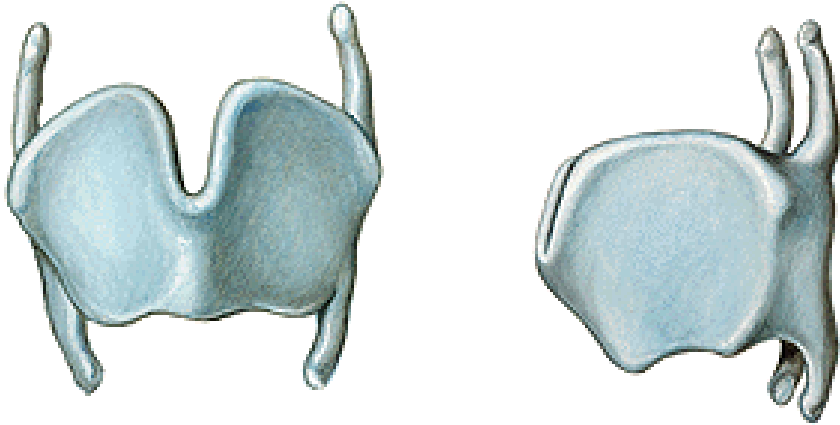
2. The lower respiratory tract

Larynx



The cartilages of the larynx

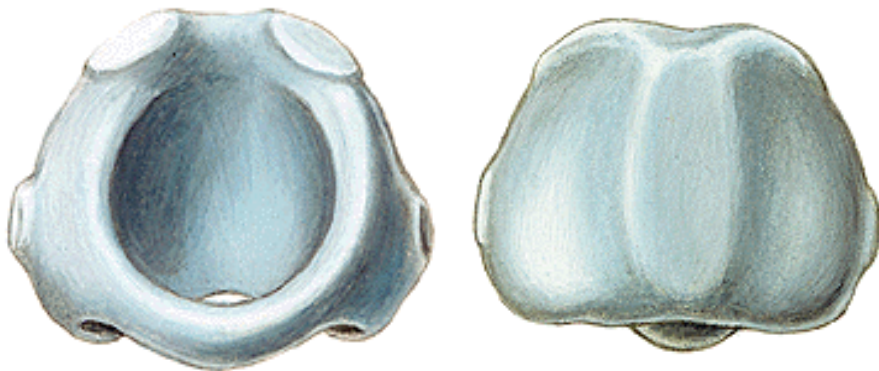
Cart. thyroidea (laminae, cornua, linea obliqua)



Cart. epiglottica (petiolus)



Cart. cricoidea (arcus, lamina)



Cartt. arytenoideae (proc. muscularis and vocalis)

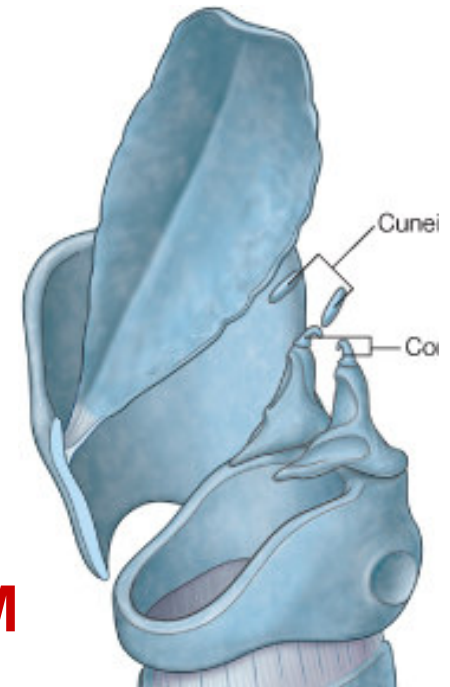
Cartt. cuneiformes

Cartt. corniculatae



V

M



The joints of the larynx

Membrana thyrohyoidea

Membrana quadrangularis

(from epiglottis till the arytenoid cartilage, ligg. vestibularia)

Conus elasticus

(between ligg. vocalia and arcus cartilagineus cricoideae), [Lig. cricothyroideum](#) (coniotomy)

Membrana fibrocartilaginea laryngis

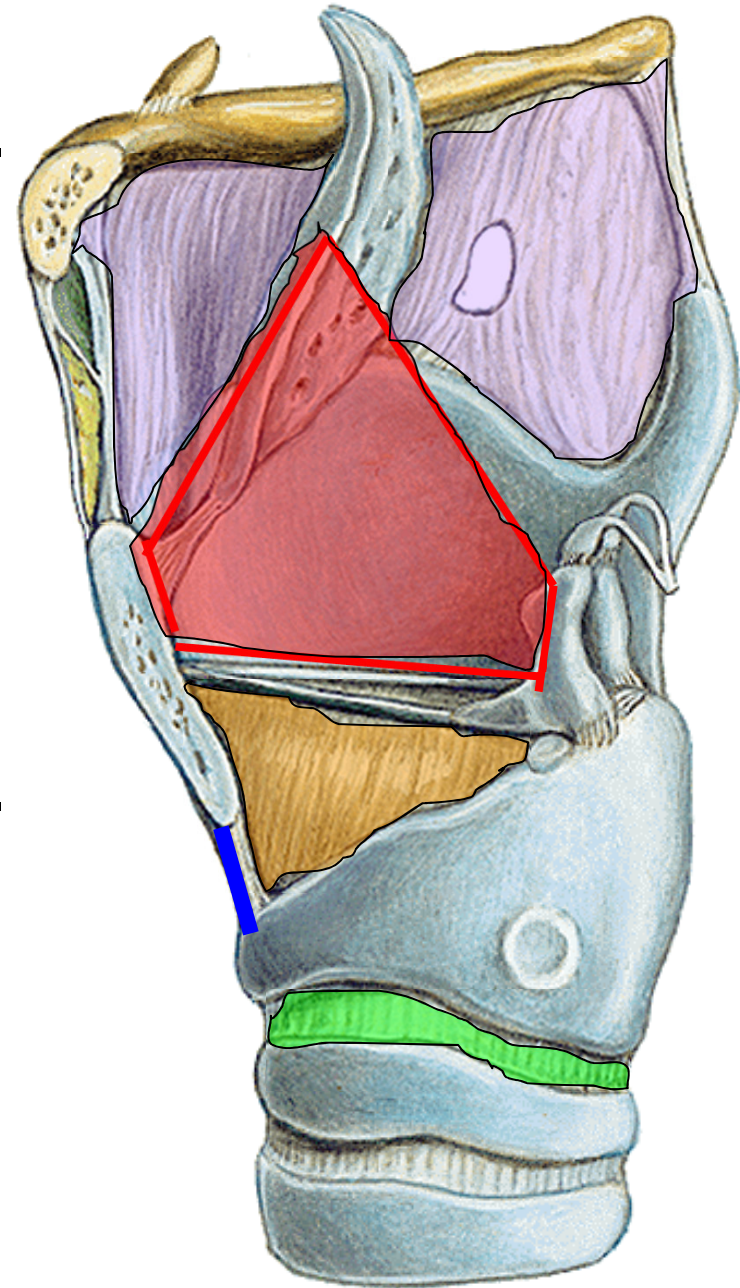
conus elasticus + membrana quadrangularis

Ligg. vestibularia (reinforced margin of membrana quadrangularis)

Ligg. vocalia (reinforced margin of conus elasticus)

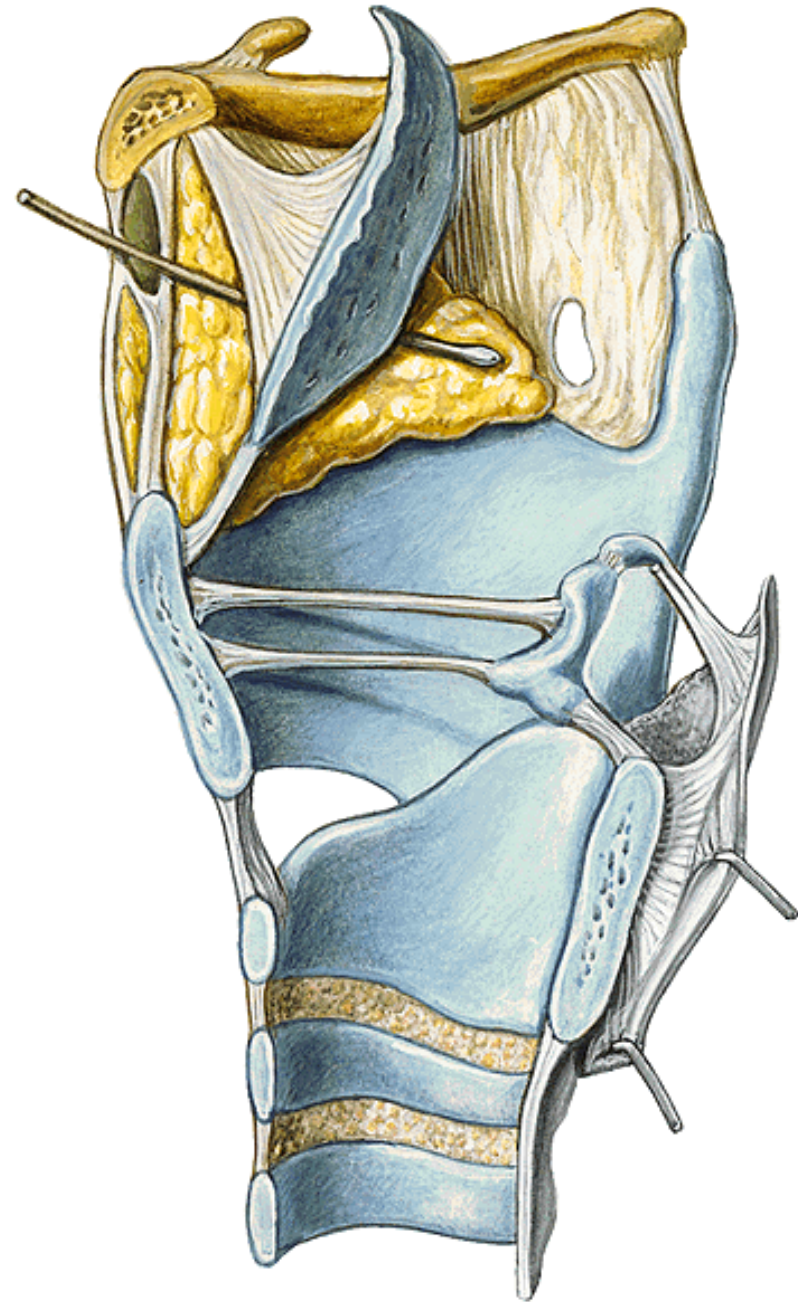
- stratified squamous epithelium, yellowish colour
-

Lig. cricotracheale



Ligamentum hyoepiglotticum

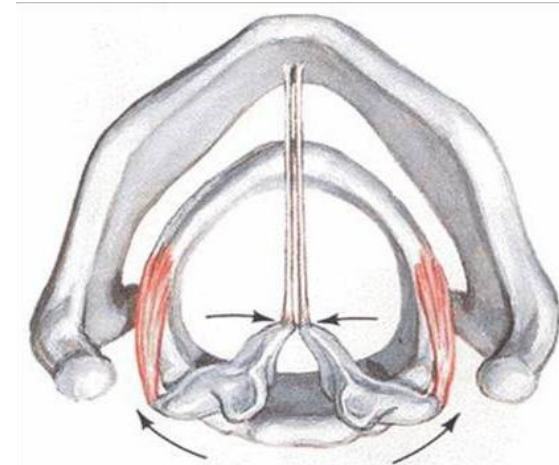
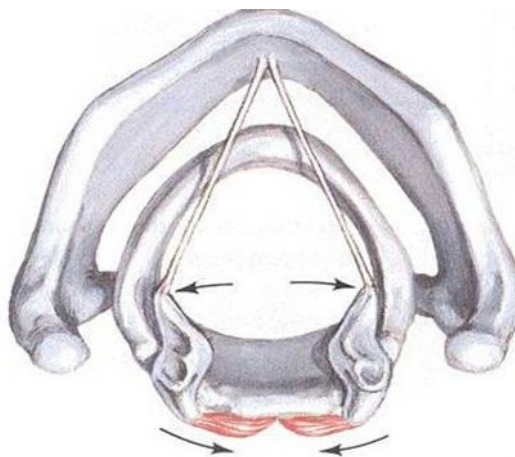
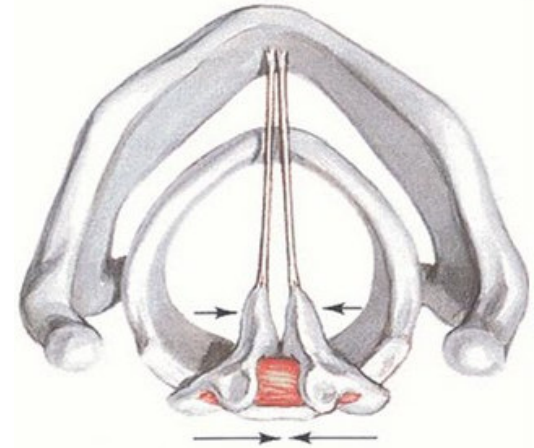
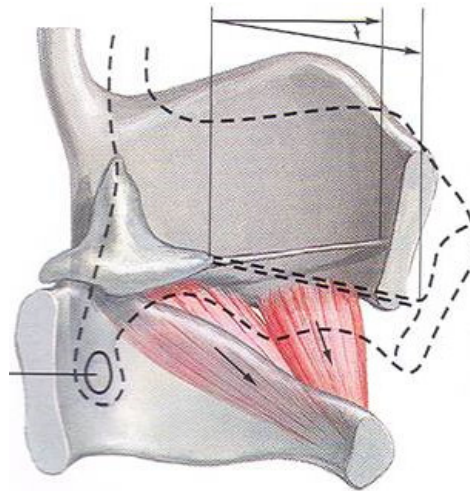
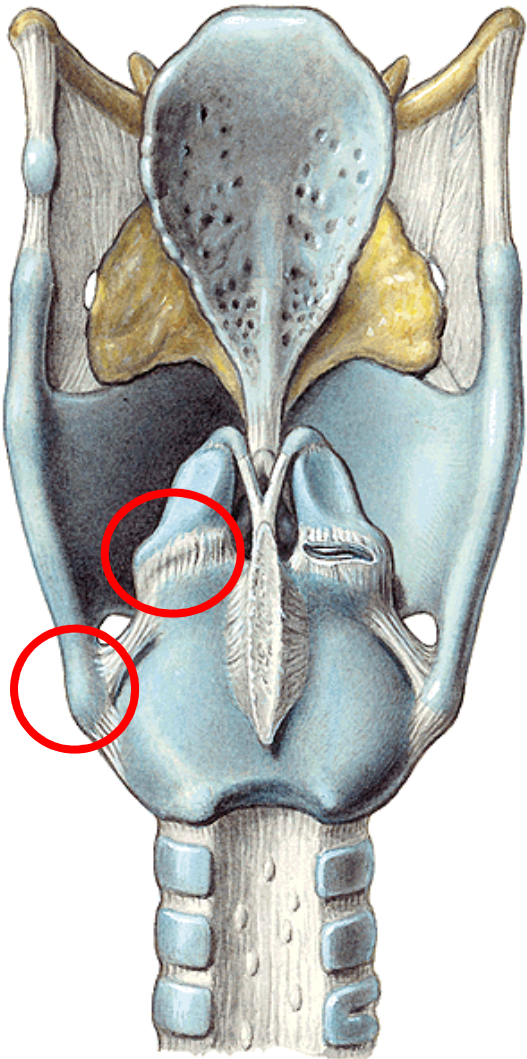
Ligamentum thyroepiglotticum



Joints:

Art. cricothyroidea (the oscillative motions)

Art. cricoarytenoidea (rotation and sliding movements– base of the abduction and adduction of the vocal cords)

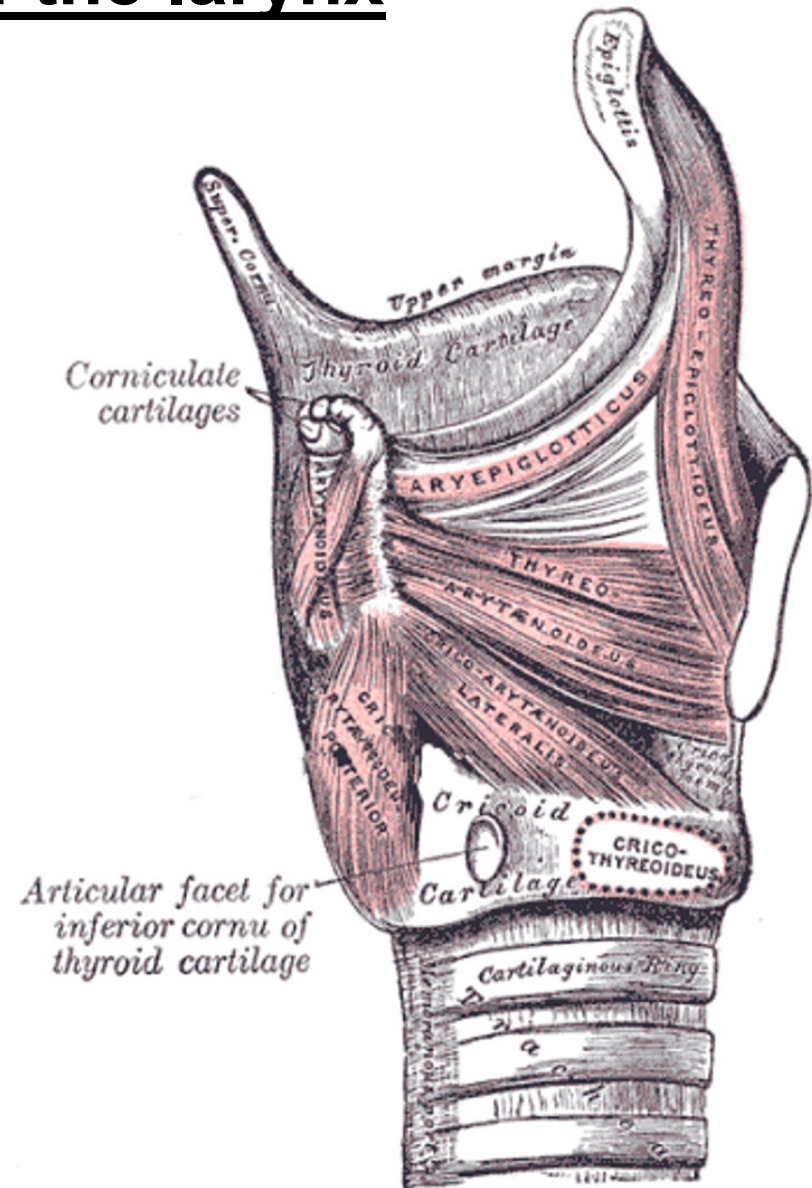


The muscles of the larynx

- affect the position, length and tension of the vocal cords and the position of the *epiglottis*

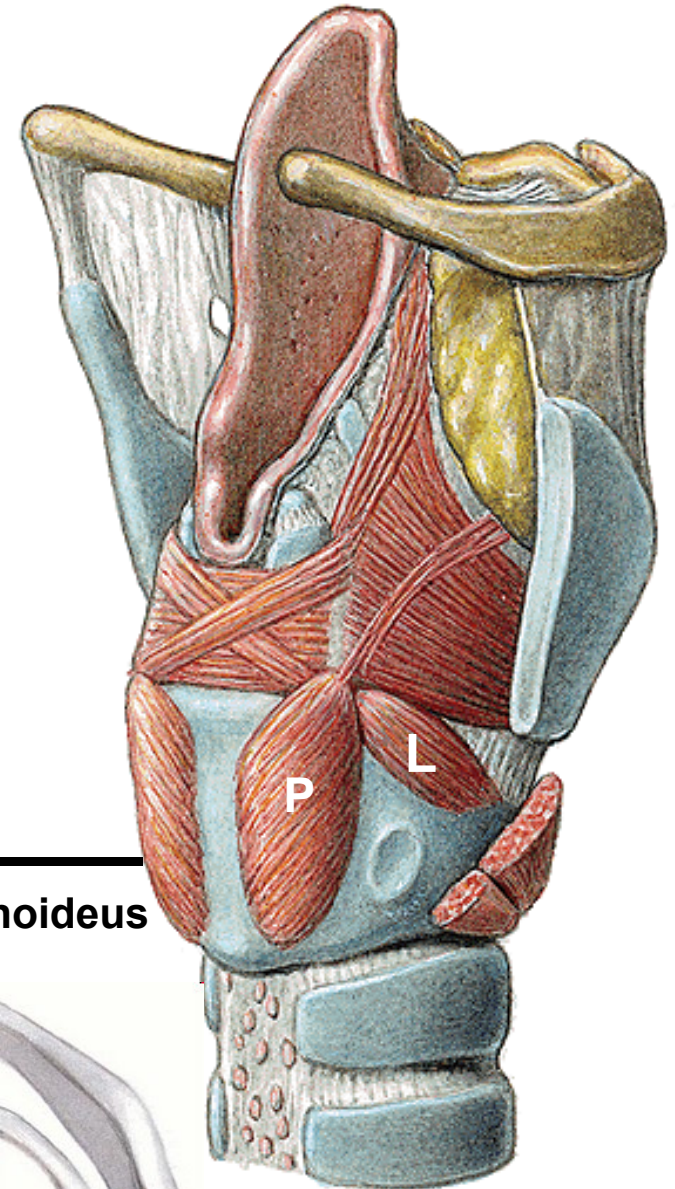
1) The muscles regulating the epiglottic cartilage:

- Musculus thyroepiglotticus opens up *aditus laryngis*
- Musculus aryepiglotticus encloses *aditus laryngis*

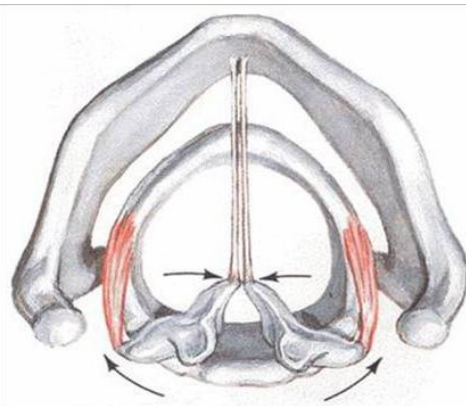


2) The muscles regulating the vocal cords:

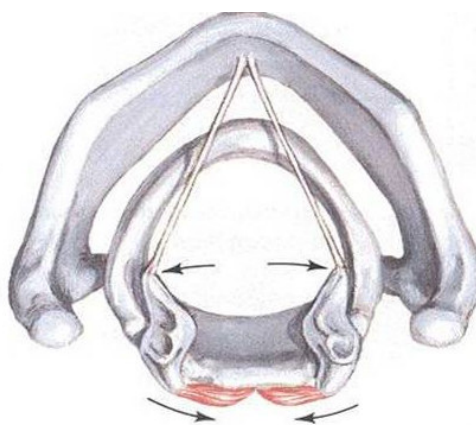
- a) Musculus cricoarytaenoideus lateralis
adduction of vocal cords – phonatory position
- b) Musculus cricoarytaenoideus posterior
(musculus posticus) abduction of vocal cords – respiratory position
- c) Musculus arytaenoideus
the strongest adductor



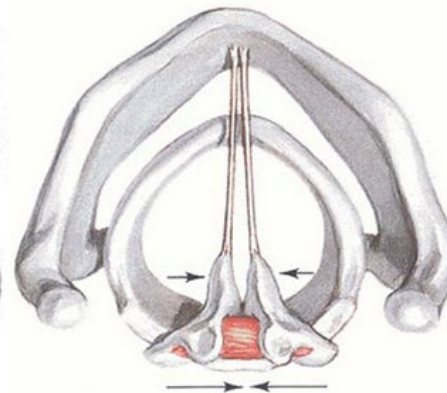
m. cricoarytaenoideus lateralis



m. cricoarytaenoideus posterior

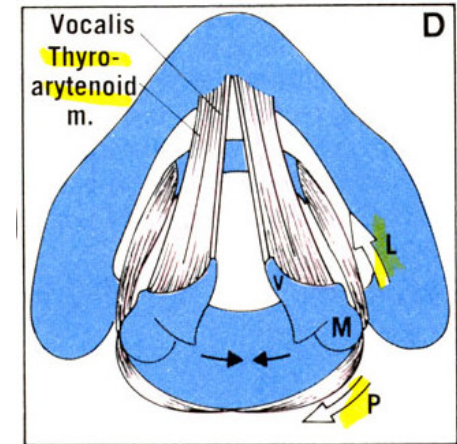
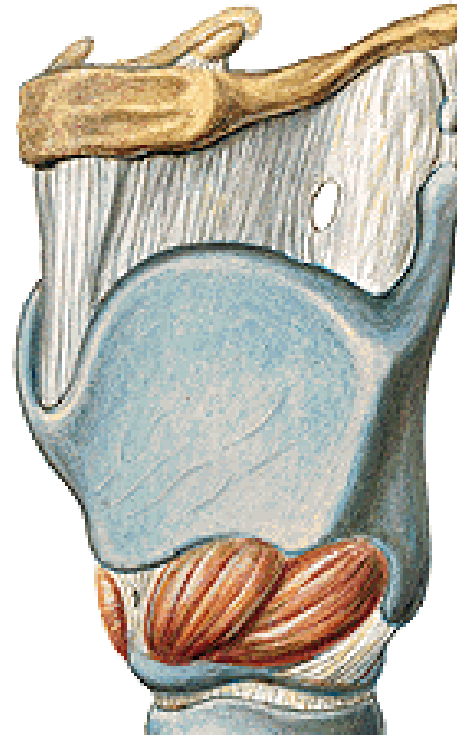
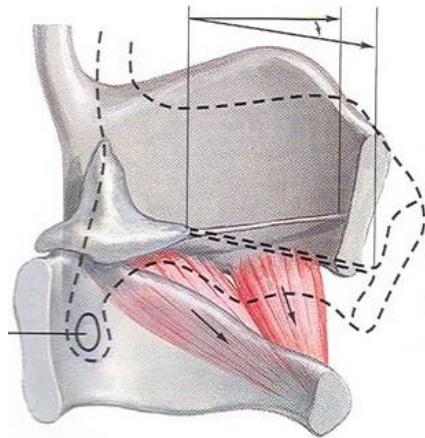


m. arytaenoideus

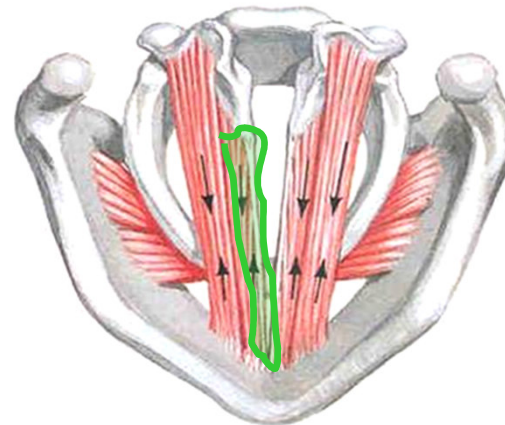


3) Muscles regulating tension of the vocal cords:

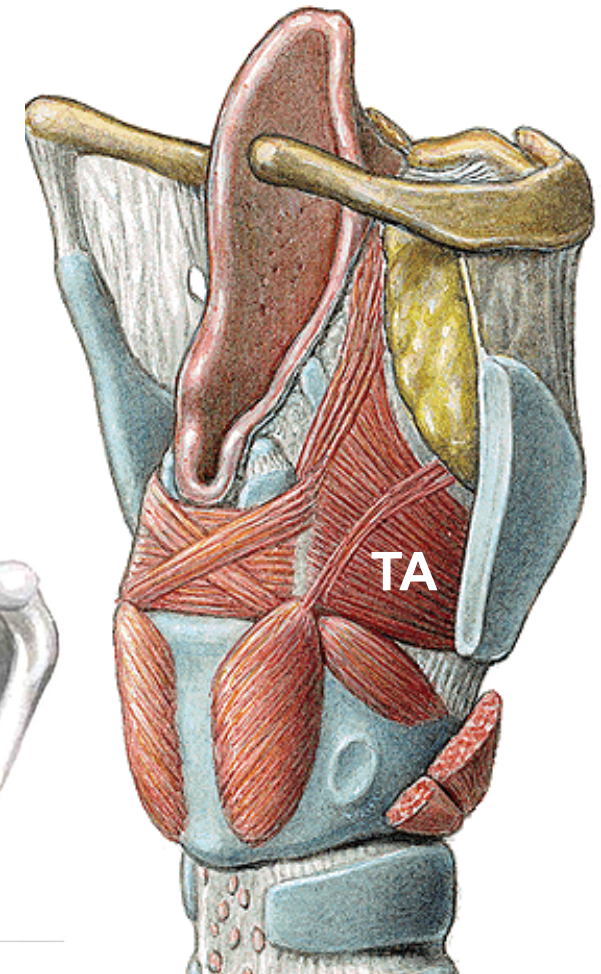
a) Musculus cricothyroideus stretches the vocal cords (tensor)



b) Musculus thyroarytaenoideus releases tension of the vocal cords



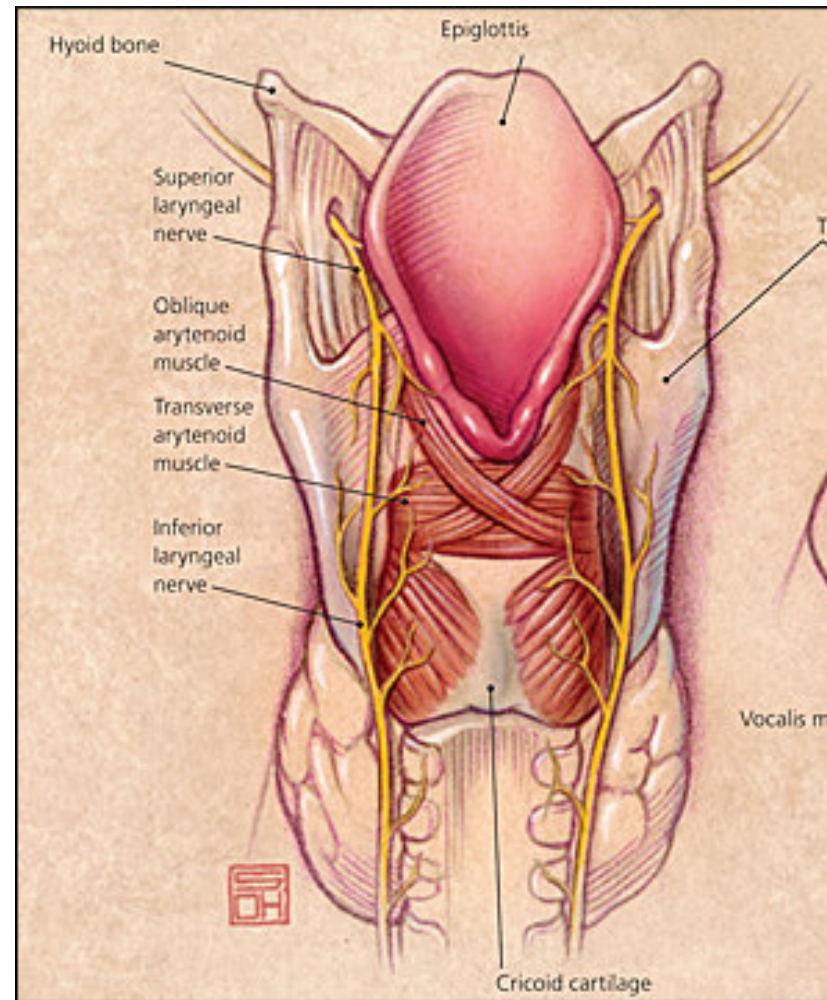
c) Musculus vocalis fine regulation of the shape and tension of the vocal cords



The muscles of the larynx are innervated by *nervus vagus* through:

nervus laryngeus superior
(*musculus cricothyroideus*)

nervus laryngeus inferior
(all other laryngeal muscles)



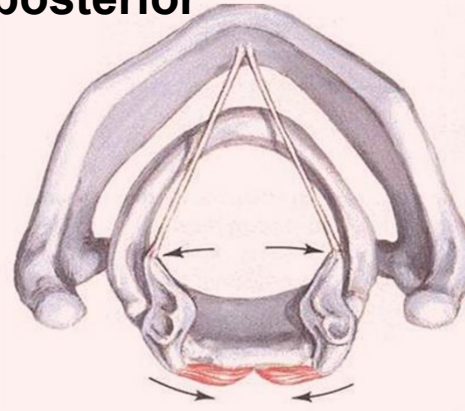
Respiratory position

Vocal cords are in **abduction**

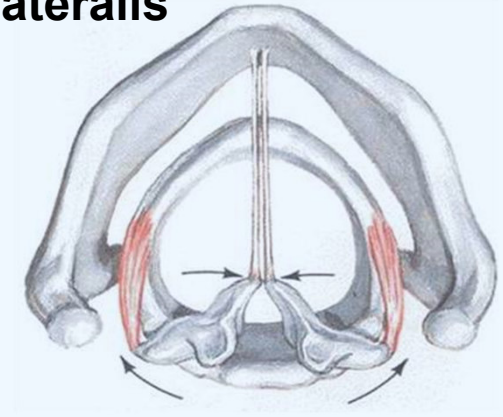
Phonatory position

Vocal cords are in **adduction**

m. cricoarytaenoideus posterior

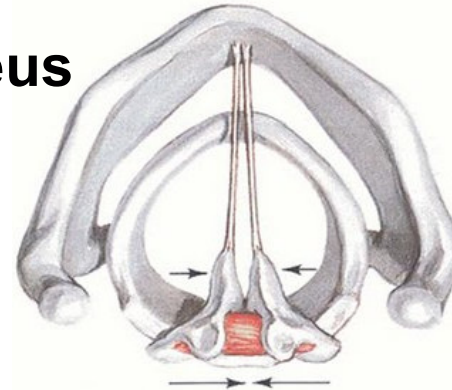


m. cricoarytaenoideus lateralis



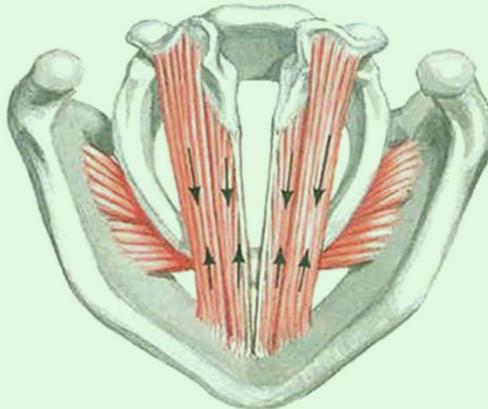
Releasing of v.c. - m. thyroarytaenoideus

Tension of v.c. - m. cricothyroideus

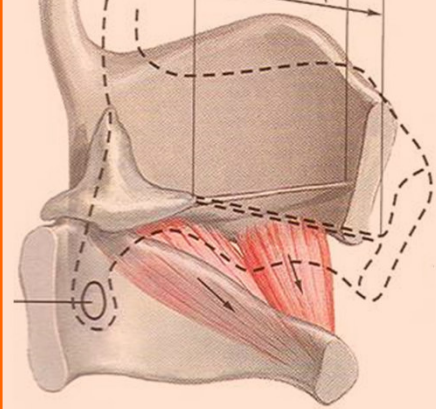


m. arytaenoideus

m. thyroarytaenoideus



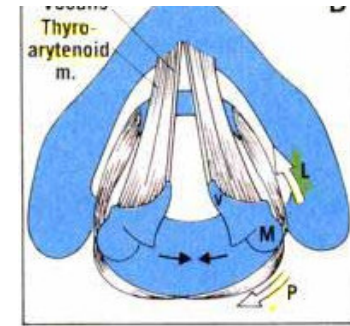
m. cricothyroideus



Larynx

1) Vestibulum laryngis

from epiglottis (aditus laryngis) till plicae vestibulares

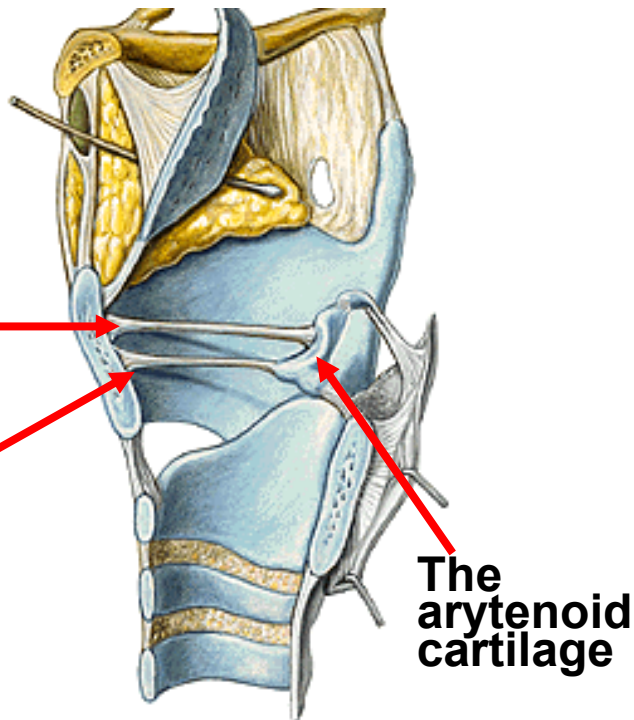


2) Glottis

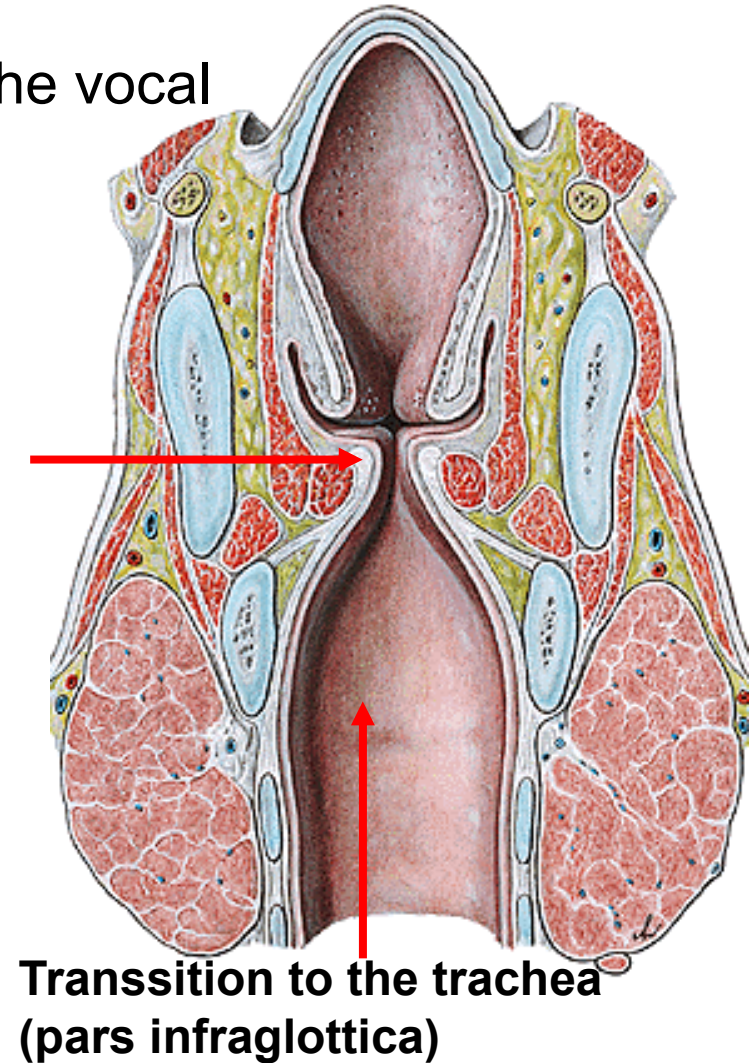
from plicae vestibulares till plicae vocales

rima glottidis – sagittal fissure between the vocal cords

3) Cavitas infraglottica

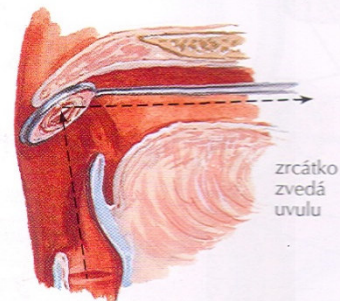
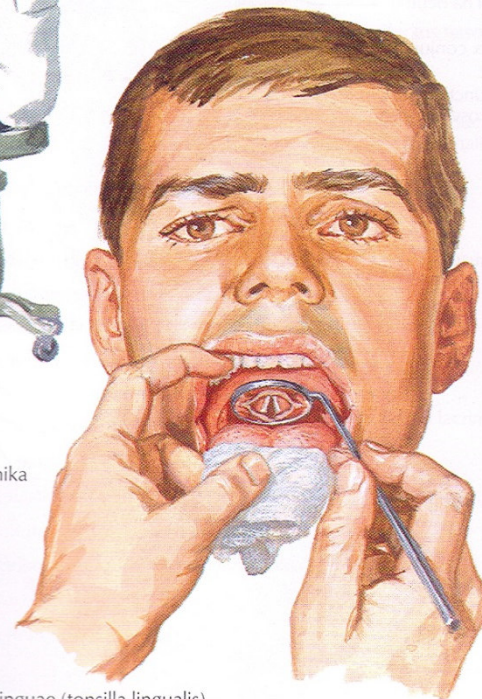
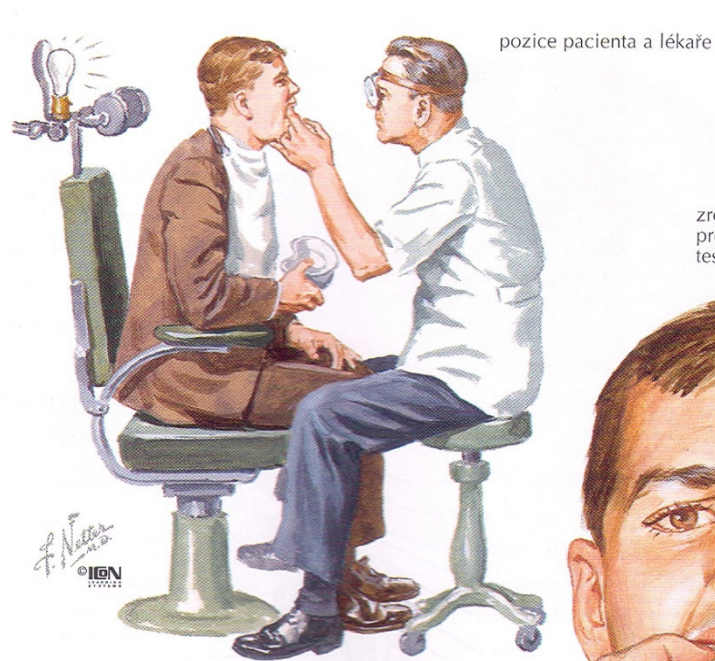
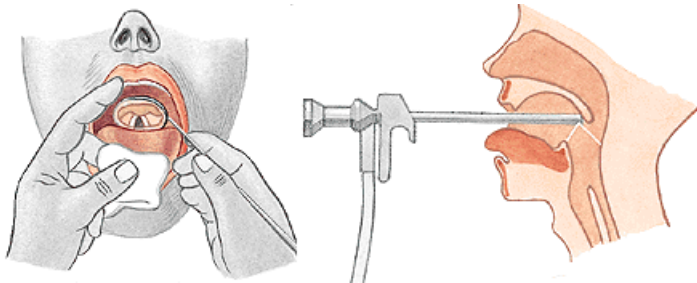


glottis



The laryngoscopic view

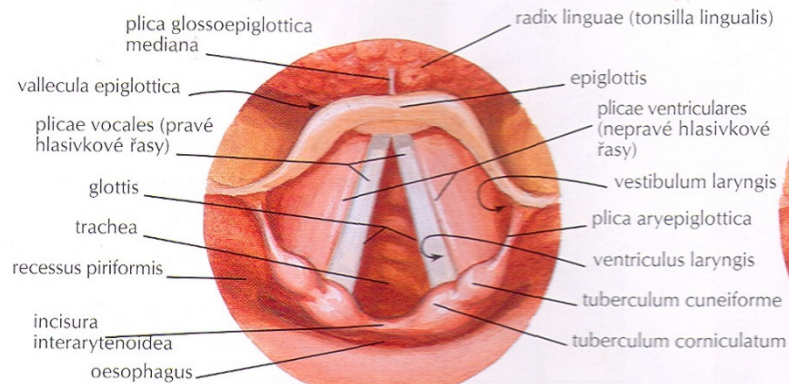
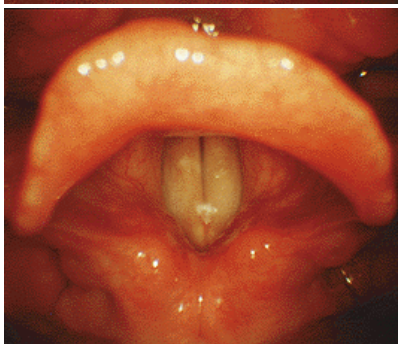
laryngoscopy



Respiratory position



Phonatory position



hrtan: inspirační poloha

hrtan: fonační poloha

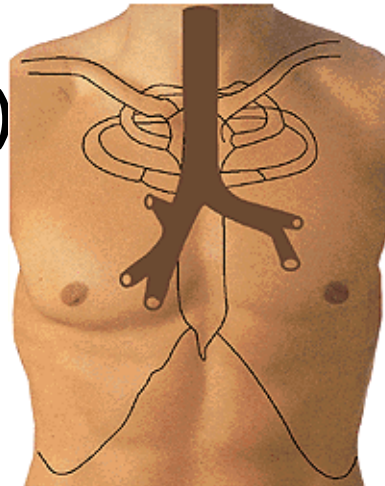
Trachea (The windpipe)

Pars cervicalis (C6- C7)

Pars thoracica (Th1-Th4)

Newborn from C4

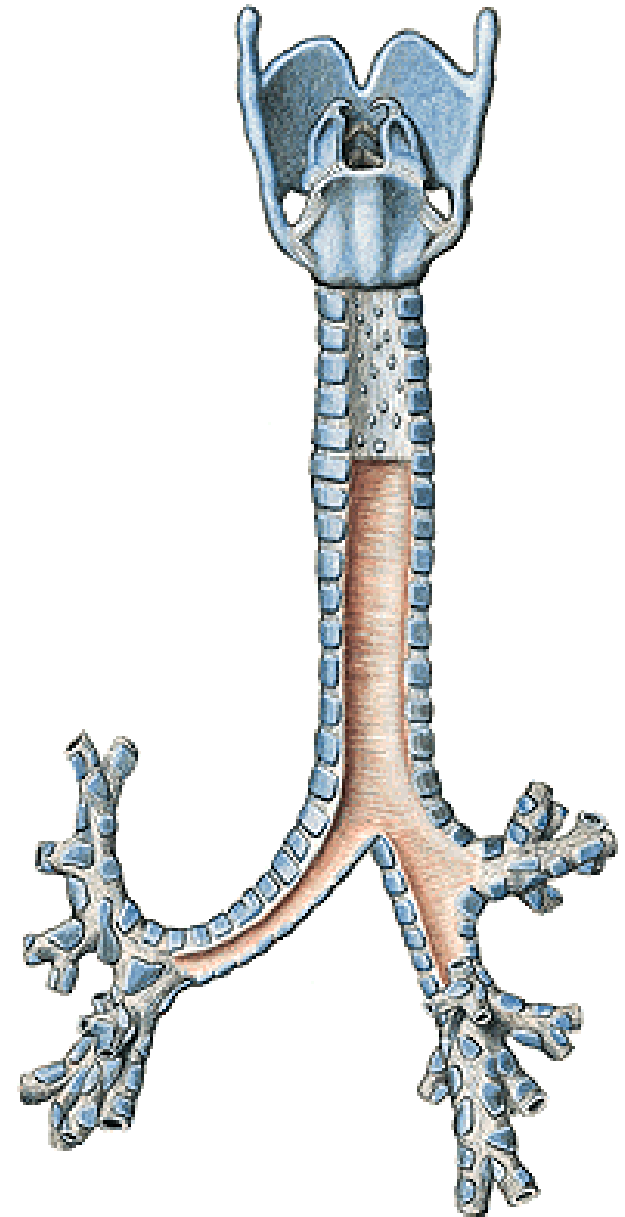
Child from C5



Bifurcatio tracheae (Th4)

= 1st division of the bronchial tree

Carina tracheae



length 10-11 cm, diameter 12 mm

Trachea (C6–Th4 or 5)

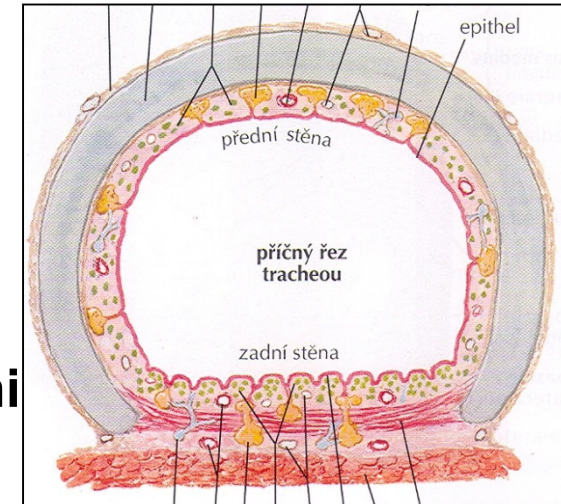
Cartilagine tracheales (15-20, horseshoe shape)
Ligamenta anularia
Paries membranaceus (fibrous tissue, smooth muscles)

Ciliated columnar epithelium

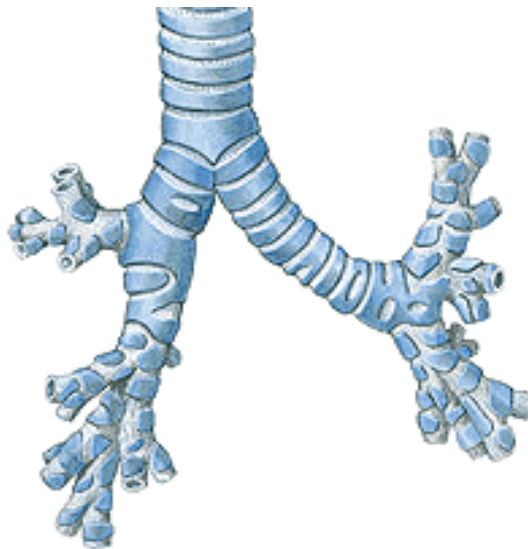
Trachea divides by Th₄₋₅ into: main (primary) bronchi

Bronchus principalis dexter

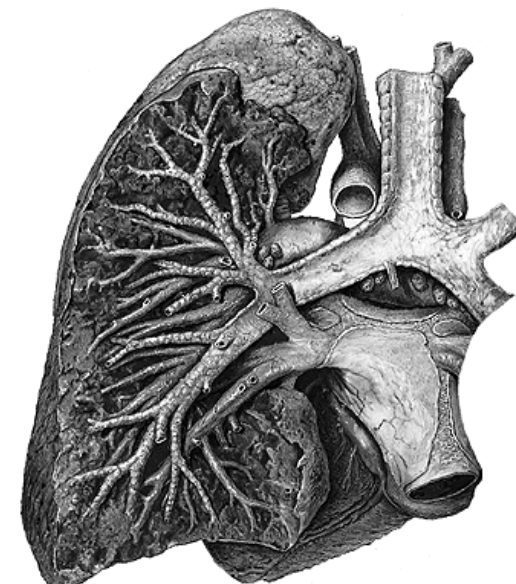
Bronchus principalis sinister



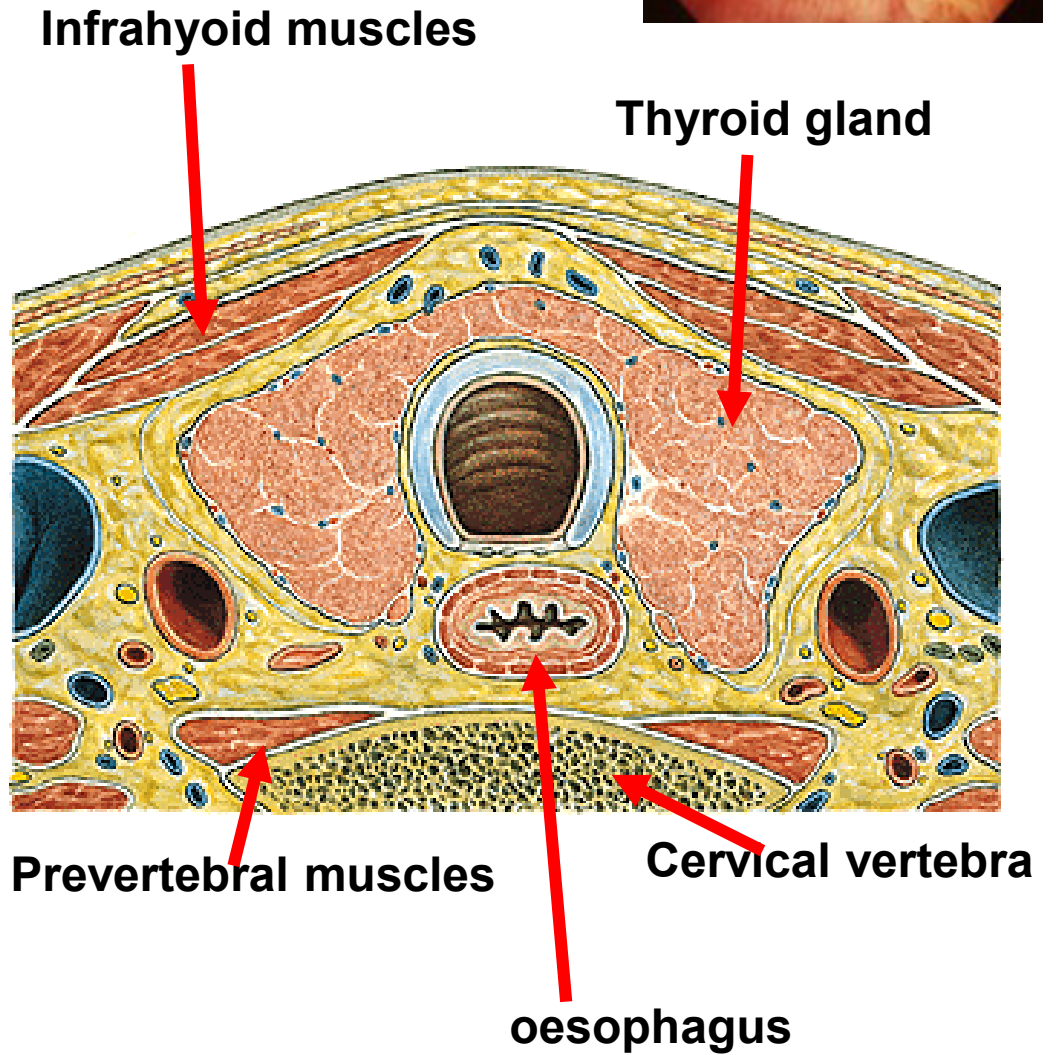
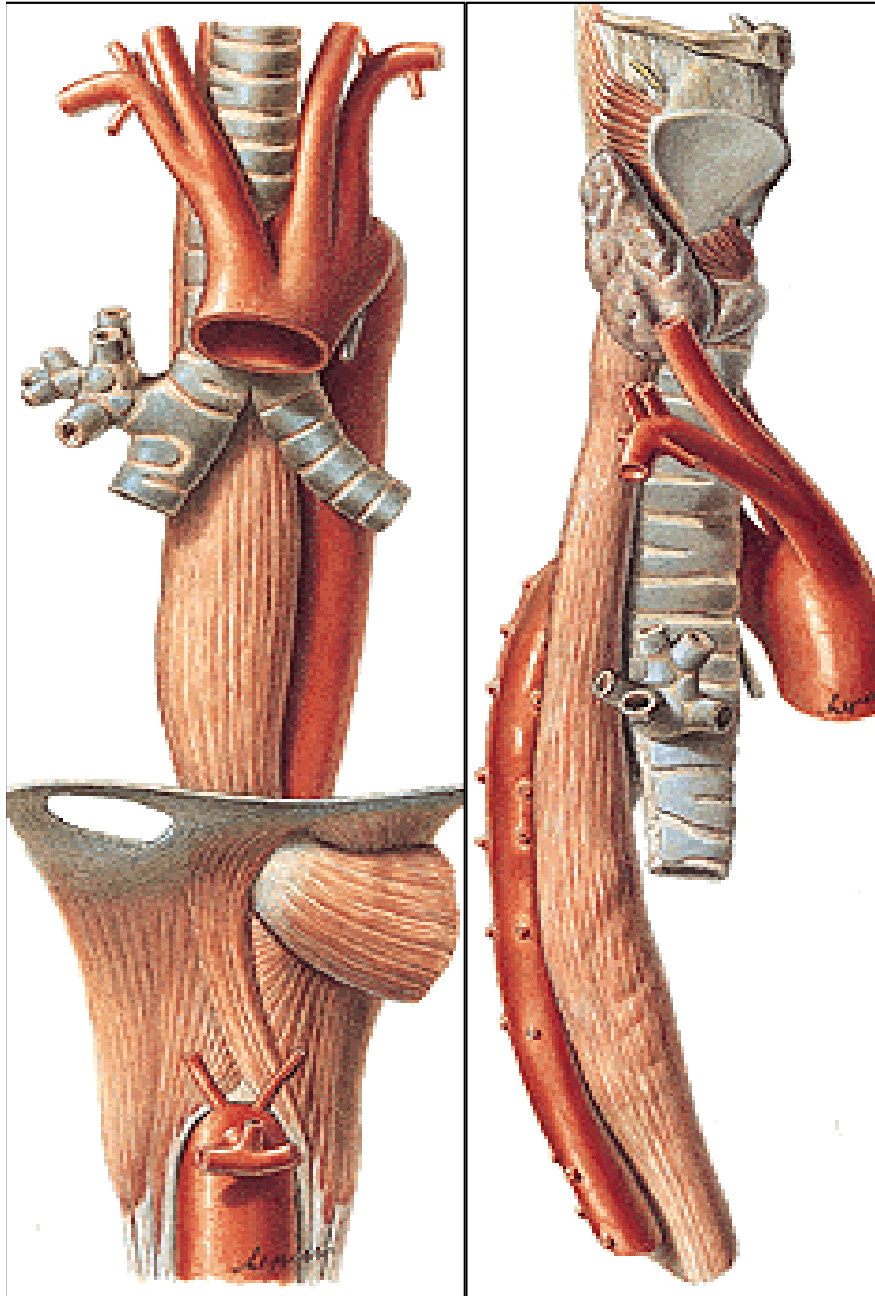
shorter, wider → **Foreign body intrudes in 75% to the right bronchus**



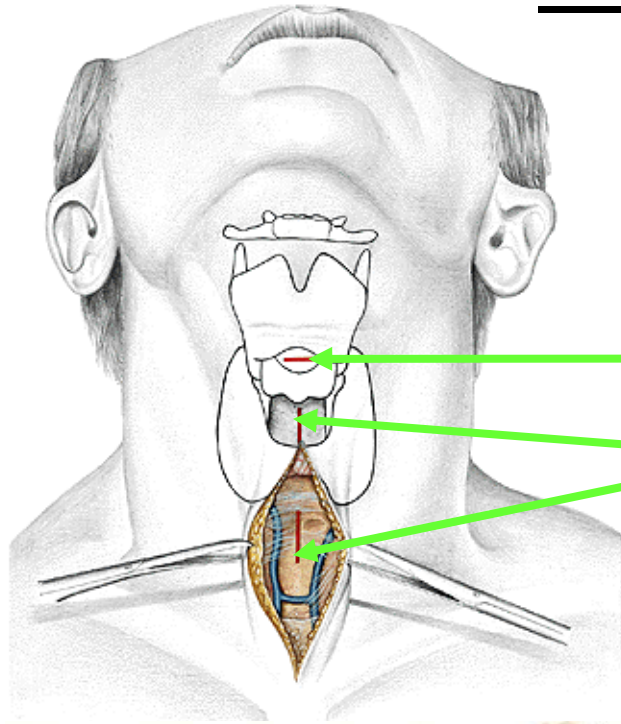
(bronchial tree– arbor bronchiales)



Syntopy: *in front* thyroid gland, *behind* oesophagus

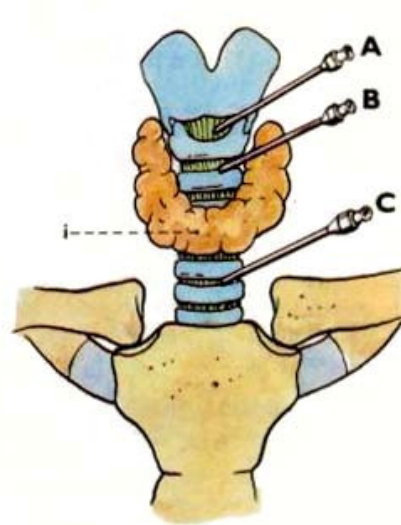
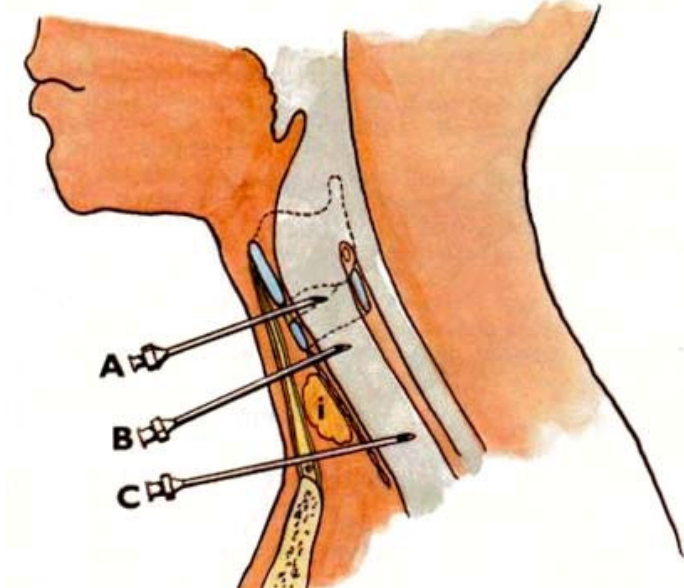


The coniotomy, The tracheotomy



Coniotomy (lig. cricothyroideum)

Tracheotomy superior and inferior



Coniotomy

Tracheotomy superior

Tracheotomy inferior

Arbor bronchiales

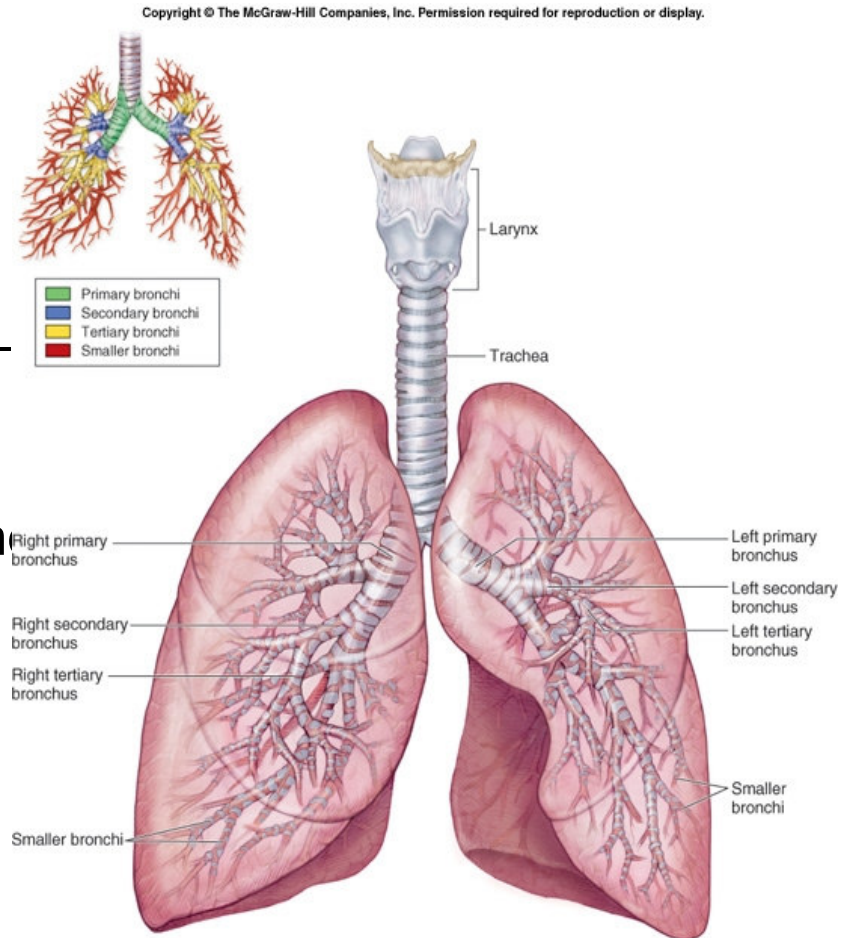
Bronchi principales divide into:

- **bronchi lobares** (right 3, left 2) - secondary bronchi
- **bronchi segmentales** (9-10 sin., 10 dx.) – tertiary bronchi

(the pulmonary segment is of pyramidal shape, the apex is located in the area of the pulmonary hilus, segmentectomy)

The last section form:

- **bronchioli terminales** (<1mm, have no reinforcement, the wall is formed by smooth muscles – they can enclose the bronchial lumen)



Arbor alveolaris – breathing compartment of the lungs–

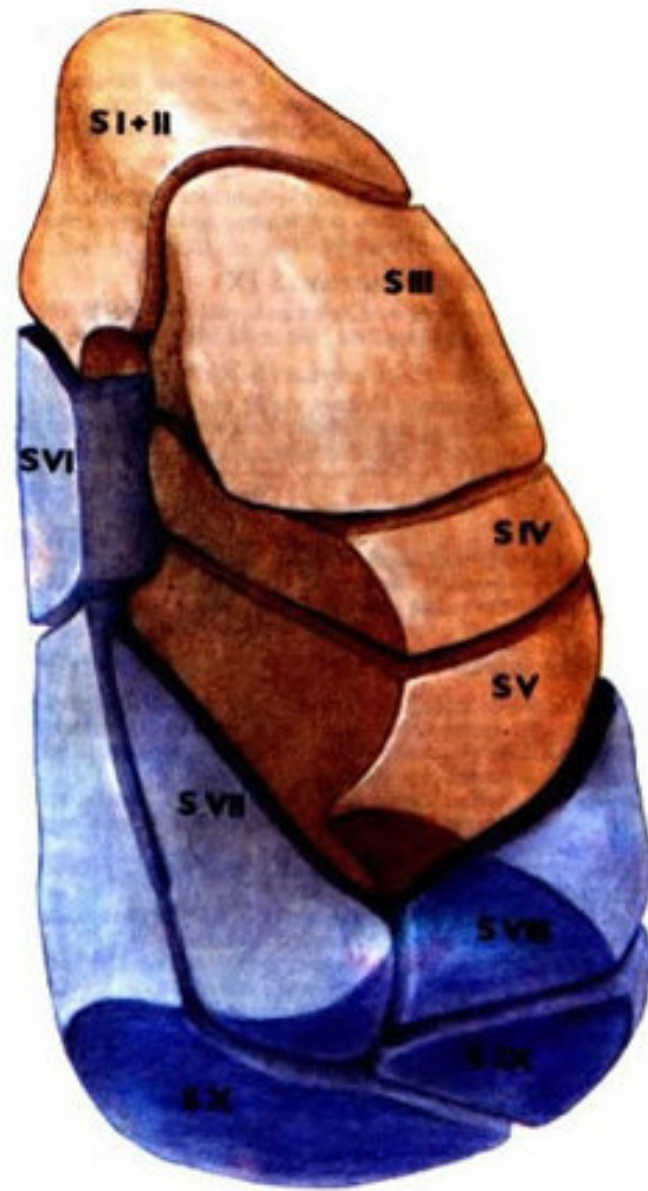
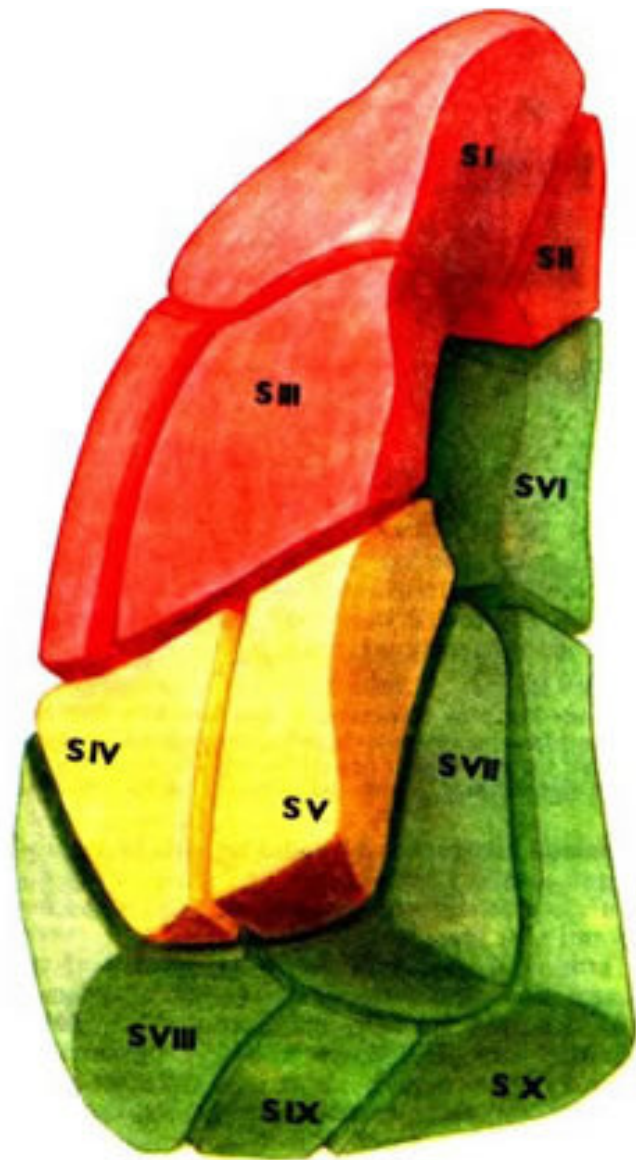
exchange of respiratory gases

- **bronchioli respiratorii**
- **ductuli alveolares** – atrium - **sacculi alveolares** - **alveoli pulmonis**

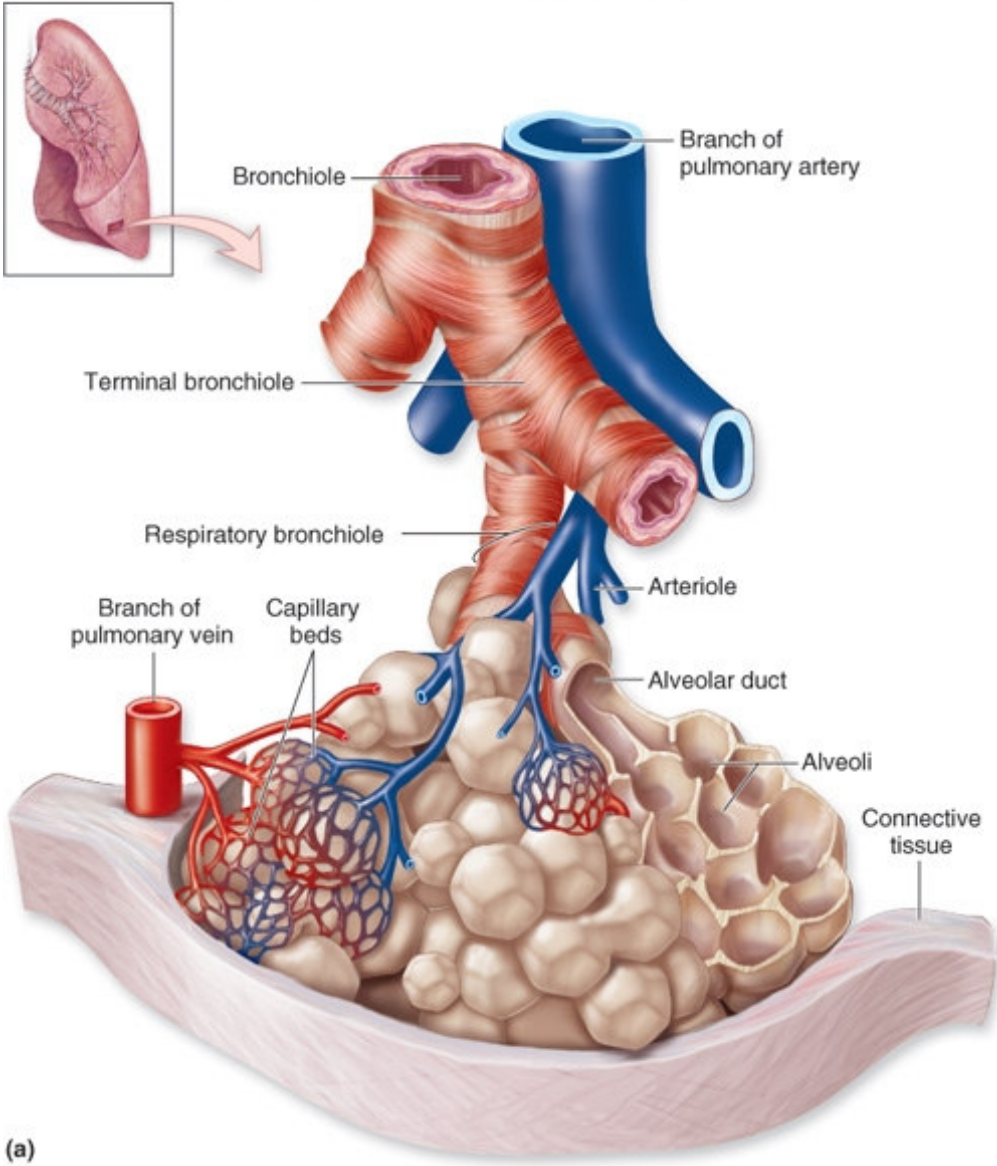
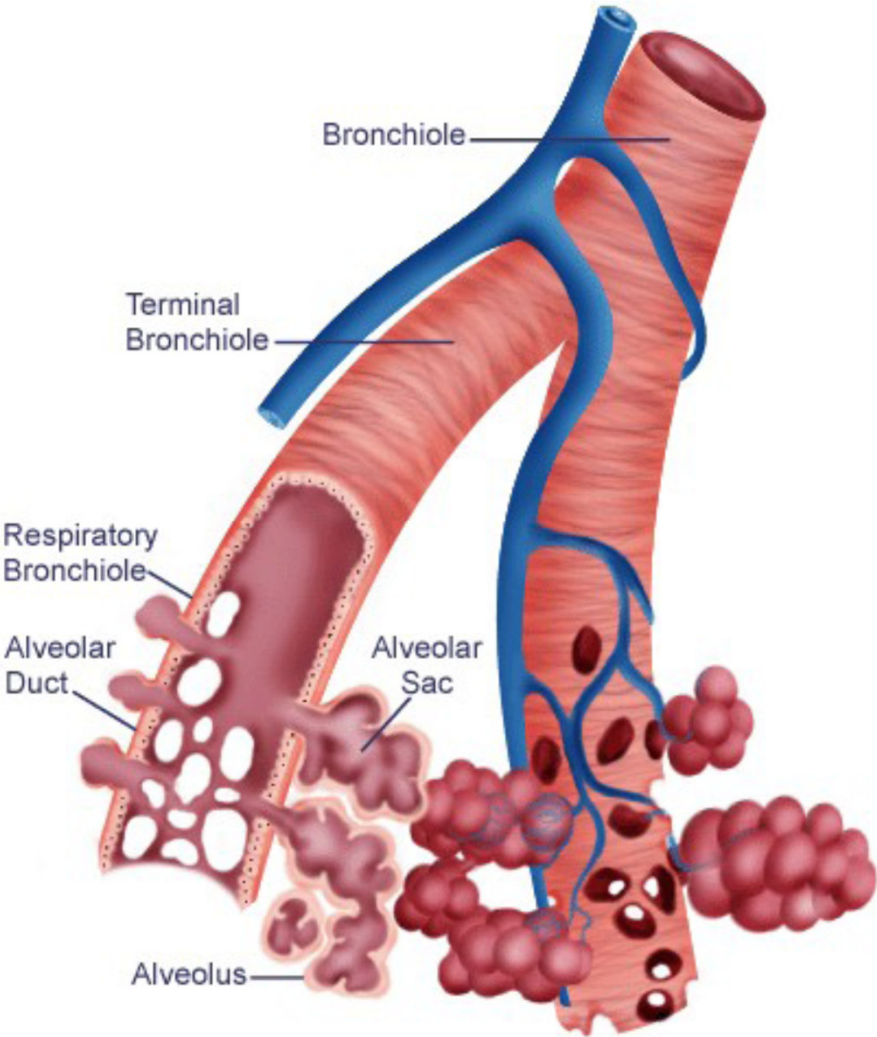
Thin-walled tubules

Alveolar sacs

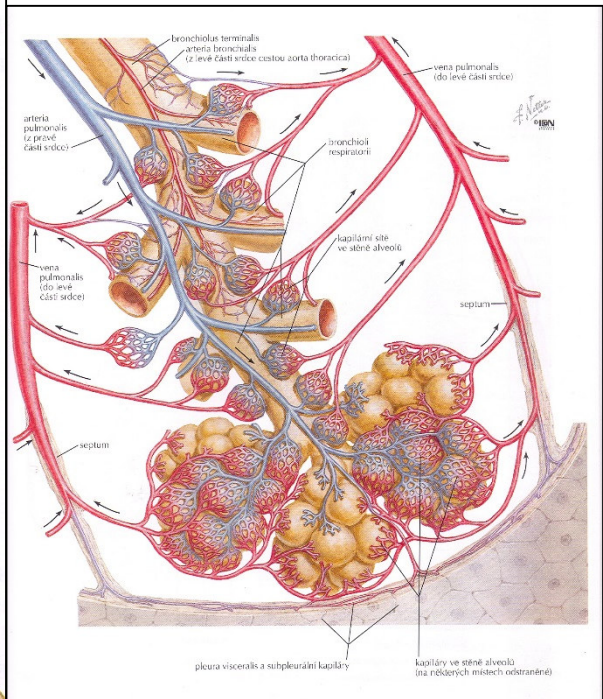
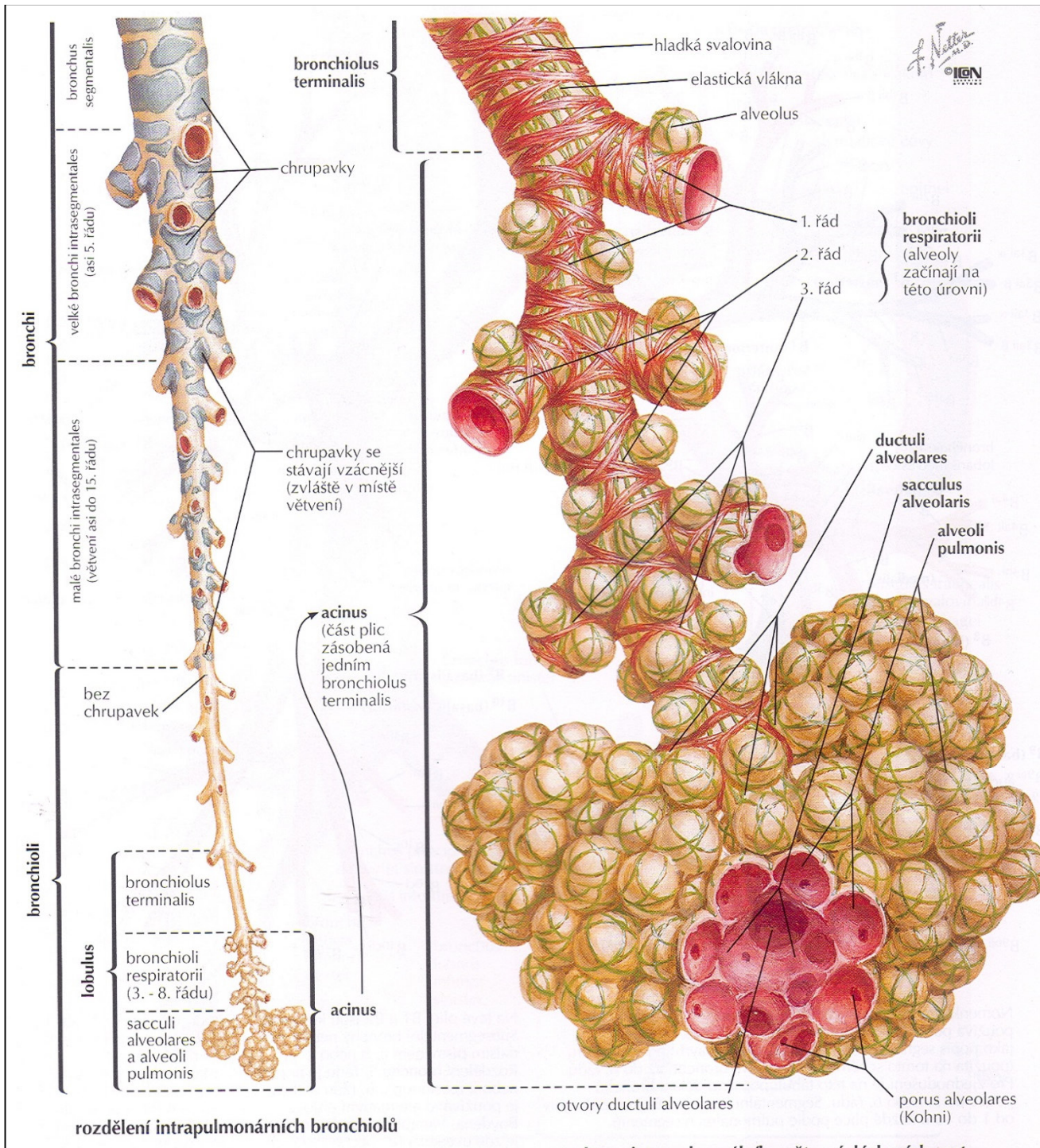
alveoli



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(a)

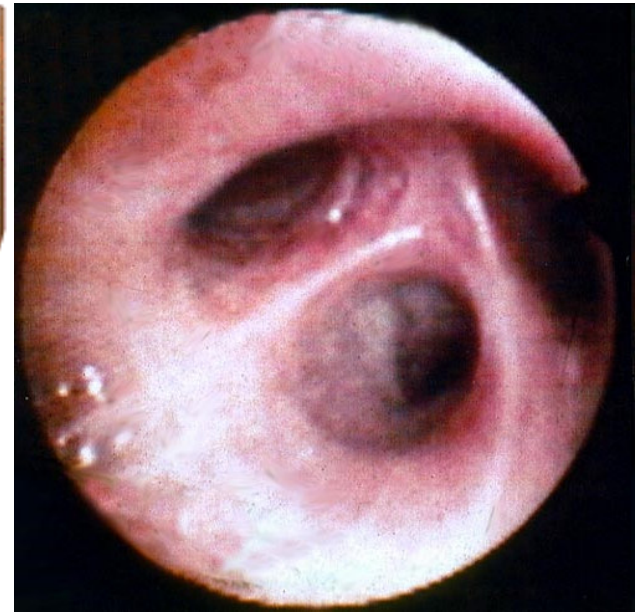
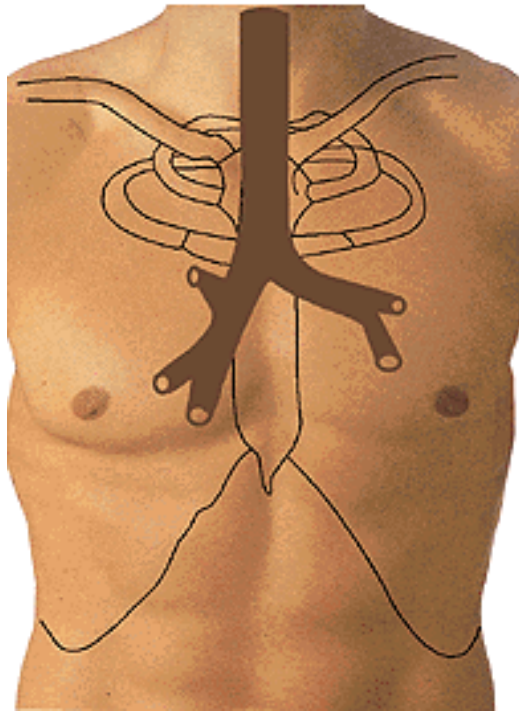


rozdělení intrapulmonárních bronchiolů

Bronchography



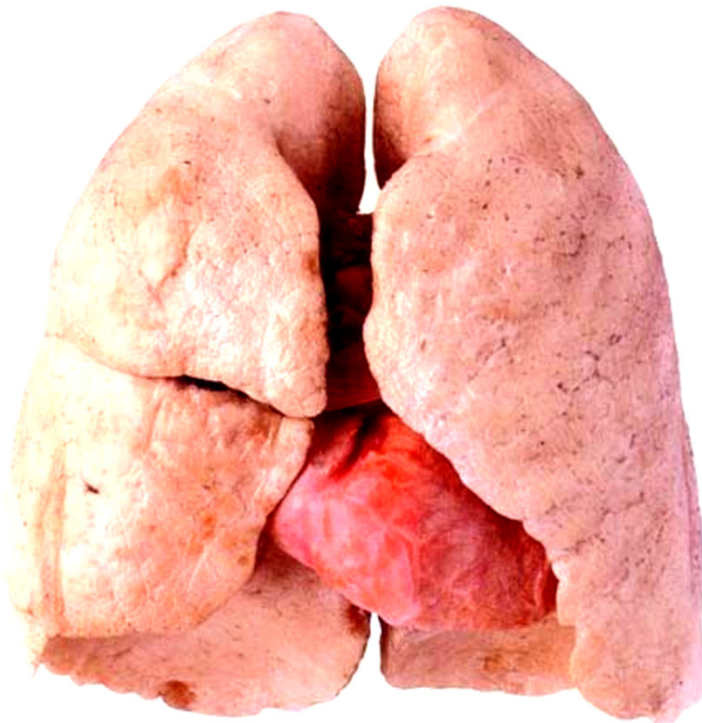
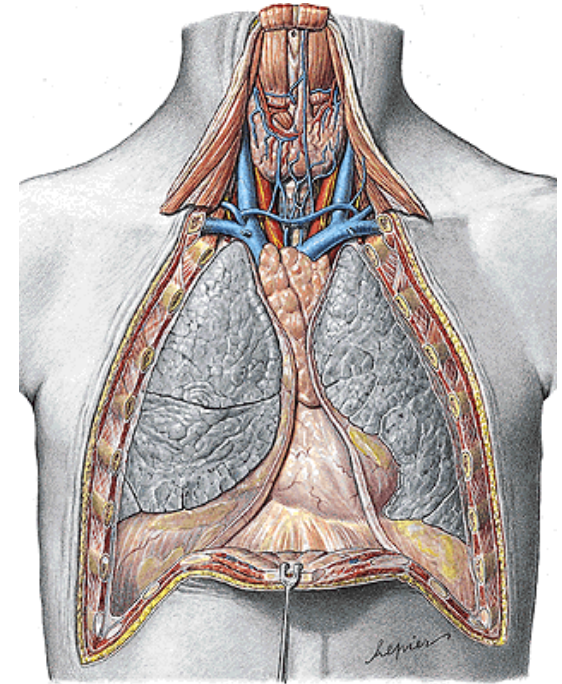
Bronchoscopy



The lungs - pulmo

Position of the lungs:

Thoracic cavity– pleural cavities
height 20-24 cm, weight 600 – 700g
colour pink– marbling – grey/black



The lungs (*Pulmo, Pneumon*)

Description of the lungs:

facies diaphragmatica - base

apex pulmonis - top (reaches above apertura thoracis superior)

facies costalis - (impressions of the ribs)

facies mediastinalis (hilus pulmonis—dx. BAV, sin. ABV)

radix pulmonis – root of the lung

Impressions

The heart

Aorta

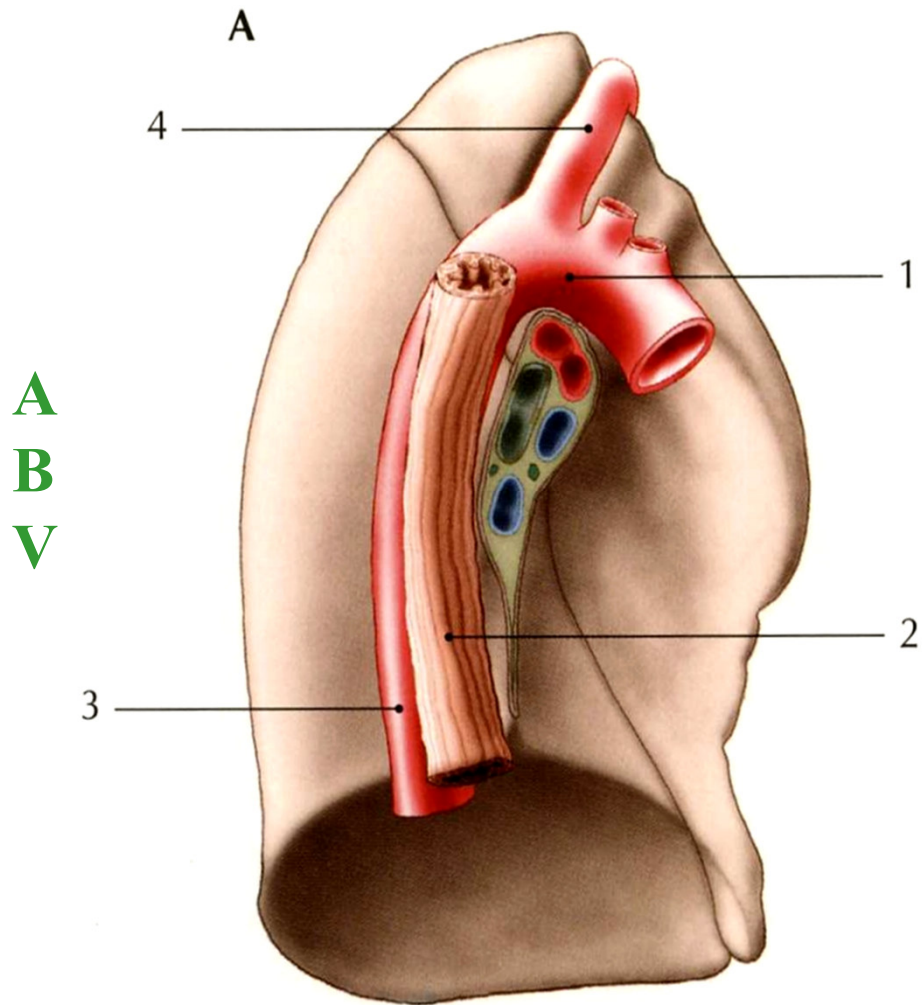
The oesophagus

1th rib

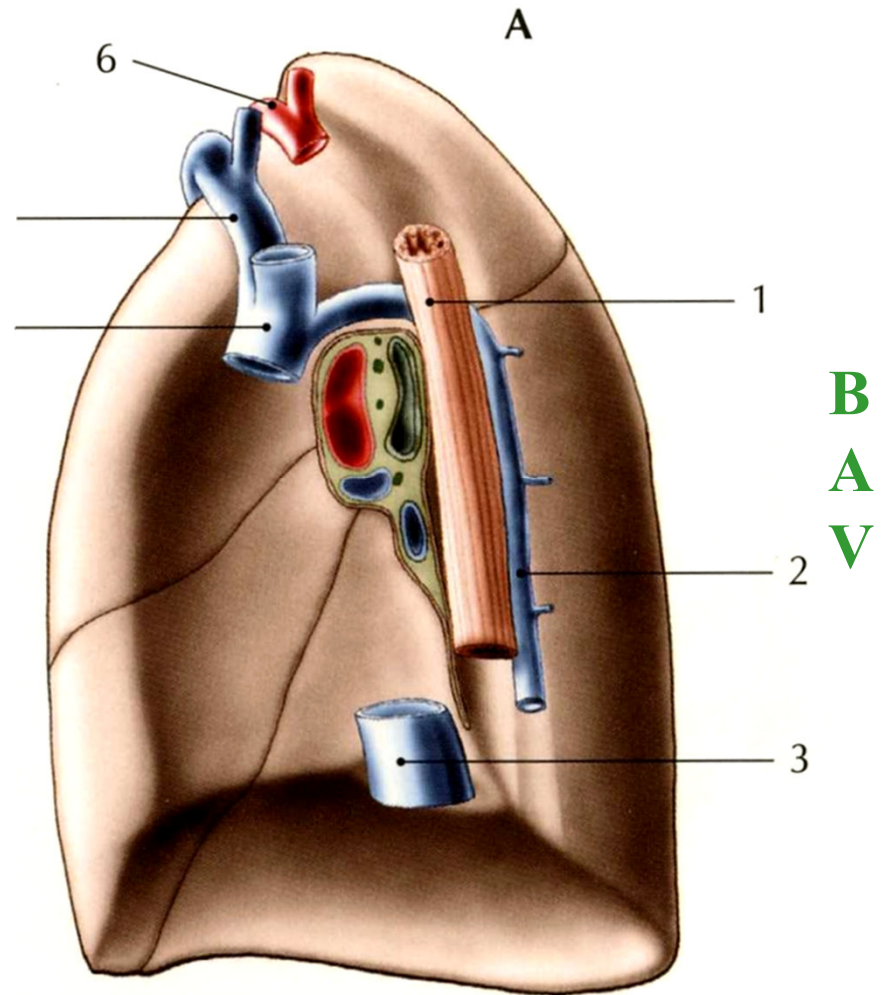
Other vessels



The left lung



The right lung

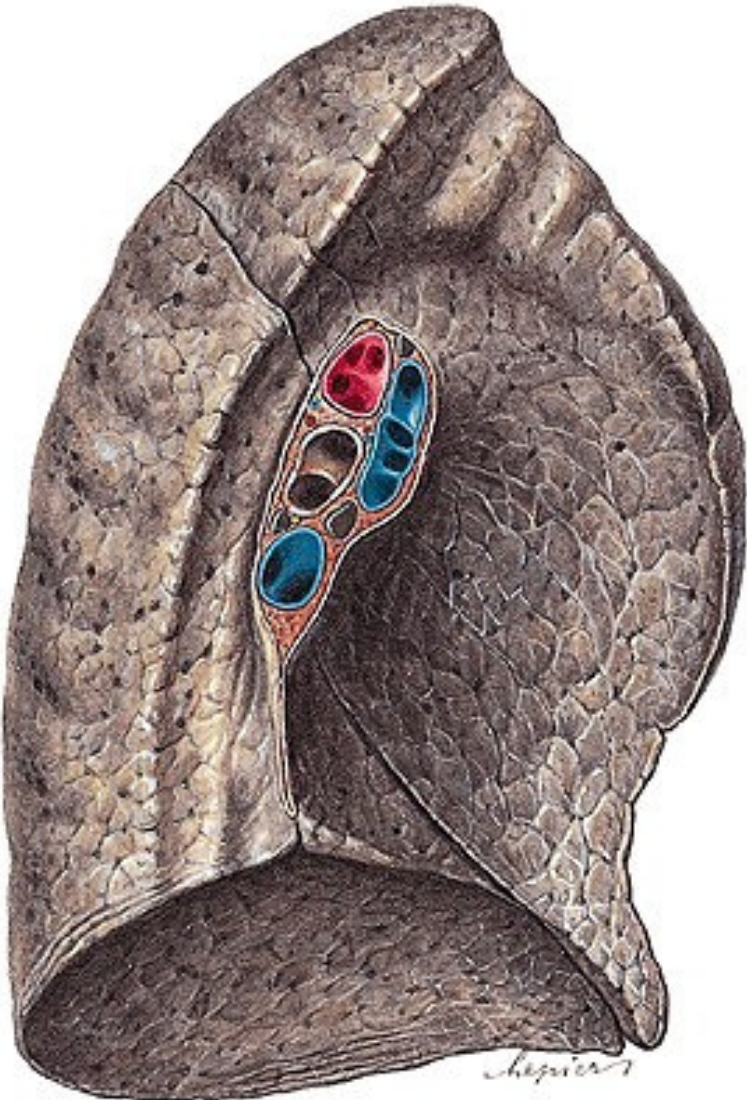


HILUM PULMONALE

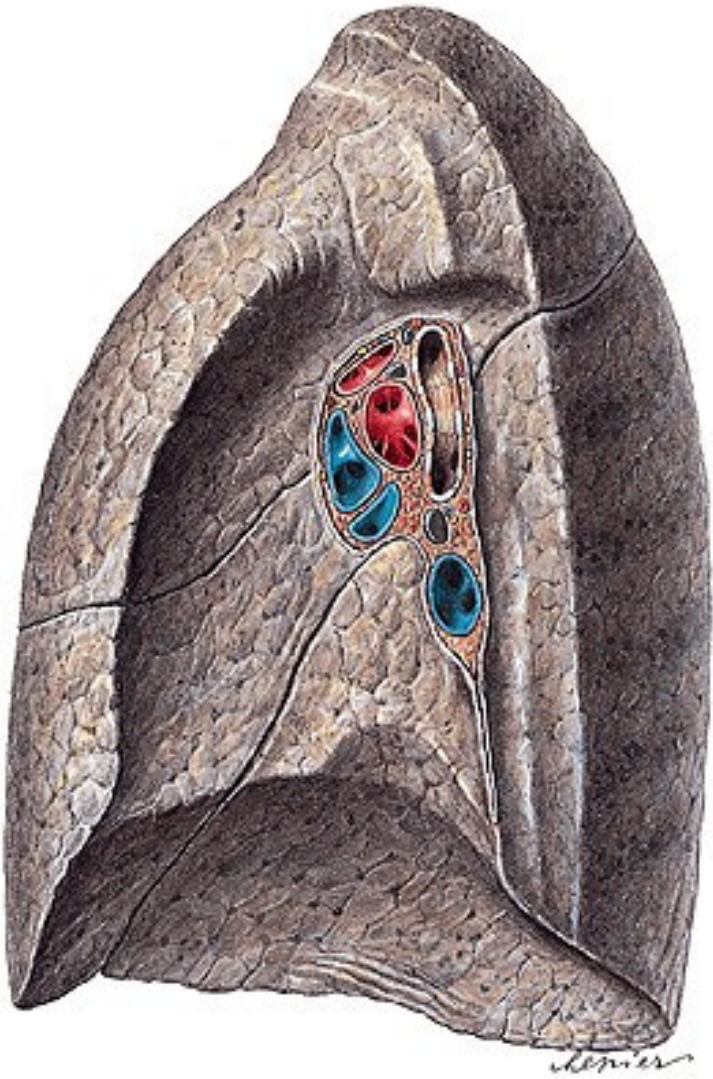
The left lung

The right lung

A
B
V



B
A
V



The lungs (*Pulmo*) - division

fissura obliqua (Th4 – VI.rib)

fissura horizontalis (along IV. rib)

Pulmo dex. 3 lobes (sup., medius, inf.)

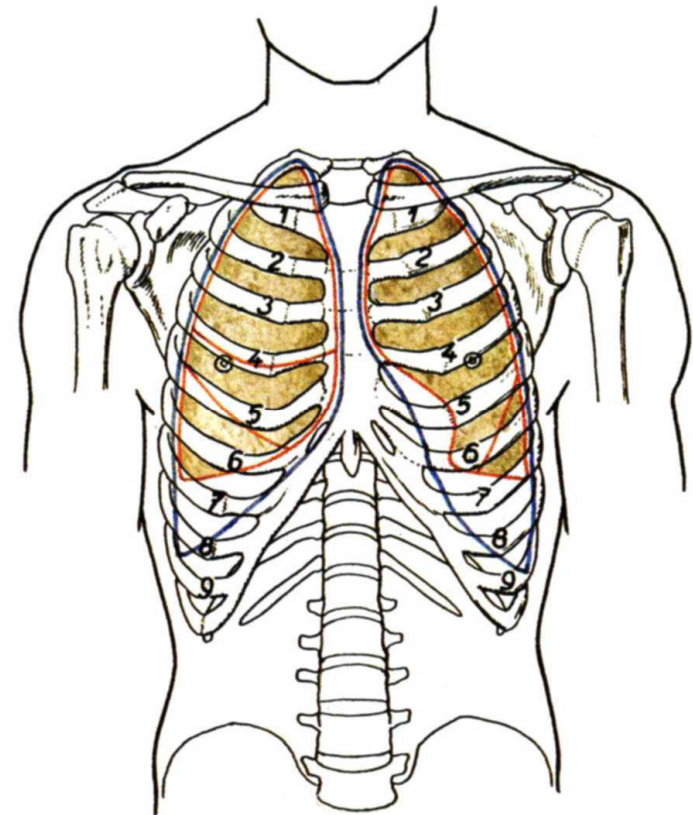
Pulmo sin. 2 lobes (sup., in.)

–Incisura cardiaca- lingula pulmonis

Segments:

Dextra - 10

Sinistra -10 (smt 8) I. and II. joined
and VII. v 90% misses

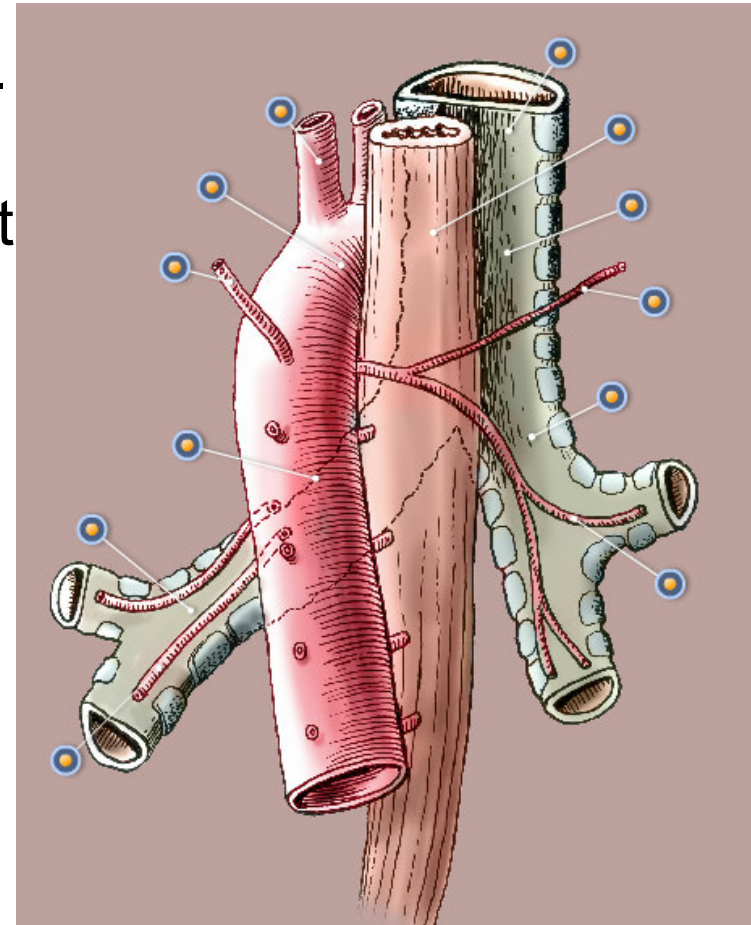


The nutritive and functional circulation

The nutritive circulation

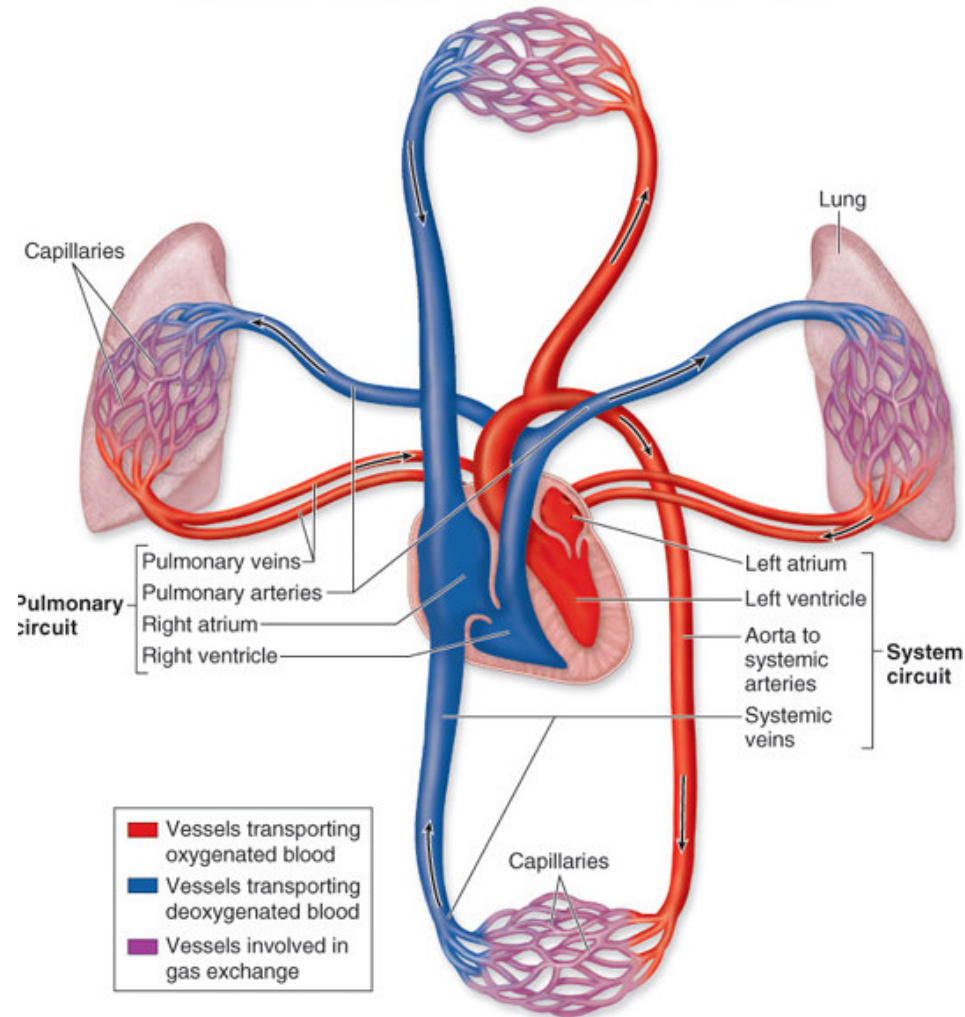
Aorta thoracica (+ intercostal arteries)

- **rami bronchiales** (1 right – most often from a. intercostalis tertia, 2 left directly from thoracic aorta)
along the bronchi till bronchioli respiratorii
- **venae bronchiales**
to v. azygos, v. hemiazygos accessoria, vv. intercostales

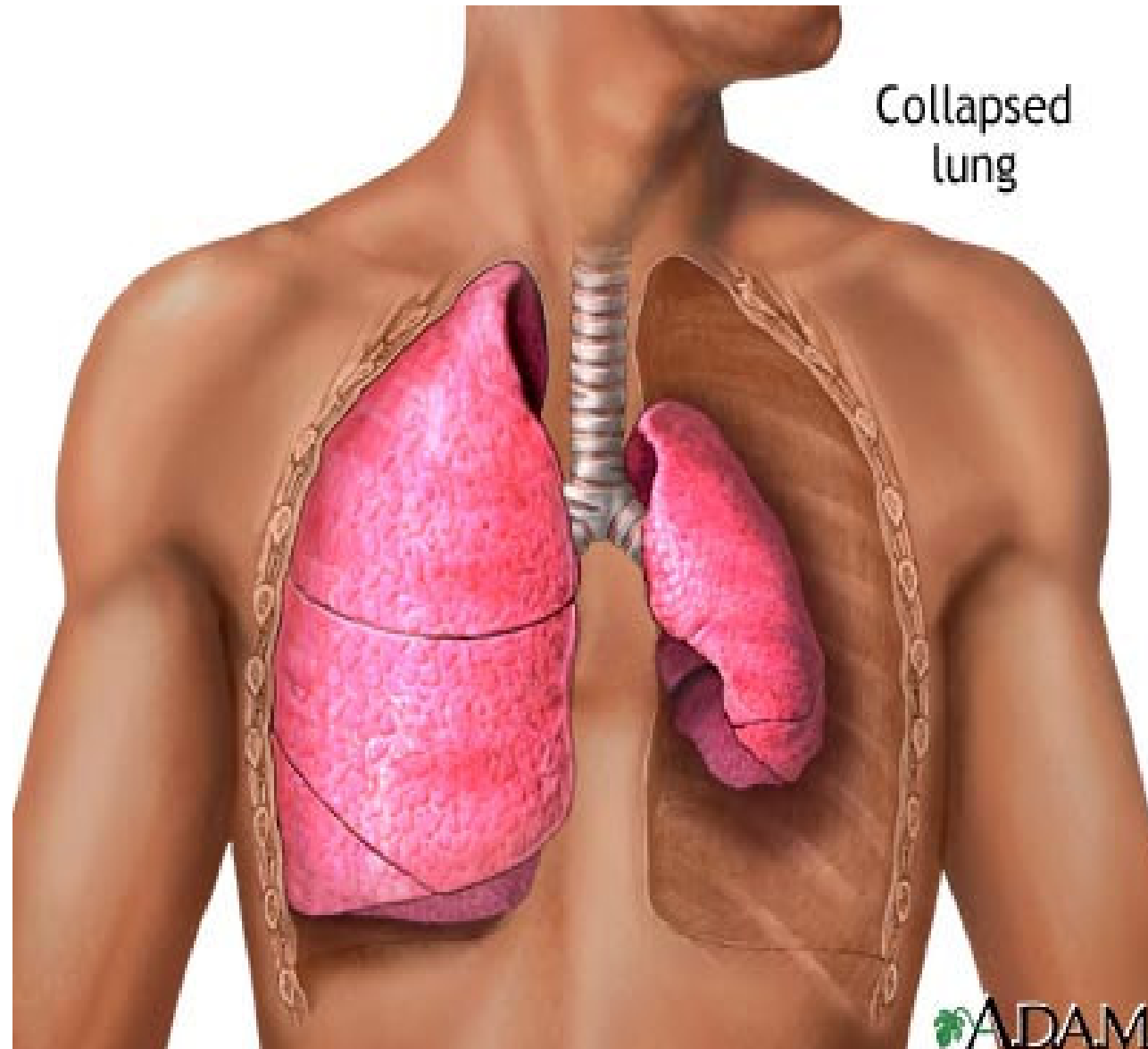


The functional circulation – small blood circulation

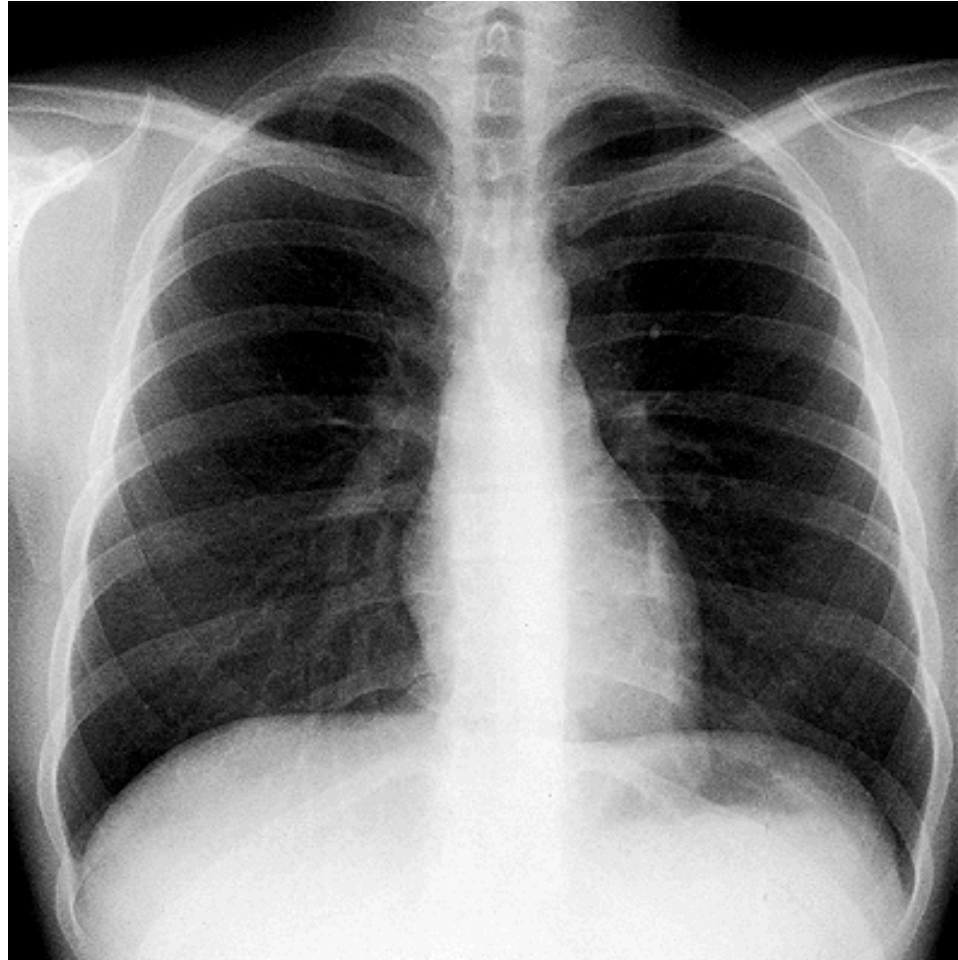
right ventricle ➡ truncus pulmonalis ➡ **arteriae pulmonales** dx.+ sin. (**blood with low content of oxygen**) ➡ capillars ➡ 4 **venae pulmonales** (2 dx., 2 sin.) (**blood with high content of oxygen**) ➡ left ventricle of the heart



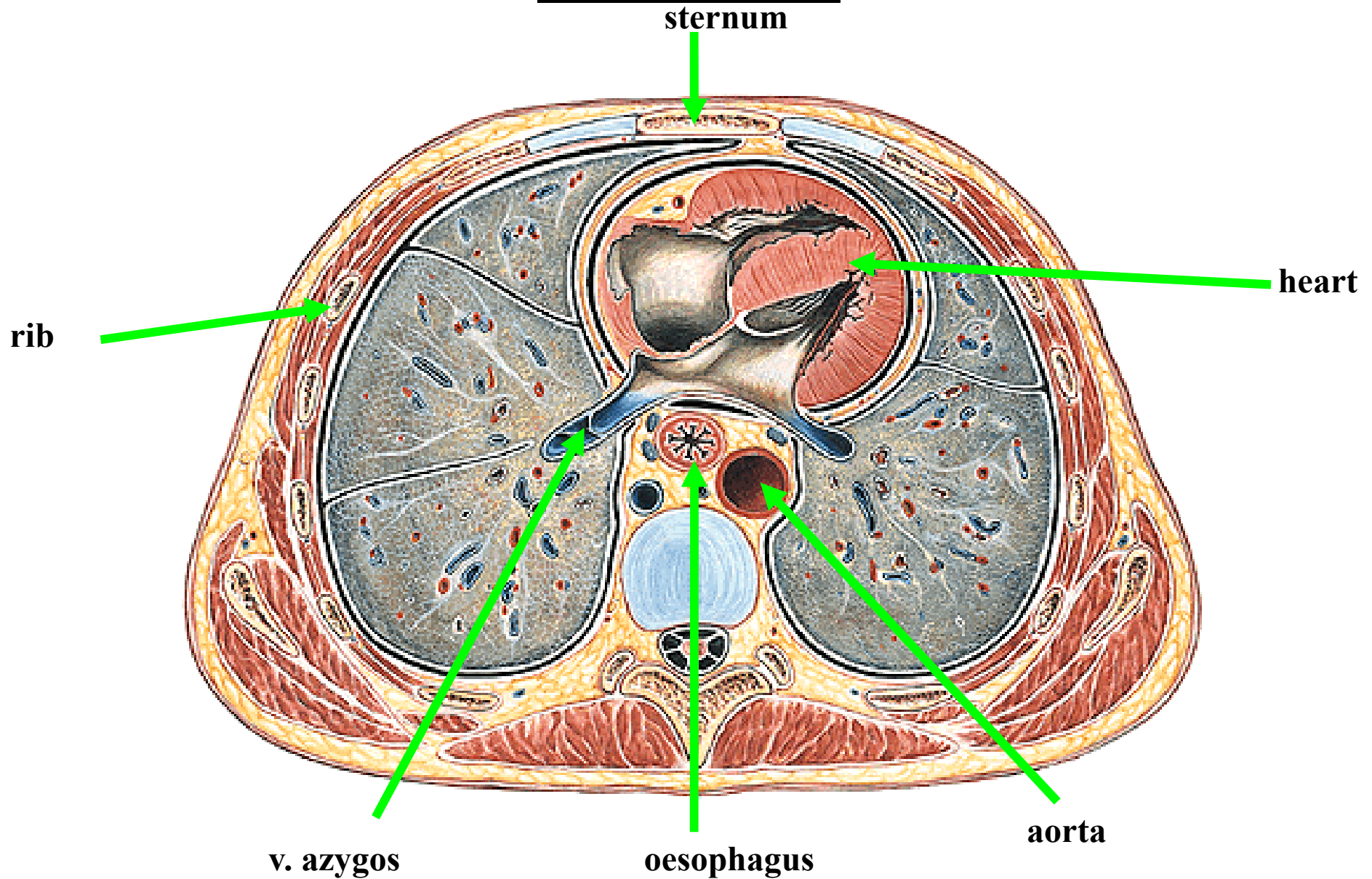
Pneumothorax



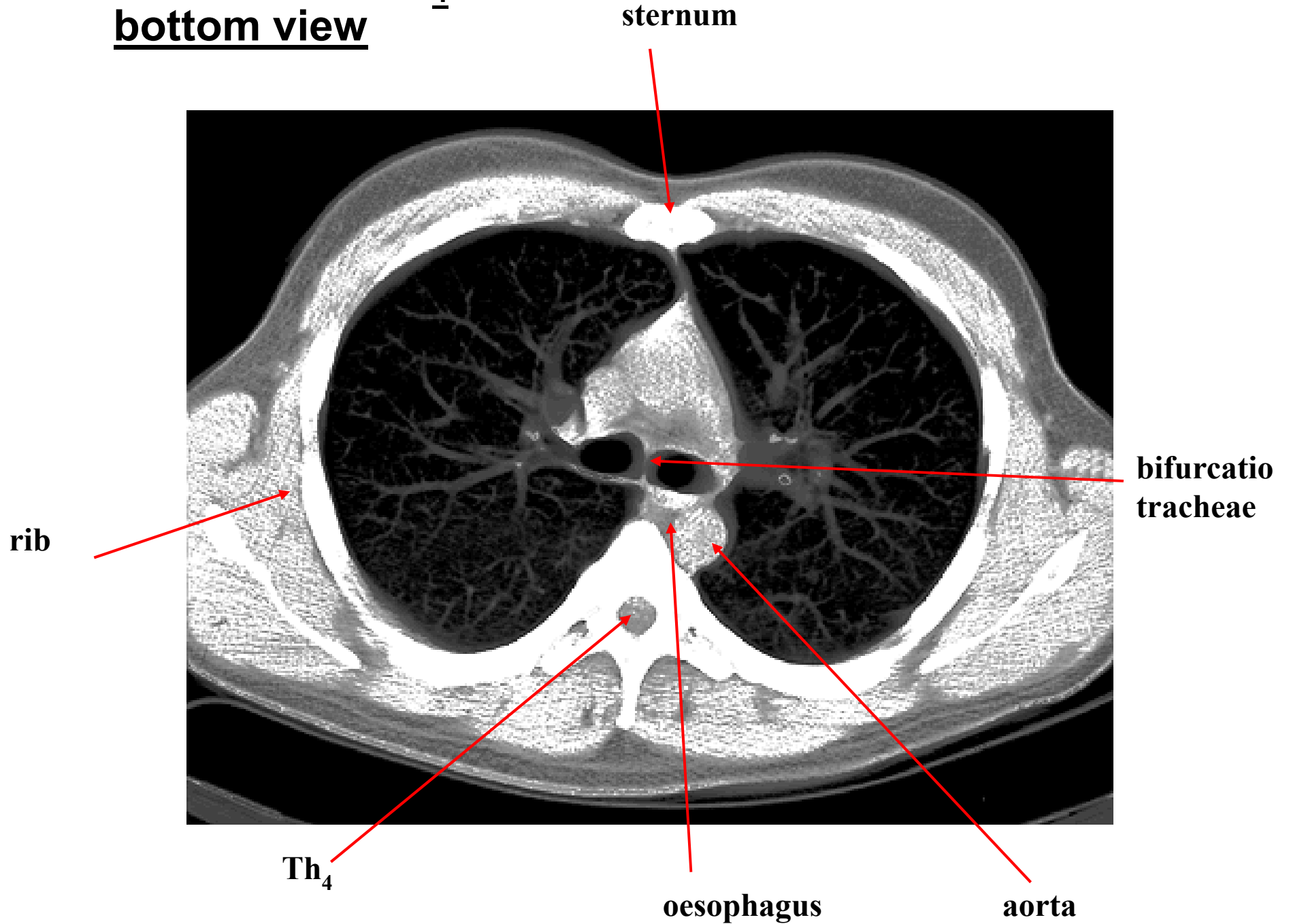
X-ray of chest



Cross-section through the thorax on the level of hilus pulmonis
(bottom view)



CT of the thorax (Th₄)
bottom view



PLEURA – serous membrane (simple squamous epithelium)

pleura visceralis (covers the surface of the lungs)

pleura parietalis (covers the pleural cavities)

Both lungs are located in the separate cavities
cavum pleurae dextrum et sinistrum

a) **Pleura costalis**

b) **Pleura mediastinalis**

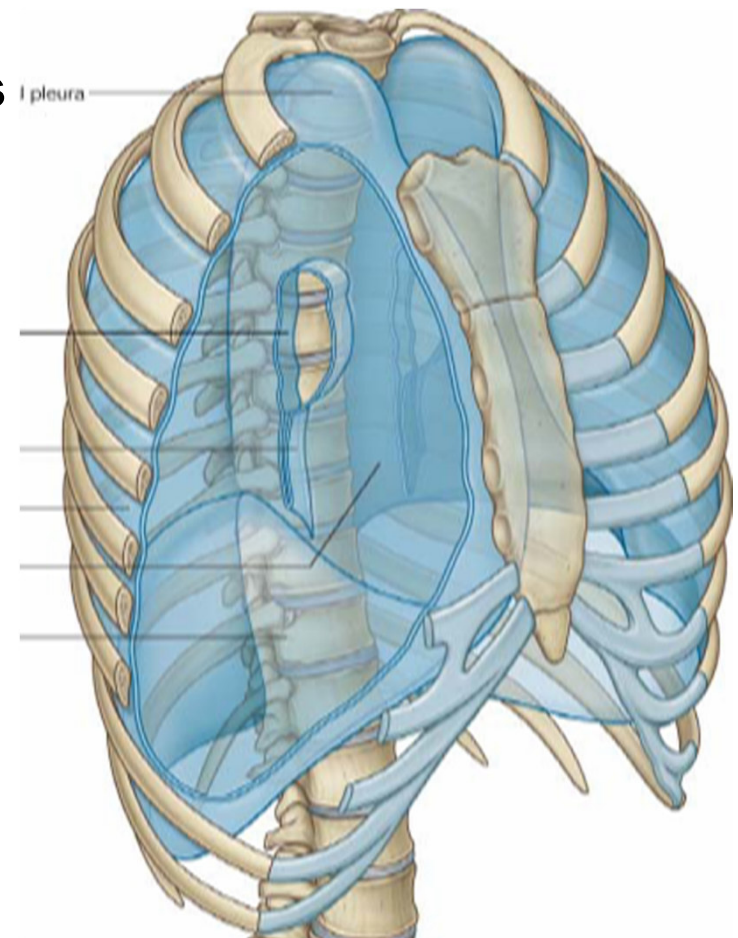
c) **Pleura diaphragmatica**

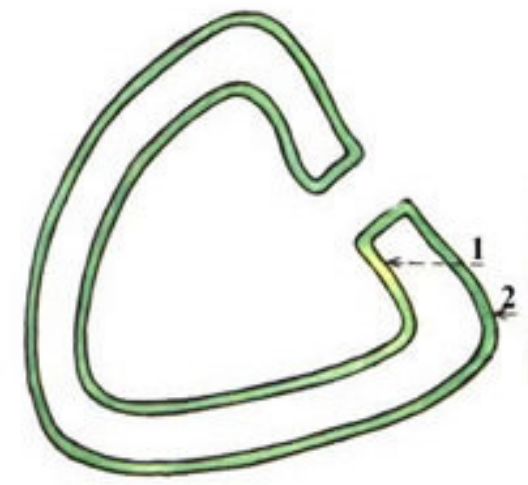
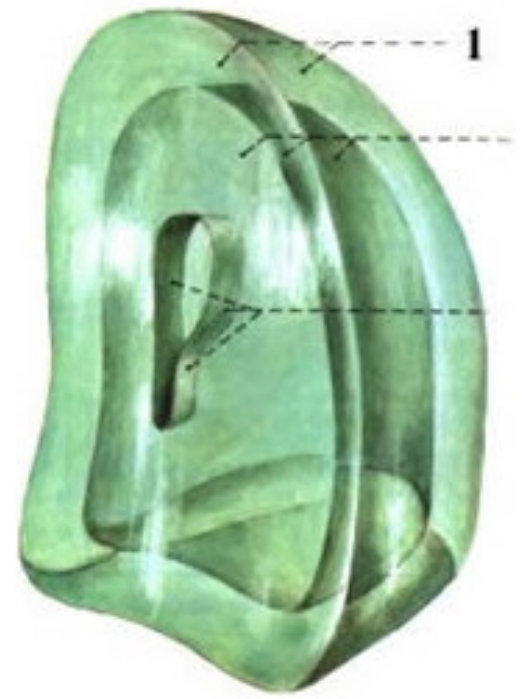
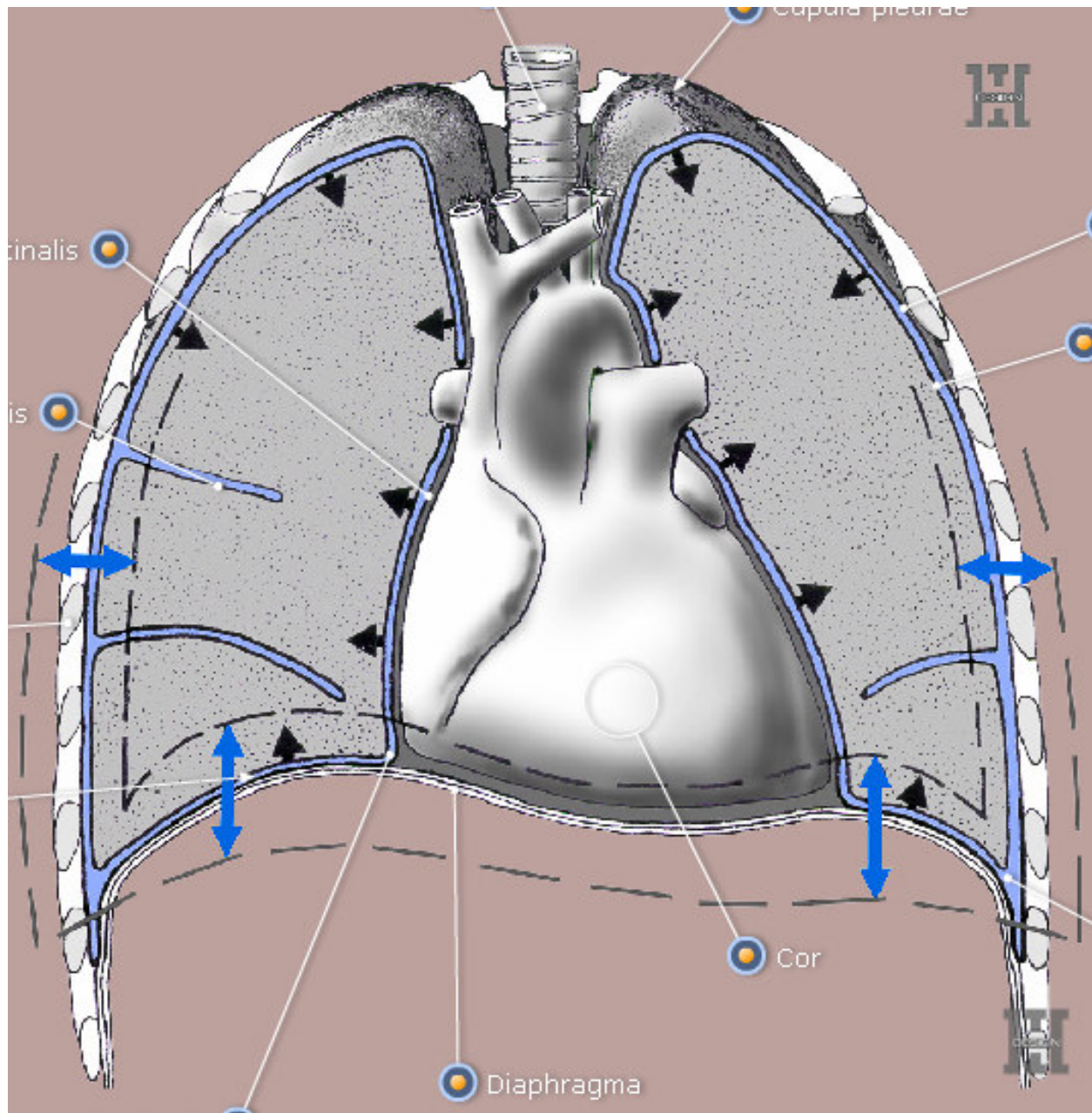
Recessus pleurales

– parts of pleura pass into each other

Cupula pleurae

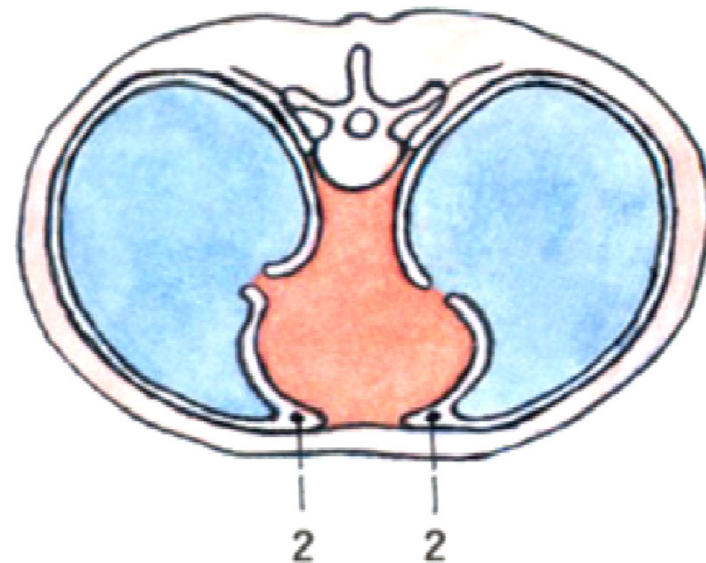
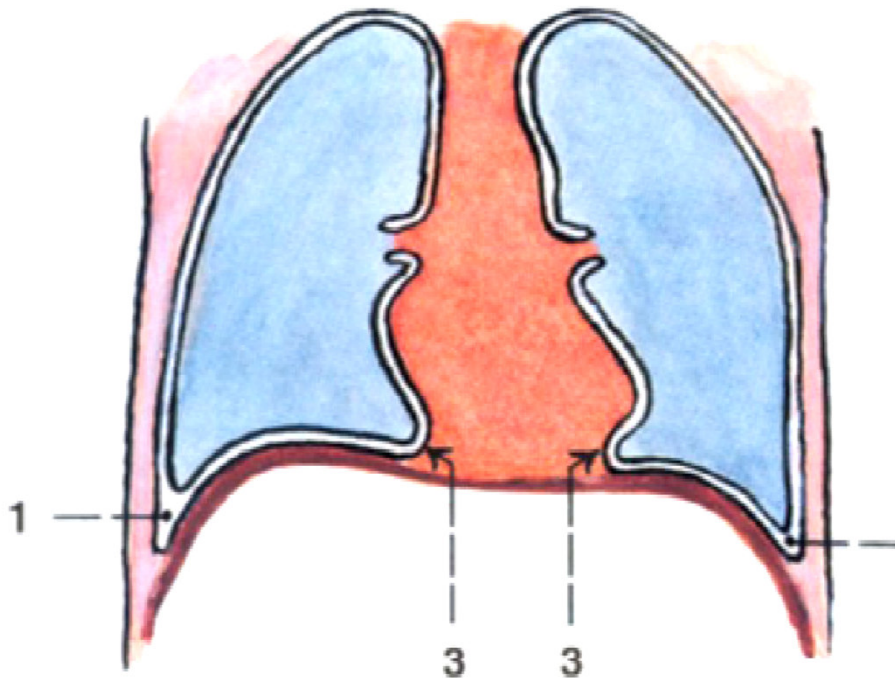
– protrudes above 1. rib and the clavicle





Recessus pleurae

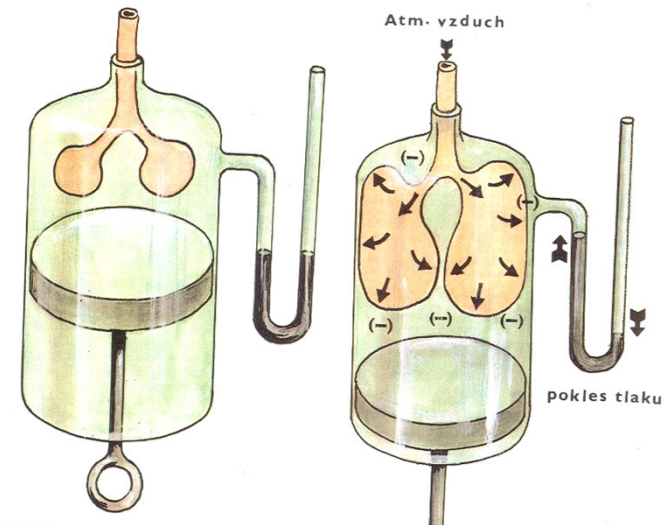
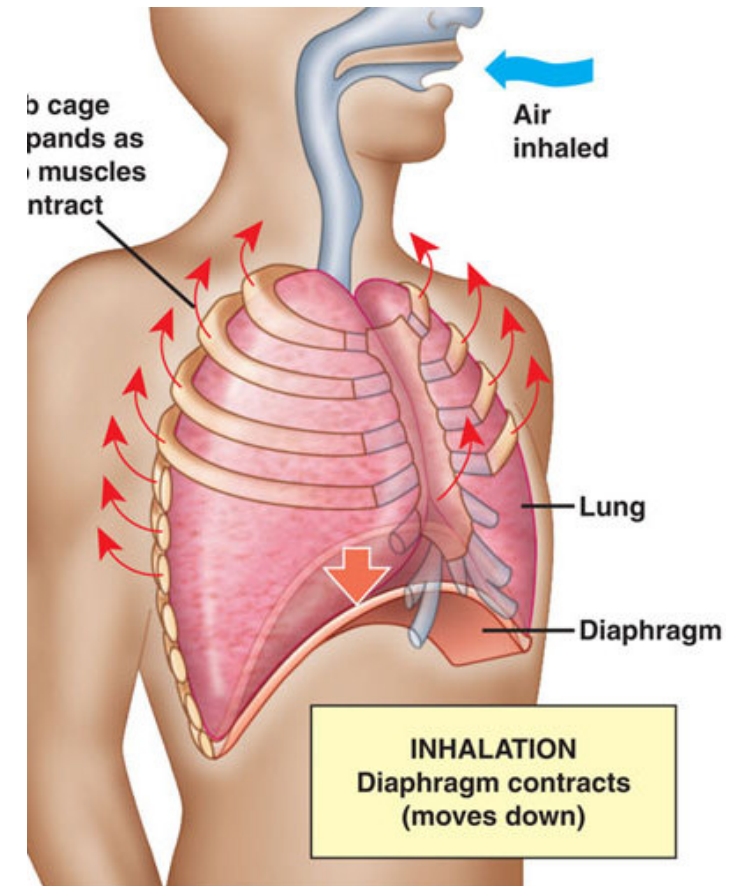
- 1) Recessus costodiaphragmaticus—pathological effusions collect there
- 2) Recessus costomediastinalis
- 3) Recessus phrenicomediastinalis



The mechanism of the breathing
 Breathing in (inspiration) using the diaphragm and mm. intercostales ext.
 Breathing out (expiration) using mm. intercostales int. and intimi

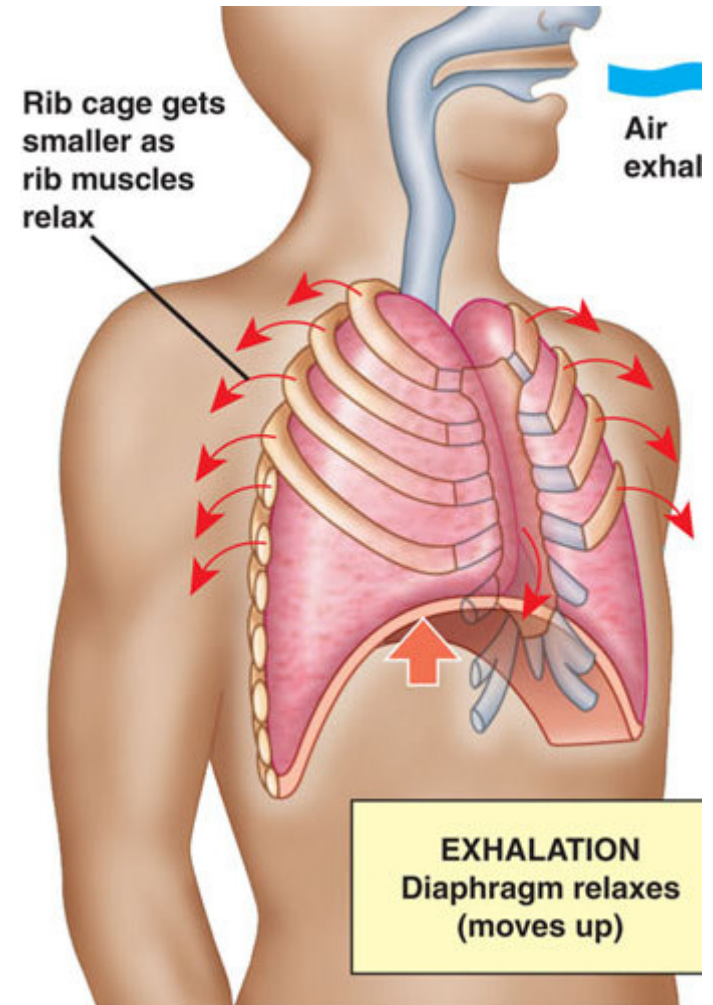
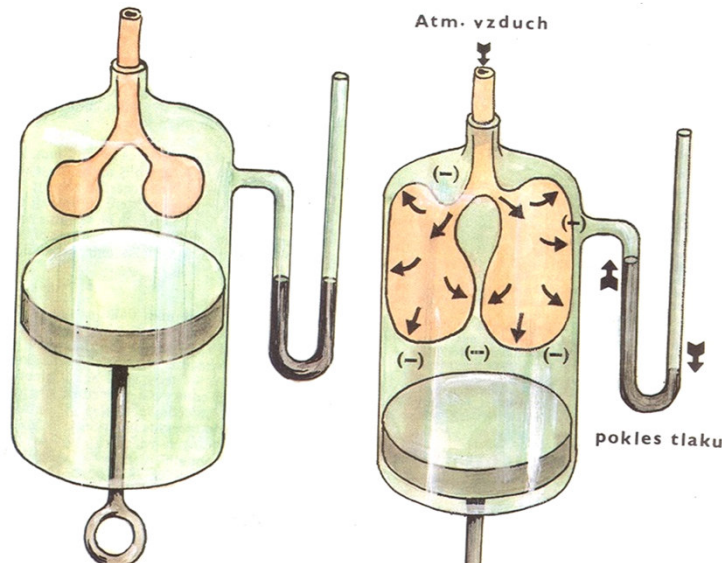
Inspiration- active

- Contraction of the diaphragm – enlargement of thorax in the longitudinal direction
- Contraction of mm. intercost. ex. – enlargement of thorax in the sagittal direction
- Pressure drop in pleural cavity
- The lungs follow the movement of the thorax and the air goes to the lungs



Expiration - passive

- Relaxation of the diaphragm (contraction of abdomen muscles)
- Contraction of mm. intercostales interni and intimi, decrease of the ribs – expiration



Respiratory muscles

- **Muscles of inspiration**

- **Main:** mm. intercostales externi, diaphragma (mm. scaleni, mm. levatores costarum)
- **Auxiliary:** m. pectoralis major + minor, m. latissimus dorsi, m. serratus anterior + post. sup., m. sternocleidomastoideus, m. subclavius, (m. sternothyroideus, m. sternohyoideus)



- **Muscles of expiration**

- **Main:** mm. intercostales interni (+ intimi, m. subcostales)
- **Auxiliary:** m. rectus abd., m. obliquus abd. ext. + int., m. transversus abd., m. serratus post. inf., m. transversus thoracis, (m. quadratus lumborum)

Orientation lines:

linea mediana ant.

linea sternalis

linea parasternalis

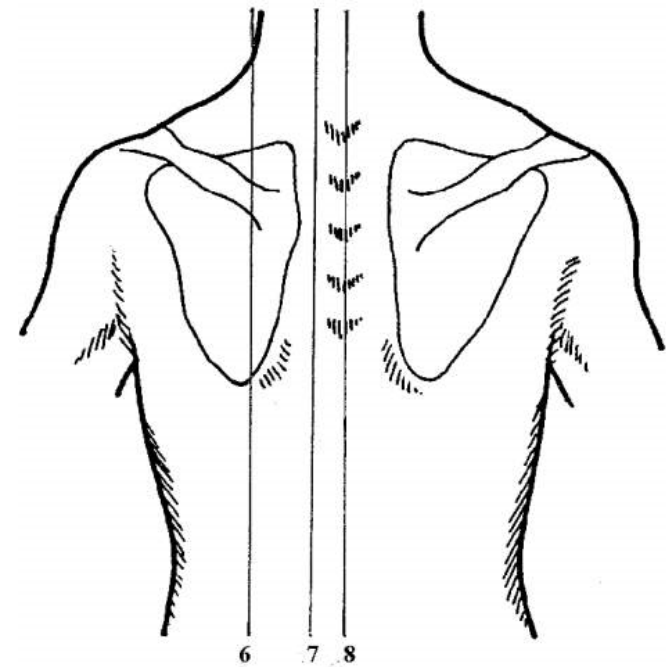
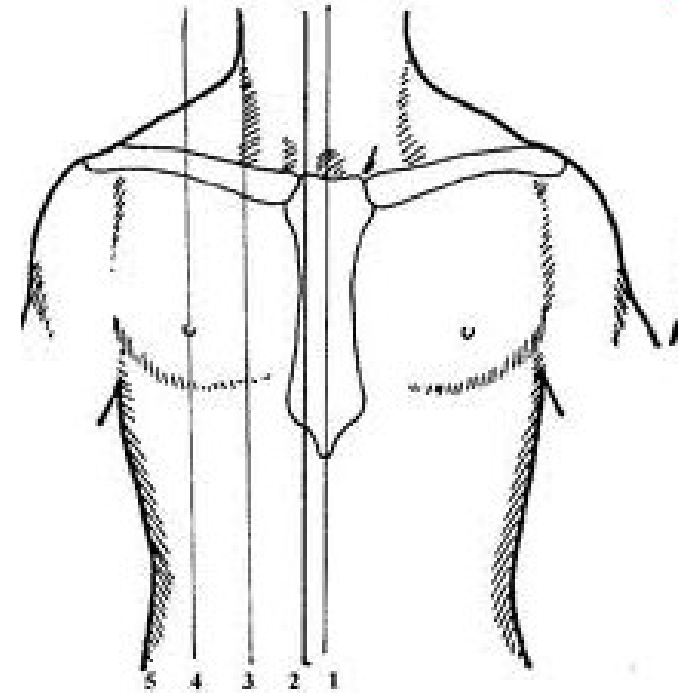
linea medioclavicularis

linea axillaris ant., med., post.

linea scapularis

linea paravertebralis

linea mediana post.



The borders of the pleura

Cupula pleurae - 1-2 cm above the clavicle

Area interpleuralis superior

2. rib – 4. rib parallel, dx till 6. rib, sin. incisura cardiaca

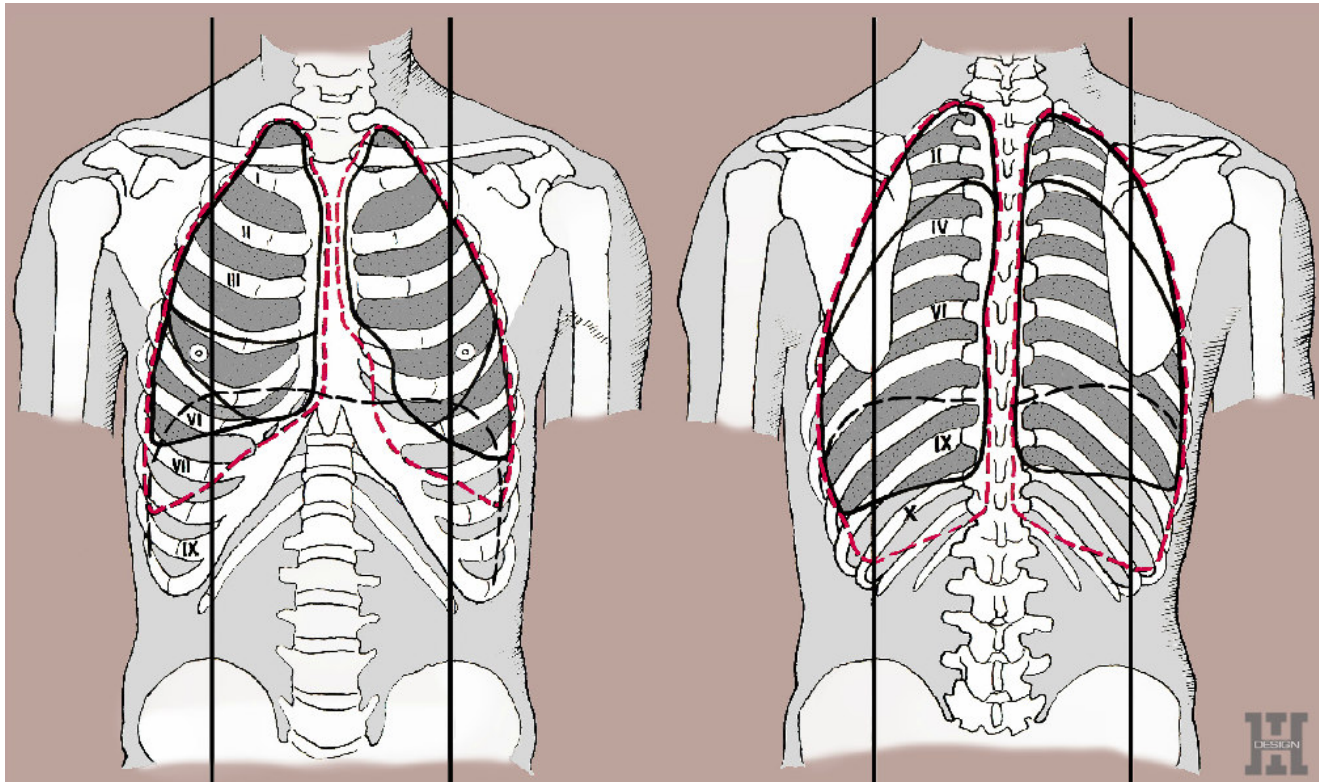
Area interpleuralis inferior

Medioclavicular line 7. rib

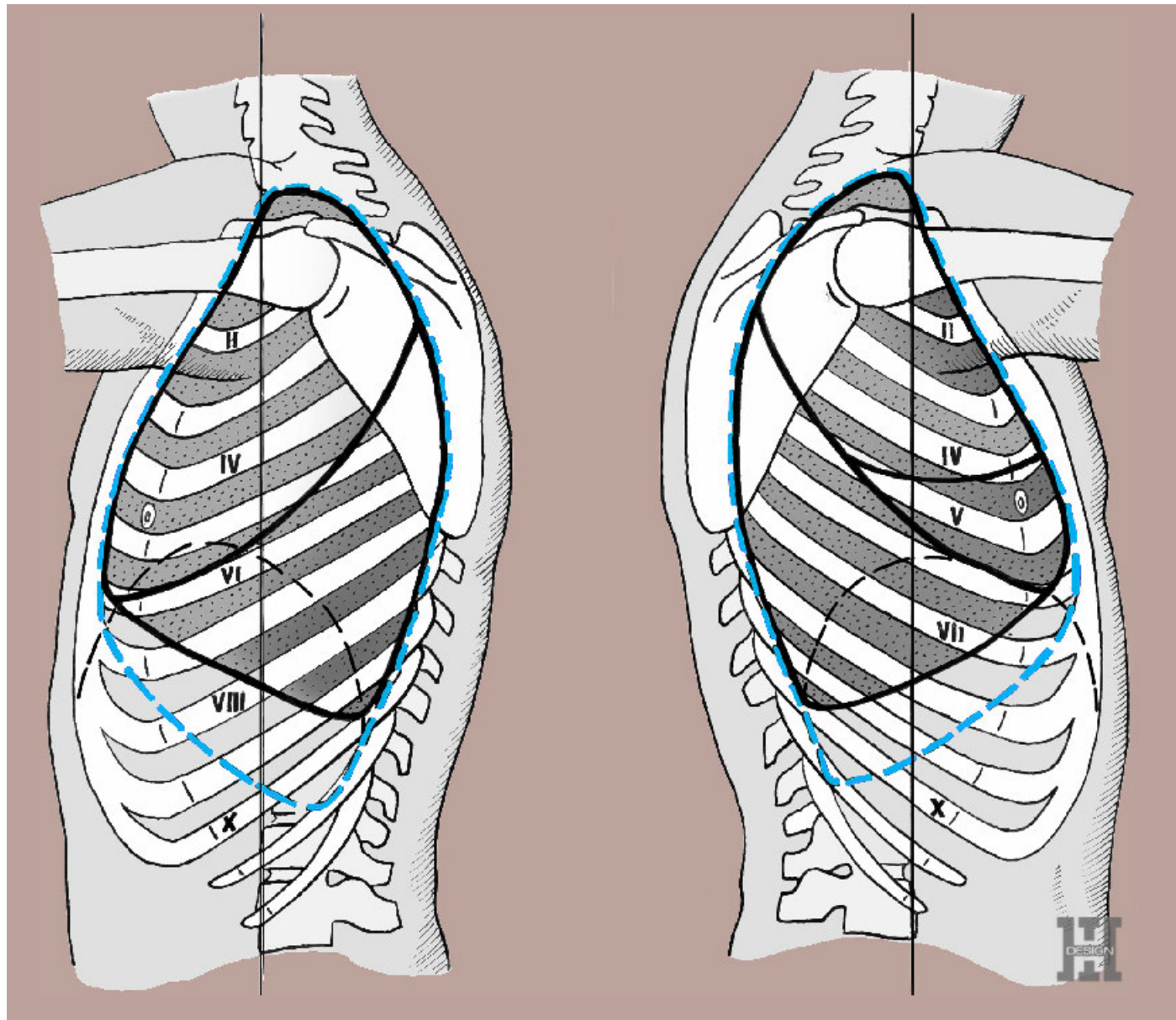
Middle axillary line 9. rib

Scapular line 11. rib

Paravertebral line 12. rib – then to C₇ and to cupula pleurae

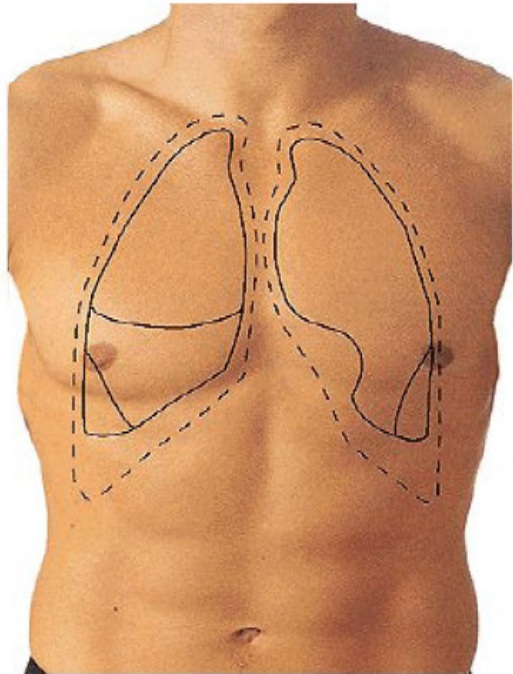


The borders of the pleura



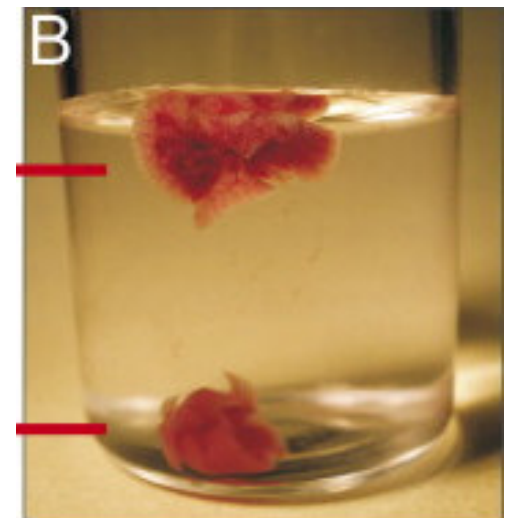
The borders of the lungs

- *apex pulmonis* fills *cupula pleurae*, reaches 1–2 cm over the clavicle
- Anterior margin: corresponds during the inspiration with the anterior margin of the pleura
- Inferior margin: projects about 1 till 2 ribs more cranially than the inferior border of the pleura
- Posterior margin: projects laterally from the spinous processes within the range Th11 till Th2.



The lungs of a newborn

- a newborn can survive the preterm labor between 24th and 28th week (formerly lungs are not yet sufficiently prepared for gas exchange, do not produce surfactant)
- The lungs of a newborn, who has done the inspiration, keep afloat, the lungs of stillborn sink to the bottom
- The importance in the forensic pathology



Regional anatomy of the thorax

Pleural cavities

Mediastinum: space between the pleural cavities: it contains organs, vessels and nerves, there is also the loose fibrous connective tissue present

Dividing of the mediastinum:

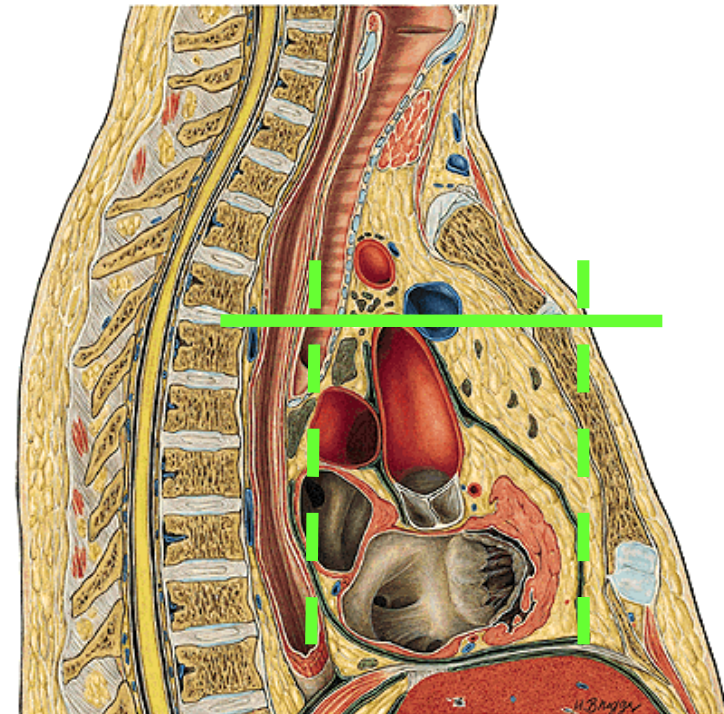
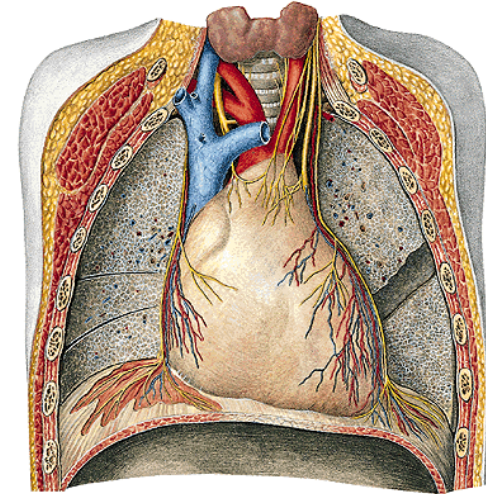
(border: horizontal plane going through the upper margin of the heart)

1. mediastinum superius (thymus, layer of veins, layer of arteries, trachea, oesophagus)
2. mediastinum inferius

mediastinum anterius (lymph nodes)

mediastinum medium (heart)

mediastinum posterius (oesophagus, aorta, ductus thoracicus, v. azygos et hemiazygos, truncus sympaticus, lymph nodes)



Pictures:

Atlas der Anatomie des Menschen/Sobotta.

Putz,R., und Pabst,R. 20. Auflage. München:

Urban & Schwarzenberg, 1993

Netter: Interactive Atlas of Human Anatomy.

Naňka, Elišková: Přehled anatomie. Galén, Praha 2009.

Čihák: Anatomie I, II, III.

Drake et al: Gray's Anatomy for Students. 2010