

Respiratory system

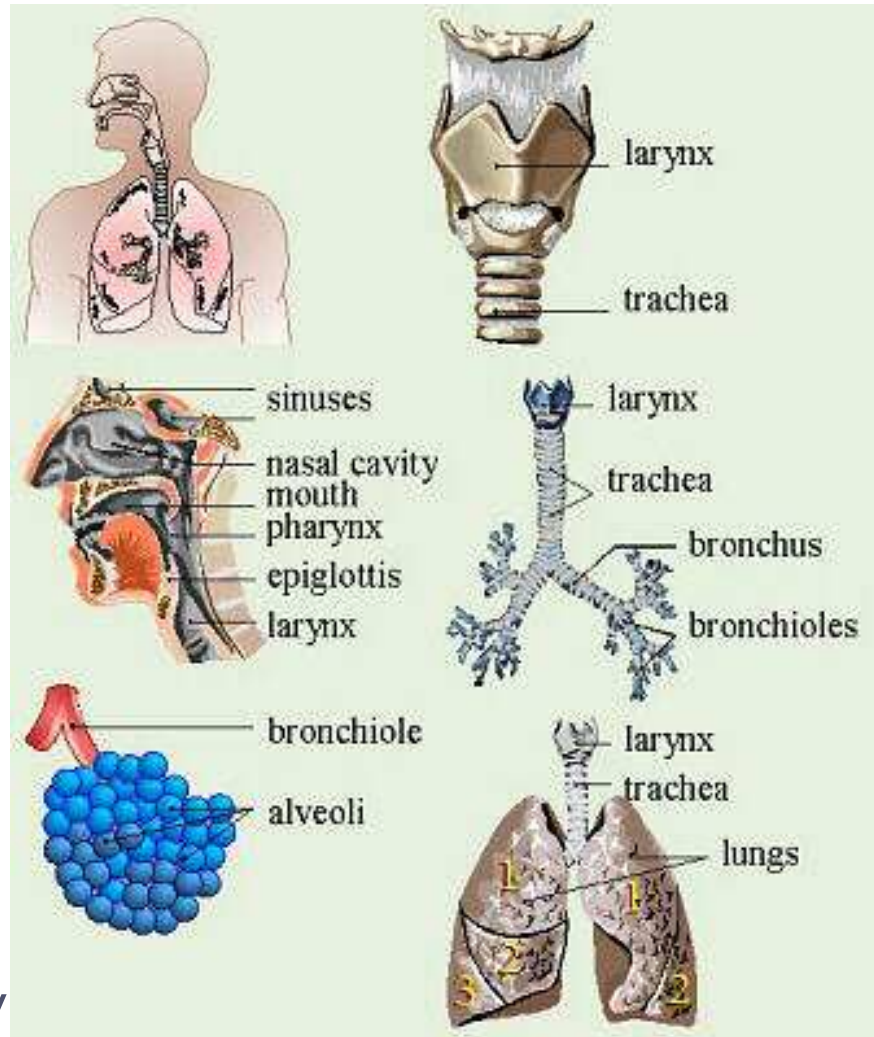
1. Respiratory system overview
2. Nose:
 - ✓ external nose
 - ✓ nasal cavity
3. Paranasal sinuses
4. Lower respiratory tract:
 - ✓ larynx
 - ✓ trachea and bronchi
5. Lungs and pleura





Respiratory system

- Respiratory system, *systema respiratorium*
 - ✓ gas exchange – under negative air pressure
 - conducting portion – respiratory passages
 - respiratory portion – in lungs
 - ✓ phonation – larynx
 - ✓ smell sensation (olfaction) – nasal cavity

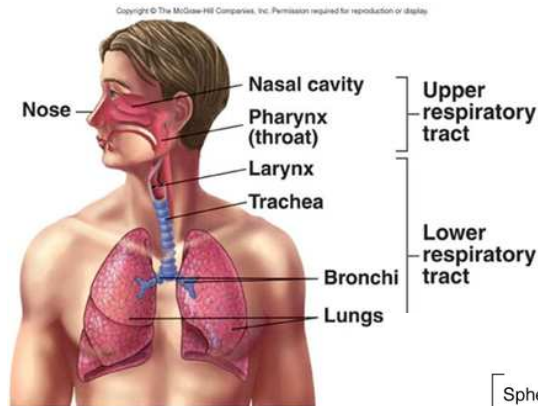




Parts of the respiratory system

- Conducting portion – respiratory passages:

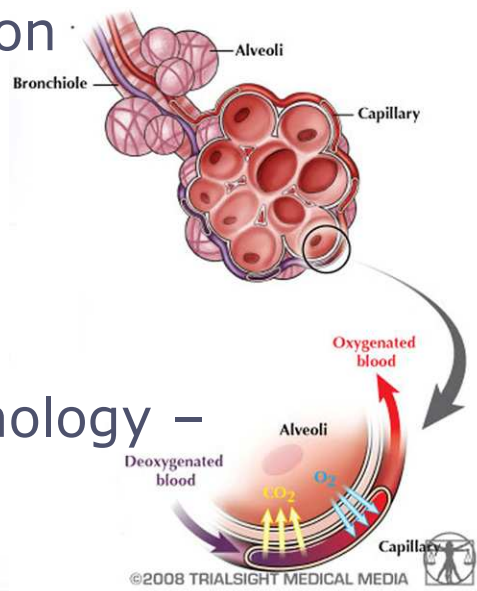
- ✓ upper respiratory tract:
 - nose
 - pharynx
- ✓ lower respiratory tract:
 - larynx
 - trachea
 - bronchi
 - terminal bronchioles



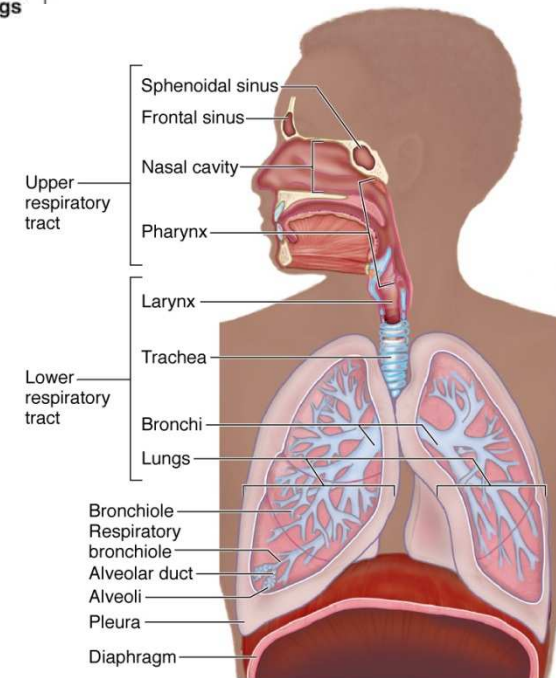
- Upper tract
 - Nose, pharynx and associated structures
- Lower tract
 - Larynx, trachea, bronchi, lungs

- Respiratory portion – in the lungs:

- ✓ respiratory bronchioles
- ✓ alveolar ducts
- ✓ alveolar sacs
- ✓ alveoles



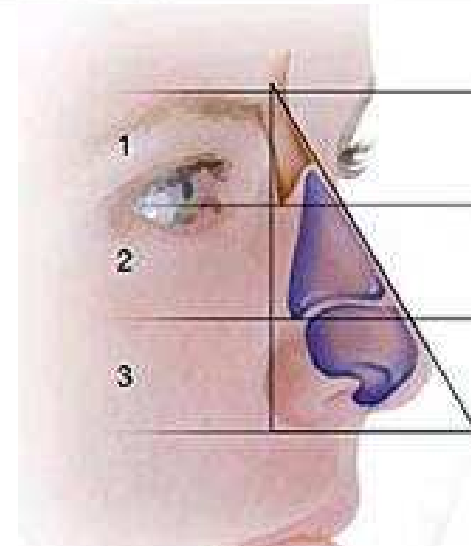
- Functional morphology – air conditioning



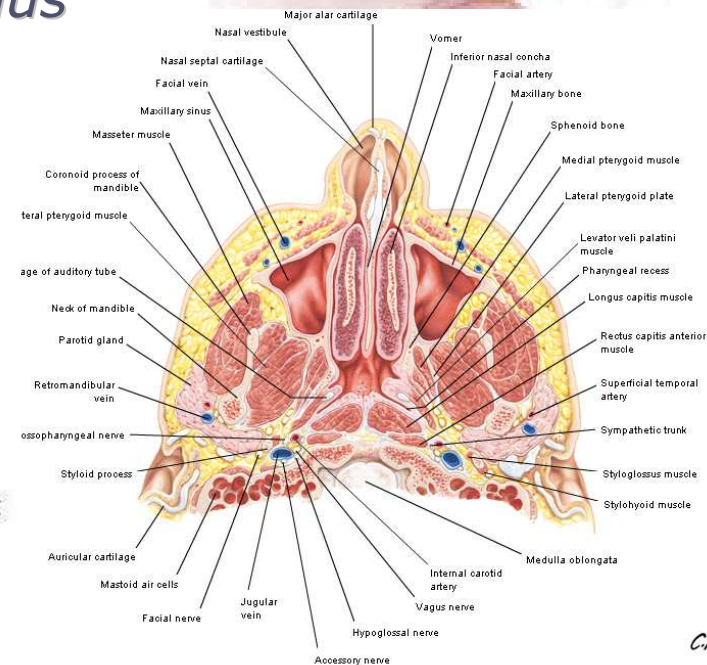
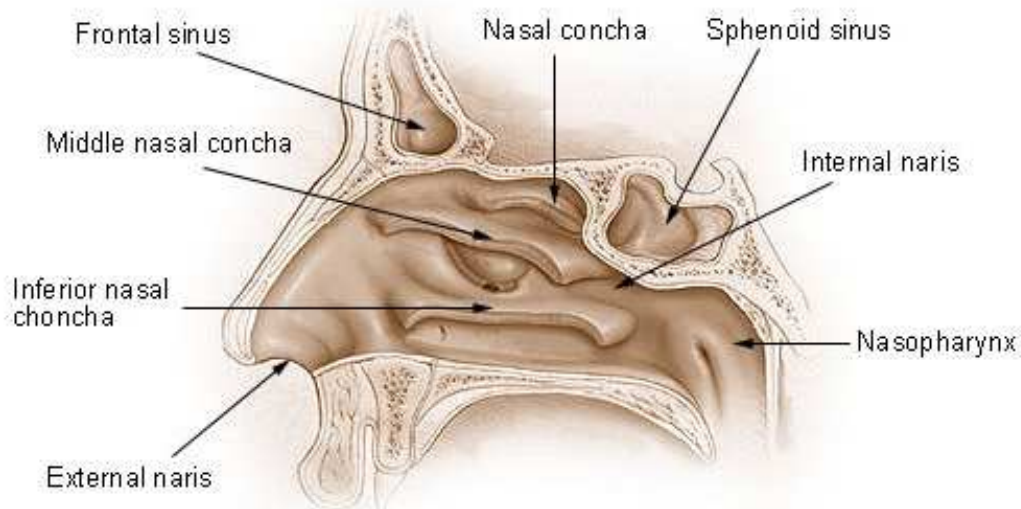


Nose

- Nose – *nasus* (Gr. *rhis, rhinos*):
 - ✓ respiratory and olfactory organ
 - ✓ role in the formation of timbre
- Anatomical parts:
 - ✓ external nose, *nasus externus*
 - ✓ nasal cavity, *cavitas nasi*



Nose and Nasal Cavities

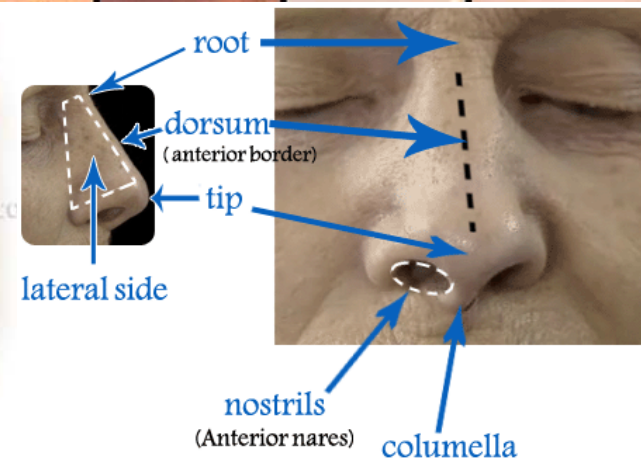
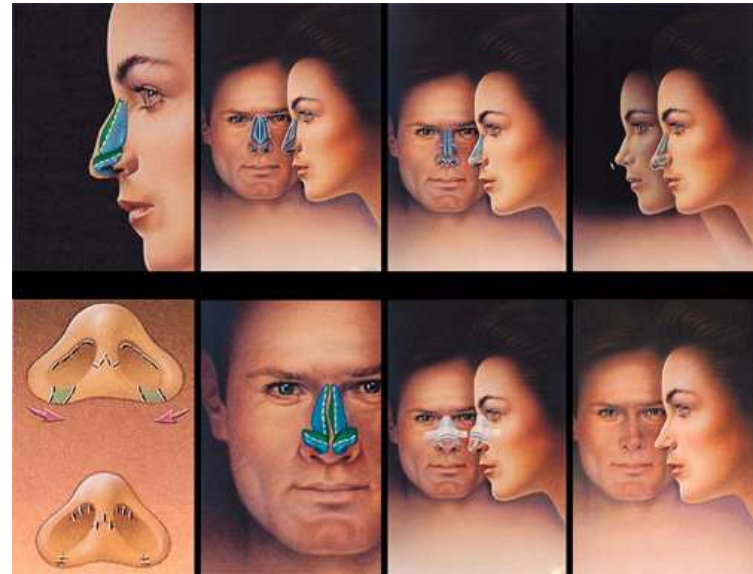


C. Machado
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External nose

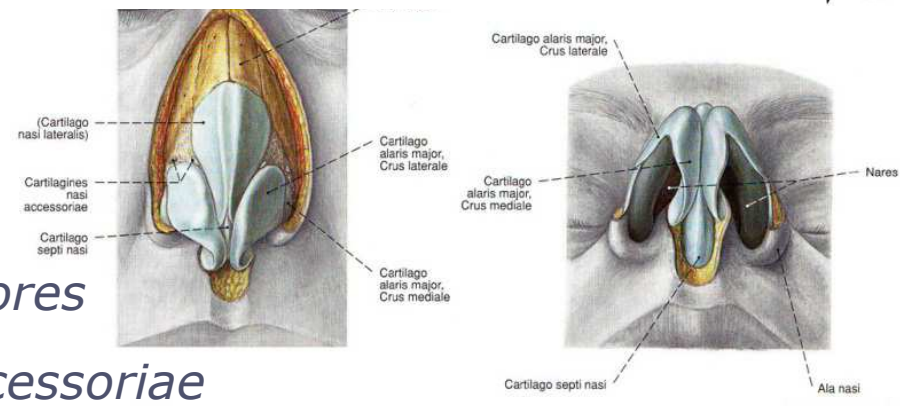
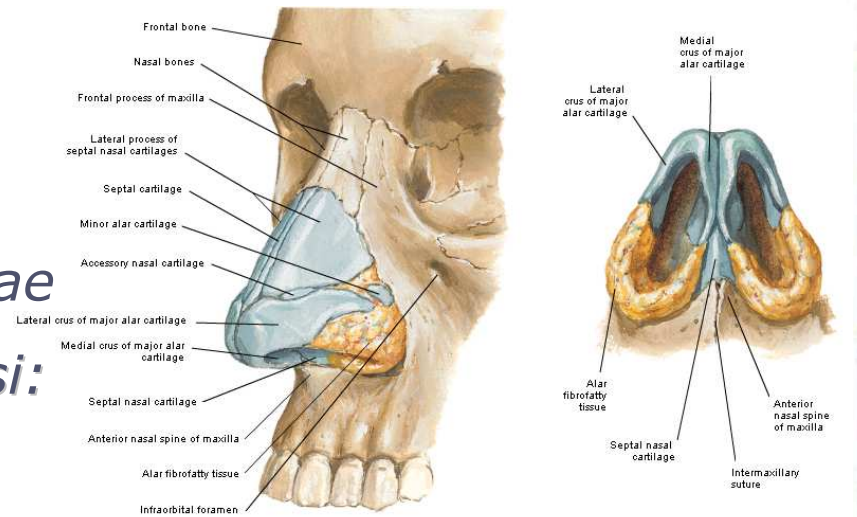
- External nose, *nasus externus*:
 - ✓ in the center of the face
 - ✓ pyramidal in shape
 - ✓ a human trait – three forms:
 - strait, fleshy and hawk nose
- Anatomical parts:
 - ✓ base, *basis nasi*
 - ✓ lateral side
 - wings, *alae nasi*
 - ✓ dorsum, *dorsum nasi*
 - root, *radix nasi*
 - tip, *apex nasi*
 - ✓ nostrils, *nares*
 - ✓ *columella*





Skeleton of the nose

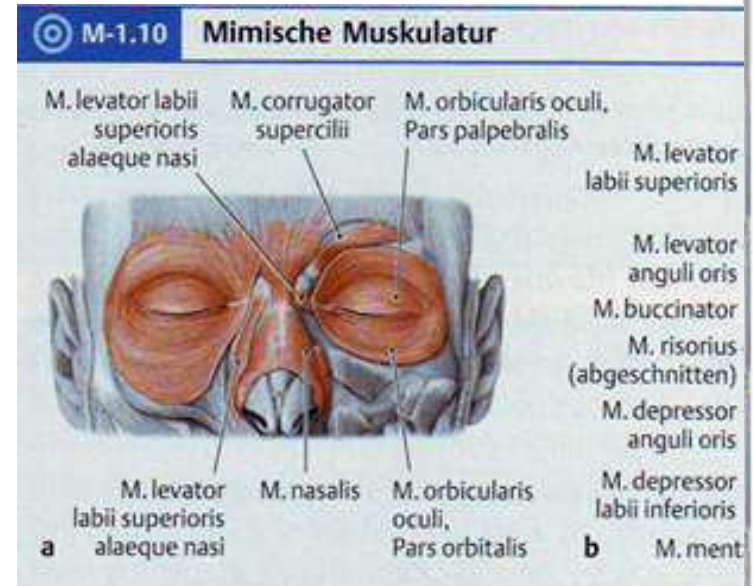
- Bony skeleton – *apertura piriformis*:
 - ✓ *ossa nasalia*
 - ✓ *processus frontalis maxillae*
- Cartilages, *cartilagine nasii*:
 - ✓ unpaired:
 - *cartilago nasi septi*
 - ✓ paired:
 - *cartilago nasi lateralis*
 - *cartilago alaris major*
 - *cartilagine alares minores*
 - *cartilagine nasales accessoriae*





Wall of the external nose

- Muscles of the nose – rudimentary:
 - ✓ *m. procerus*
 - ✓ *m. nasalis*
 - ✓ *m. depressor septi nasi*
 - ✓ *m. apicis nasi* – variable
 - ✓ *m. compressor nares*
 - ✓ *m. levator labii superioris alaeque nasi*
- Connective tissue
- Skin:
 - ✓ fine hairs
 - ✓ sweat glands
 - ✓ enlarged sebaceous glands



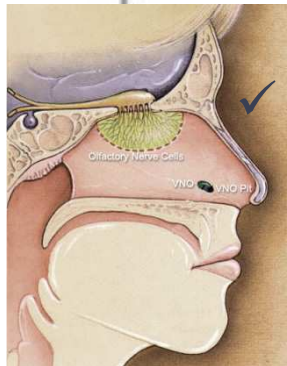
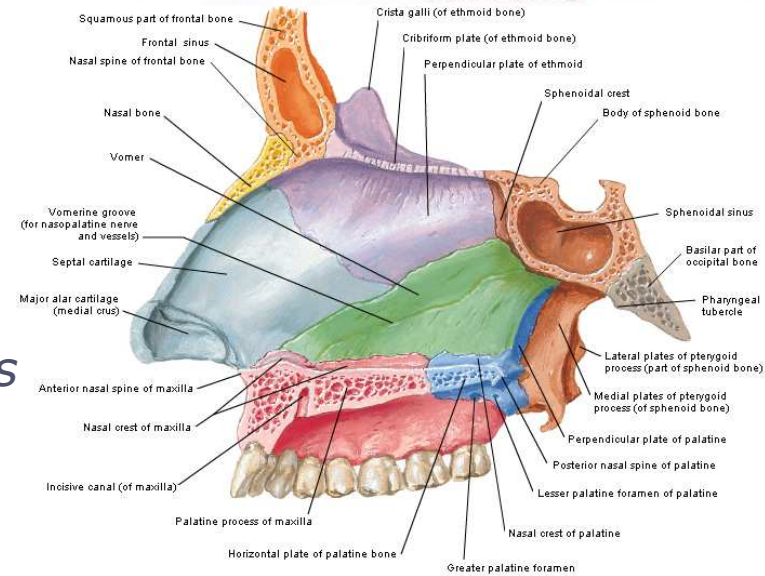
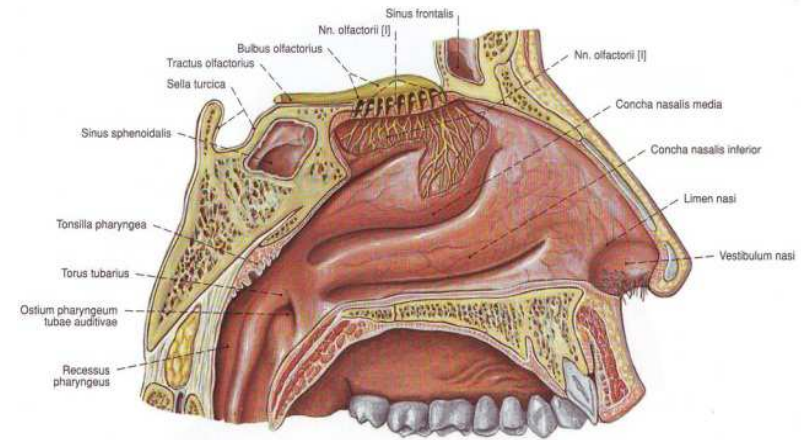


Nasal cavity

- Nasal cavity, *cavum (cavitas) nasi*:
 - ✓ vestibule, *vestibulum nasi*
 - ✓ nasal cavity proper, *cavum nasi proprium*

- Nasal septum, *septum nasi*:

- ✓ *pars ossea*
 - vomer
 - lamina perpendicularis ossis ethmoidalis
- ✓ *pars cartilaginea*
 - cartilago septi nasi
 - cartilagineae alares majores
 - organum vomeronasale (Jacobsoni) – феромони
 - locus Kiesselbachi
- ✓ *pars membranacea*
 - deviatio septi nasi

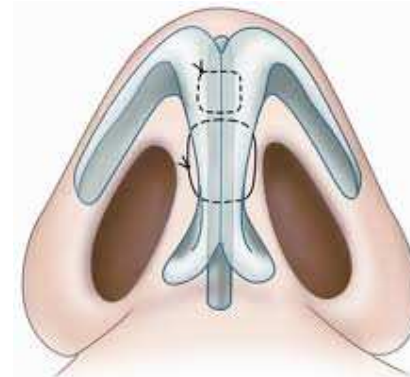
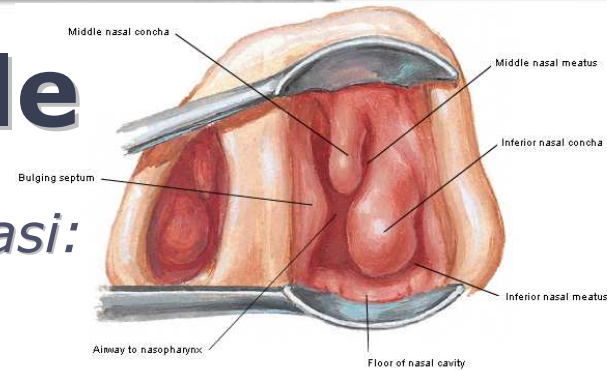


N. Lazarov
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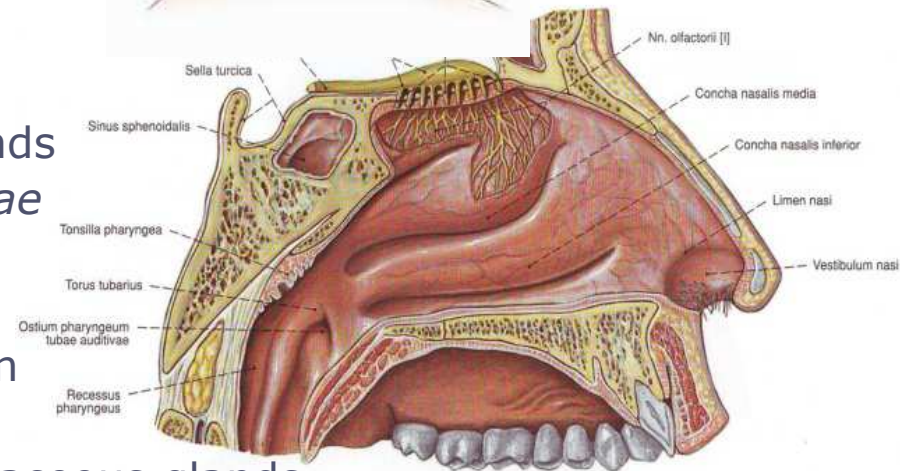


Nasal vestibule

- Nasal cavity, *cavum (cavitas) nasi*:
 - ✓ anterior (external) nares, nostrils
 - personality and racial traits
 - ✓ posterior (internal) nares, *choanae*
- Vestibule, *vestibulum nasi*:
 - ✓ *limen nasi*
 - ✓ *agger nasi*
 - ✓ *regio cutanea*
 - sweat and sebaceous glands
 - stiff (guard) hairs, *vibrissae*
 - ✓ transitional region
 - stratified squamous non-keratinized epithelium
 - seromucous glands
 - absence of sweat and sebaceous glands



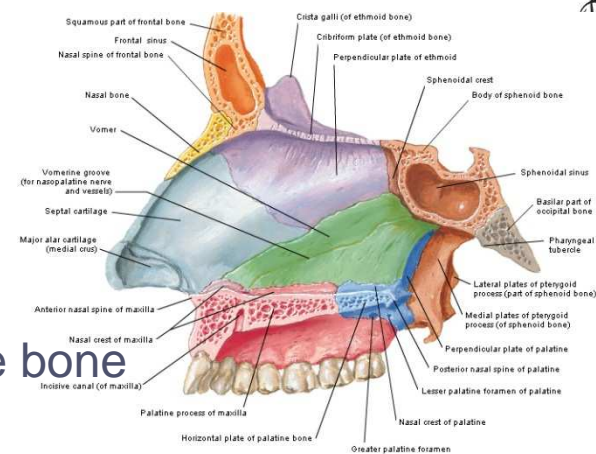
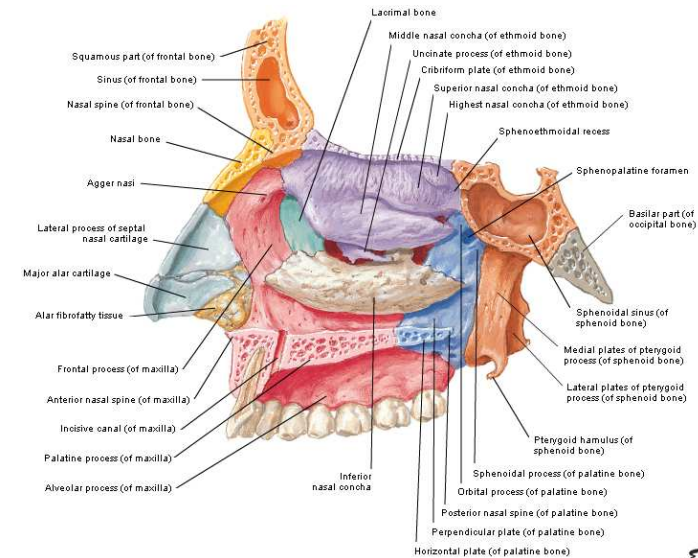
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Nasal cavity proper

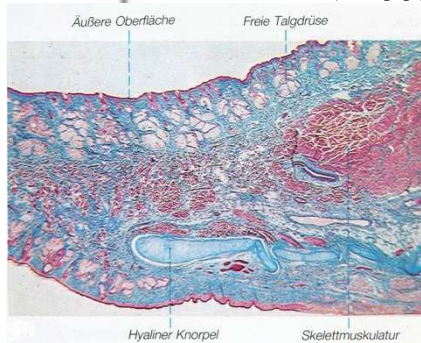
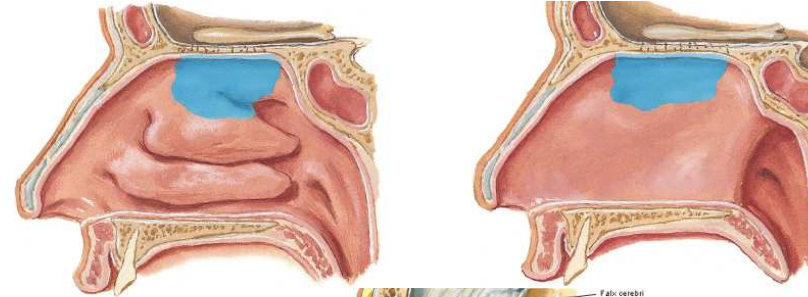
- Bony nasal cavity, *cavitas nasalis ossea*:
 - ✓ bony skeleton – walls
 - floor – hard palate
 - roof:
 - nasal bone
 - ethmoid bone
 - sphenoid bone
 - medial wall – nasal septum
 - lateral wall:
 - maxilla
 - lacrimal bone
 - labyrinth of the ethmoid
 - perpendicular plate of the palatine bone
 - sphenoid bone
 - *conchae nasales, superior, media et inferior*





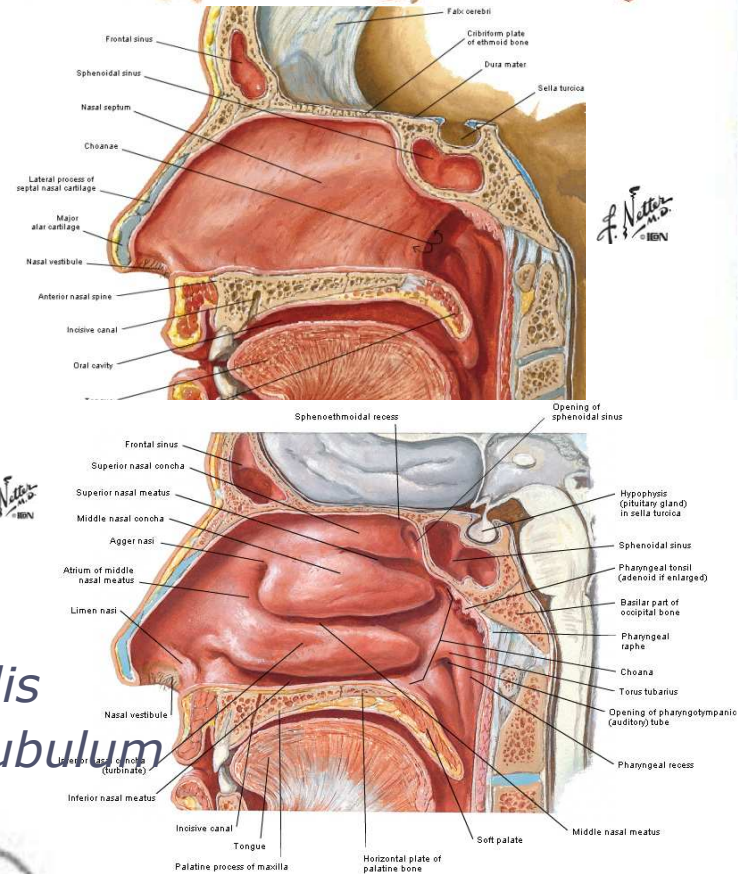
Nasal cavity proper

- Nasal mucosa:
 - ✓ medial wall
 - regio respiratoria
 - regio olfactoria
 - lateral wall
 - nasal conchae
 - nasal meatuses:



- meatus nasi superior
- meatus nasi medius
- meatus nasi inferior
- meatus nasi communis
- meatus nasopharyngeus

- openings of nasal sinuses:
 - recessus sphenothmoidalis
 - hiatus semilunaris, infundibulum
 - plica lacrimalis

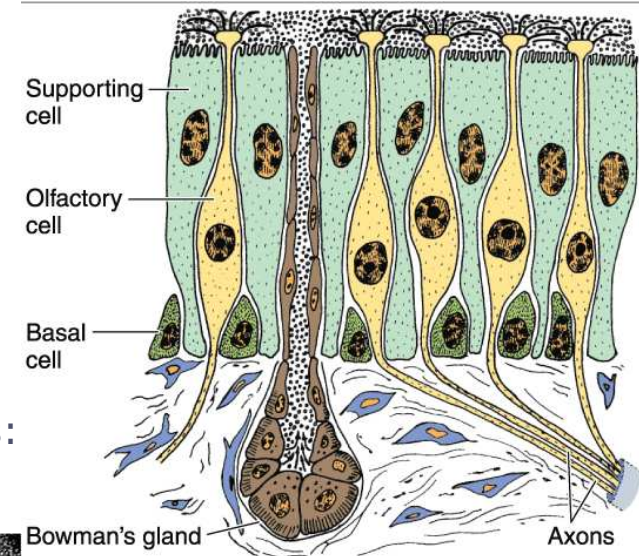




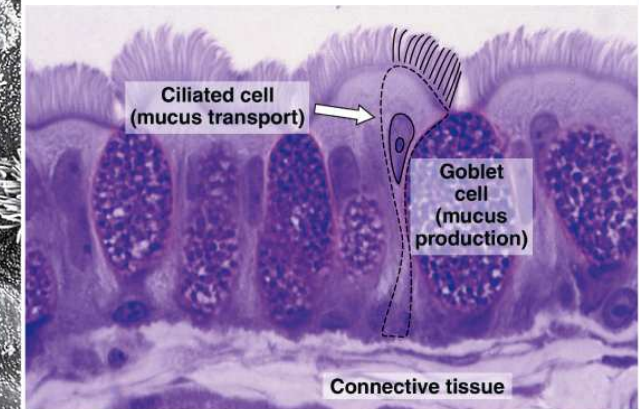
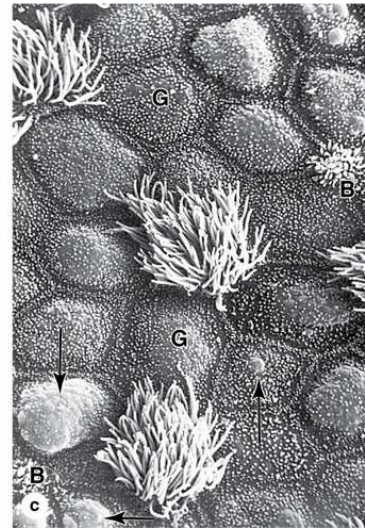
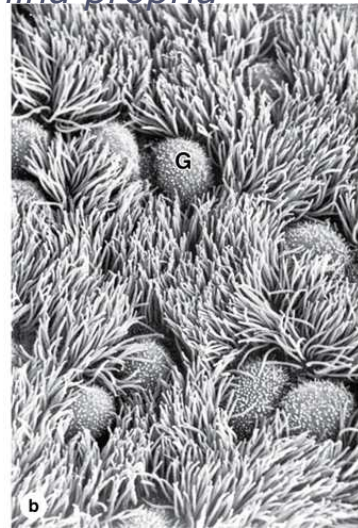
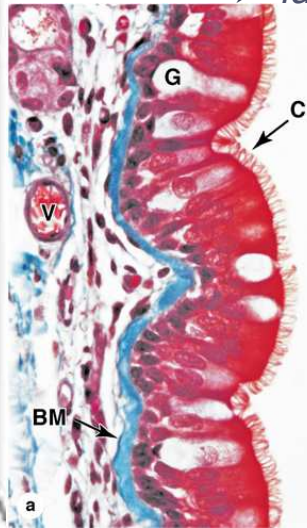
Nasal cavity proper

Microscopic anatomy:

- ✓ olfactory mucosa – 5-10 cm²
 - olfactory epithelium
 - *epithelium olfactorium* – olfactory and supporting cells
 - *lamina propria* – *gll. olfactoriae* (Bowman)
 - absent *tela submucosa*
- respiratory mucosa – 1-3 mm
 - *lamina epithelialis* – pseudostratified ciliated columnar epithelium – 3 cell types: ciliated columnar, goblet and basal cells
 - *lamina propria*



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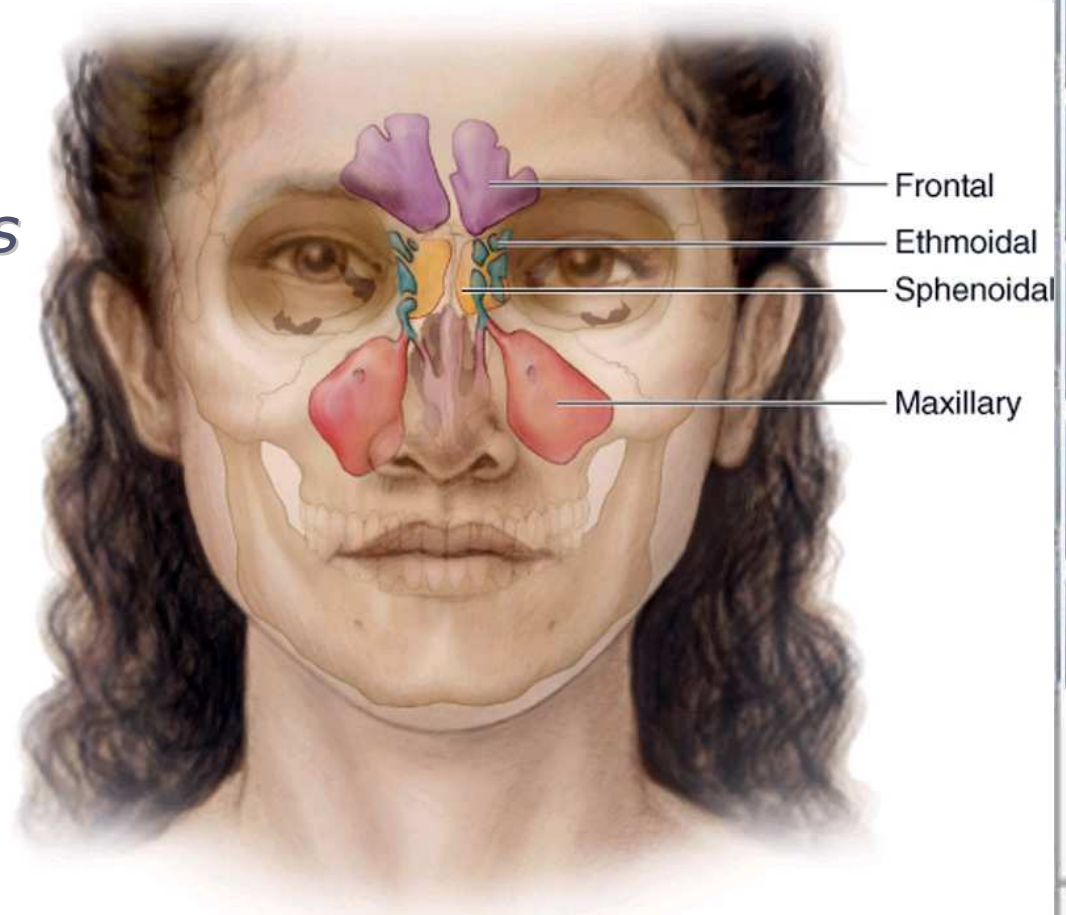


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Paranasal sinuses, *sinus paranasales*

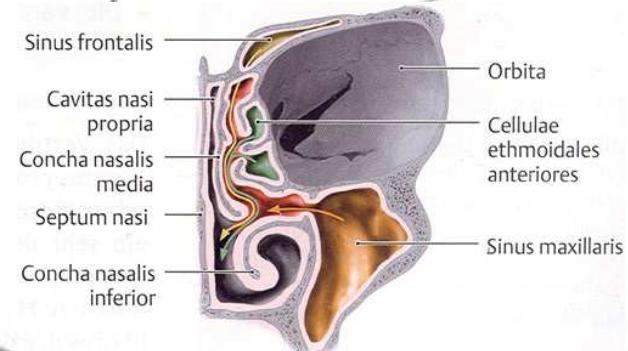
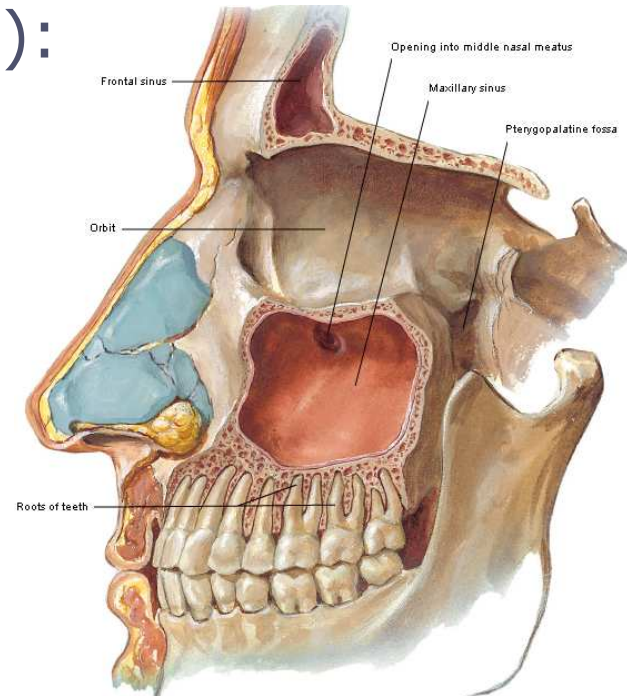
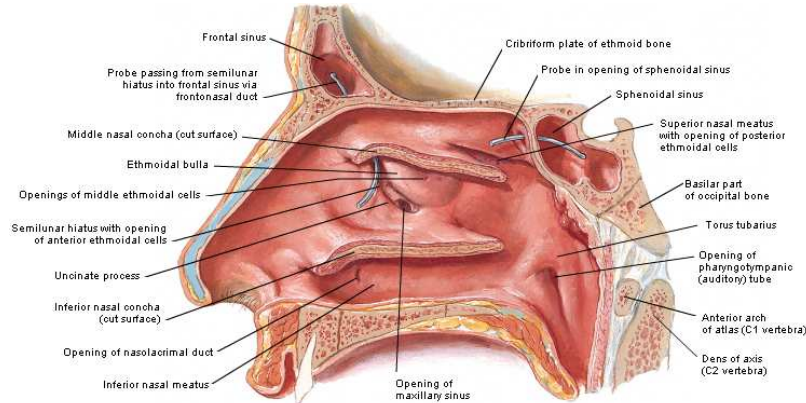
- ✓ *sinus maxillaris (antrum Highmori)*
- ✓ *sinus frontalis*
- ✓ *sinus ethmoidalis*
- ✓ *sinus sphenoidalis*





Maxillary sinus, *sinus maxillaris*

- Maxillary sinus (Highmore):
 - ✓ largest sinus
 - ✓ in the body of the maxilla
 - hiatus maxillaris ⇨ hiatus semilunaris
 - drainage ⇨ meatus nasi medius



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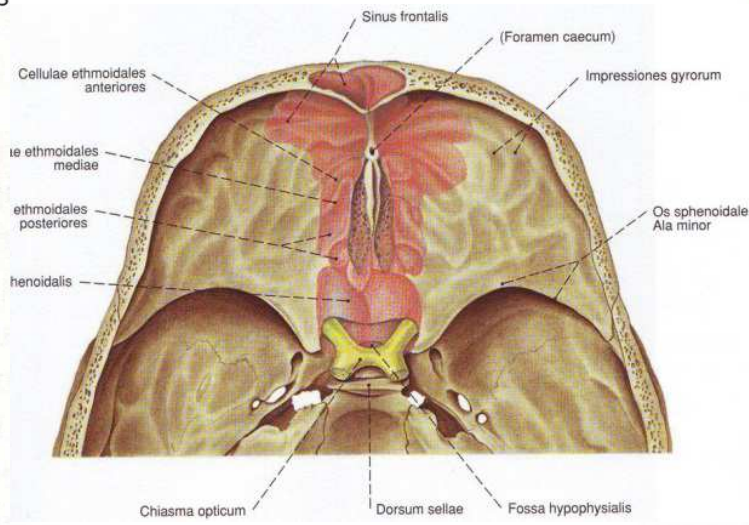
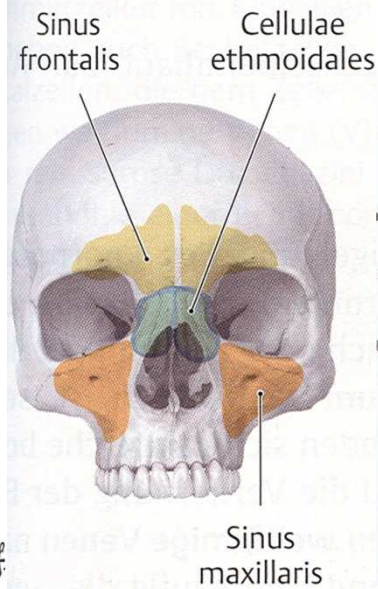
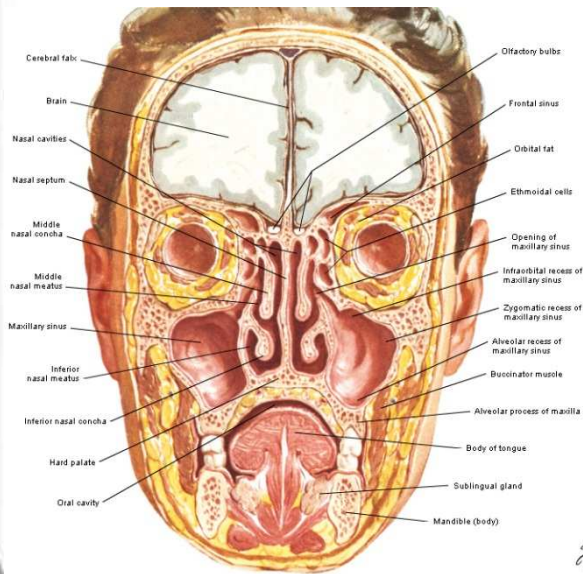
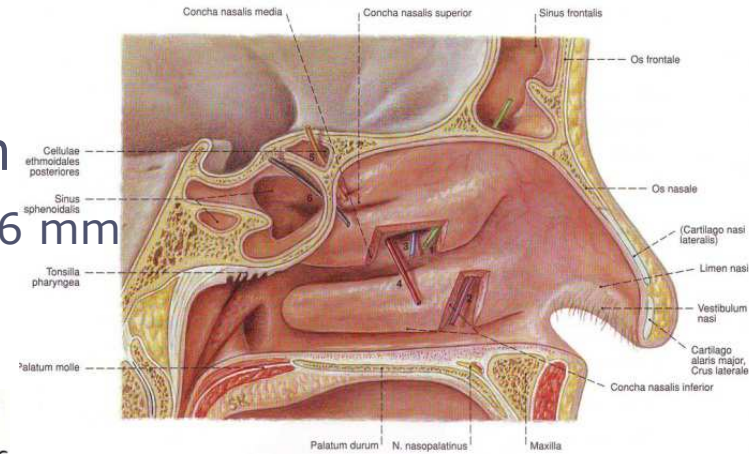


Frontal sinus, *sinus frontalis*

■ Frontal sinus:

✓ in the frontal bone

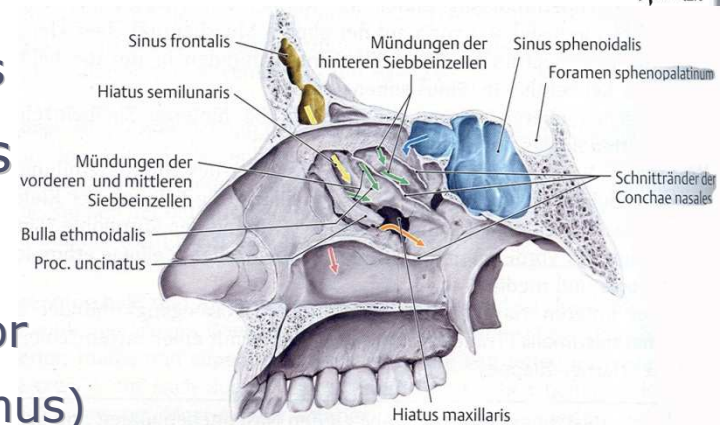
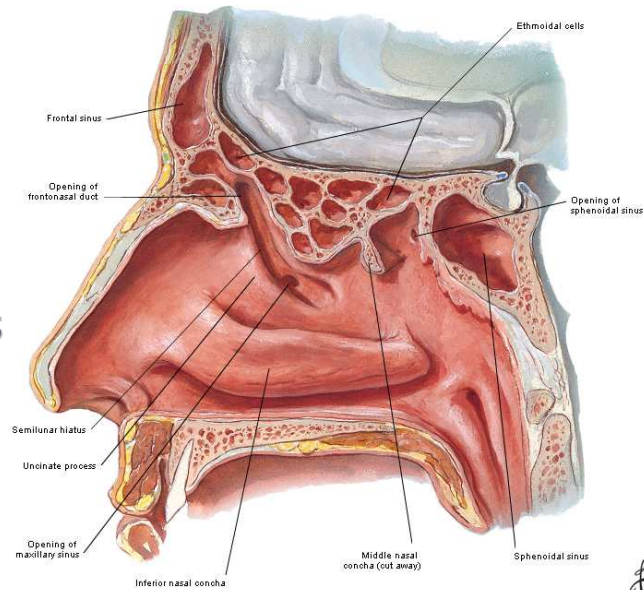
- septum sinuum frontalem
- ductus nasofrontalis – 12-16 mm
- drainage ⇨ infundibulum of meatus nasi medius





Ethmoid sinus, *sinus ethmoidalis*

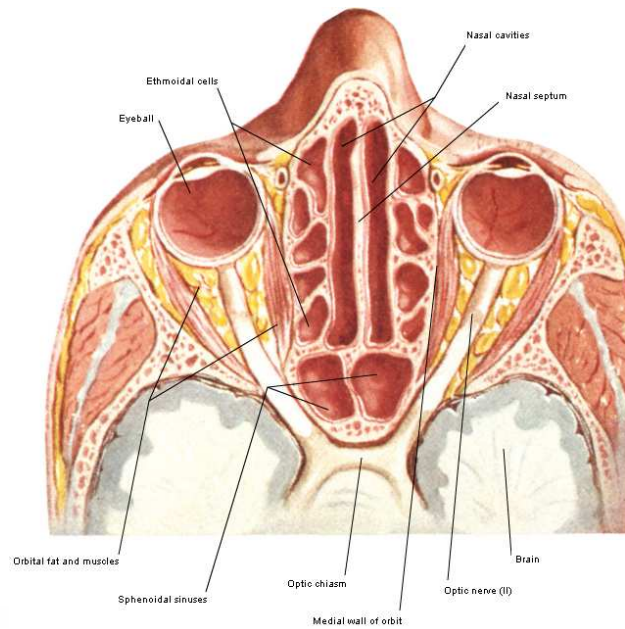
- Ethmoid cells – 10 (5-16):
 - ✓ cellulae ethmoidales anteriores
 - 2-3 in number
 - drainage ⇒ meatus nasi medius
 - ✓ cellulae ethmoidales medii, incl. bulla ethmoidalis
 - 3-4
 - drainage ⇒ meatus nasi medius
 - ✓ cellulae ethmoidales posteriores
 - 4-5
 - drainage ⇒ meatus nasi superior (meatus nasi supremus)



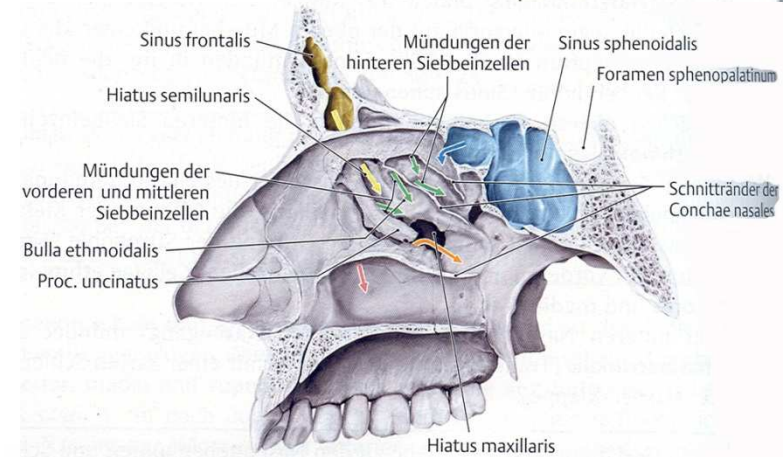
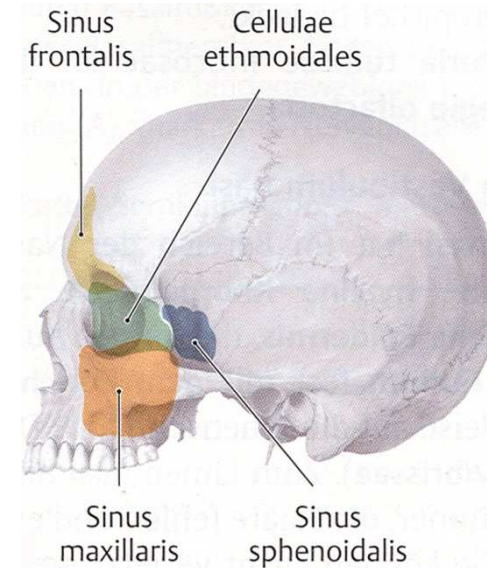


Sphenoid sinus, *sinus sphenoidalis*

- Sinus sphenoidalis:
 - ✓ in the sphenoid body
 - septum sinuum sphenoidalium
 - apertura sphenoidalis
 - drainage ⇒ recessus sphenothmoidalis



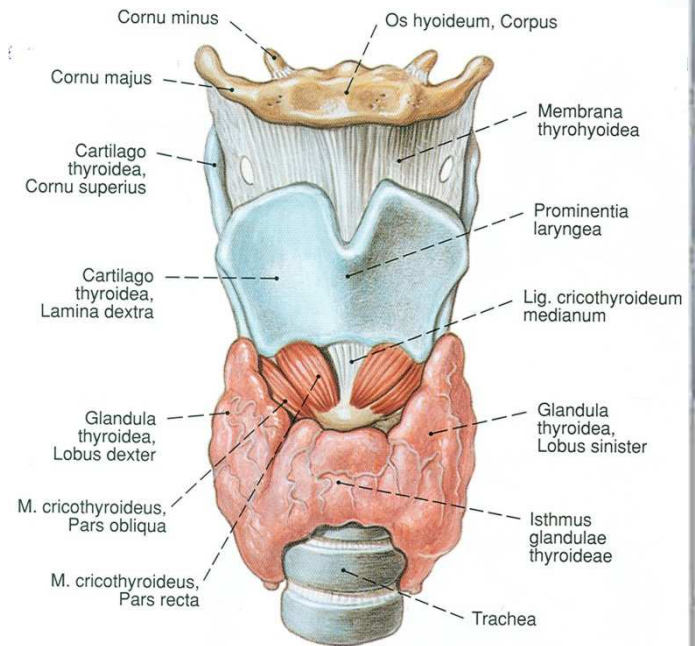
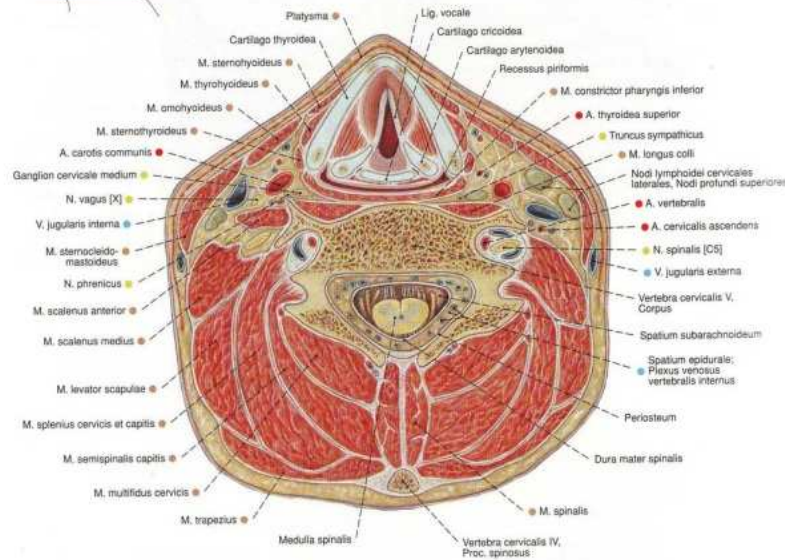
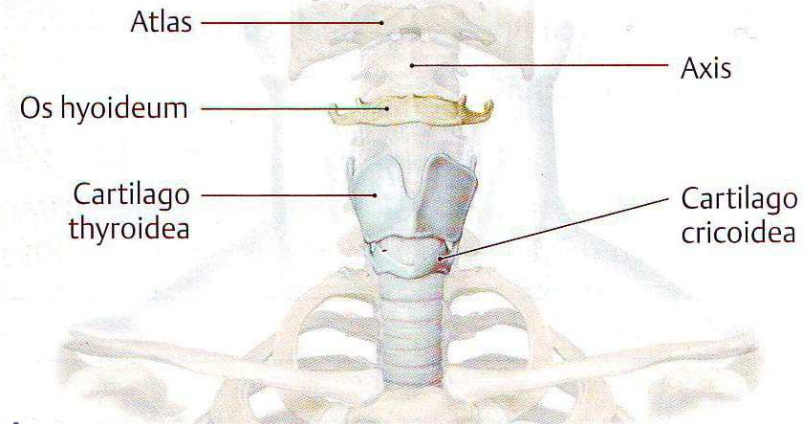
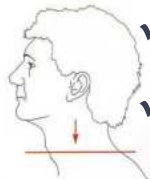
F. Netter M.D.
1909





Larynx, *larynx*

- Larynx, *larynx*:
 - ✓ irregular tube
 - ✓ "voicebox" ⇒ phonation
- Anatomical position:
 - ✓ in the anterior neck
 - ✓ at the level – C₃-C₆ vertebrae





Skeleton of the larynx

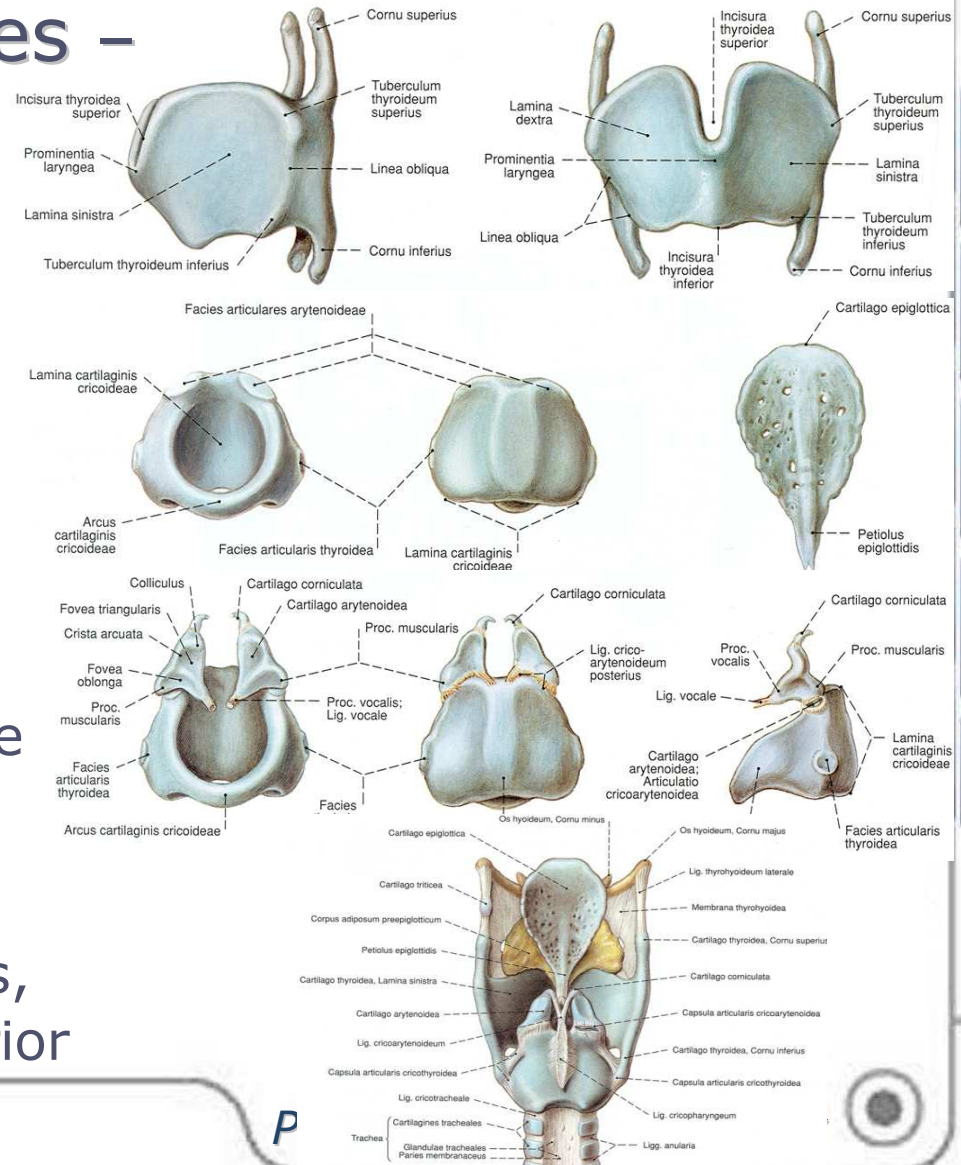
■ Laryngeal cartilages – hyaline and elastic cartilages:

✓ single:

- thyroid cartilage
- cricoid cartilage
- epiglottic cartilage

✓ paired:

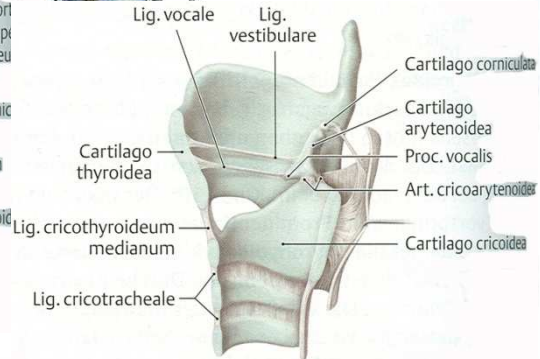
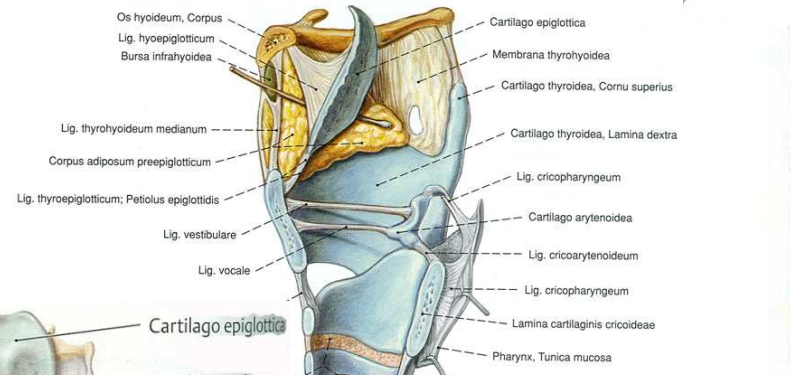
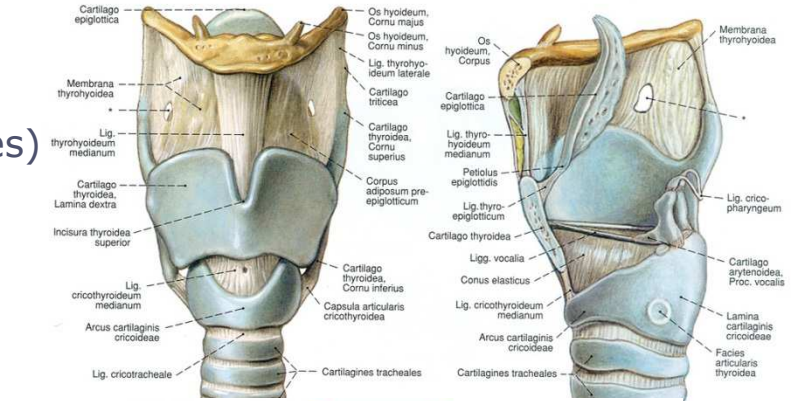
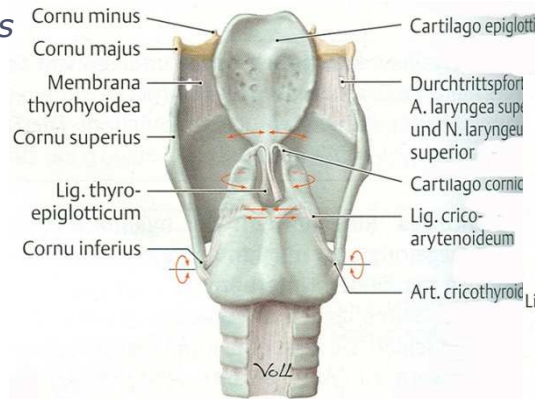
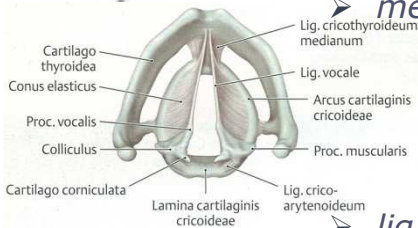
- arytenoid cartilage
- corniculate cartilage
- cuneiform cartilage
- *cartilago triticea*
- sesamoid cartilages, anterior and posterior





Skeleton of the larynx

- Ligaments of the larynx:
 - ✓ syndesmoses (ligaments and membranes)
 - *membrana thyrohyoidea*
 - *lig. thyrohyoideum medianum et laterale*
 - *lig. thyroepiglotticum*
 - *membrana fibroelastica – conus elasticus*
 - *lig. vocale*
 - *lig. cricothyroidem (lig. conicum)*
 - *lig. cricoarytenoideum*
 - *membrana quadrangularis*
 - ⇒ *lig. ventriculare*
 - *lig. cricotracheale*
 - ✓ articulations:
 - *art. cricothyroidea*
 - *art. cricoarytenoidea*





Muscles of the larynx

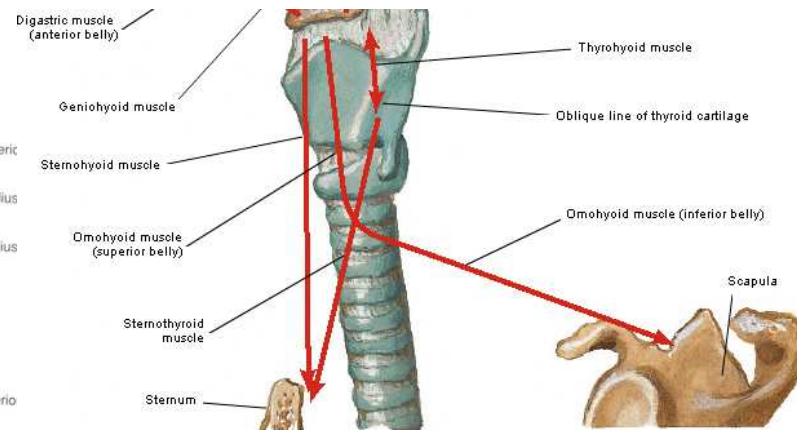
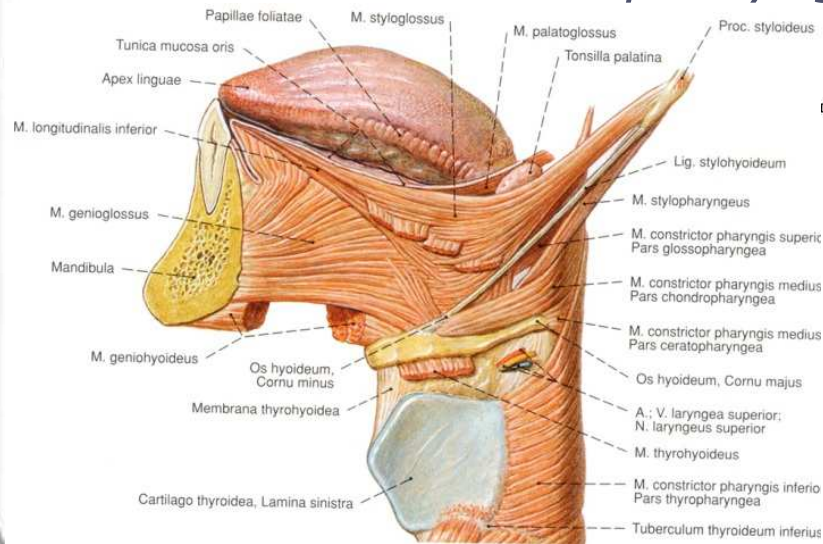
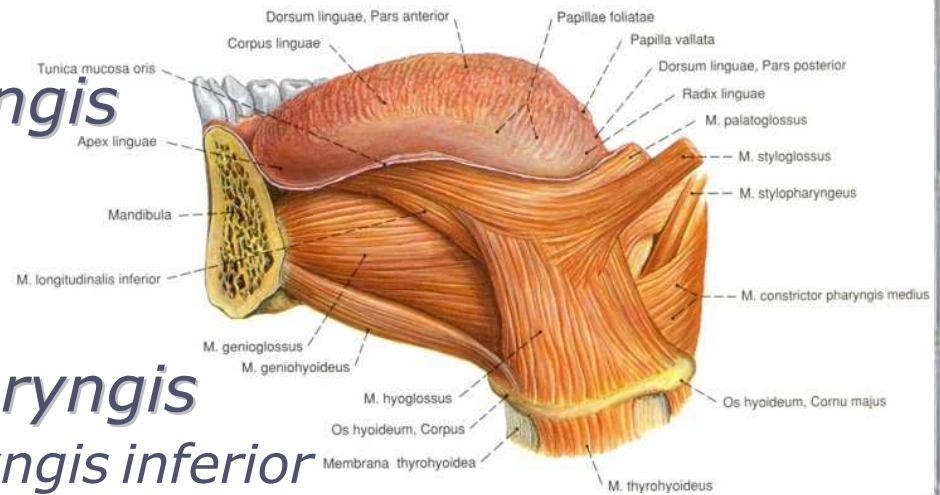
■ Extrinsic muscles:

✓ *mm. levatores laryngis*

- *m. stylohyoideus*
- *m. geniohyoideus*
- *m. digastricus*

✓ *mm. detractores laryngis*

- *m. constrictor pharyngis inferior*



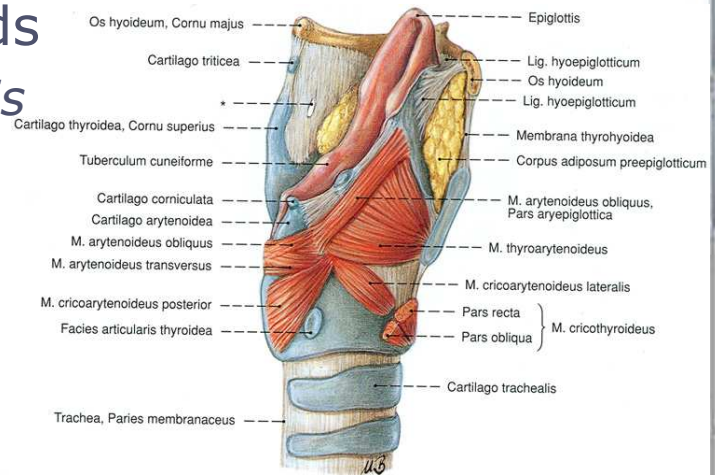
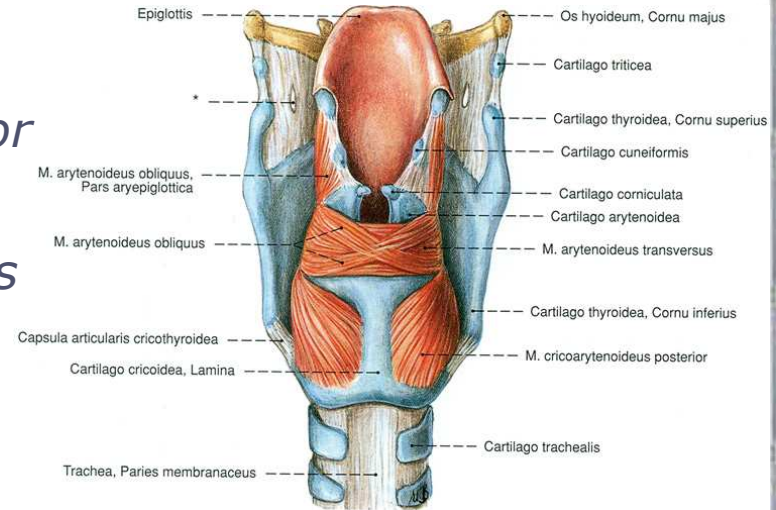
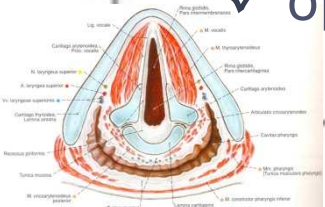
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Muscles of the larynx

■ Intrinsic muscles:

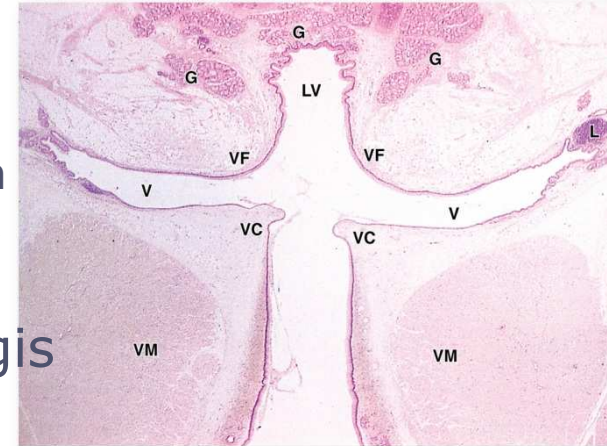
- ✓ open the glottis
 - *m. cricoarytenoideus posterior*
- ✓ close the glottis
 - *m. cricoarytenoideus lateralis*
 - *m. arytenoideus transversus*
- ✓ elongation of the vocal folds
 - *m. cricothyroideus (anticus)*
- ✓ relax and shorten the vocal folds
 - *m. thyroarytenoideus, m. vocalis*
- ✓ close the larynx opening
 - *m. aryepiglotticus* ⇔
m. arytenoideus obliquus
- ✓ open the larynx opening
 - *m. thyroepiglotticus*



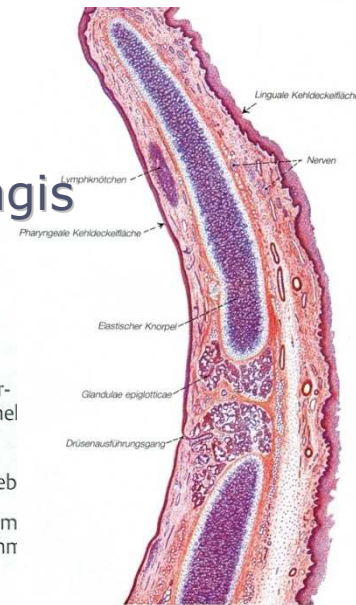
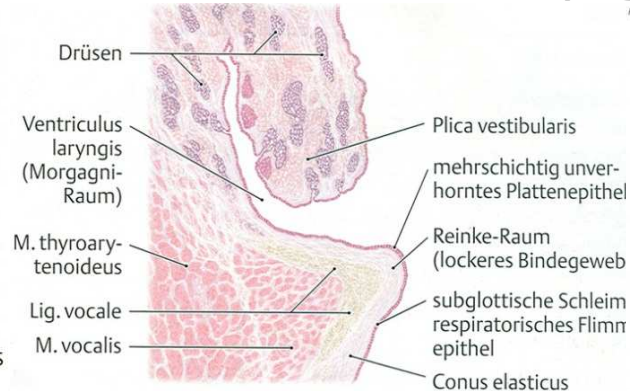
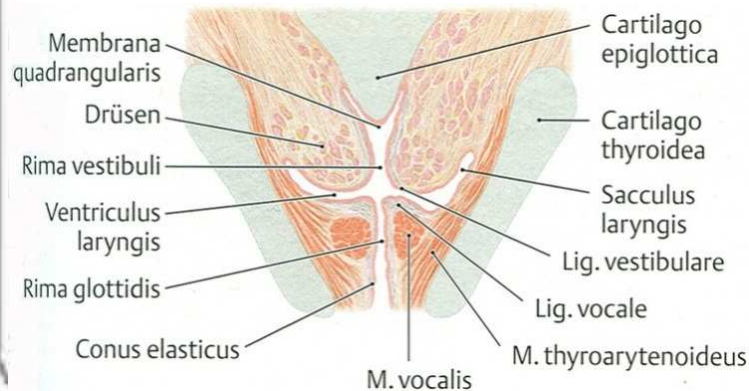


Microscopic anatomy

- **Tunica mucosa laryngis:**
 - ✓ lamina epithelialis
 - stratified ciliated columnar epithelium
 - stratified squamous nonkeratinized ⇒ vocal folds, vestibule
 - ✓ lamina propria – oedema laryngis
 - laryngeal glands
 - o gll. epiglotticae
 - o gll. ventriculi laryngis
 - lymphatic follicles, tonsilla laryngis



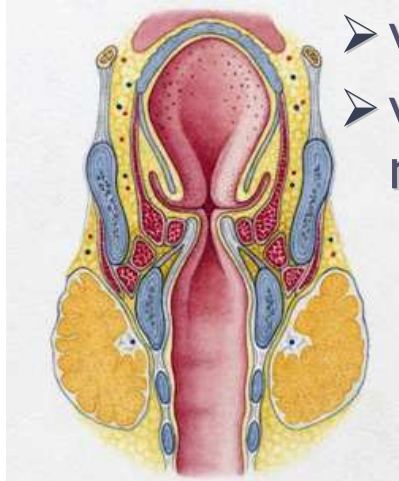
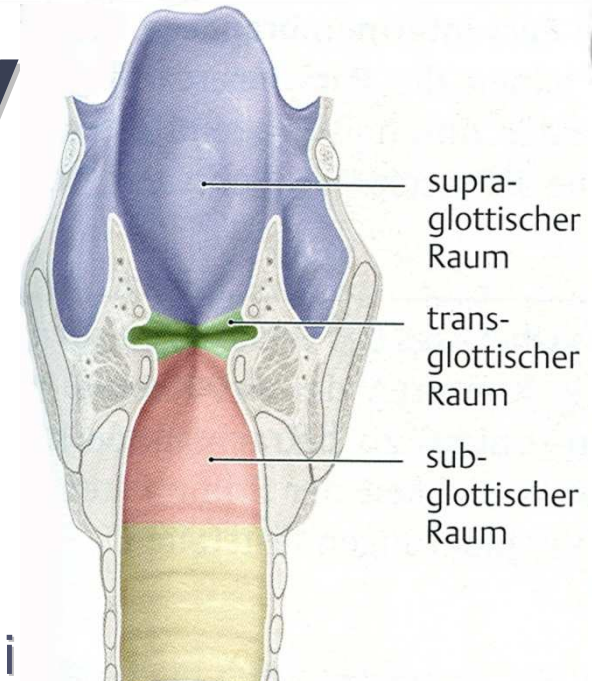
- **Tela submucosa – membrana fibroelastica laryngis**





Laryngeal cavity

- Three clinical compartments – hour-glass configuration:
 - ✓ supraglottic space, vestibule, vestibulum laryngis
 - laryngeal inlet, aditus laryngis
 - ✓ transglottic space

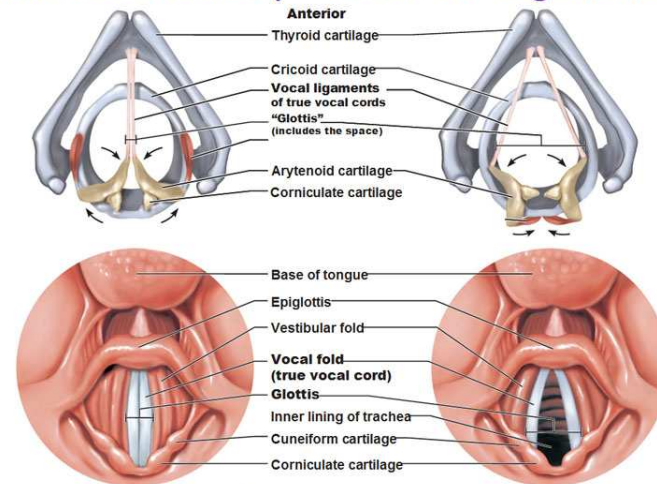


- vestibular folds ⇒ rima vestibuli
- vocal folds (m. vocalis) ⇒ rima glottidis (glottis)

- o intermembranous part, pars intermembranacea
- o intercartilagineous part, pars intercartilaginea

- ✓ infraglottic cavity, cavitas infraglottica

True Vocal Cords (= "Folds" or "Ligaments")

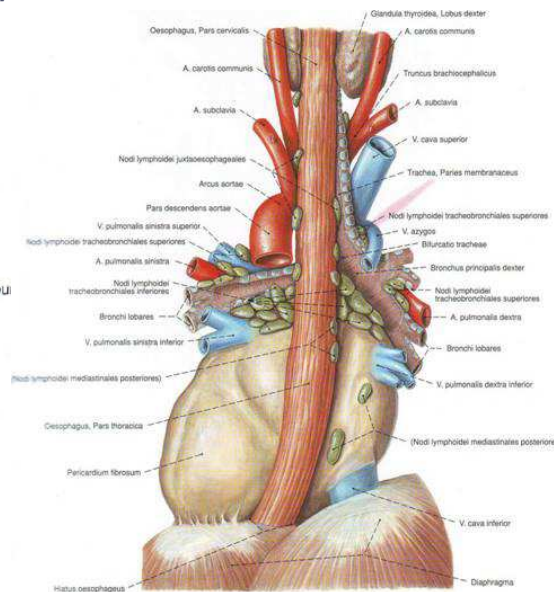
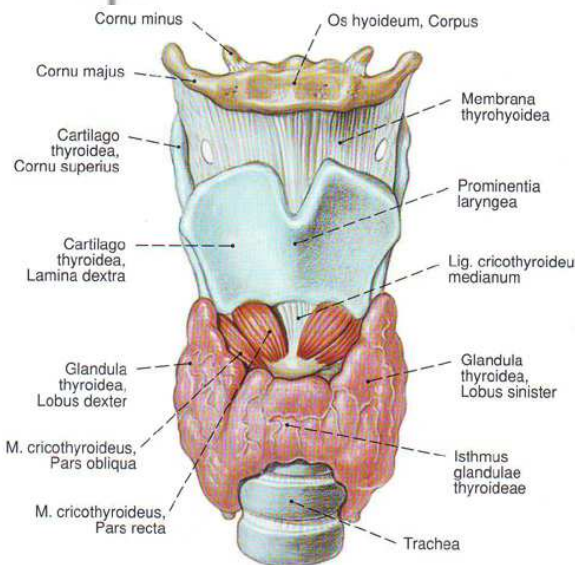
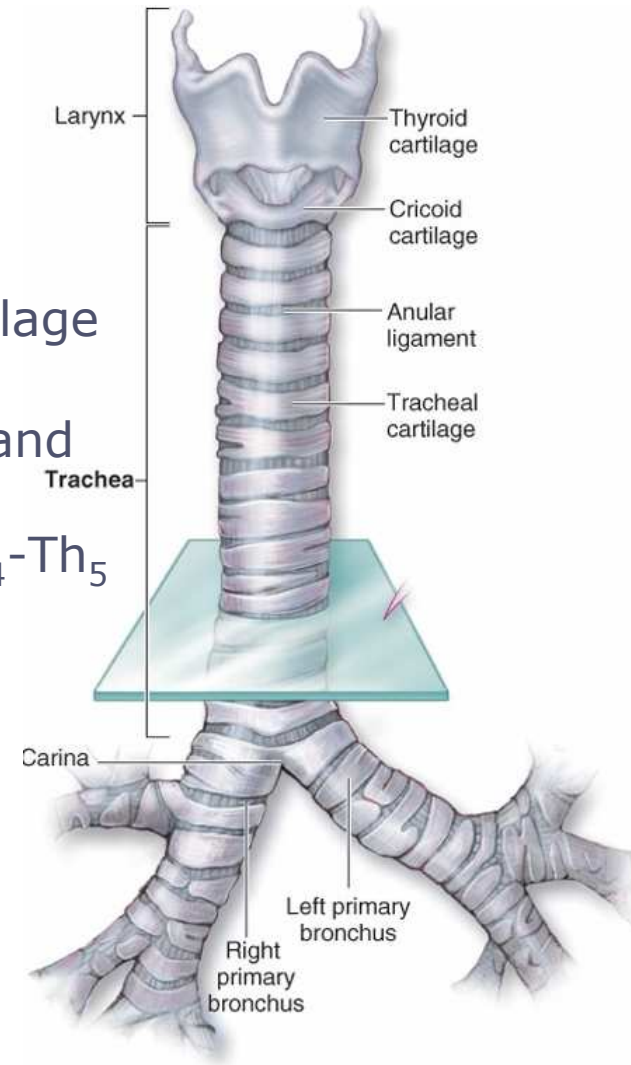


(a) Vocal folds in closed position; closed glottis (b) Vocal folds in open position; open glottis



Trachea, *trachea*

- **Trachea, *trachea*:**
 - ✓ "windpipe"
 - ✓ in the neck and thorax, *pars cervicalis et pars thoracica*
 - ✓ length 11-13 cm; 2.5 cm in diameter
 - ✓ 15-20 C-shaped rings of hyaline cartilage
- **Topography:**
 - ✓ anterior to the esophagus, thyroid gland
 - ✓ begin – C₆-C₇
 - ✓ inferior end, *bifurcatio tracheae* – Th₄-Th₅





Primary bronchi, *bronchi principales*

- Primary bronchi, *bronchi principales*:

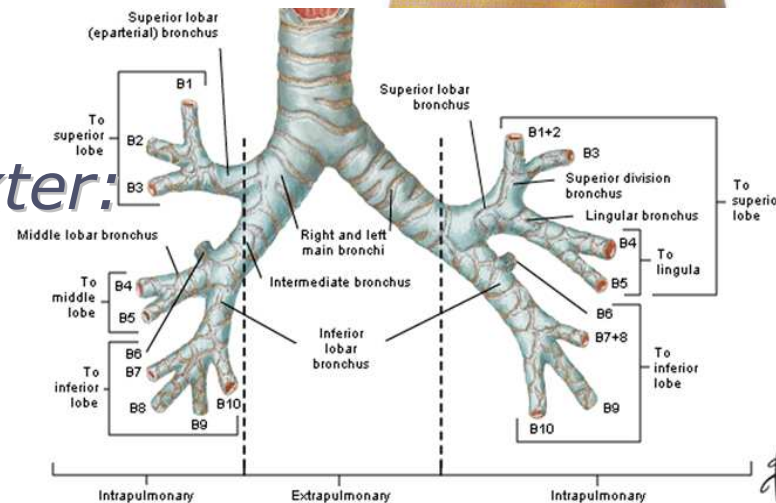
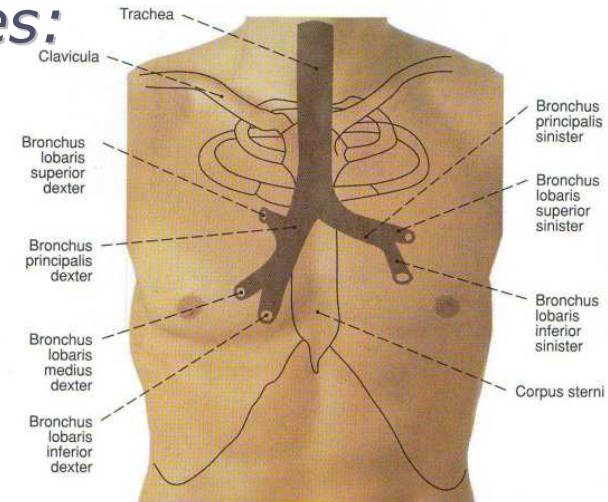
- ✓ *bifurcatio tracheae* – Th₄-Th₅;
Th₂ (newborns)-Th₇ (in elderly person)
- ✓ angle – 55-65° (adults); 70-80° (infants)
- ✓ *carina tracheales*

- *Bronchus principalis sinister*:

- ✓ more horizontal
- ✓ longer
 - length – 4-5 cm
 - 9-12 cartilages
- ✓ narrower – 10-11 mm

- *Bronchus principalis dexter*:

- ✓ more vertical
- ✓ shorter
 - length – 3 cm
 - 6-9 cartilages
- ✓ slightly wider – 15-16 mm



F. Natter
M.D.
© IBN



Structure of tracheal wall

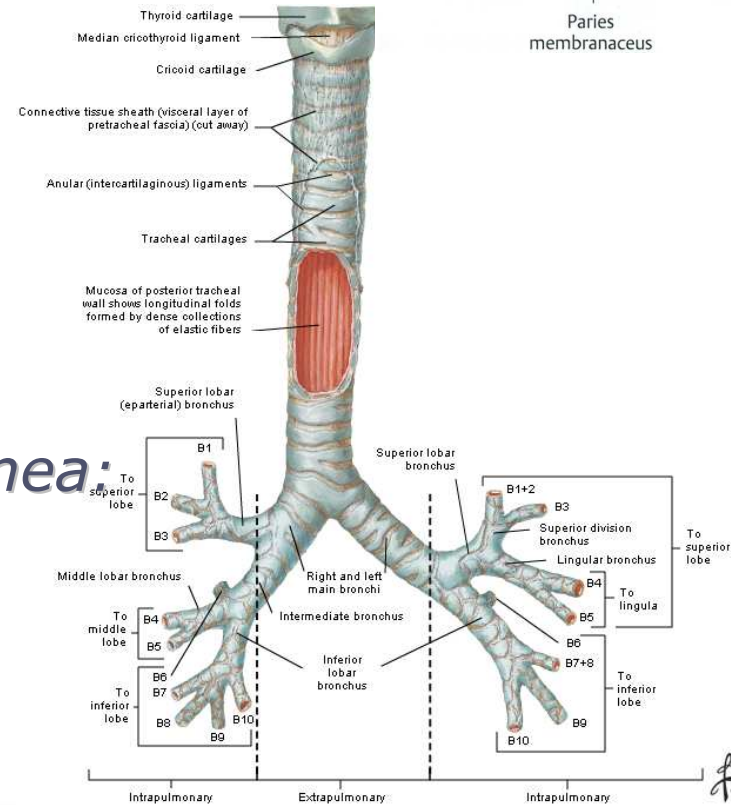
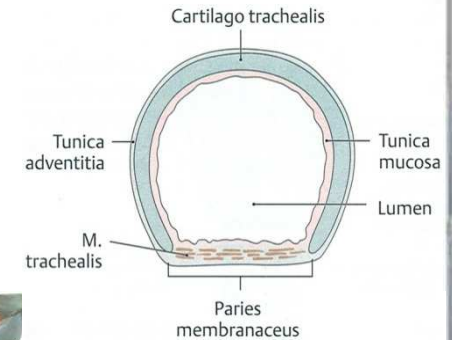
- *Mucosa, tunica mucosa respiratoria:*

- ✓ *lamina epithelialis*
 - pseudostratified columnar ciliated epithelium
- ✓ *lamina propria*
 - elastic fibers and blood vessels
 - lymph follicles– BALT
- ✓ *tela submucosa*
 - *gll. tracheales*
 - *lamina fibrarum elasticum*

- *Tunica fibromusculocartilaginea:*

- ✓ *cartilagine tracheales*
- ✓ *m. trachealis*
- ✓ *lig. anularia*

- *Tunica adventitia*

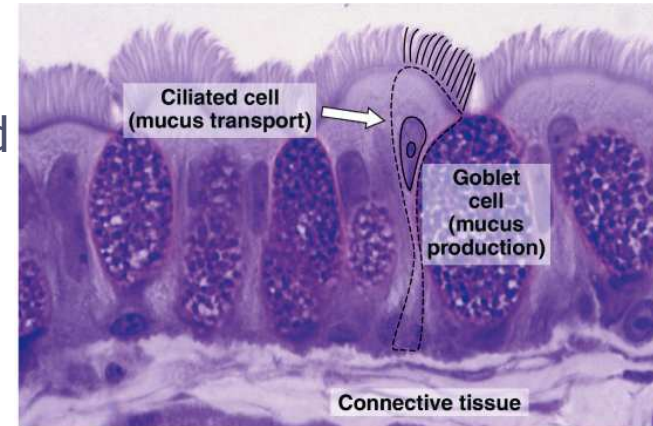


F. Netter M.D.

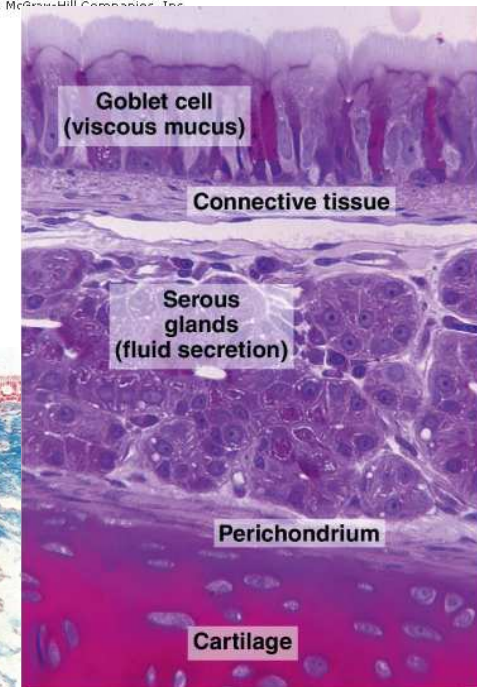


Microscopic anatomy

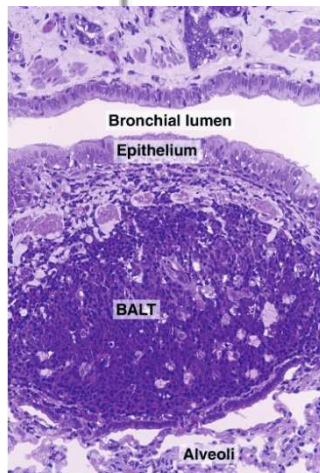
- *tunica mucosa respiratoria*:
 - ✓ *lamina epithelialis* – pseudostratified columnar ciliated epithelium:
 - ciliated cells, *epitheliocyti ciliati* – 250-300 kinocilia
 - goblet cells, *exocrinocyti caliciformis*
 - basal cells
 - brush cells – microvilli, receptor cells
 - granular cells of *Kulchitsky* – neuroendocrine cells
 - interciliary cells – mucous production



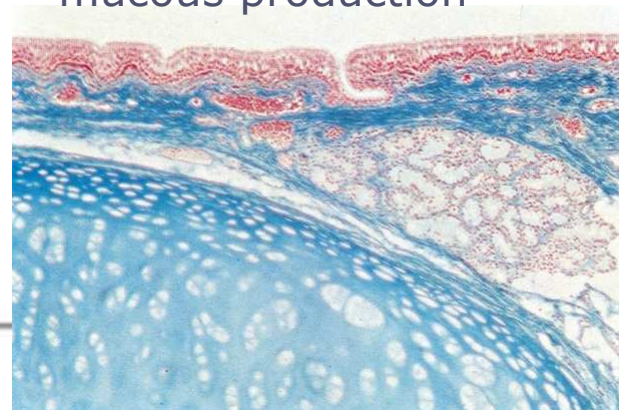
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Structure of the bronchial wall

- Mucosa, *tunica mucosa respiratoria*:

- ✓ *lamina epithelialis*

- stratified columnar ciliated epithelium

- ✓ *lamina propria*

- elastic fibers and blood vessels

- BALT

- ✓ *tela submucosa*

- *gll. bronchiales*

- *lamina fibrarum elasticum*

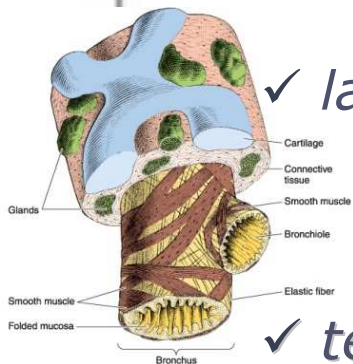
- *Tunica fibromusculocartilaginea*:

- ✓ *cartilagine bronchiales*

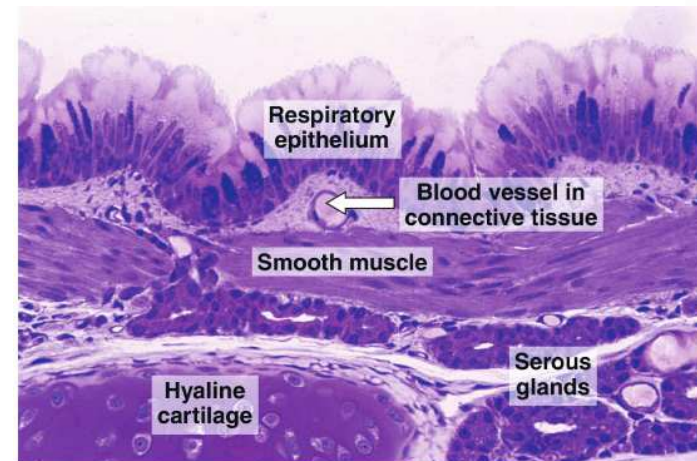
- ✓ *m. bronchialis*

- ✓ *lig. anularia*

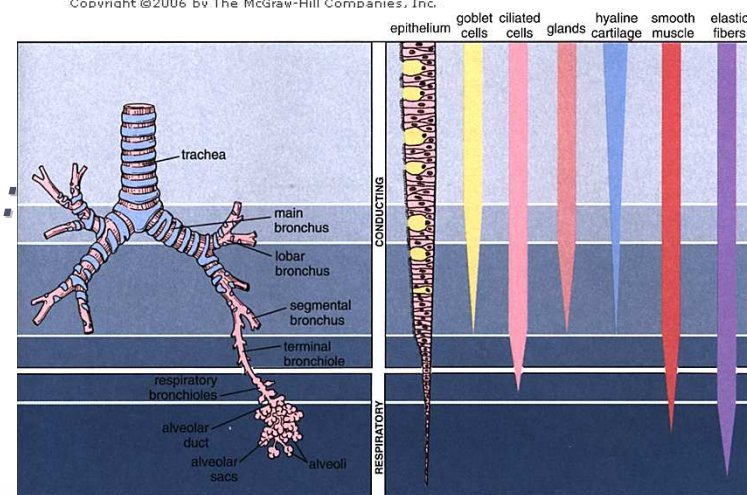
- *Tunica adventitia*



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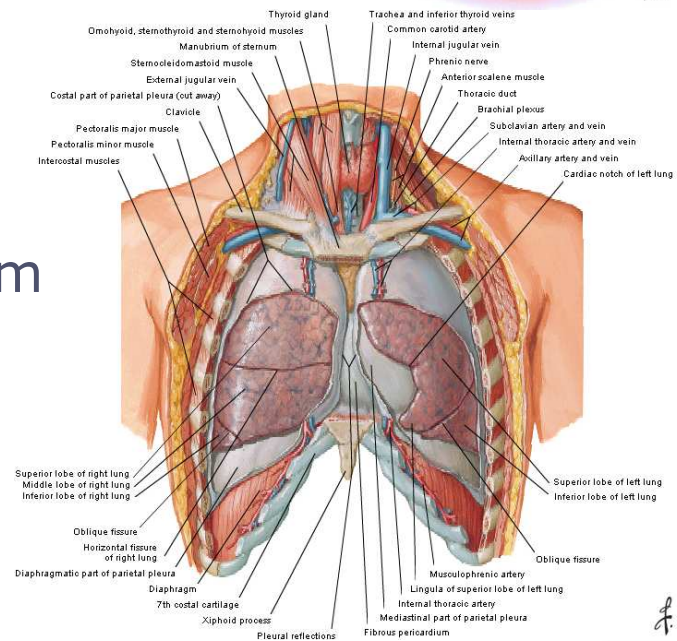
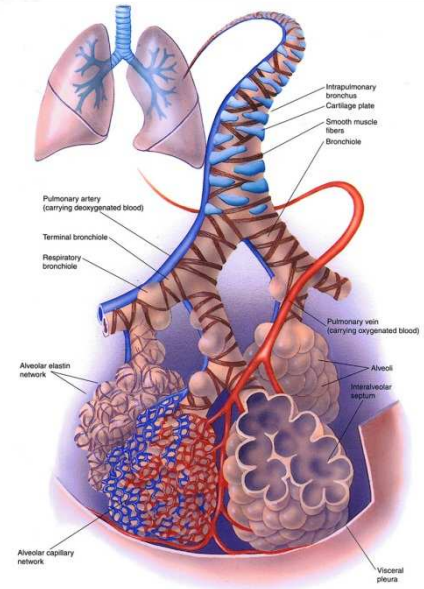




Lungs

- Lung, *pulmo* (*Gr. pneumon*):
 - ✓ gas exchange (“external breathing”)
 - functional features:
 - respiratory passages
 - blood vessels – functional and nutritional
 - parenchyma

- Lungs *in situ*:
 - ✓ in thoracic cavity – mediastinum
 - ✓ resting on the diaphragm
 - ✓ covered by pleura, *pleura visceralis*

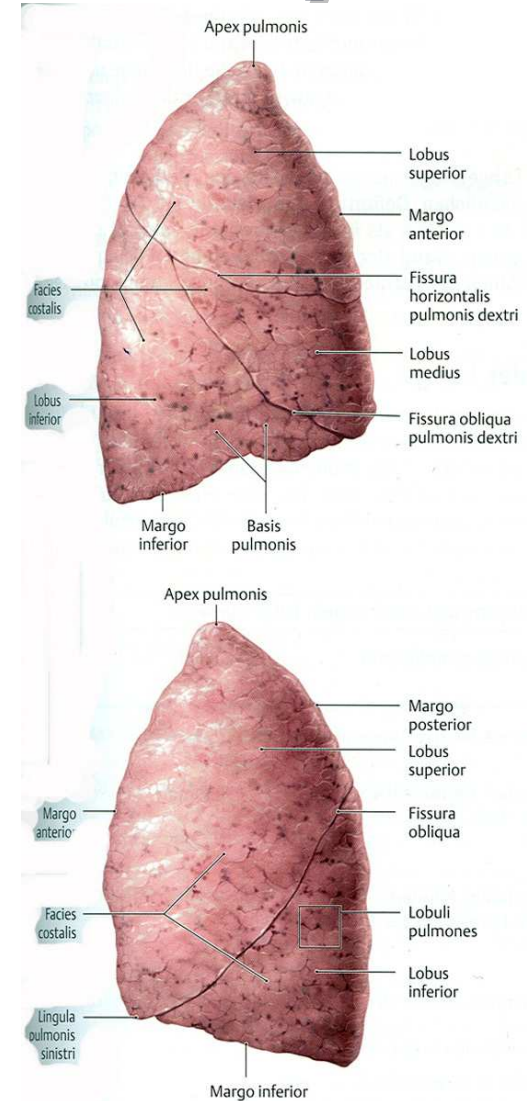


A. Nestor
MD



Macroscopic anatomy

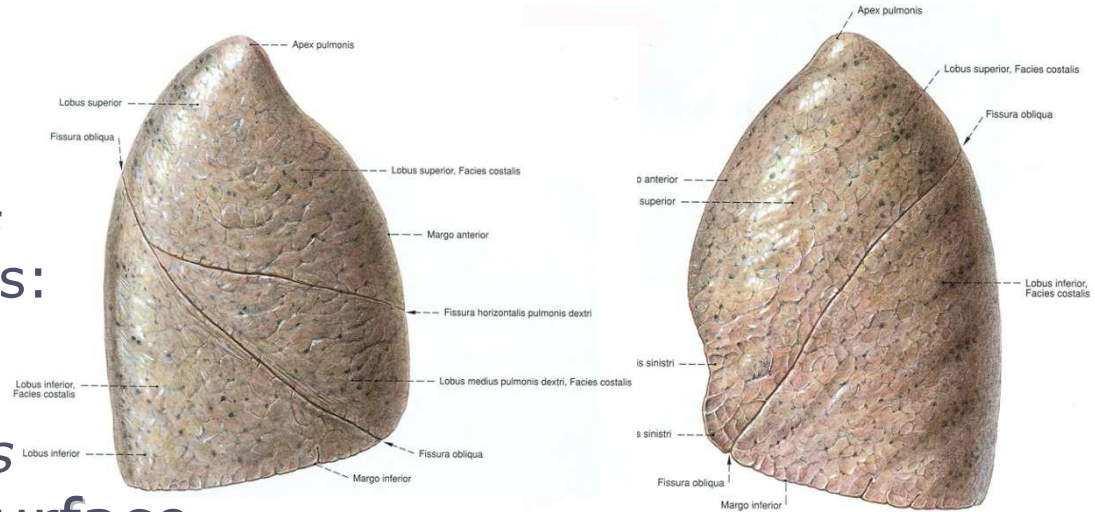
- Structure of the lungs :
 - ✓ shape – conical
 - base, *basis pulmonis*
 - blunt peak, *apex pulmonis*
 - three surfaces:
 - o *facies costalis*
 - o *facies diaphragmatica*
 - o *facies mediastinalis*
 - ✓ size – variable:
 - length ~25 cm
 - anterior-posterior ~16 cm
 - width ~10 (right); 7 cm (left) lung
 - ✓ color – age-dependent
 - red-brown – until birth
 - pinkish white – at birth
 - a dark slaty gray – in adult life
 - ✓ consistency – spongy and soft





Macroscopic anatomy

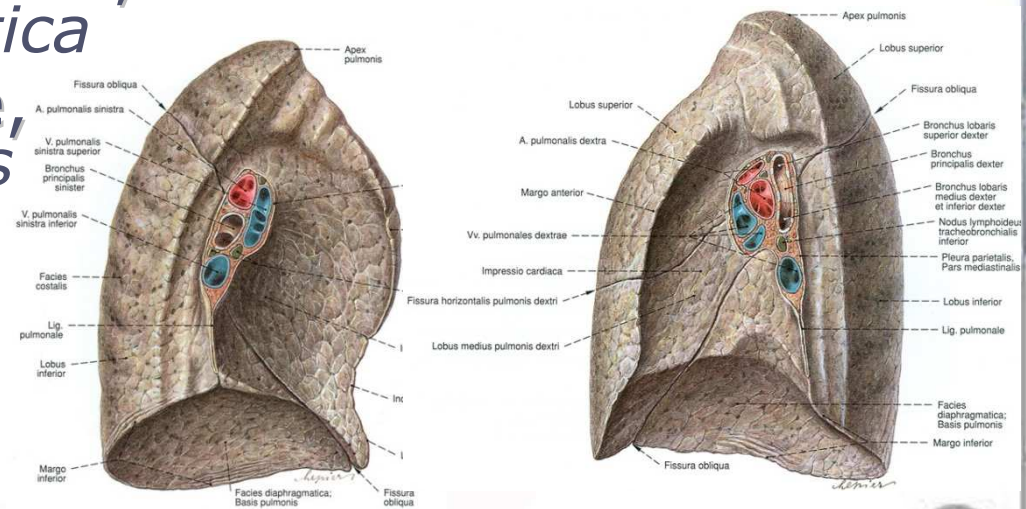
- **Costal surface, *facies costalis*:**
 - ✓ *fissura obliqua*
 - ✓ *fissura horizontalis*
 - ✓ lobes of the lungs:
 - right – 3 lobes
 - left – 2 lobes
 - ✓ *facies interlobalis*



- **Diaphragmatic surface, *facies diaphragmatica***

- **Mediastinal surface, *facies mediastinalis***

- ✓ *hilum pulmonis*
- ✓ *radix pulmonis*
 - anteriorly
 - posteriorly
 - superiorly





Lung segments

■ Bronchopulmonary segments:

✓ right lung:

➤ *lobus superior*

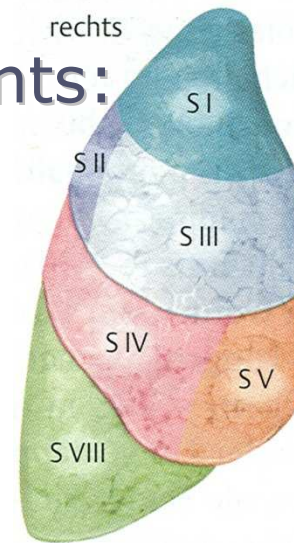
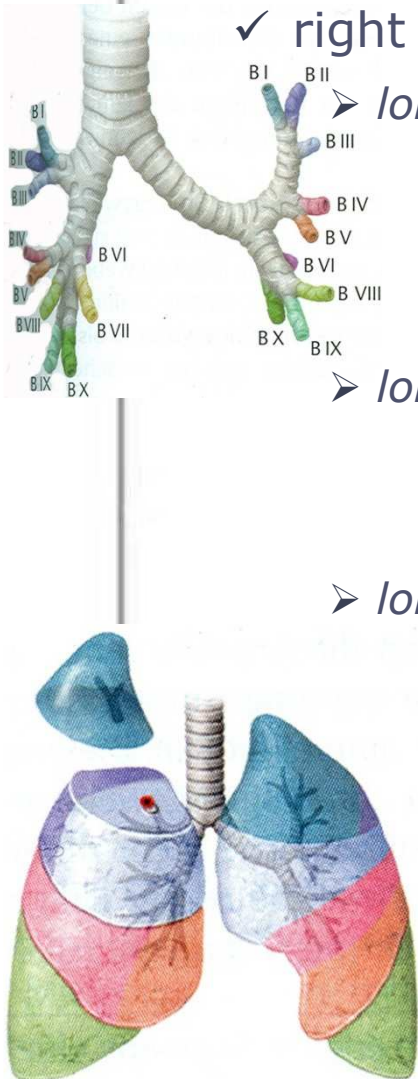
- o *segmentum apicale* (SI)
- o *segmentum posterius* (SII)
- o *segmentum anterius* (SIII)

➤ *lobus medius*

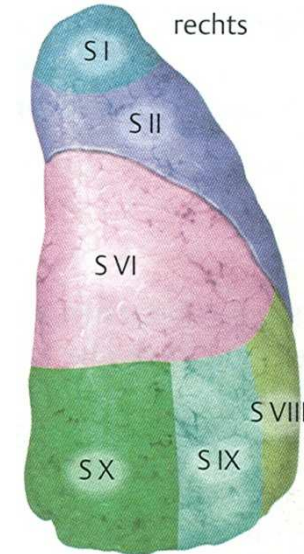
- o *segmentum laterale* (SIV)
- o *segmentum mediale* (SV)

➤ *lobus inferior*

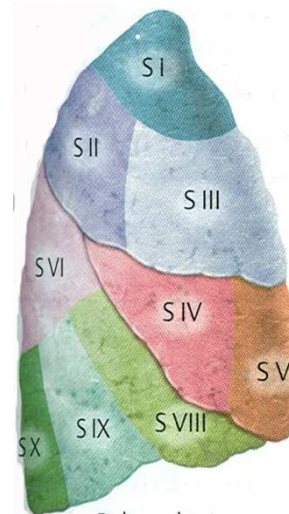
- o *segmentum apicale, superius* (SVI)
- o *segmentum basale mediale* (SVII)
- o *segmentum basale anterius* (SVIII)
- o *segmentum basale laterale* (SIX)
- o *segmentum basale posterius* (SX)



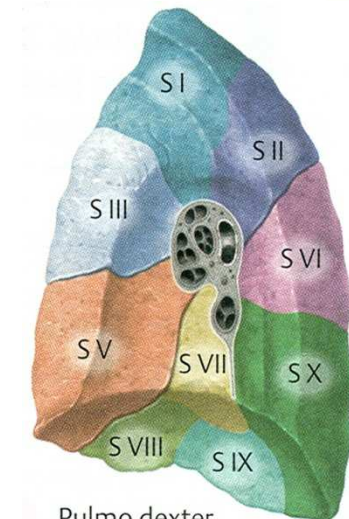
Pulmo dexter



Pulmo dexter



Pulmo dexter



Pulmo dexter



Lung segments

■ Bronchopulmonary segments:

✓ left lung:

➤ lobus superior

o segmentum apicoposterius (SI+II)

o segmentum anterius (SIII)

o segmentum lingulare superius (SIV)

o segmentum lingulare inferius (SV)

➤ lobus inferior

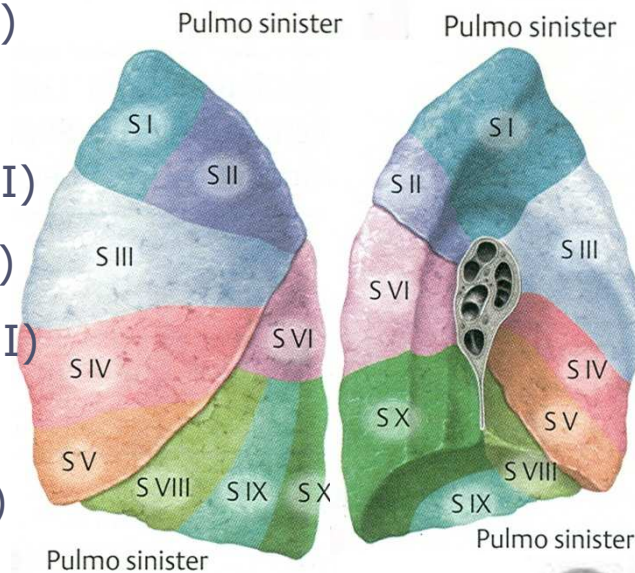
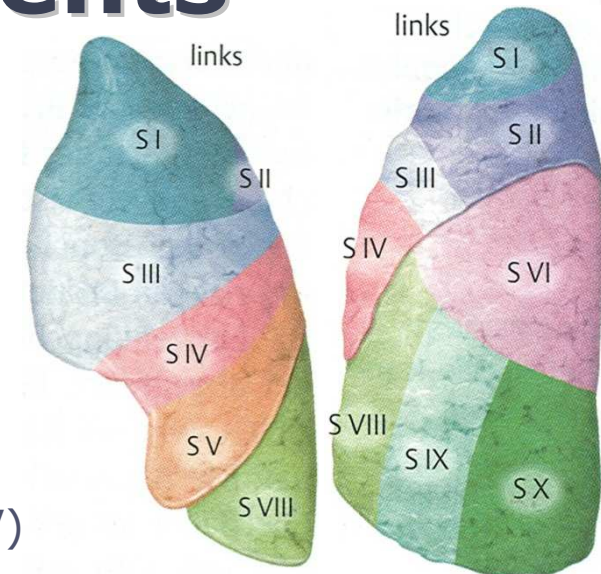
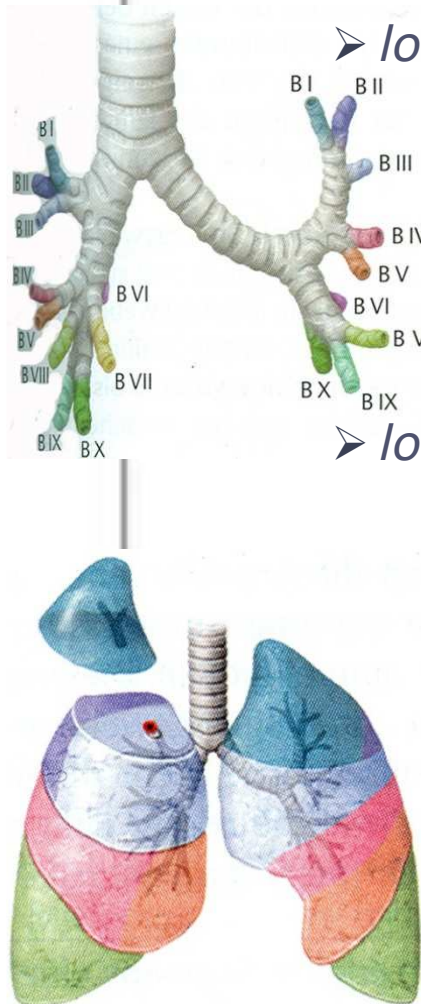
o segmentum apicale, superius (SVI)

o segmentum basale mediale (SVII)

o segmentum basale anterius (SVIII)

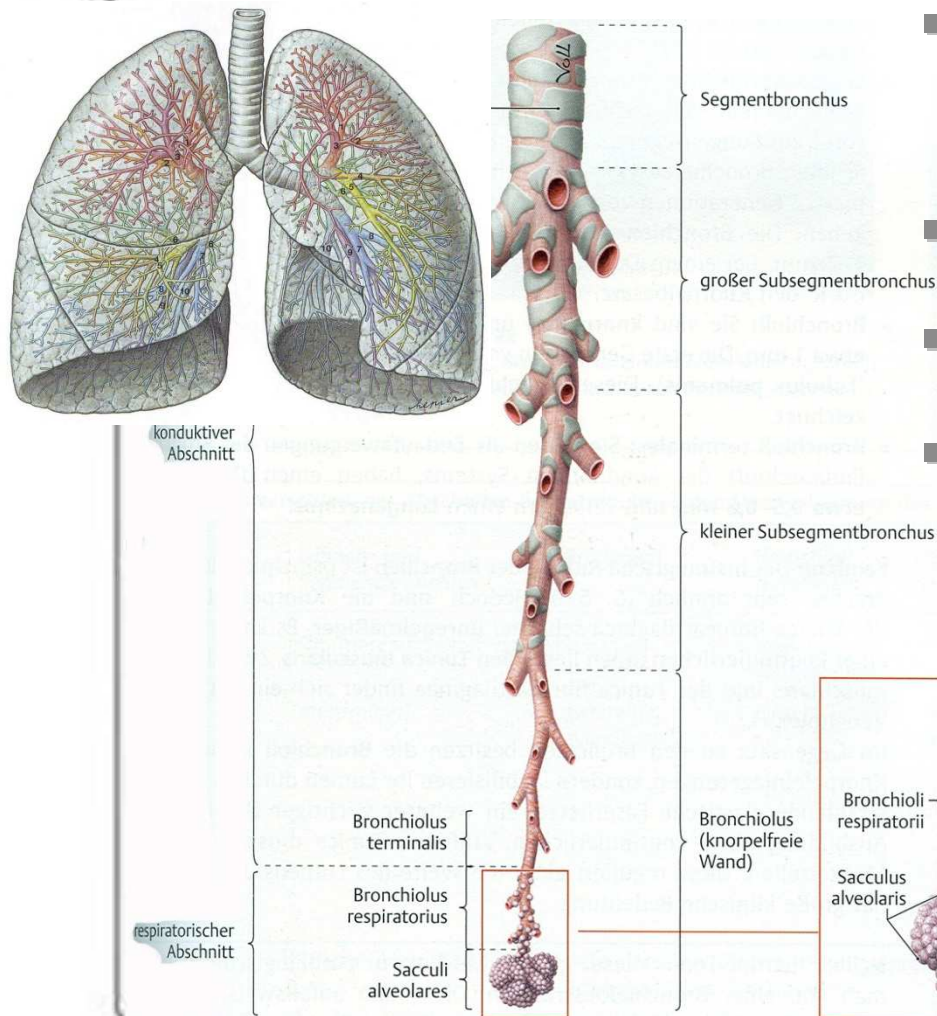
o segmentum basale laterale (SIX)

o segmentum basale posterius (SX)

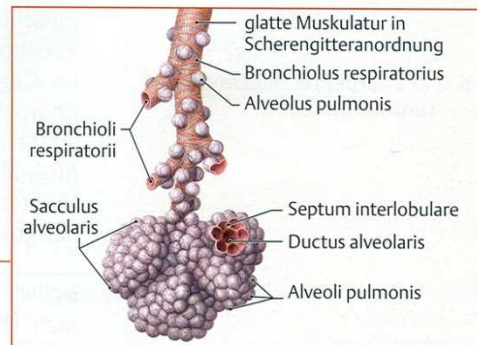




Bronchial tree, *arbor bronchialis*



- Lobar bronchi, *bronchi lobares*:
 - ✓ right – 3
 - ✓ left – 2
- Segmental bronchi, *bronchi segmentales*
- Lobular bronchi, *bronchi lobulares*, $d=1\text{ mm}$
- Terminal bronchioles, *bronchioli terminales*, $d\sim 0.3\text{ mm}$



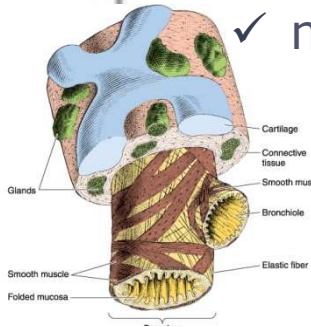
		Generation
Conducting airways	Trachea	0
	Bronchi	1
		2
Terminal respiratory units	Bronchioles Nonrespiratory	7
		8
	Respiratory	9
		15
		16
		17
		18
		19
		20
		21
Alveolar ducts	22	
	23	

Source: McPhee SJ, Ganong WF: *Pathophysiology of Disease: An Introduction to Clinical Medicine*, 5th Edition: <http://www.accessmedicine.com>
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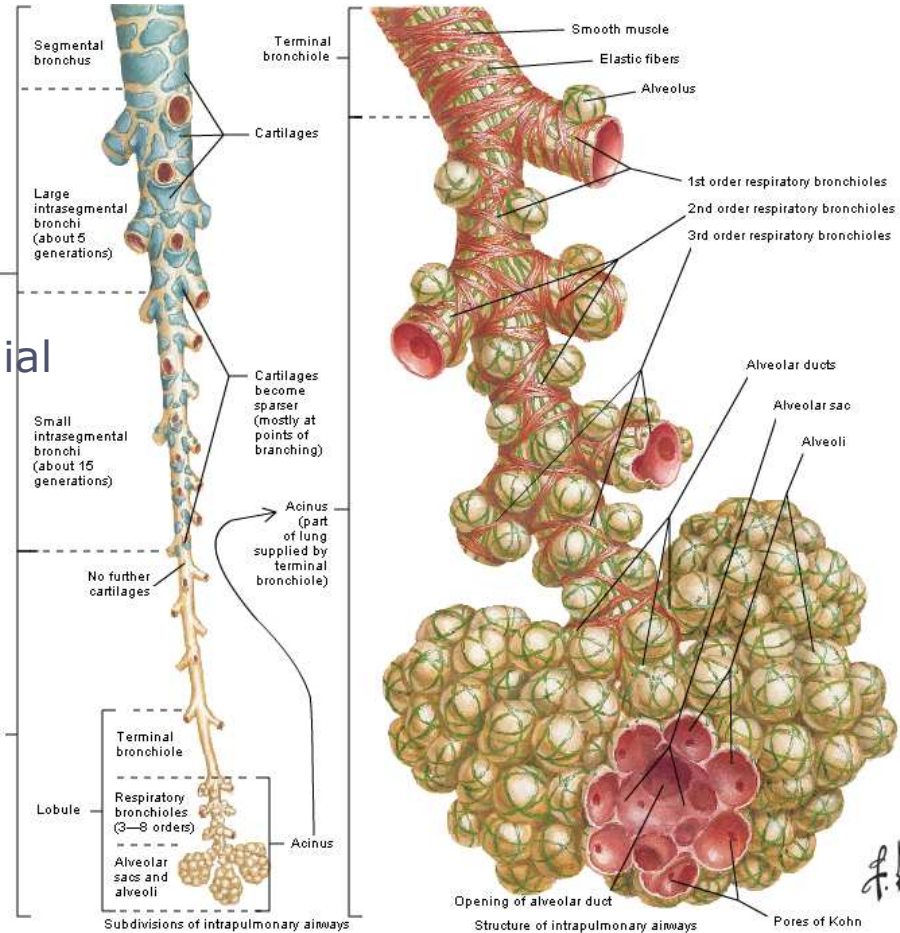
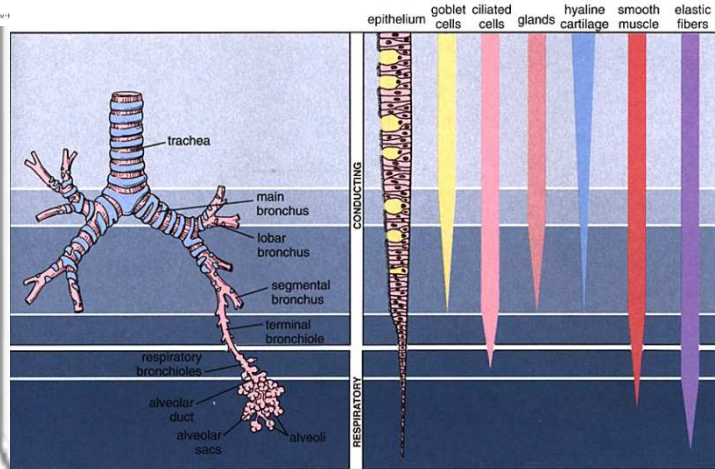


Bronchial tree, *arbor bronchialis*

- Structural changes:
 - ✓ cartilage rings ⇨ cartilage plates
 - ✓ smooth muscle layer – increases
 - ✓ mucosal alterations:
 - stratified ciliated ⇨ simple epithelium
 - goblet cells and bronchial glands – decrease
 - increase of elastic fibers



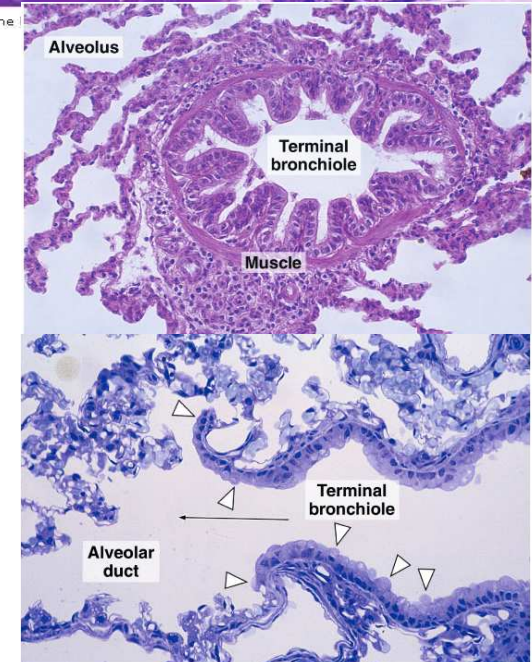
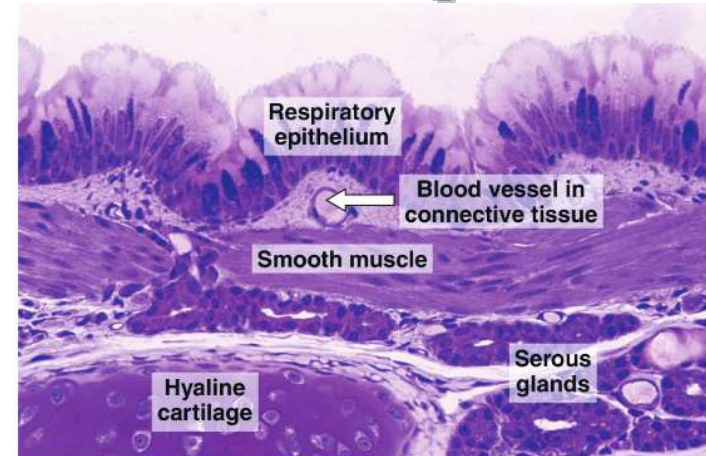
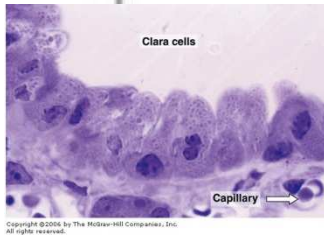
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Microscopic anatomy

- *tunica mucosa*:
 - ✓ *lamina epithelialis* – stratified columnar ciliated epithelium ⇨ simple columnar (cuboidal)
 - ciliated cells
 - goblet cells
 - basal cells – stem cells
 - brush cells – receptor cells
 - granular cells of *Kulchitsky* – neuroendocrine cells
 - *Clara* cells – secretory cells – GAG, CC16
 - ✓ *lamina propria*
 - elastic fibers and blood vessels
 - BALT
 - ✓ *tela submucosa*
 - *gll. bronchiales*
 - *lamina fibrarum elasticum*
- *tunica fibromusculocartilaginea*
- *tunica adventitia*

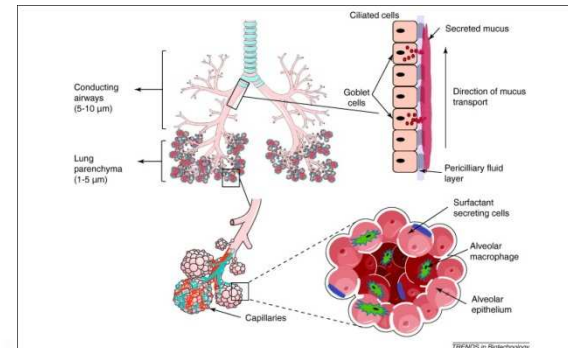
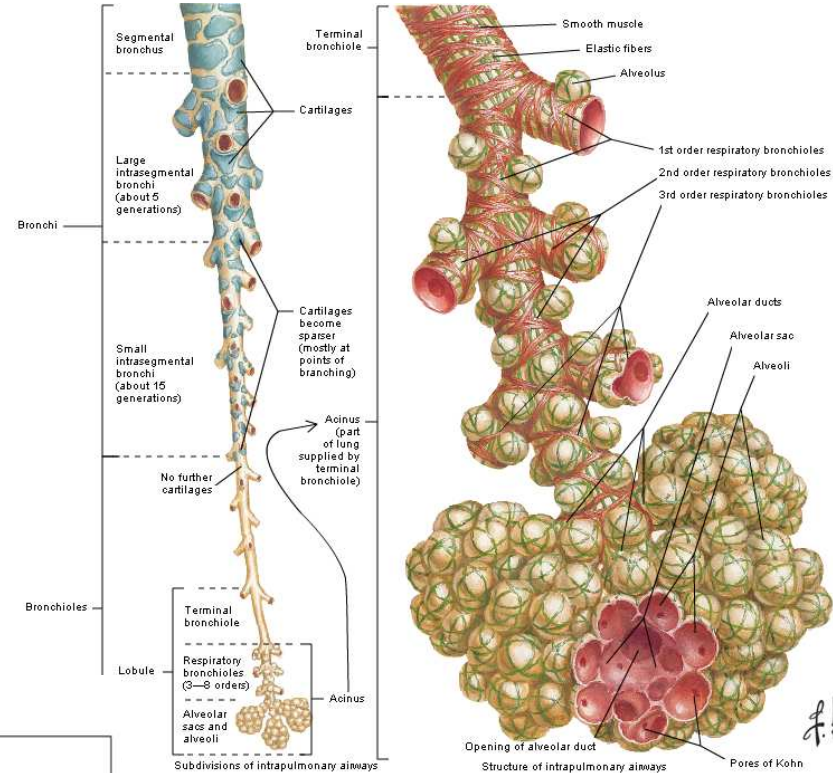
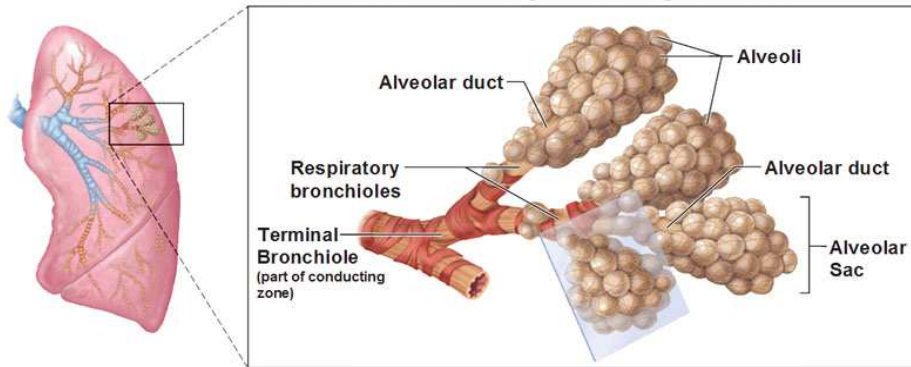




Respiratory portion

- Pulmonar acinus:
 - ✓ respiratory bronchiole
 - 1st, 2nd and 3rd order
 - ✓ alveolar ducts
 - ✓ alveolar sacs
 - ✓ alveoli – 300-500 million:
 - sac-like evaginations
 - size 0.2-0.3 mm
 - surface 30-100 m²
 - capillary network
 - interalveolar septum

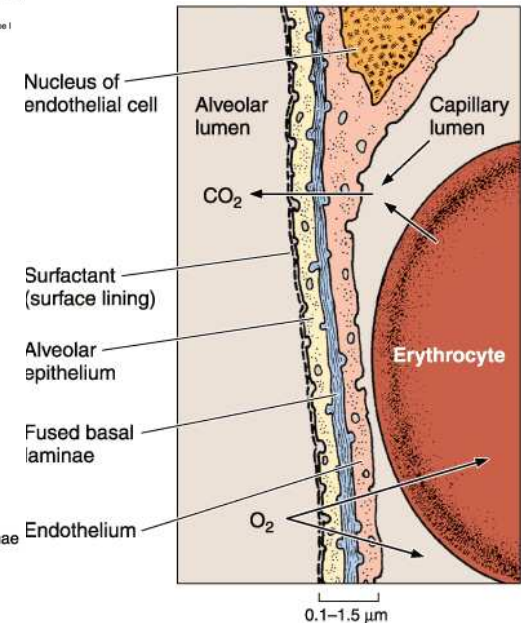
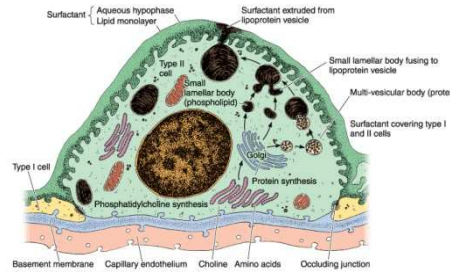
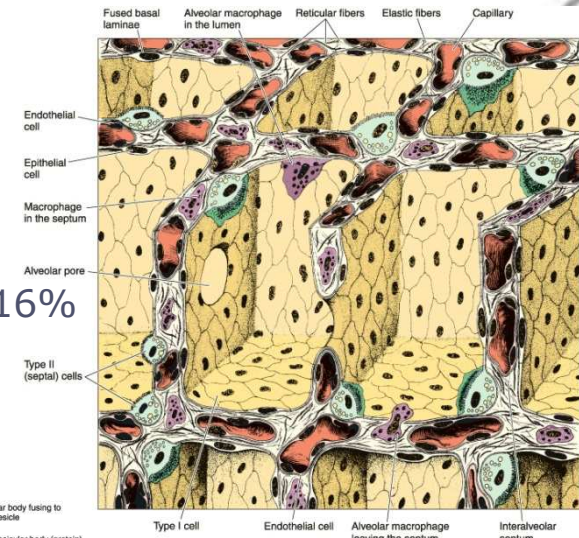
Structures of the Respiratory Zone



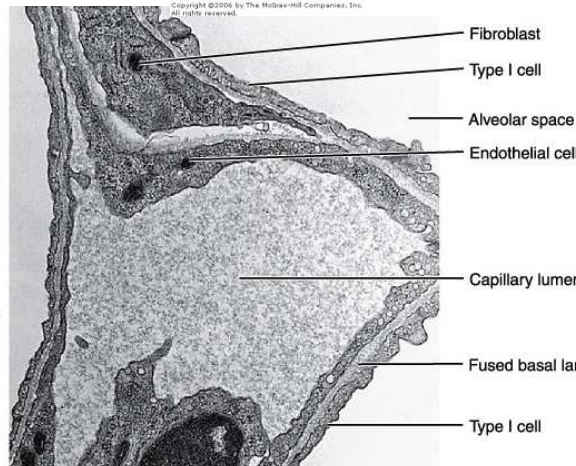
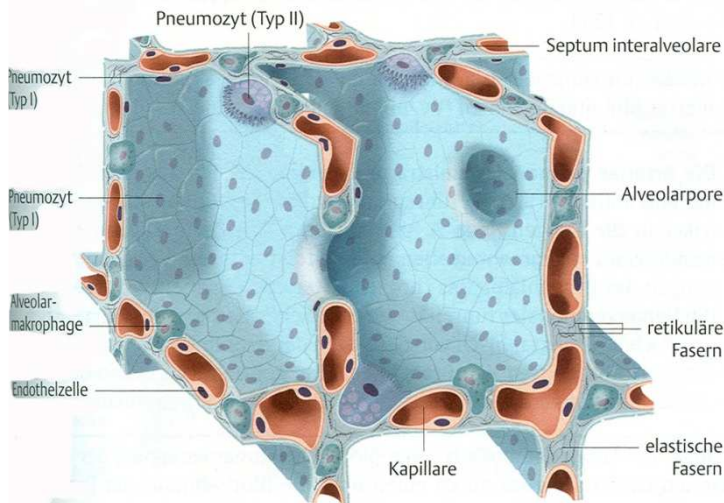


Alveolar wall

- **Septum interalveolare** – 5 cell types:
 - ✓ squamous alveolar cells (type I pneumocytes) – 8%
 - blood-air barrier – 95% of the alveolar surface
 - ✓ great alveolar (septal) cells (type II pneumocytes) – 16%
 - secretion of pulmonary surfactant
 - ✓ alveolar macrophages, “dust” cells – 10%
 - phagocytosis – mononuclear phagocytic system
 - ✓ interstitial cells – 36%:
 - fibroblasts
 - mast cells
 - ✓ capillary endothelial cells – 30%
 - ✓ *porus septi* (pores of Kohn)
 - ✓ elastic and reticular fibers



G-2.8 Wandbau der Lungenalveolen

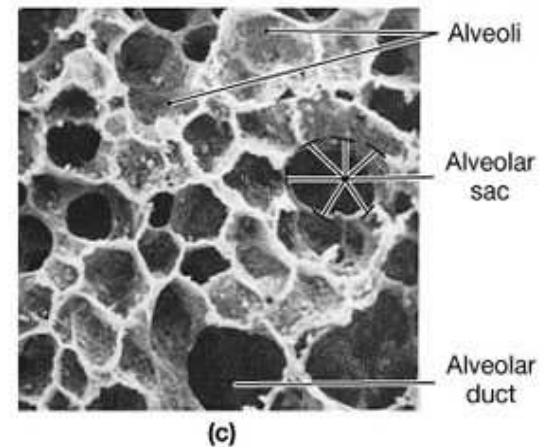
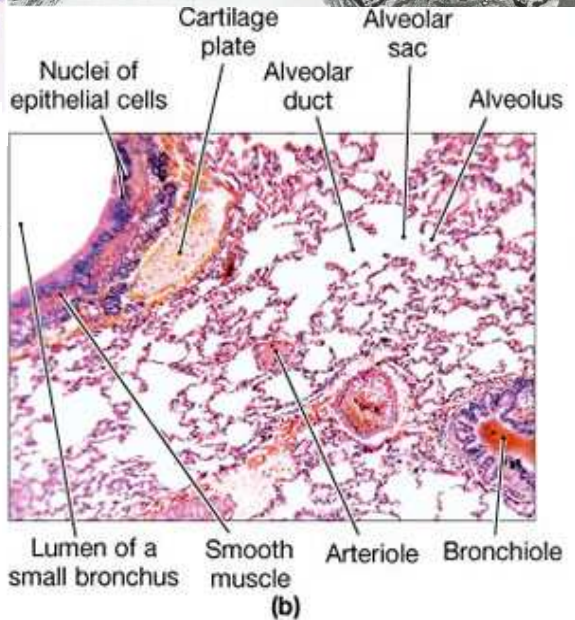
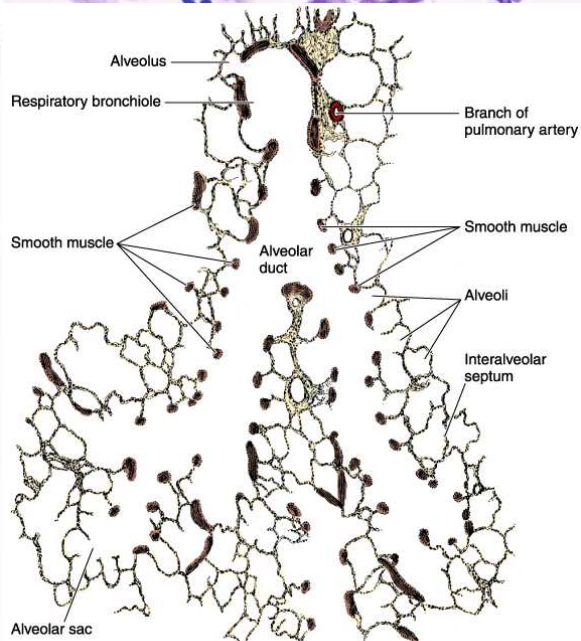
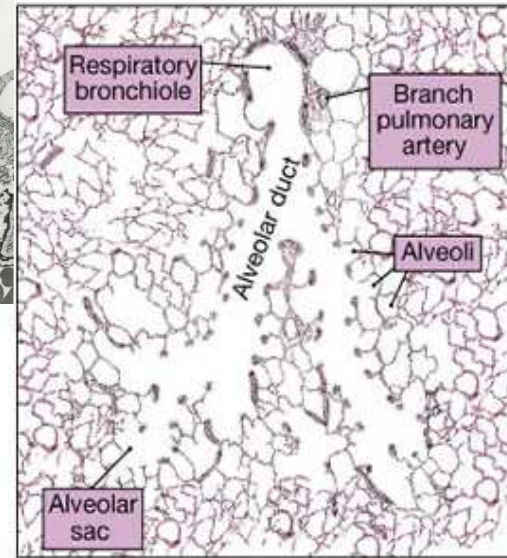
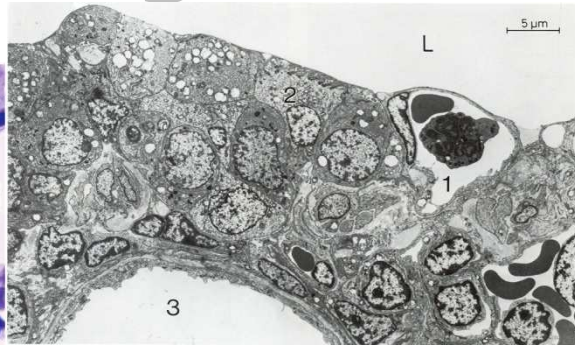
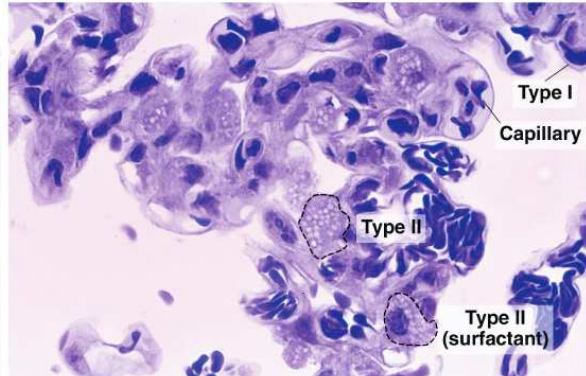


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Histological structure



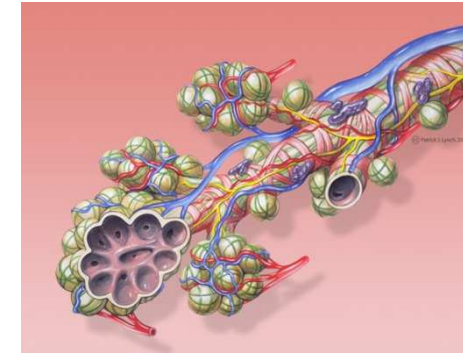
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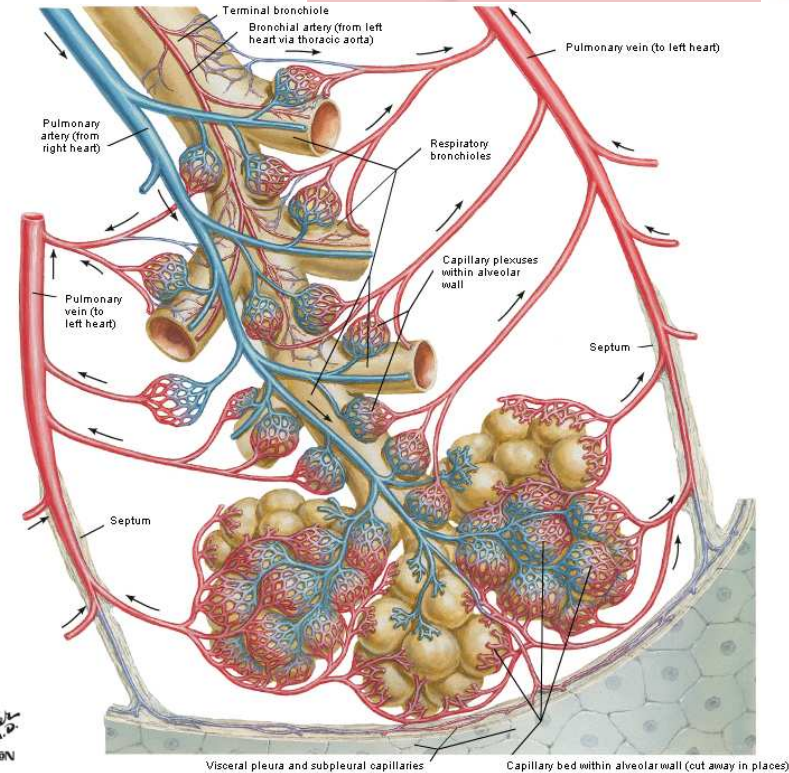
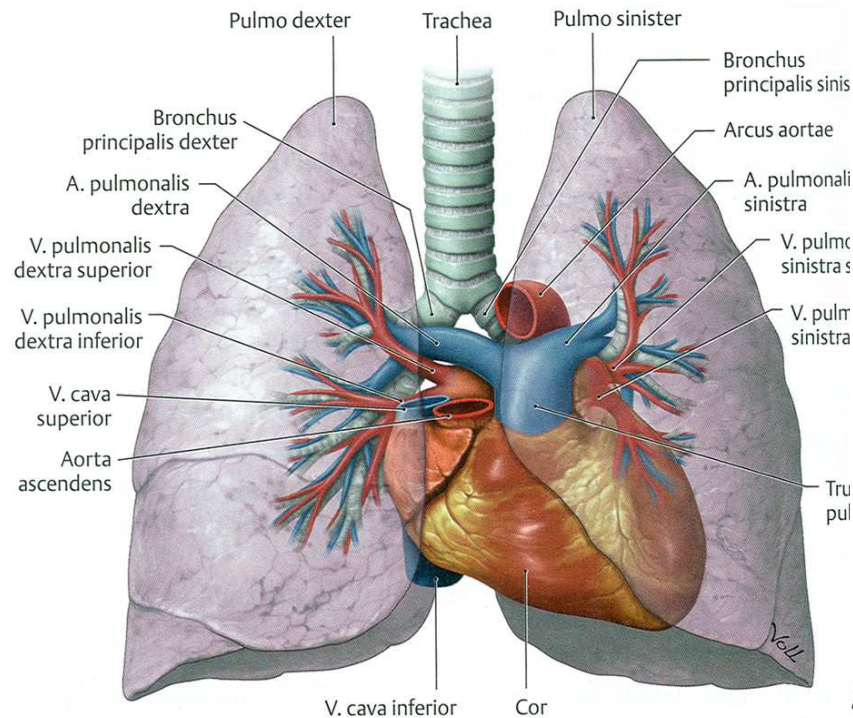


Blood supply of lungs

- Functional pulmonary circulation:
 - ✓ pulmonary circuit
 - *aa. pulmonales* – deoxygenated blood
 - *vv. pulmonales* – oxygenated blood



G-2.9 Vasa publica der Lunge

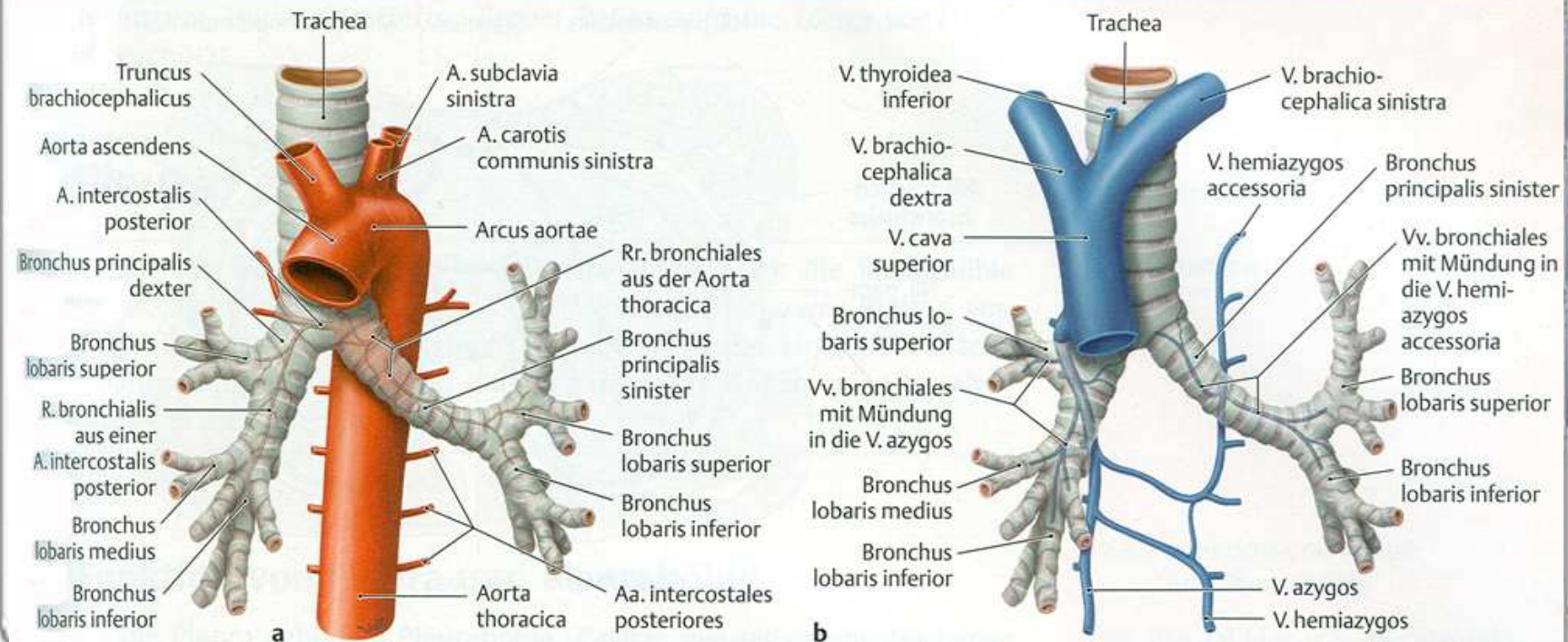




Blood supply of lungs

- **Bronchial arteries** – nutritive pulmonary circulation:
 - ✓ systemic circuit – oxygenated blood
 - *rr. bronchiales* – *aorta thoracica*, *a. subclavia*, *aa. intercostales*
 - *vv. bronchiales* ⇨ *v. azygos* et *v. hemiazygos accessoria*

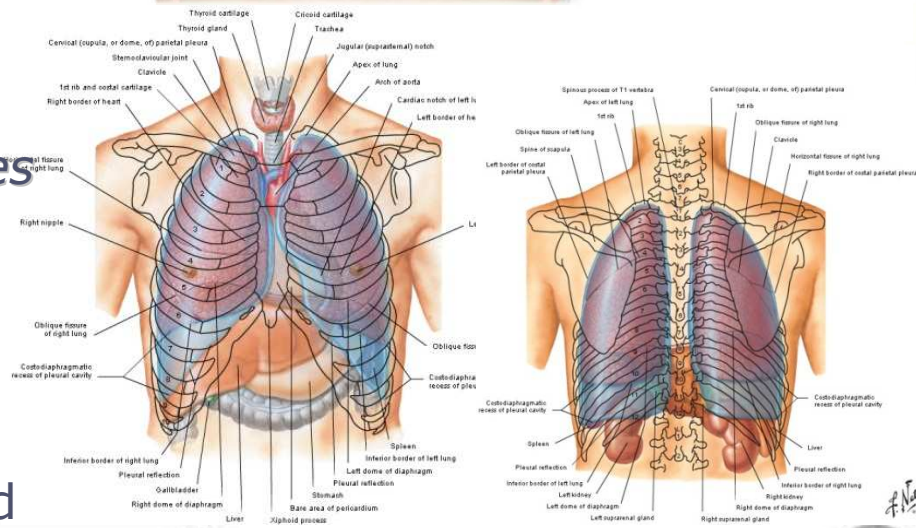
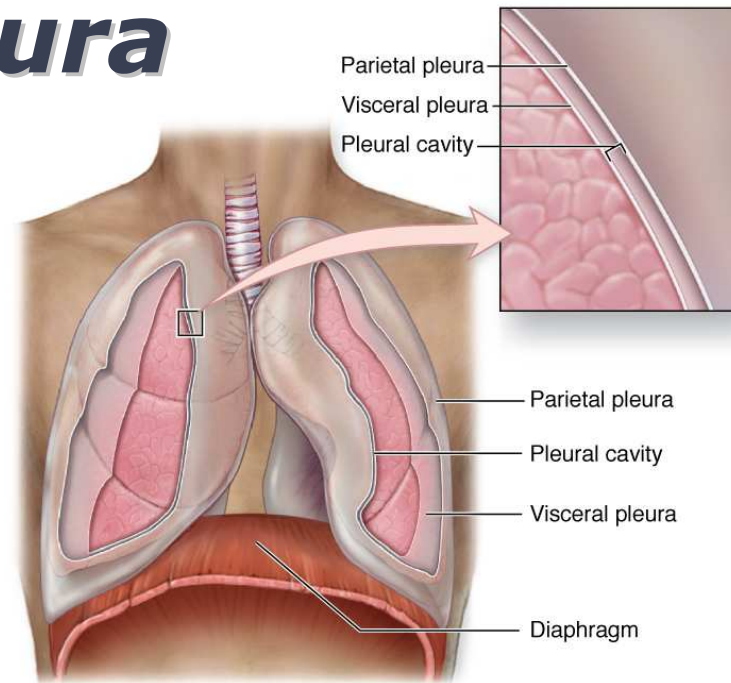
G-2.10 Vasa privata der Lunge





Pleura, pleura

- *tunica serosa*:
 - ✓ *lamina epithelialis* – simple squamous epithelium (mesothelium)
 - ✓ *lamina propria serosae* – loose connective tissue
- *tela subserosa* – collagen and elastic fibers, smooth muscle cells
- parietal pleura
 - ✓ *pleura costalis, pleura mediastinalis, pleura diaphragmatica*
 - ✓ *cupula pleurae*
 - ✓ *recessus s. sinus pleurales*
 - costodiaphragmatic,
 - costomediastinal recesses
- visceral pleura
 - ✓ *lig. pulmonalis*
- pleural cavity – pleural fluid





"To breathe or not to breathe"

Thank you ...