

RESPIRATORY SYSTEM MECHANICS OF BREATHING

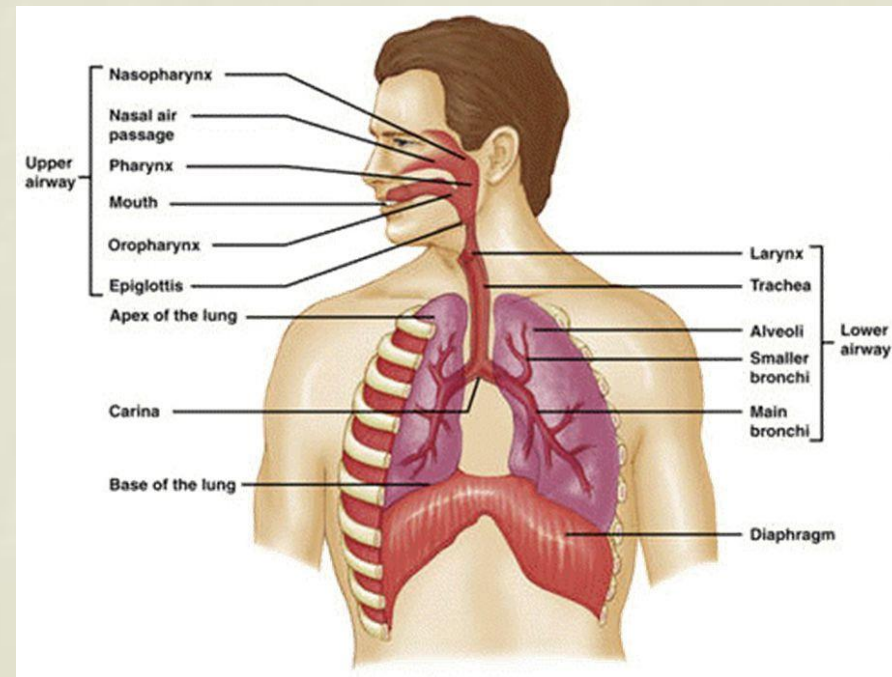
lecture from Human Morphology

19. 10. 2023

M. Chalupová

Respiratory Apparatus

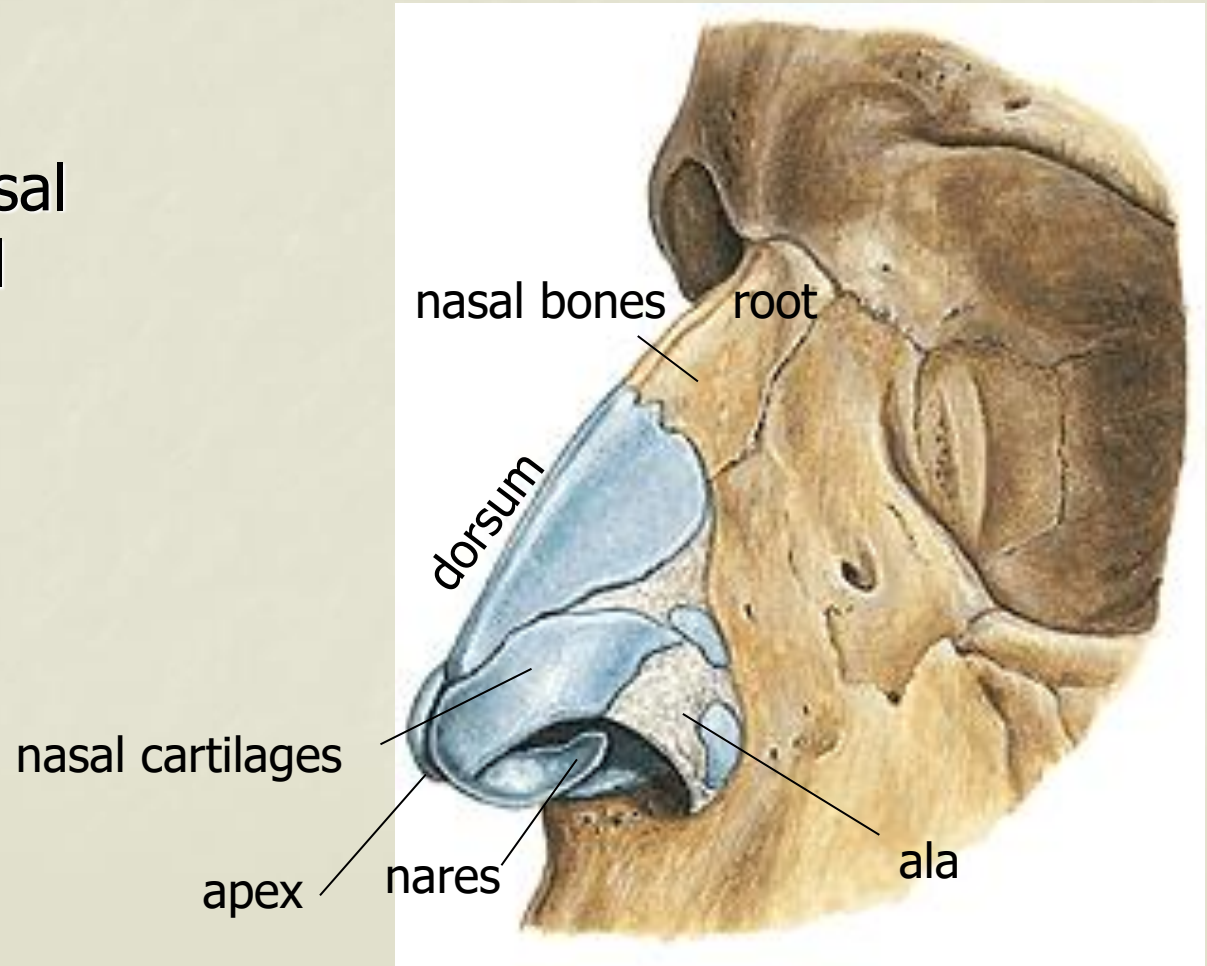
- gas exchange between environment and blood
 - **external respiration** – exchange of gases between alveoli and pulmonary capillaries
 - **internal respiration** – exchange of gases between tissue cells and systemic capillaries
- olfactory organ (top of the nasal cavity)
- voice production (larynx)
- **upper airways**
 - nose, nasal cavity, paranasal air sinuses, nasopharynx
- **lower airways**
 - larynx, trachea, bronchi, lungs



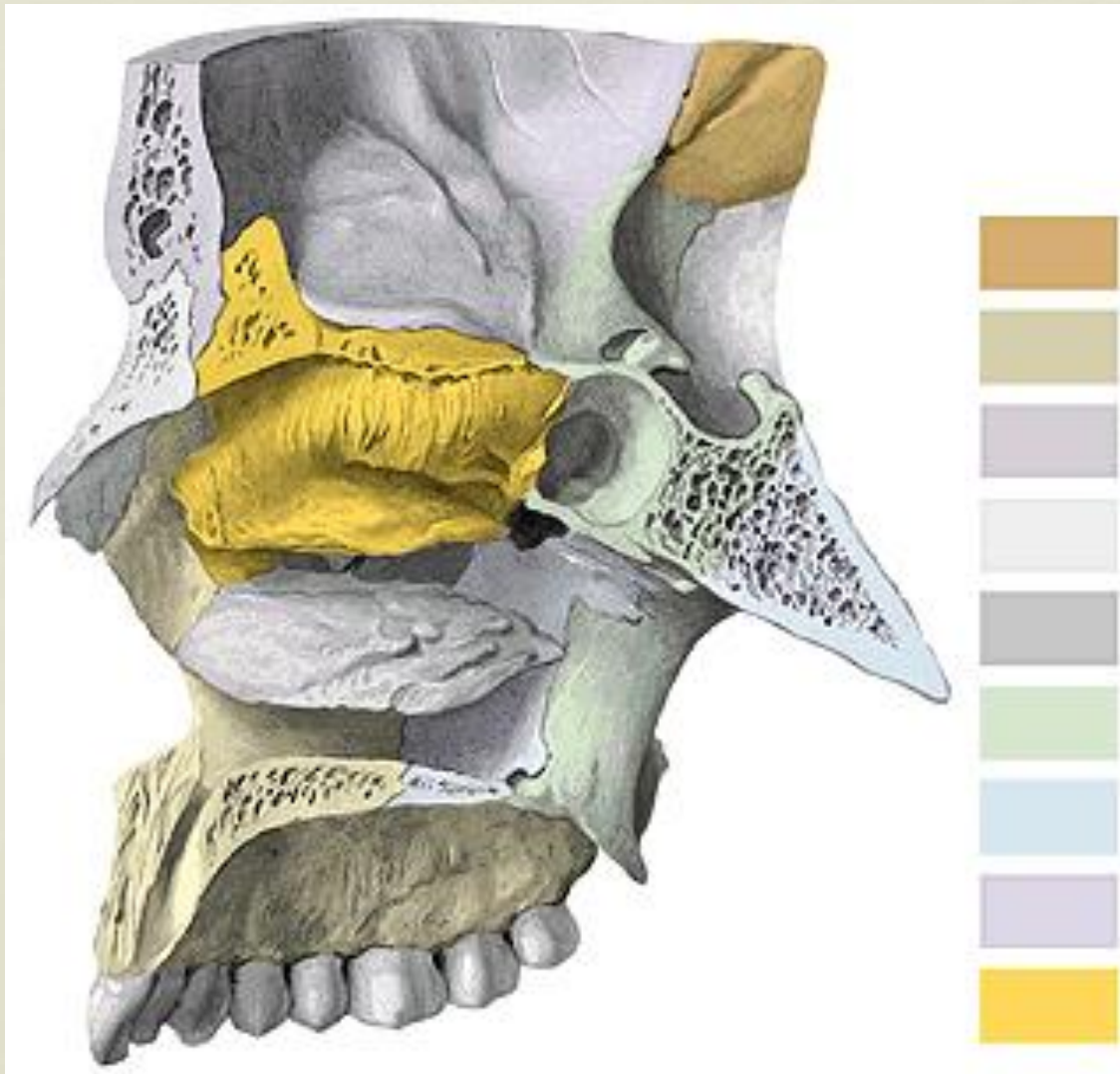
Upper airways

External Nose

- it consists of nasal bones and nasal cartilages
- root
- dorsum
- apex
- wings (ala)
- nostrils (nares)



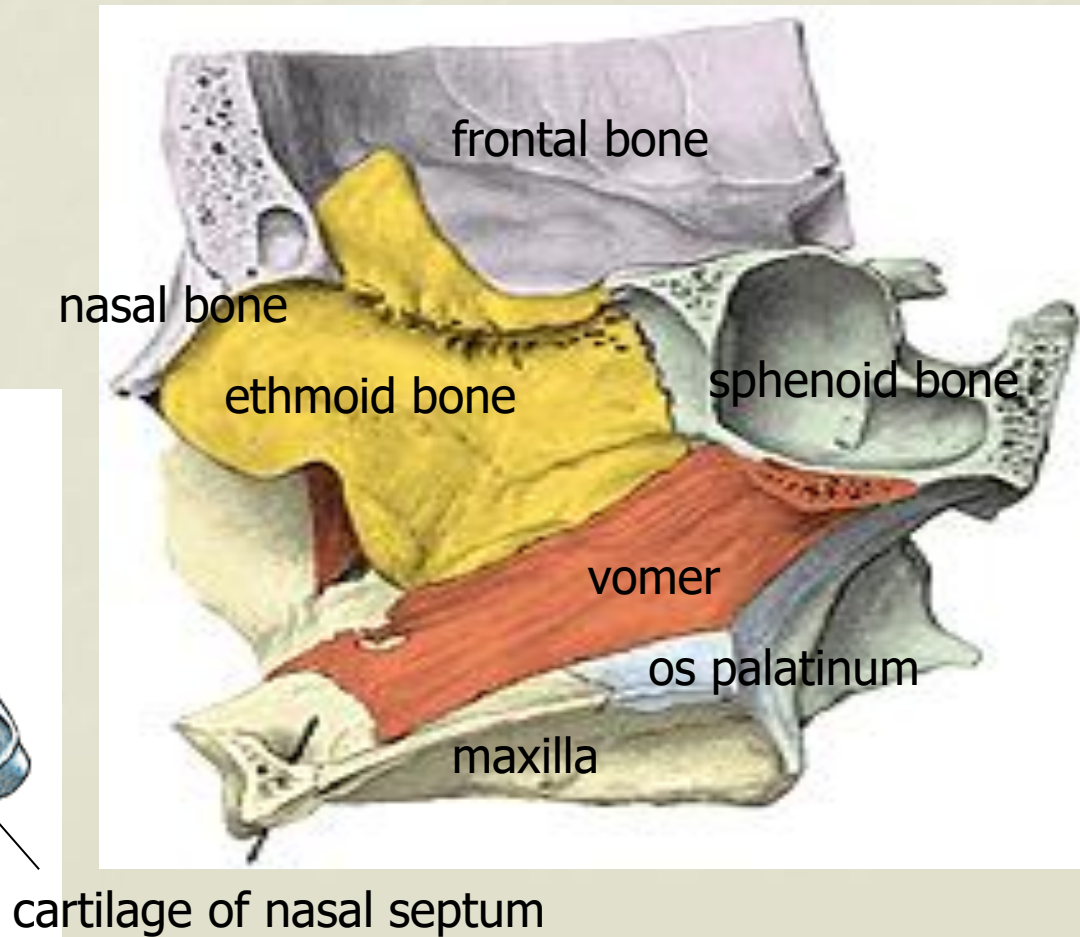
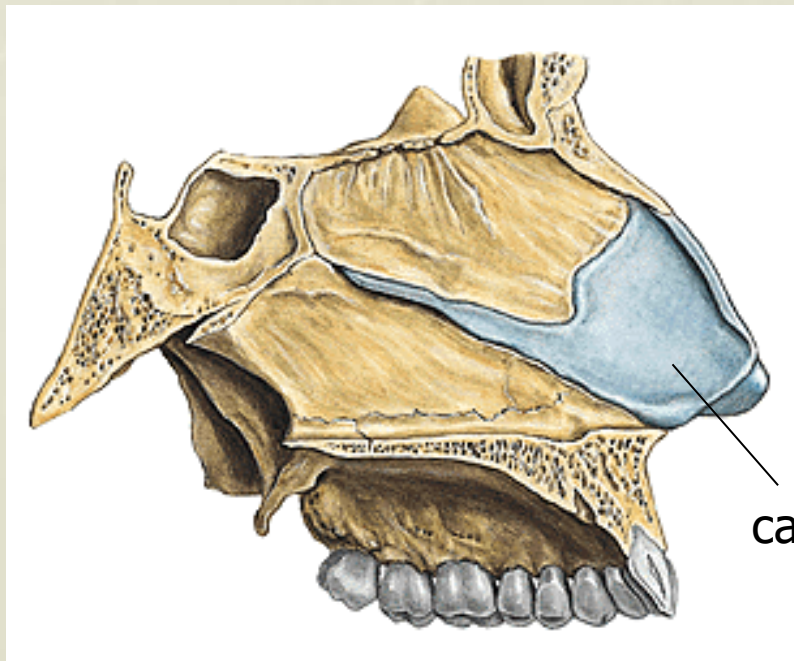
Nasal Cavity – Lateral View



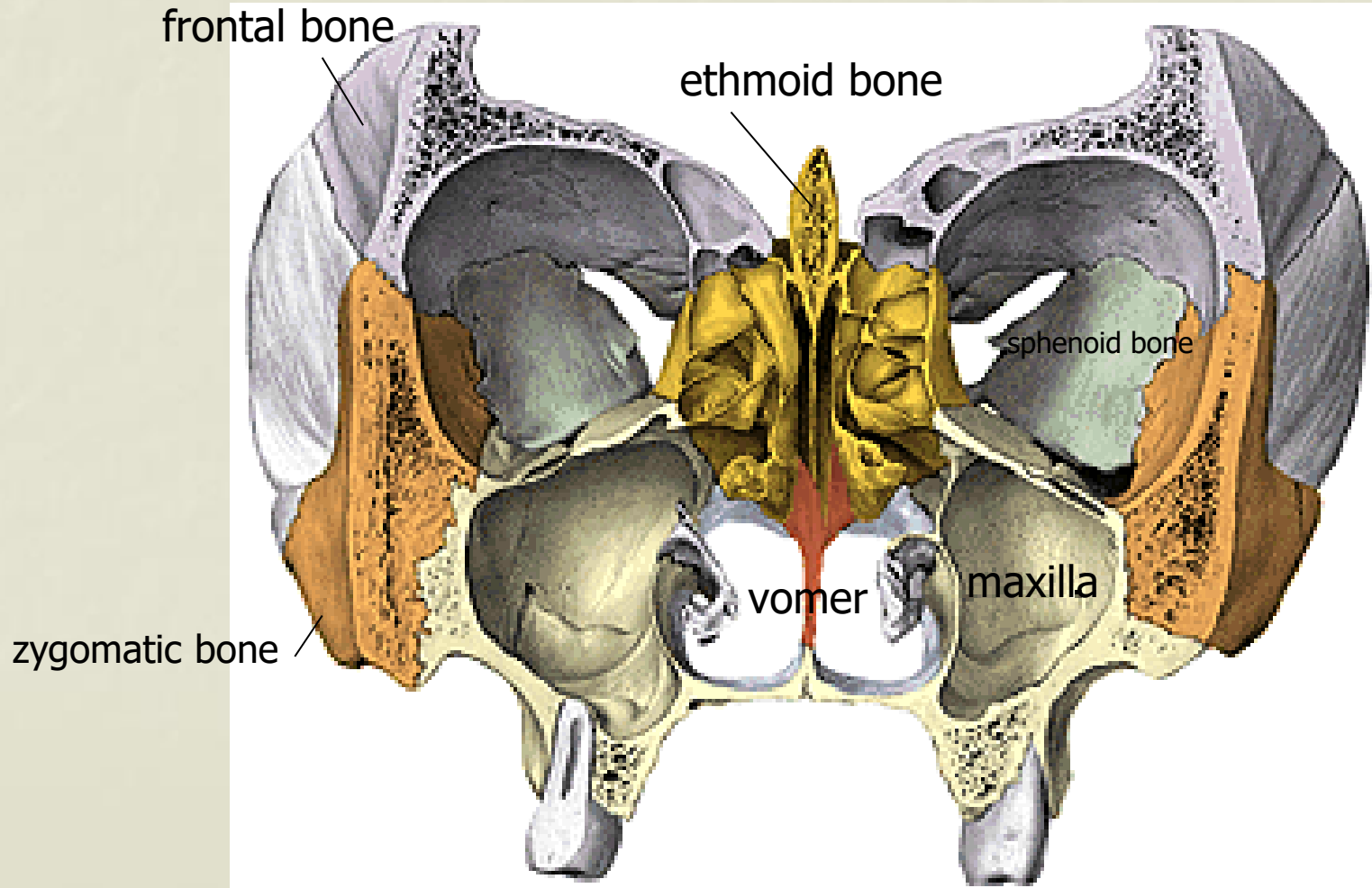
- parietal bone
- maxilla
- frontal bone
- nasal bone
- inferior nasal concha
- sphenoid bone
- occipital bone
- palate bone
- ethmoid bone

Nasal Septum

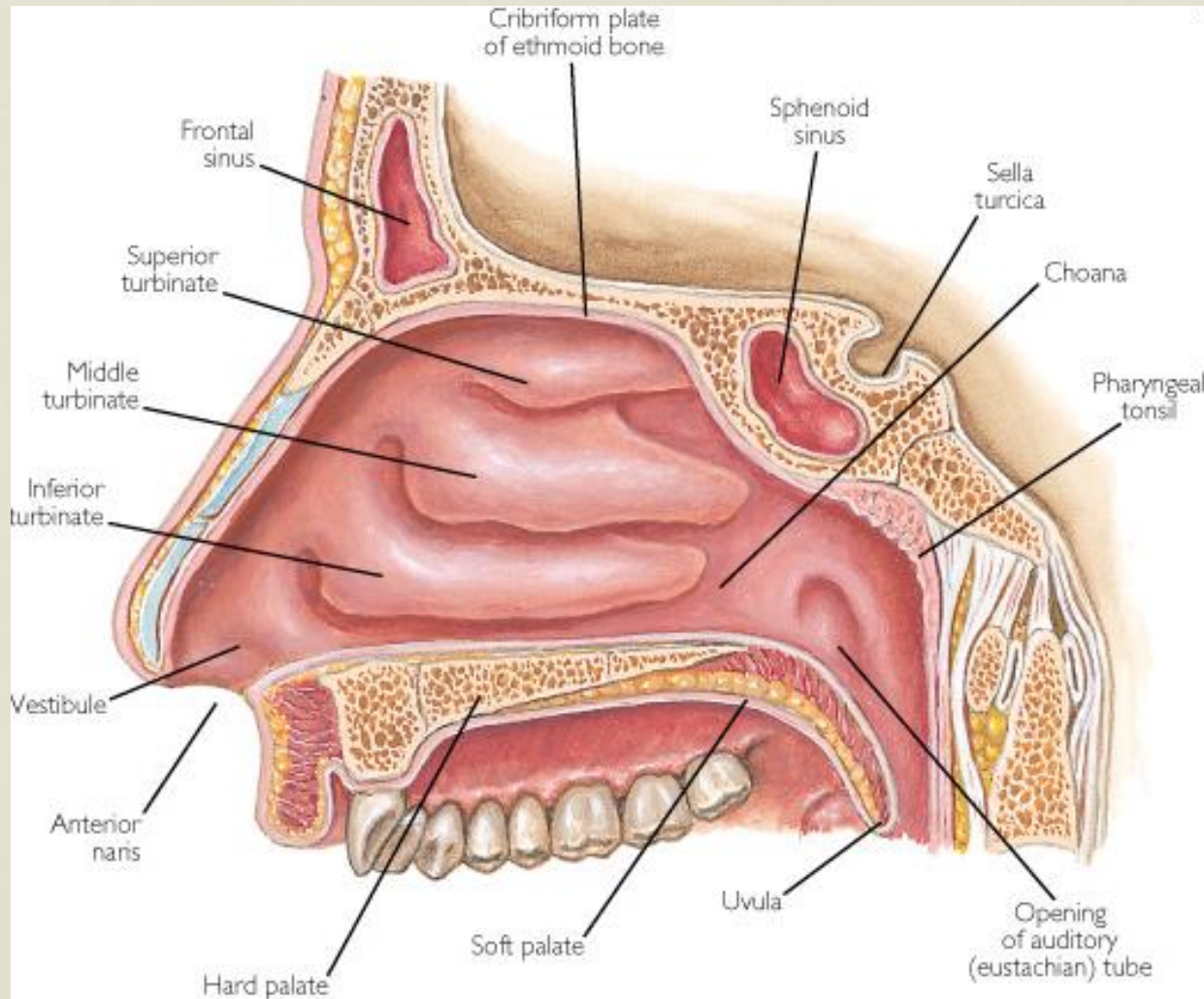
- membranous part
- cartilaginous part
- bony part



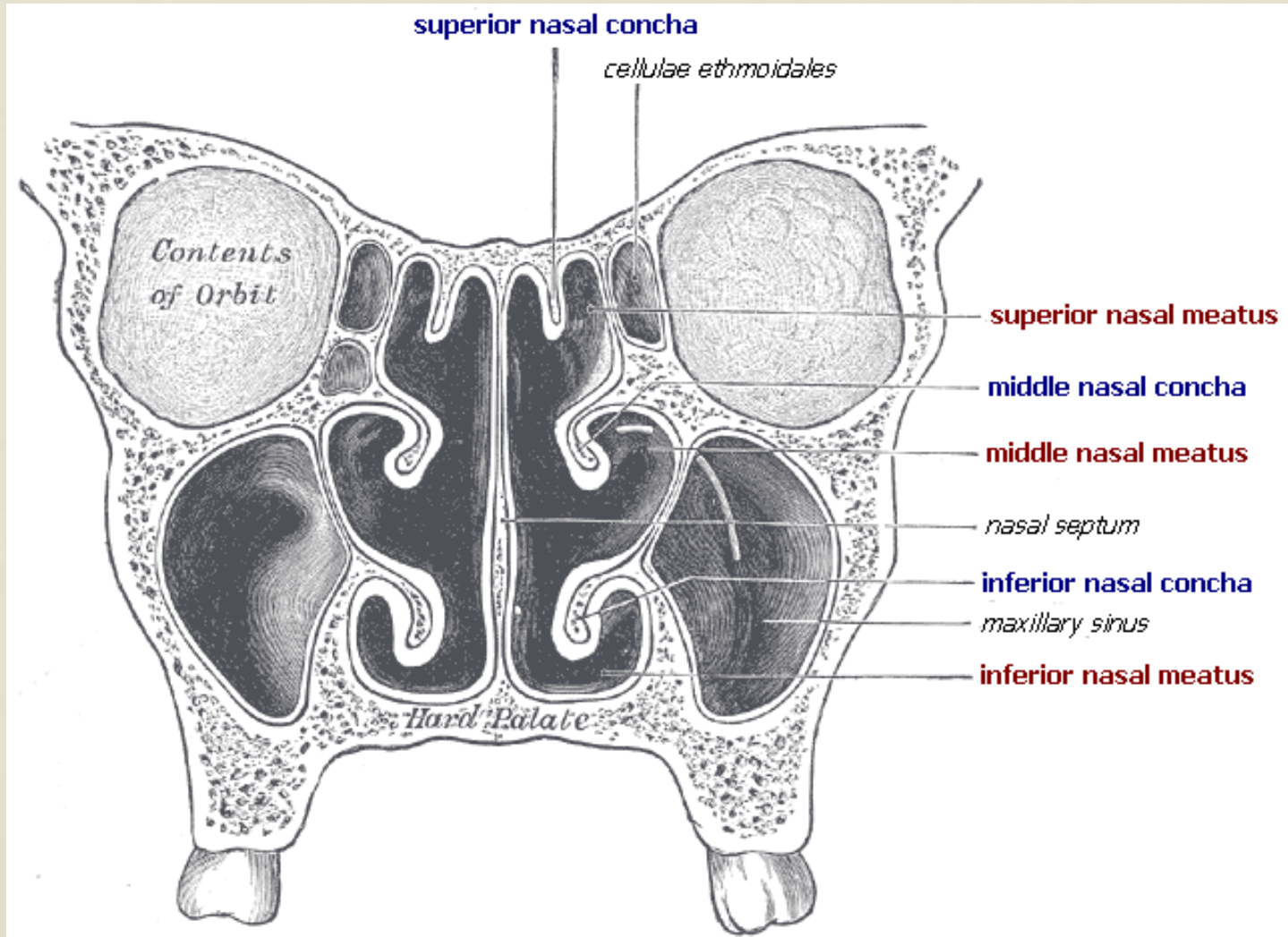
Nasal Cavity – Frontal View



Nasal Cavity – Lateral Wall

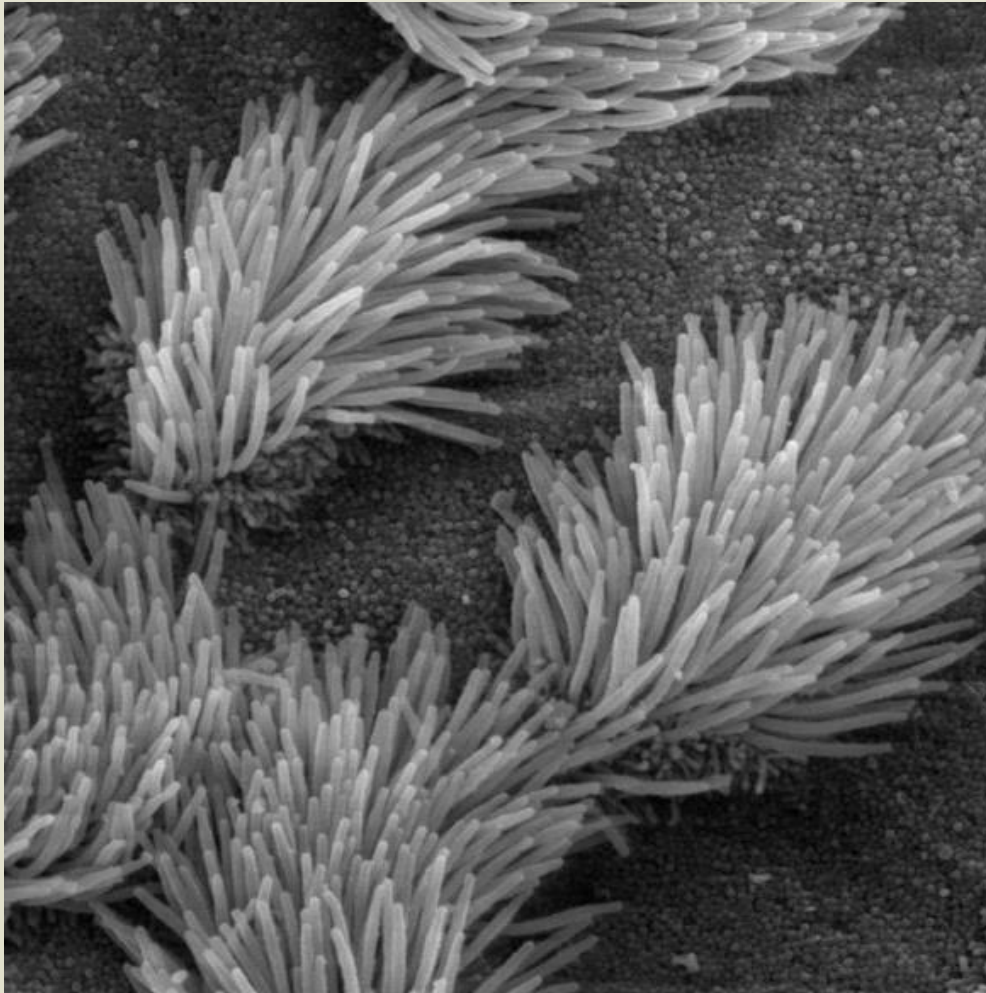


Nasal Cavity – Frontal Section



Respiratory Epithelium

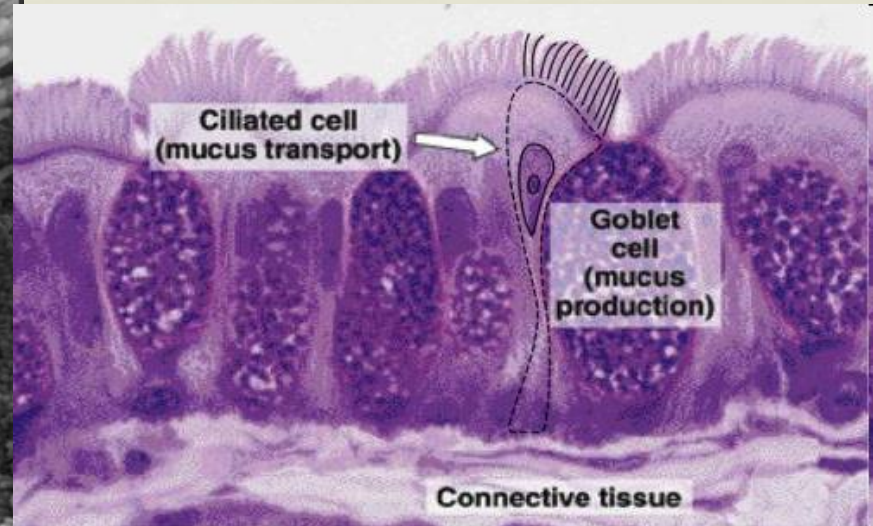
**pseudostratified columnar
ciliated epithelium**



5 µm

Lung_001

1/20/0 REMF 5000X



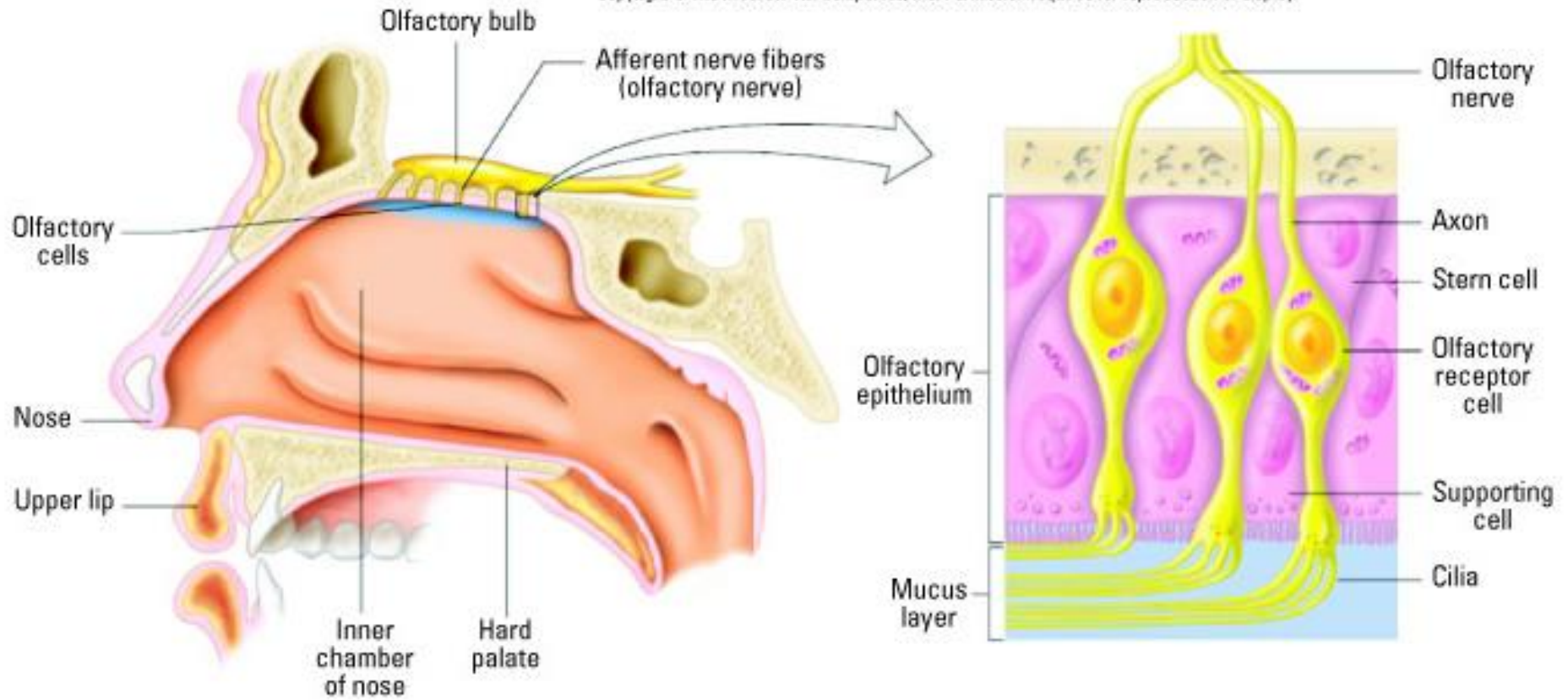
**Ciliated cell
(mucus transport)**

**Goblet
cell
(mucus
production)**

Connective tissue

Olfactory Mucosa

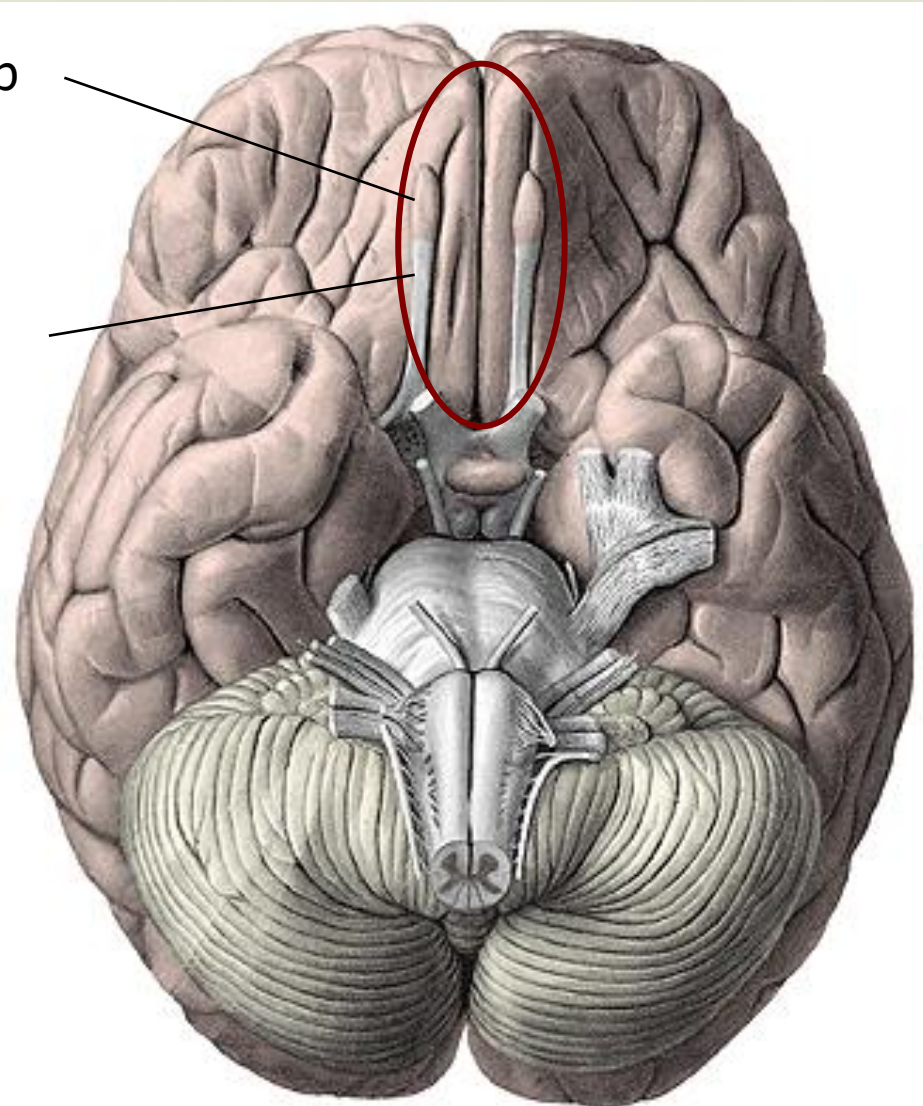
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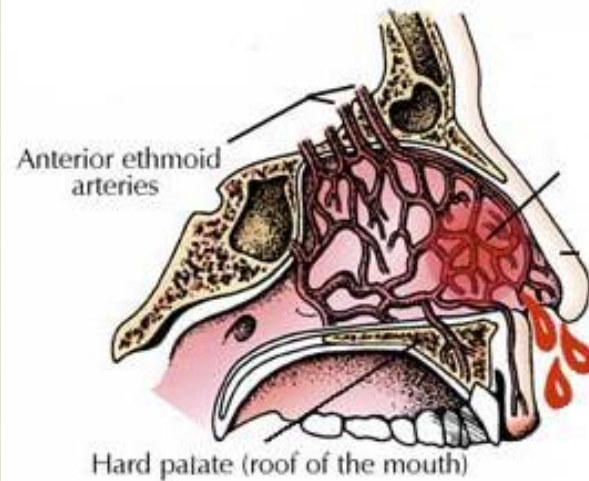
Rhinencephalon

olfactory bulb

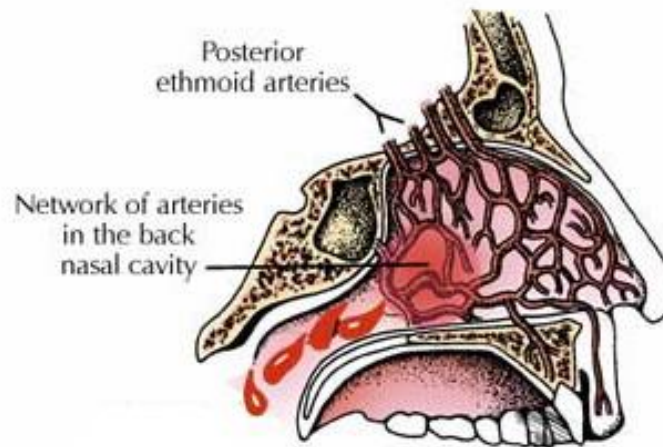
olfactory tract



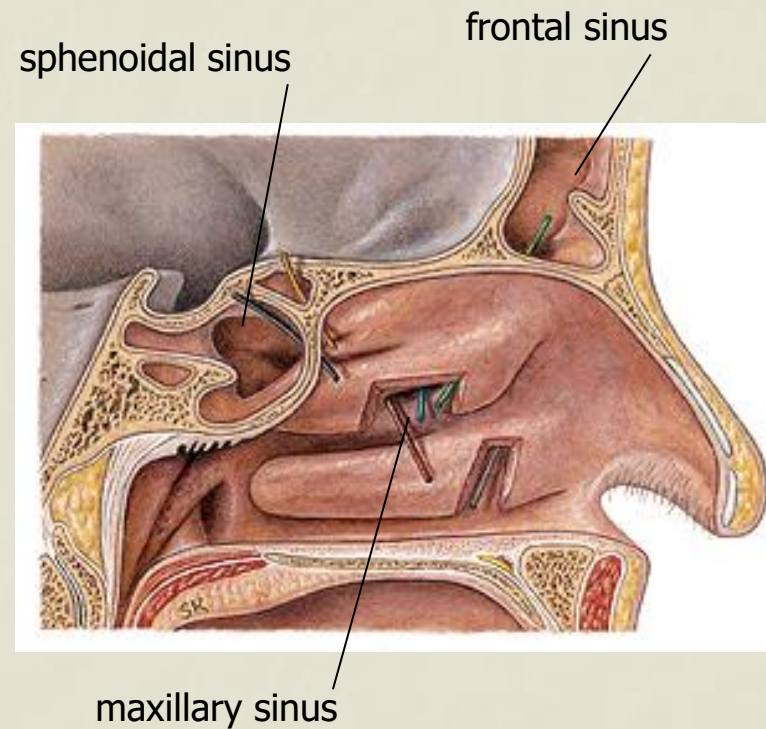
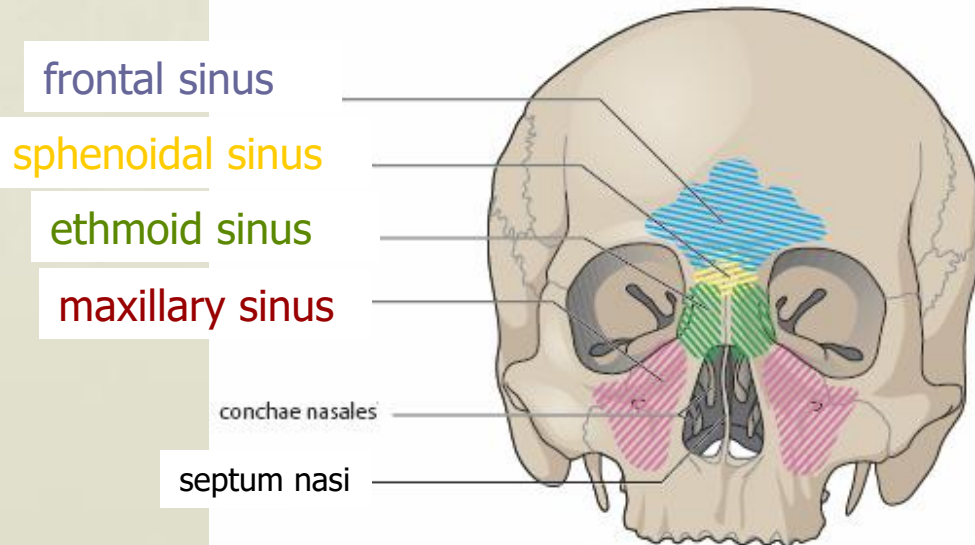
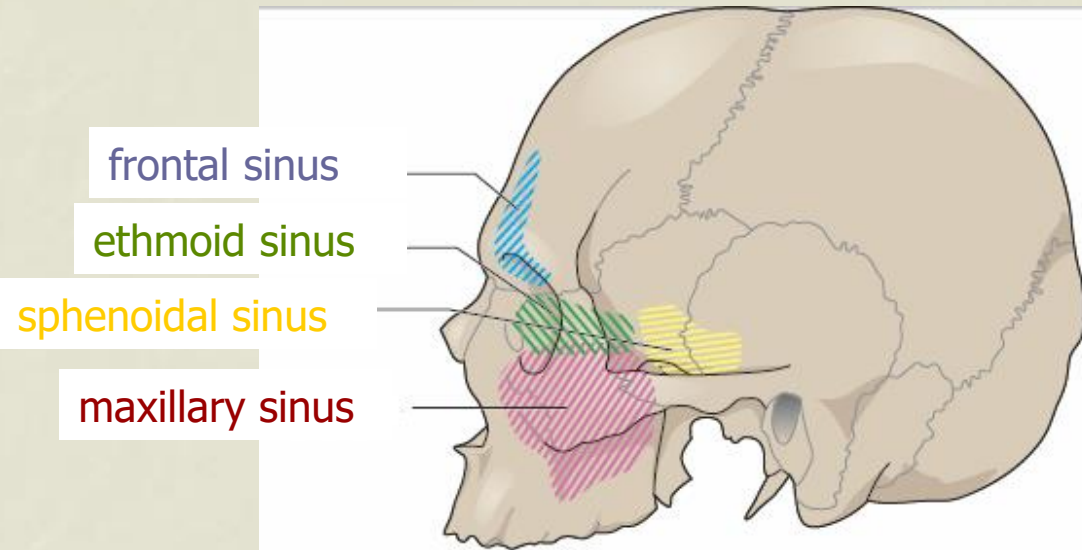
Nosebleed (Epistaxis)



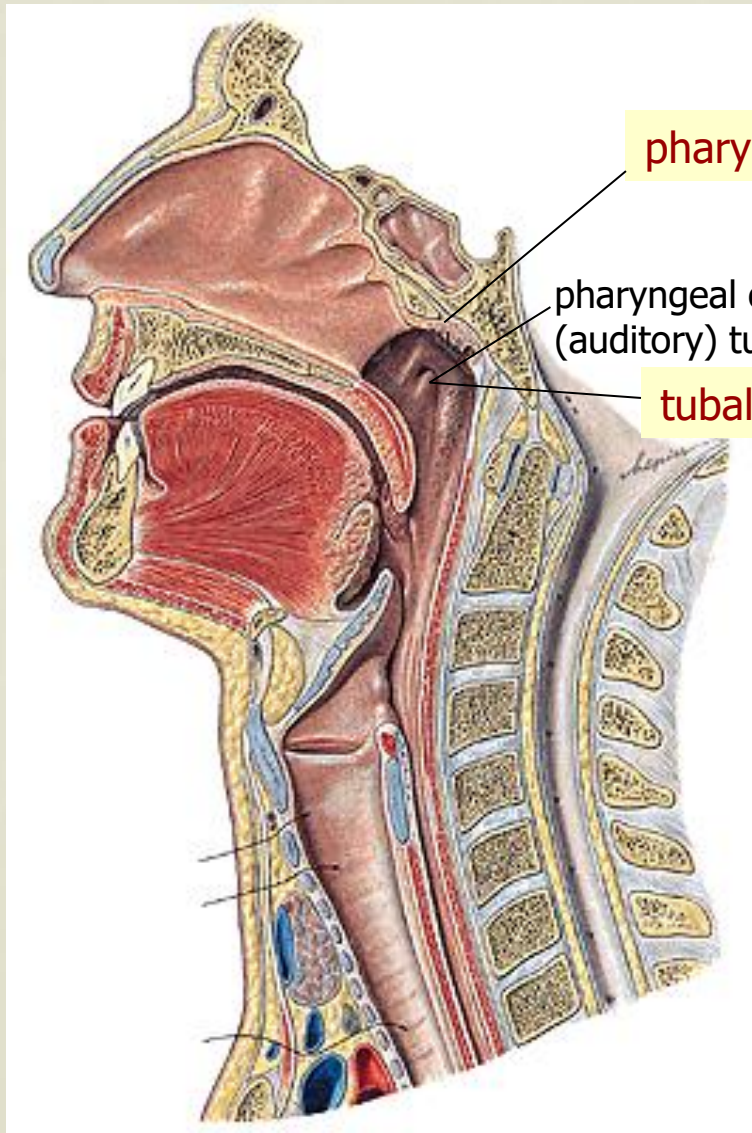
Kiesselbach's plexus



Paranasal Sinuses



Nasopharynx



pharyngeal tonsil

pharyngeal opening of Eustachian (auditory) tube

tubal tonsil

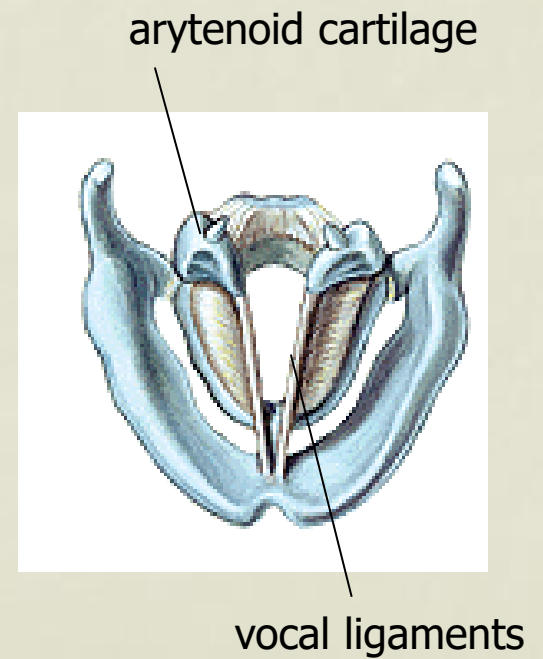
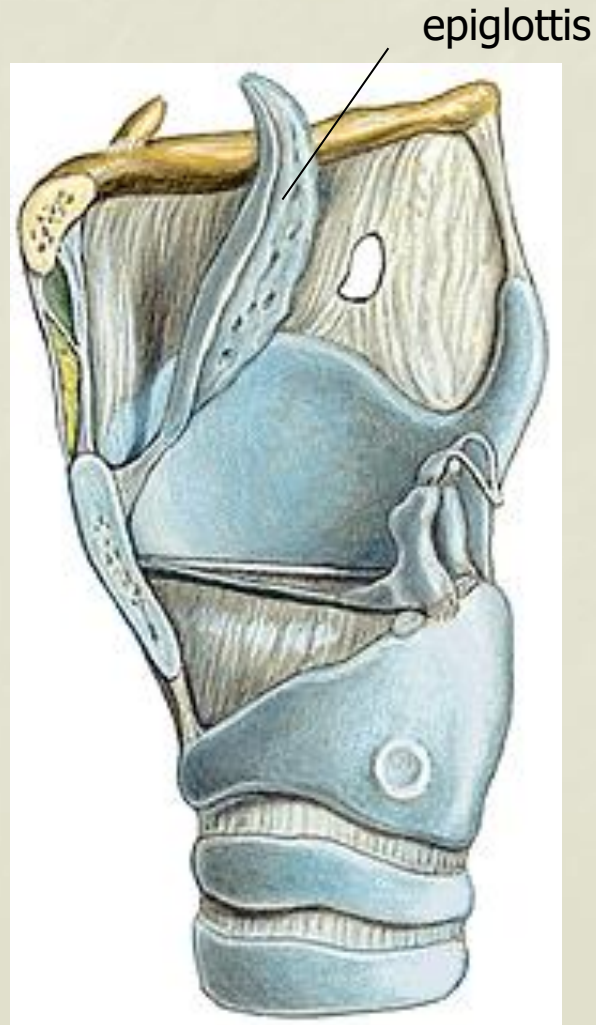
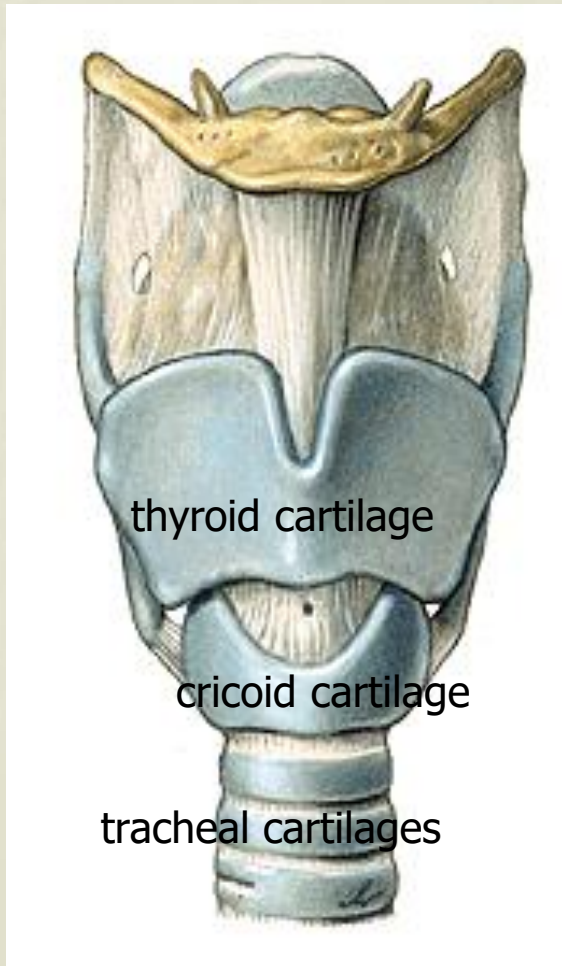
nasopharynx

oropharynx

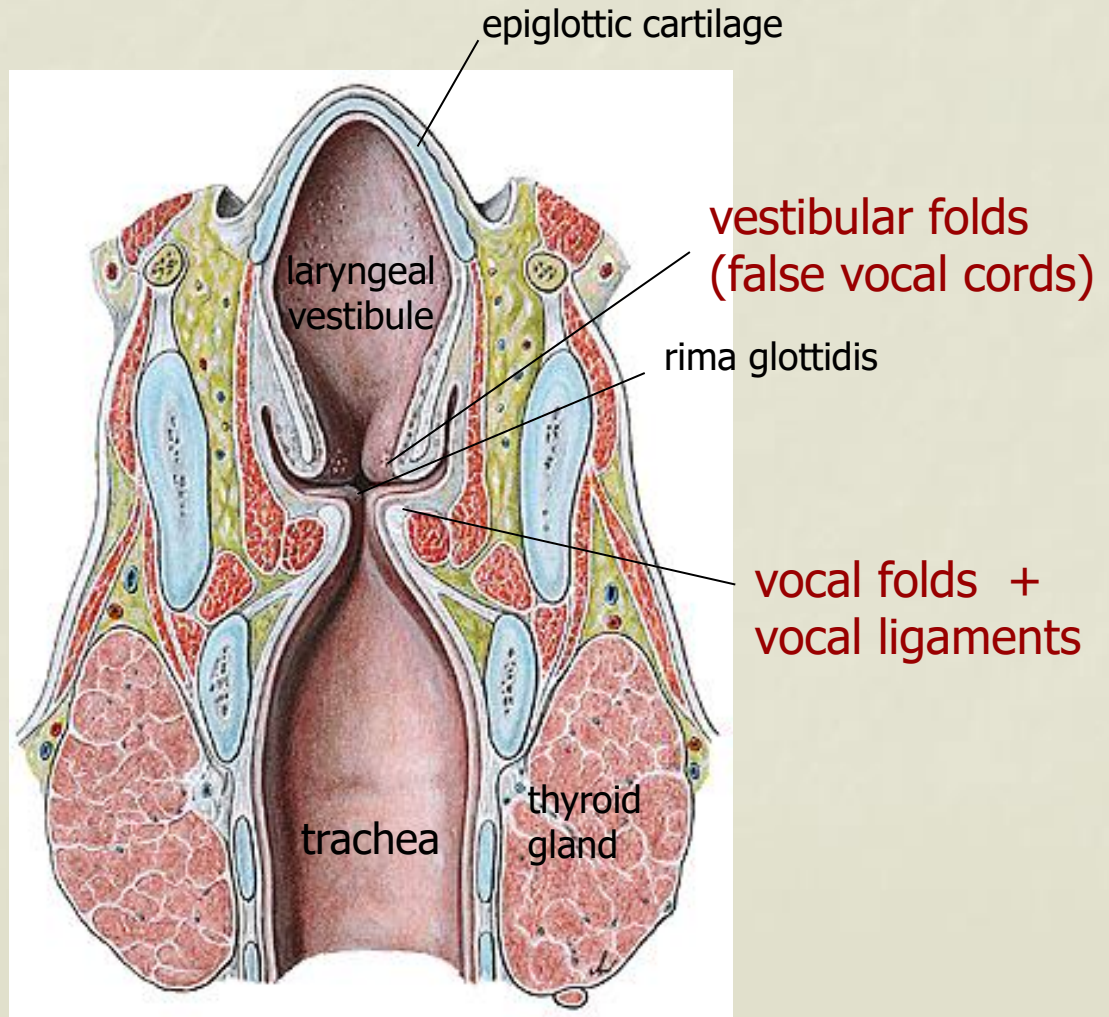
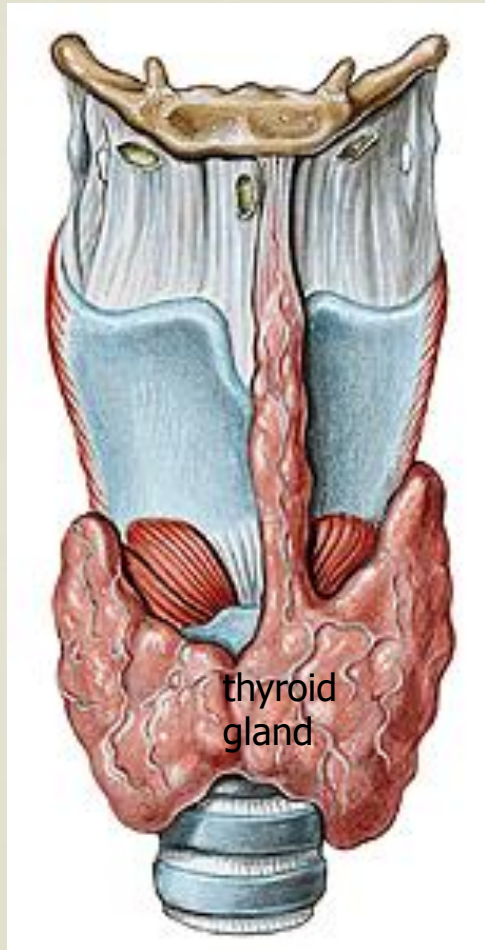
laryngopharynx

Lower airways

Larynx



Larynx



Function of the Larynx

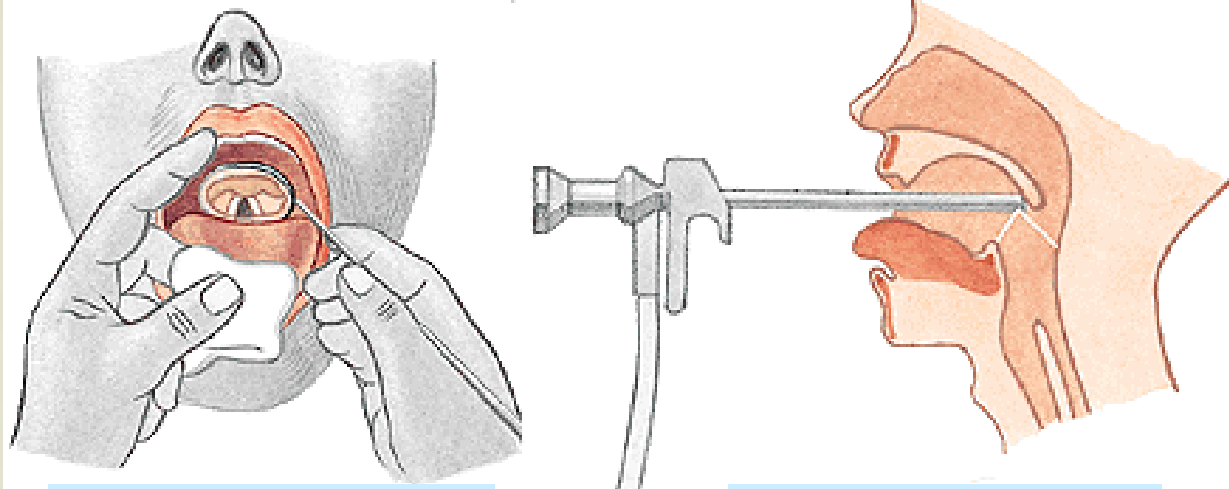
■ RESPIRATION

- vocal folds in the **respiratory position**
- rima glottidis opened

■ PHONATION (VOICE)

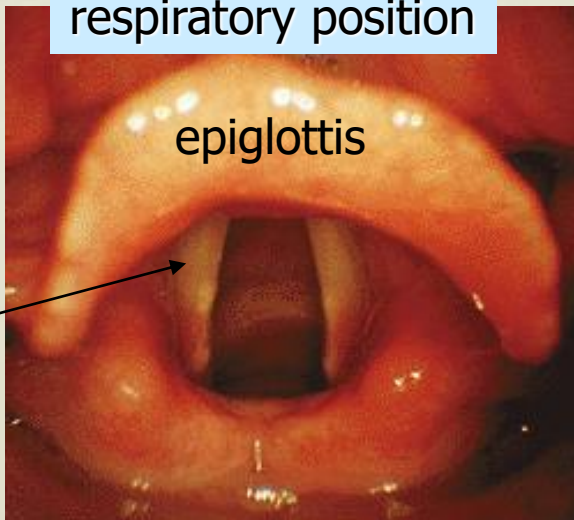
- vocal folds tensed and attached – **phonatory position**
- the volume of the sound is influenced by the force of the air stream
- pitch depends on vibration frequency, so the length, thickness and tension of the vocal ligaments
- sound obtains its colour by passing through the resonant cavities (pharynx, oral and nasal cavity, paranasal sinuses, thoracic cavity)
- sound transformation to vowels and consonants occurs in the oral cavity by the tongue, teeth, lips and palate

Laryngoscopy



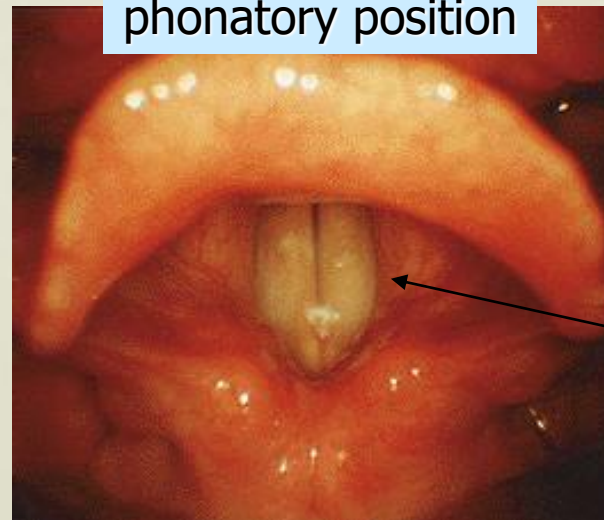
respiratory position

phonatory position



epiglottis

vocal fold

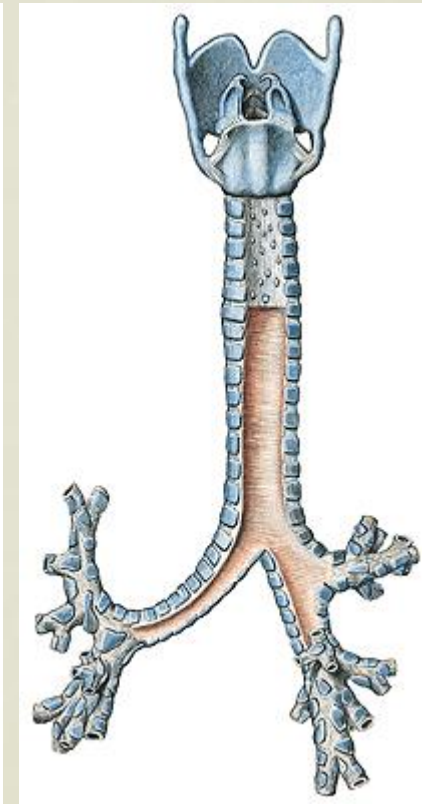
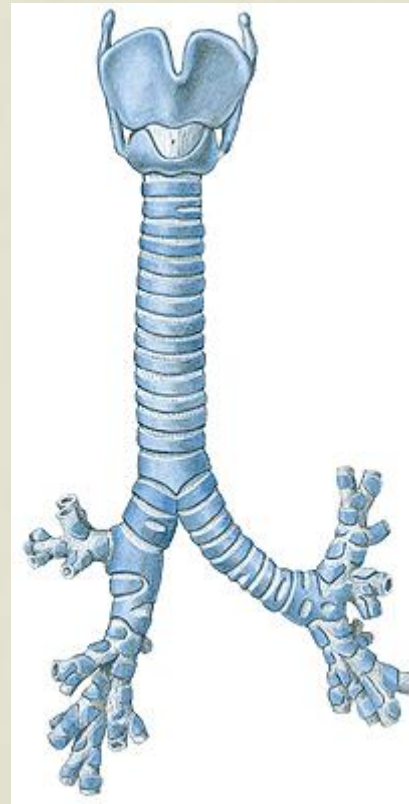


vestibular fold



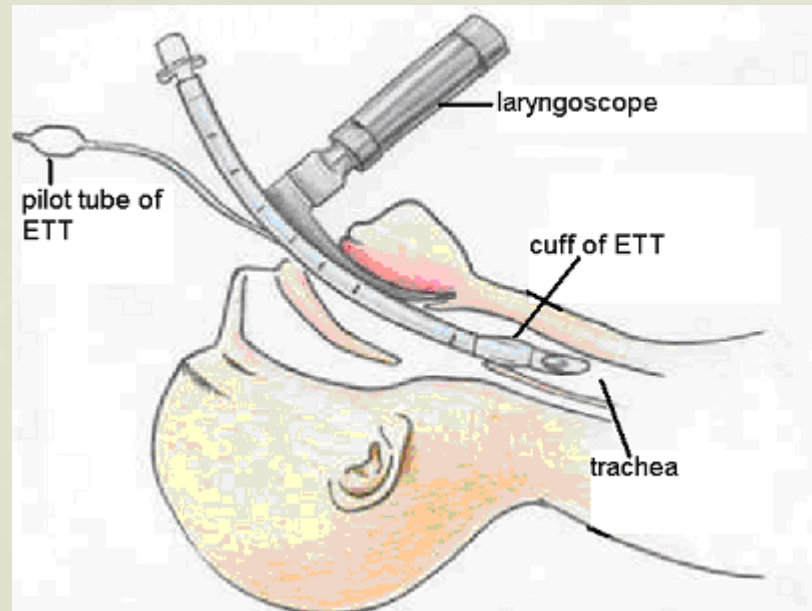
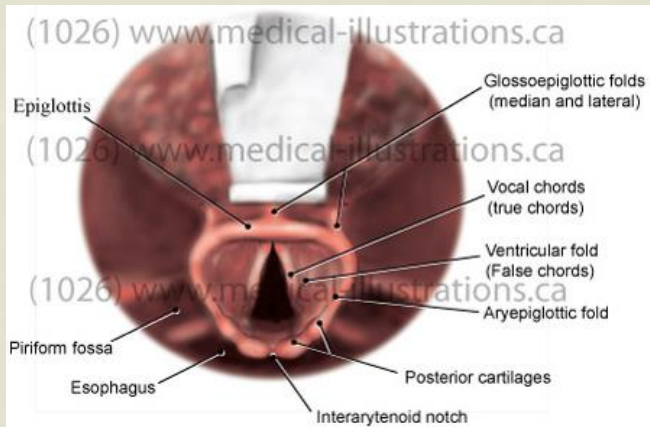
Windpipe (Trachea)

- flexible tube 10–12 cm long extending from the cricoid cartilage to the tracheal bifurcation
- made up of 16–20 horseshoe-shaped **tracheal cartilages** that are linked together by the annular ligaments and **membranous wall**
- passes through mediastinum
- at the level of Th₄₋₅ trachea divides into main bronchi in the tracheal bifurcation
 - **right main bronchus**
 - **left main bronchus**
- bronchi enter the lungs in hila

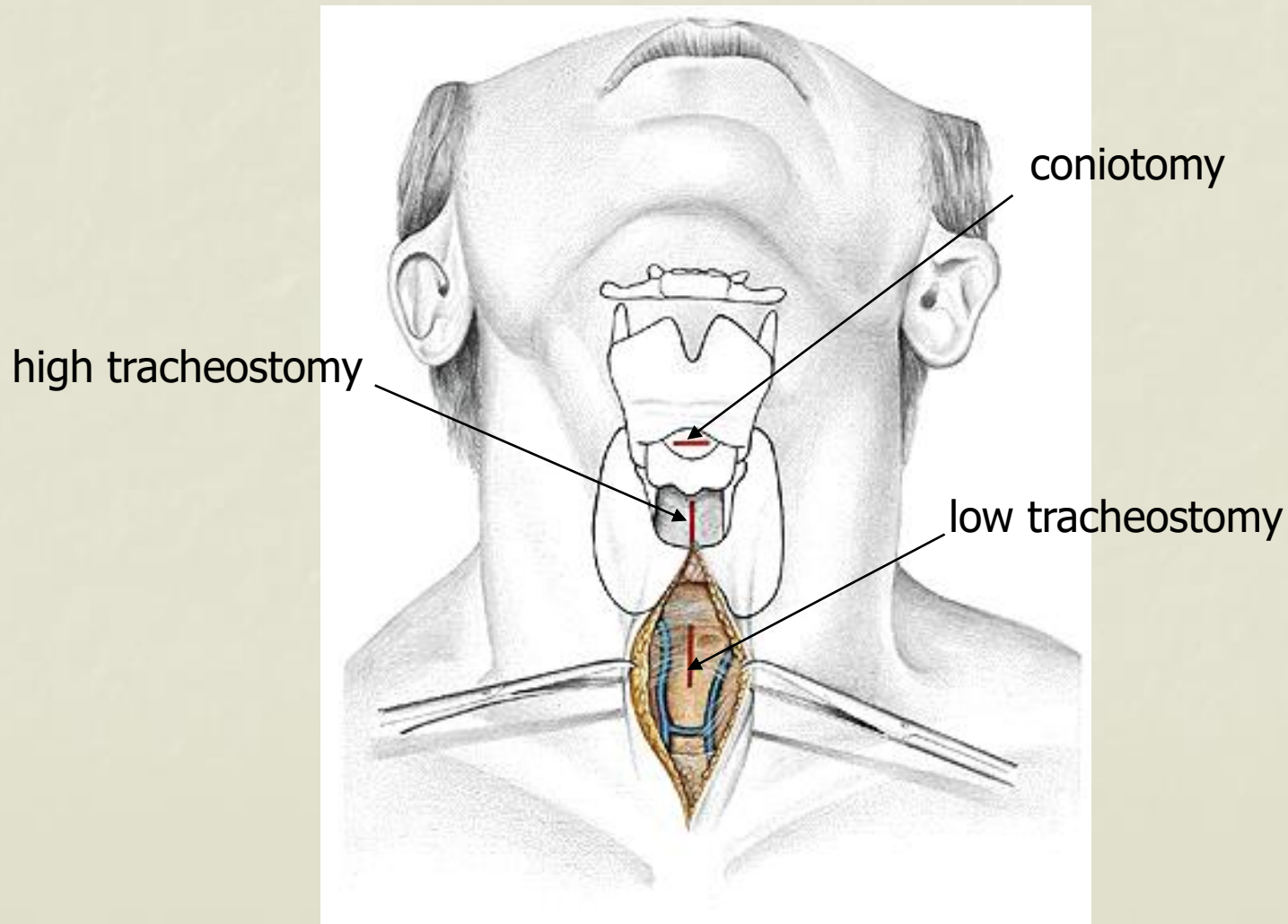


Orotracheal Intubation (OTI)

- unconscious patients, artificial pulmonary ventilation
- general anesthesia (muscle relaxation)

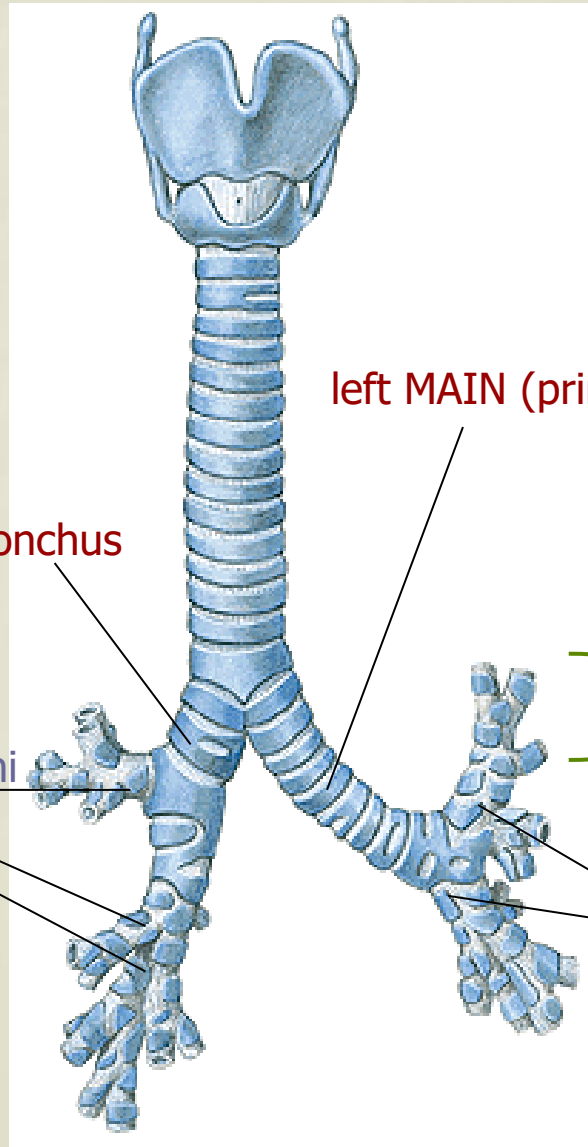


Invasive Procedures in the Airways





Bronchi



left MAIN (primary) bronchus

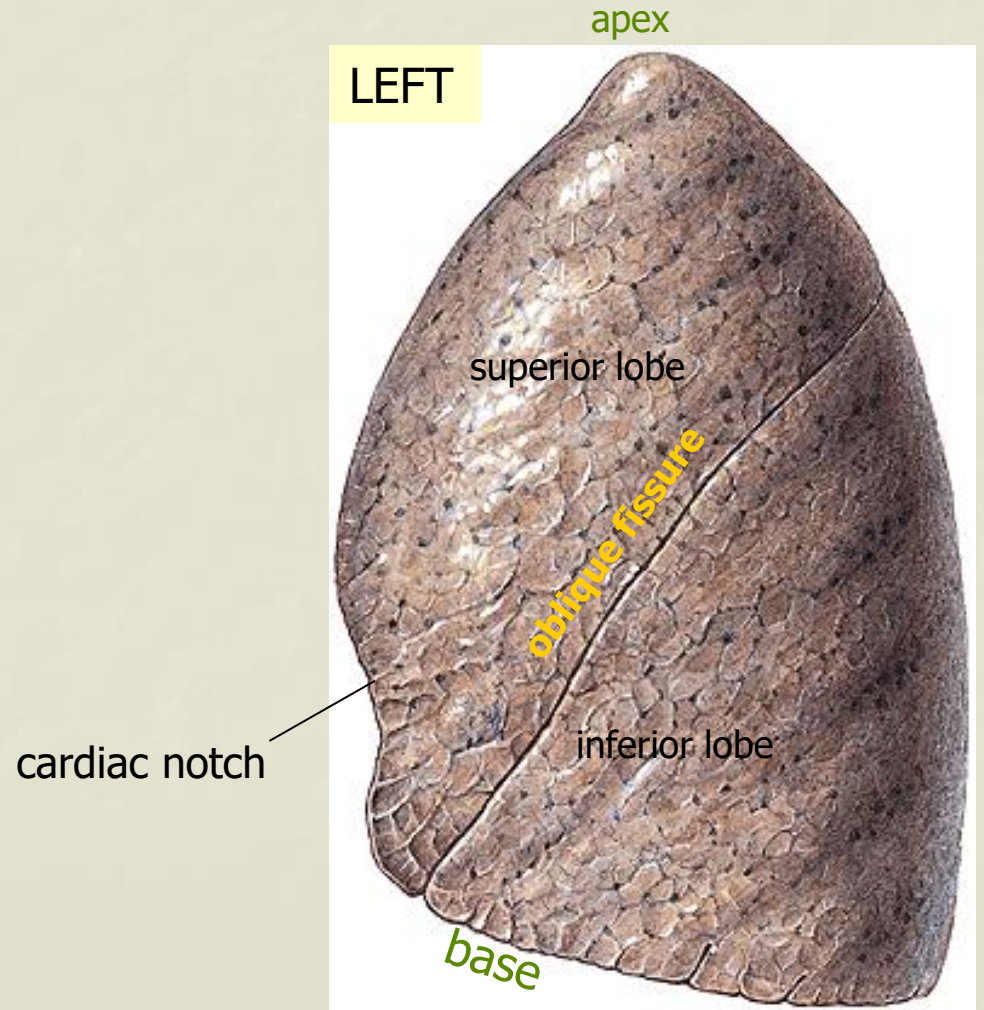
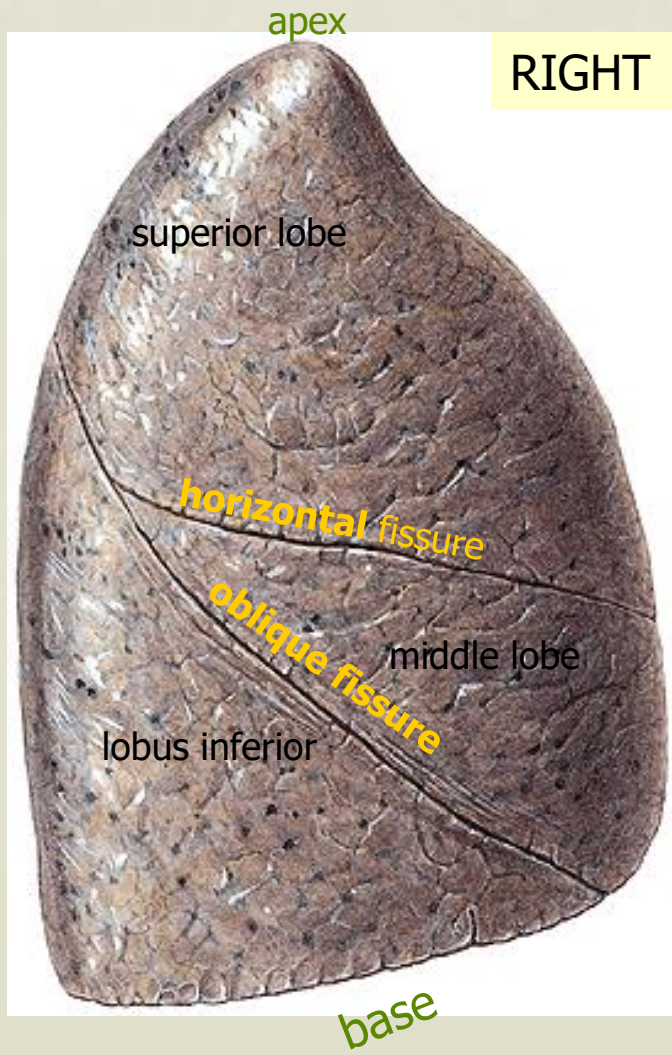
right MAIN (primary) bronchus

SEGMENTAL (tertiary) bronchi

right LOBAR (secondary) bronchi

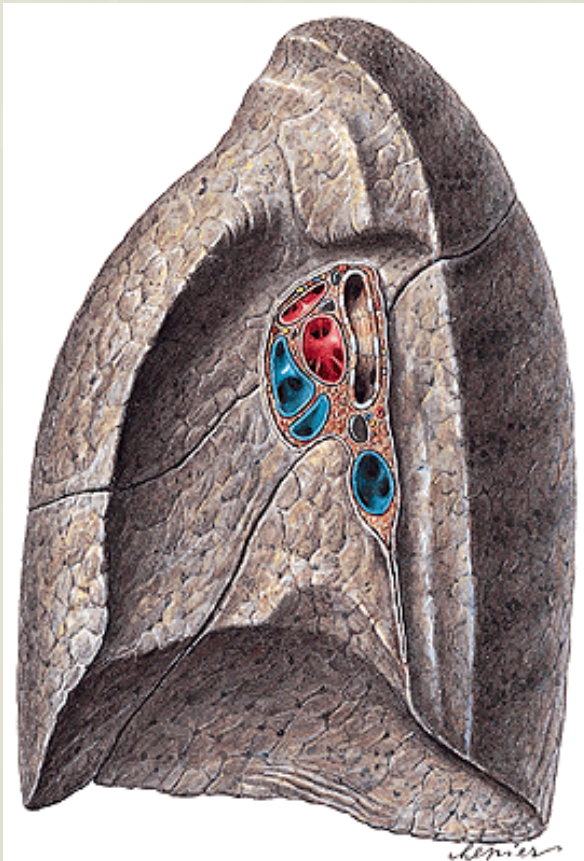
left LOBAR (secondary) bronchi

Lungs

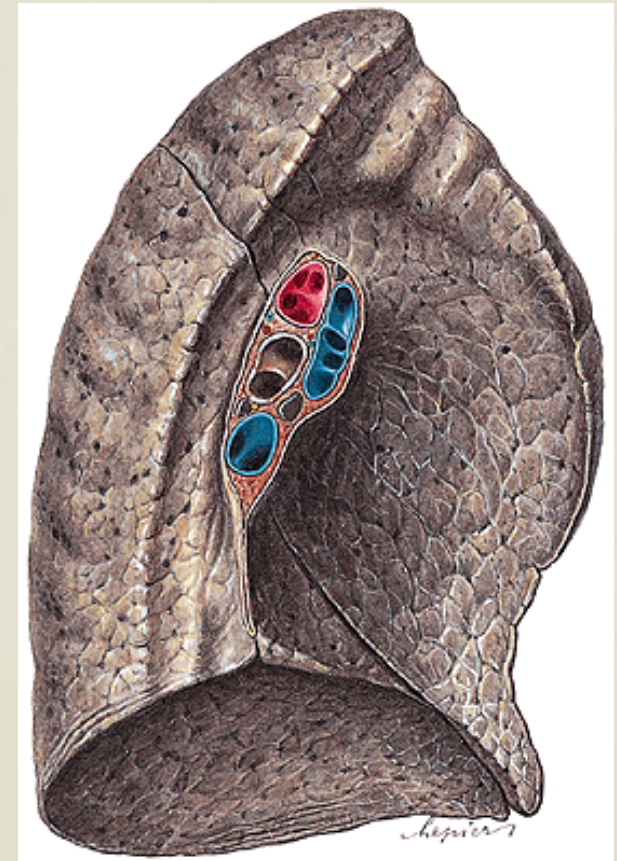


Pulmonary Roots (Hila)

RIGHT LUNG



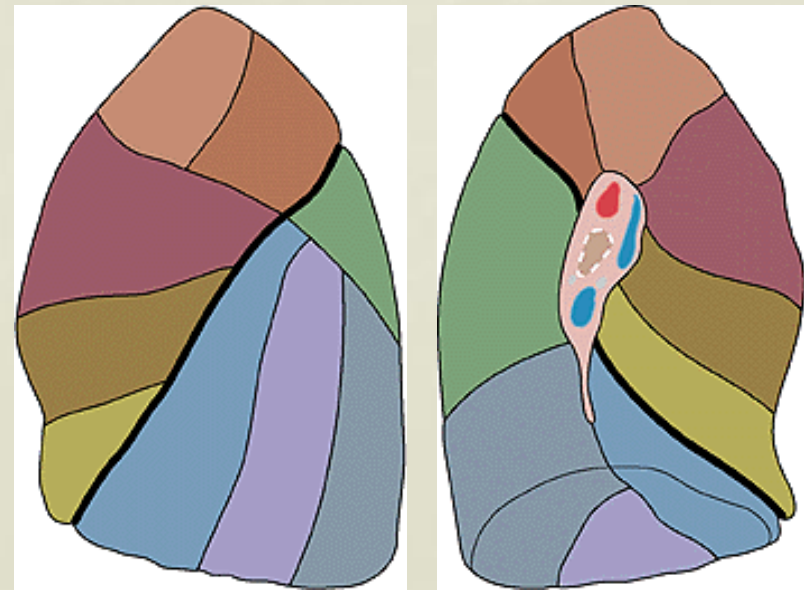
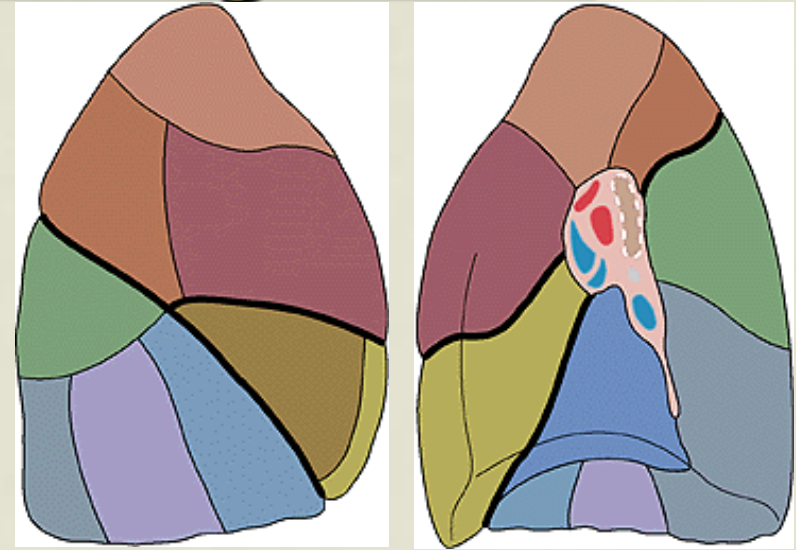
LEFT LUNG



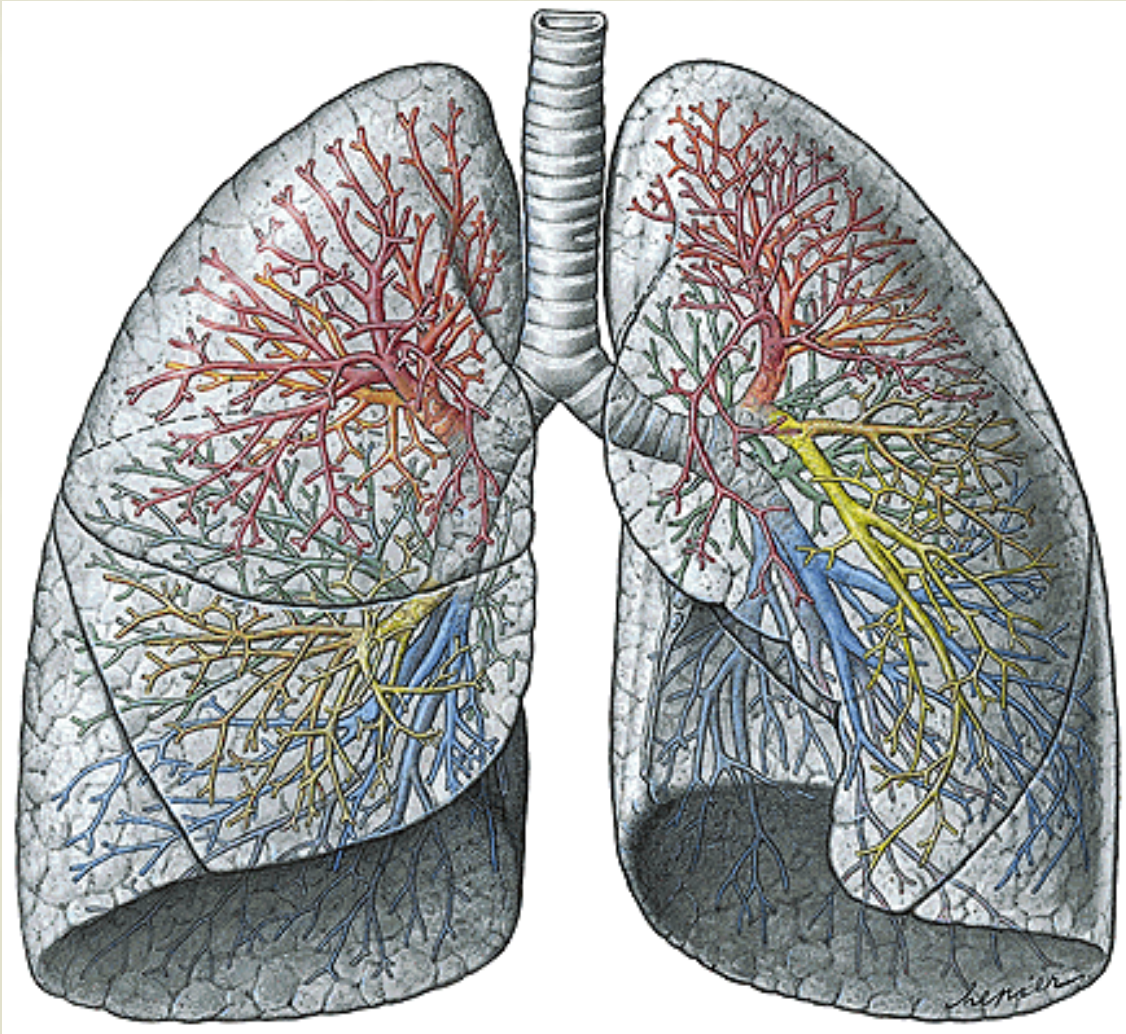
primary bronchus
pulmonary artery
pulmonary veins
lymphatic nodes

Bronchopulmonary Segments

- parts of the lung bordered by fibrous tissue with its own branch of bronchus, pulmonary artery and vein
- 10 segments both in right and left lung
- importance in endoscopic examination (tracheobronchoscopy) and thoracic surgery
 - **lobectomy** = 20 % of lung tissue
 - **segmentectomy** = 5 % of lung tissue

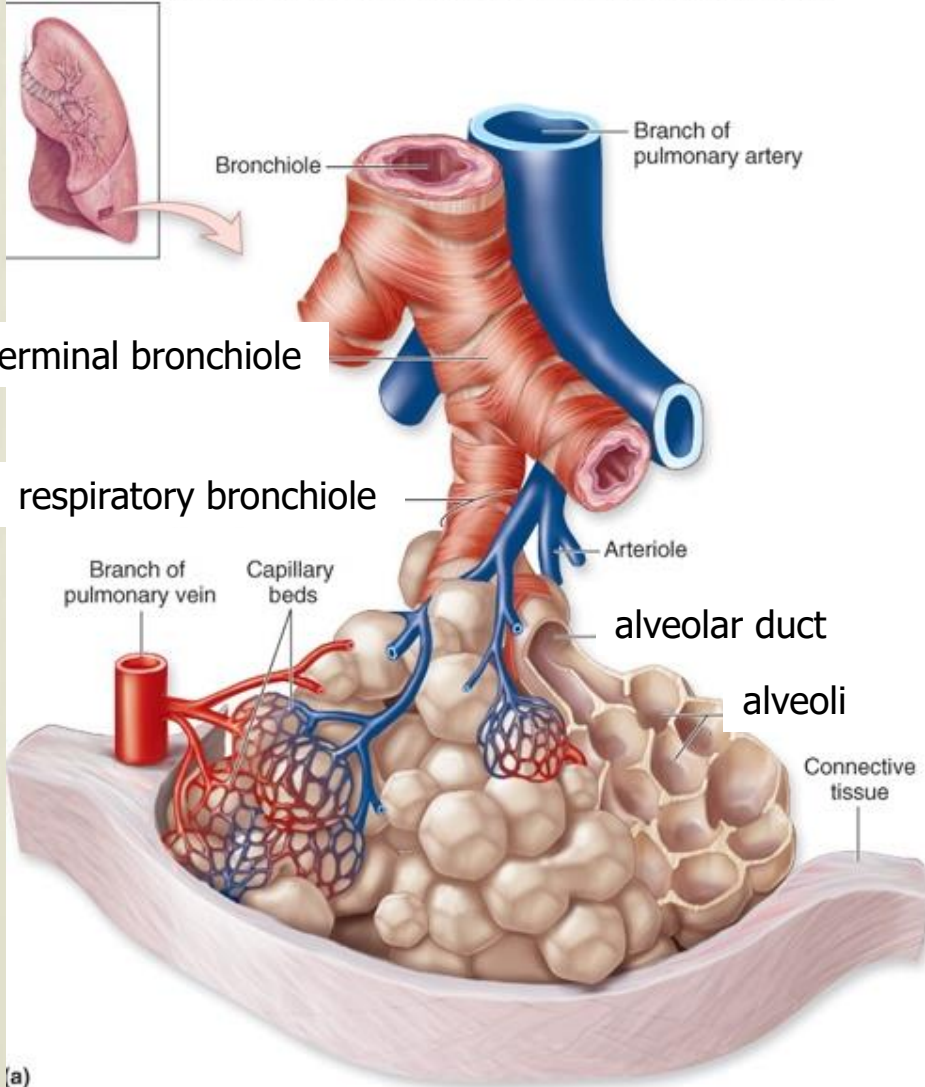


Bronchial Tree, Bronchography



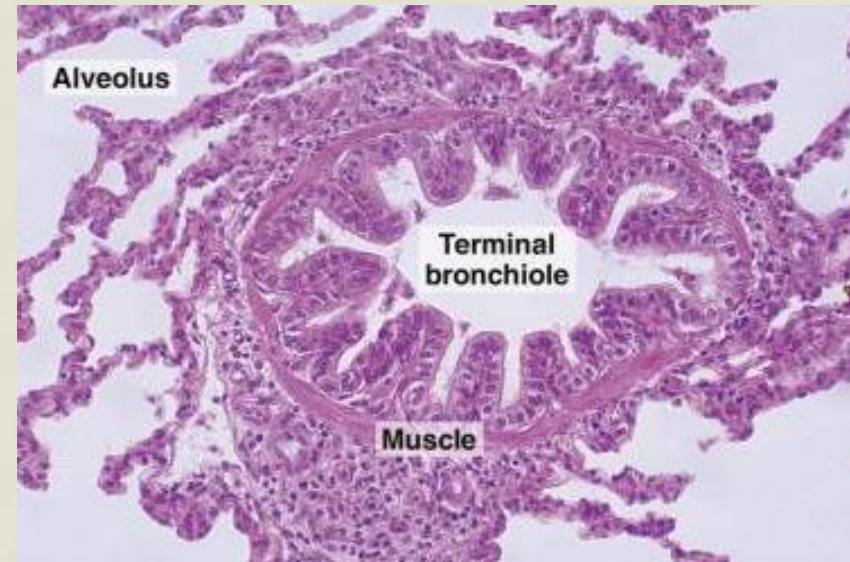
Bronchial Tree in Lungs, Alveoli

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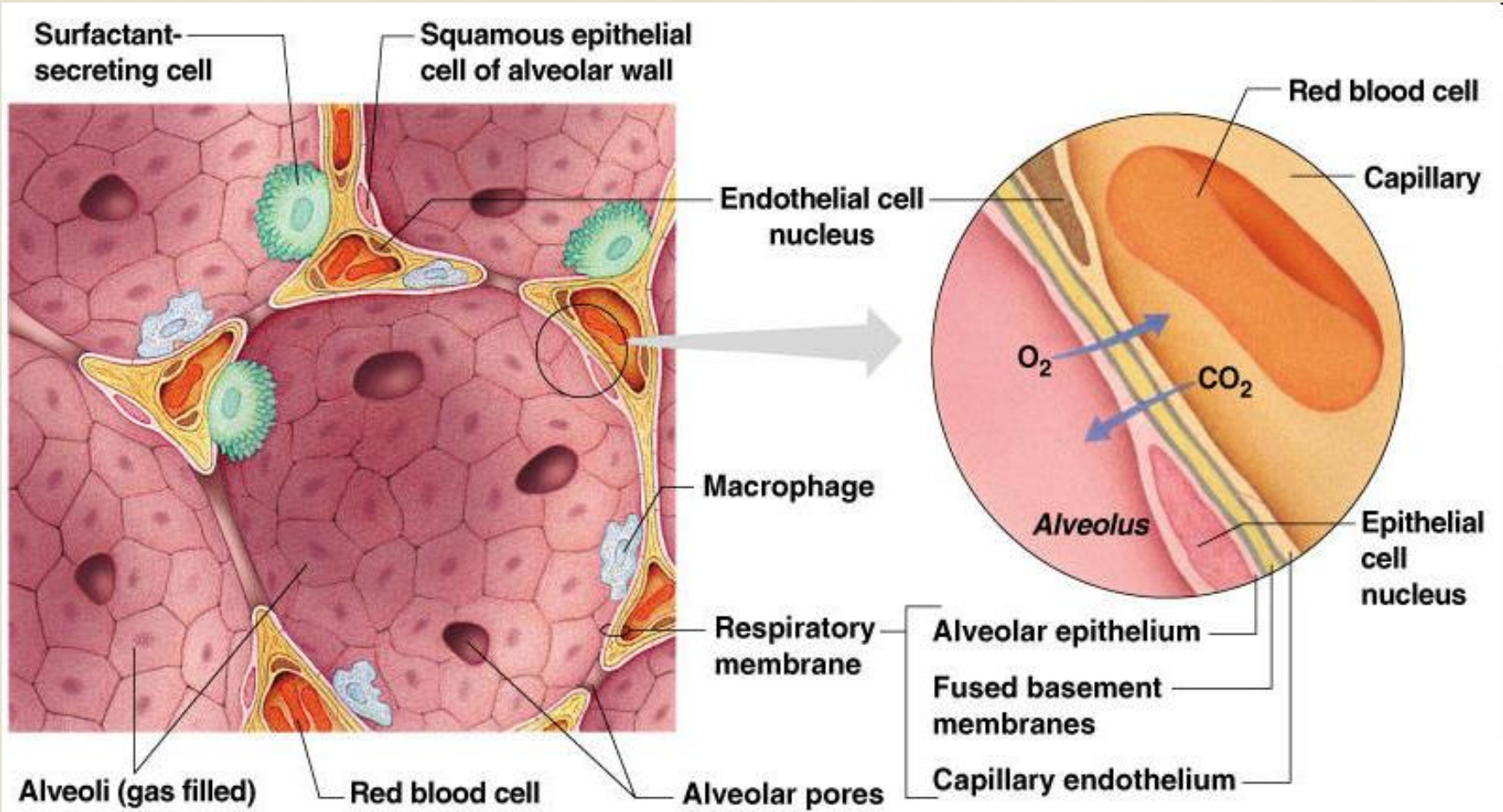


BRONCHIOLES

- diameter < 1mm
- no cartilage !!



Alveolo-capillary Membrane



Blood Circulation in Lungs

NUTRITIVE

- provides metabolic demands of lungs
- bronchial branches from the thoracic aorta

FUNCTIONAL

- gas exchange between air and blood

- pulmonary artery

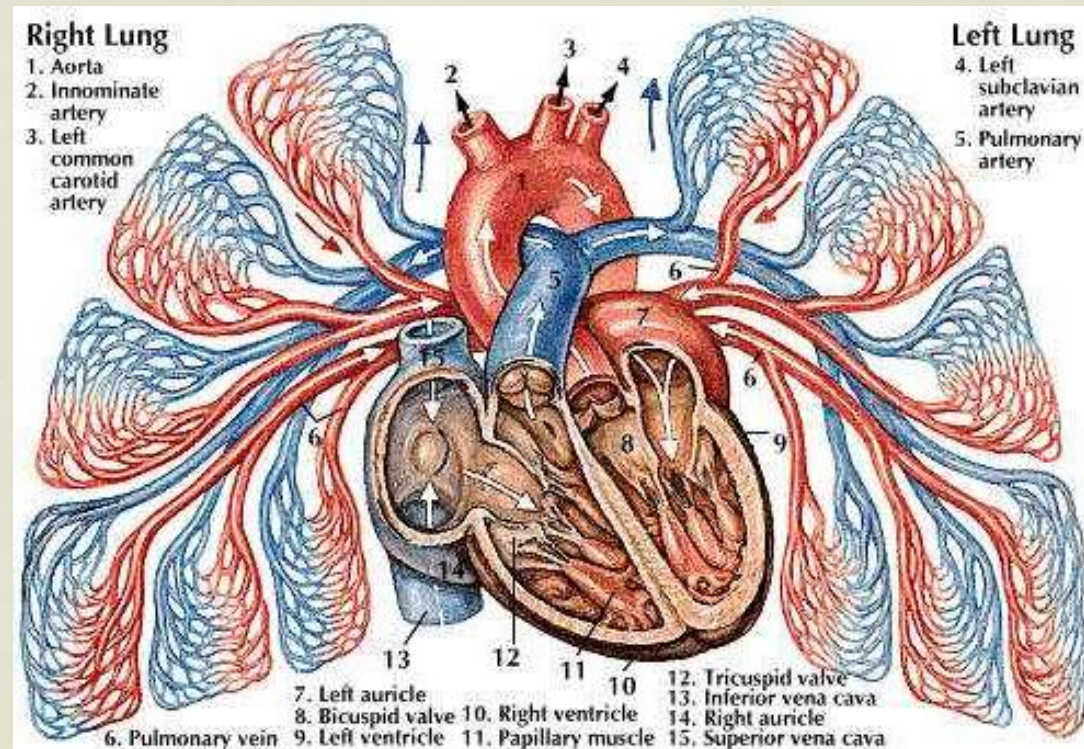


capillar plexi round alveoli

- pulmonary veins

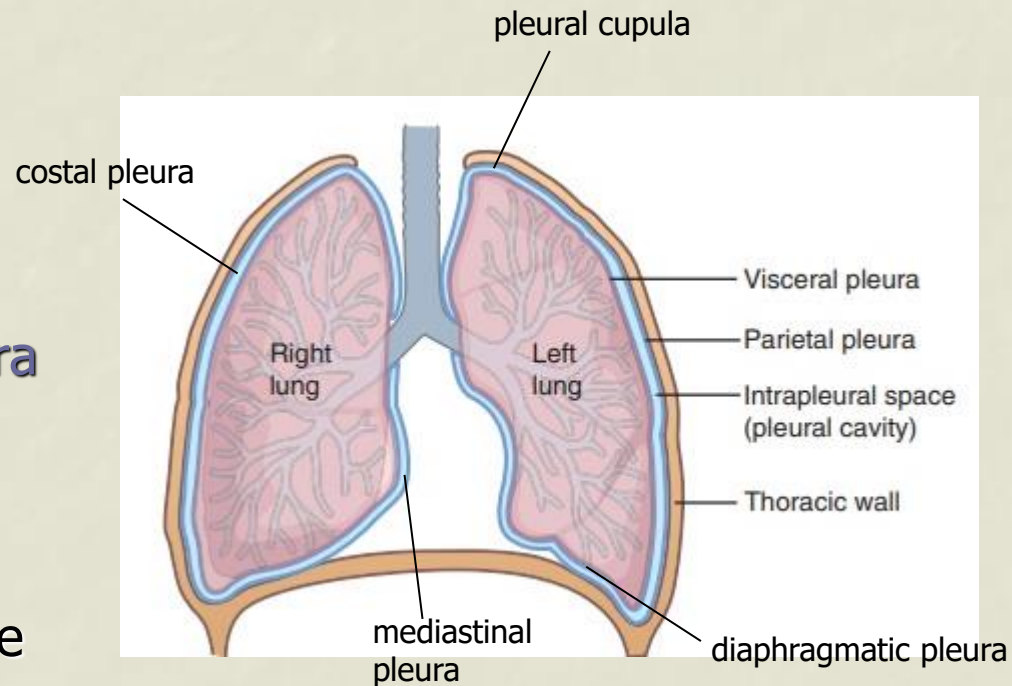


left atrium



Pleural Cavity

- thin space between the two pleural layers
- normally contains a small amount of pleural fluid
- **visceral (pulmonary, inner) pleura**
– covers the lungs
- **parietal (outer) pleura**
– forms the peripheral wall of the pleural cavity
- pleurae lined with a thin layer of flat cells – **mesothelium**
- in normal conditions it is closed with a negative air pressure



Mechanics of Breathing

- the exchange of gases between pulmonary alveoli and the environment requires pressure changes in the thorax generated by active and passive forces

INSPIRATION – the thoracic cavity and lung volume enlarge, ribs move upward

- rib muscles (external intercostal mm.) contract, so the rib cage expands
- the diaphragm is contracted and moves down
- air goes into the lungs
- **accessory inspiratory muscles** (scalene, latissimus dorsi, pectoralis major et minor, sternocleidomastoid...)
 - **thoracic breathing** (women) – prevalence of intercostal muscles
 - **abdominal breathing** (men) – prevalence of diaphragm
 - **mixed** – in normal conditions

EXPIRATION – the thoracic cage and lung volume decrease, ribs move downward

- rib muscles (internal intercostal mm.) contract
- the diaphragm relaxes, the domes of the diaphragm move upward, decreasing the size of the thoracic cavity
- air flows out of the lungs
- **accessory expiratory muscles** (abdominal muscles...)

Mechanics of Breathing

