5th and 6th lectures

in

Anatomy and Physiology

for

1st Class

By

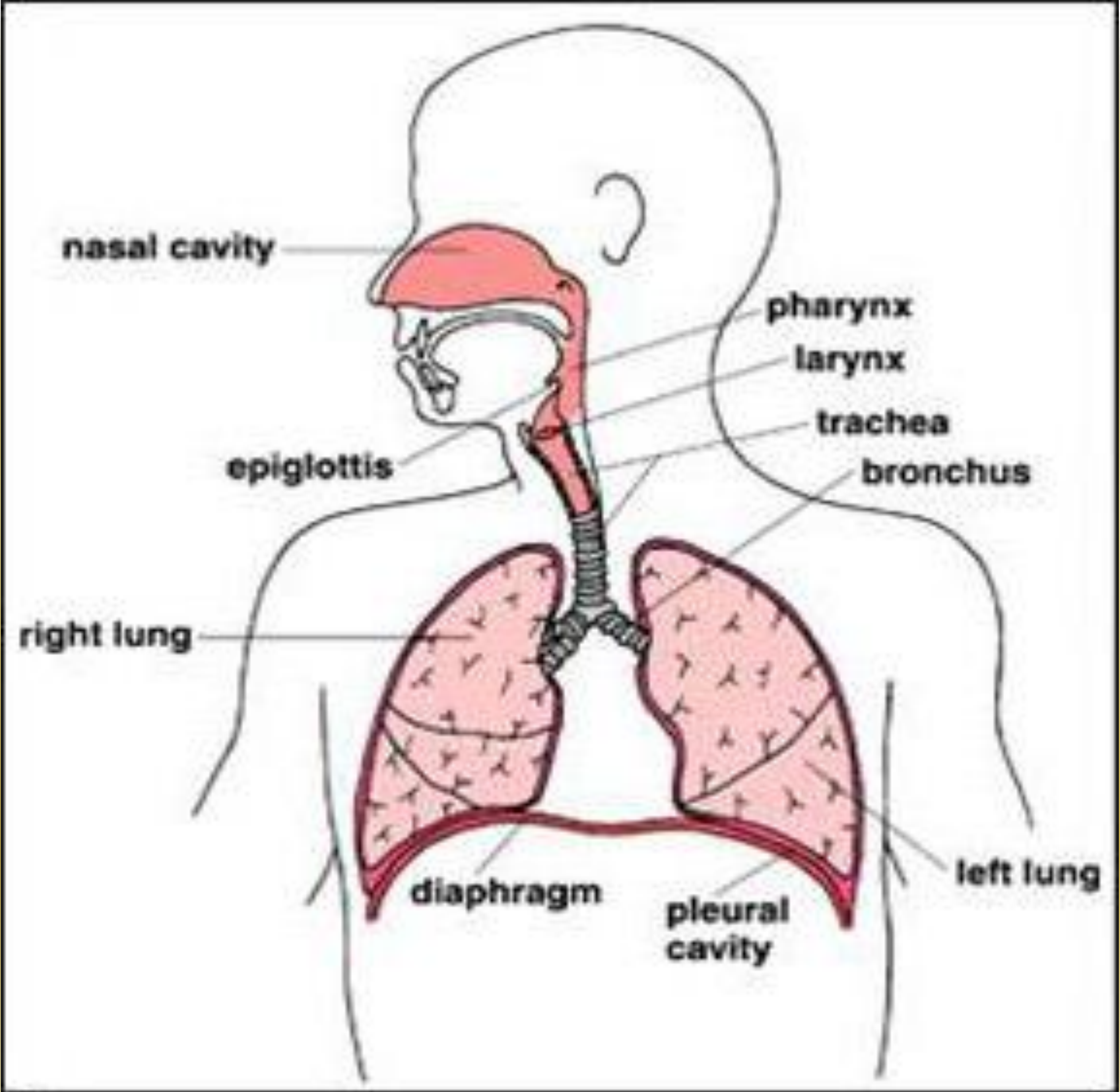
Dr. Ala’a Hassan Mirza

Respiratory System

- This system is responsible for bring O2 into the body and get rid carbon dioxide (CO2) from the body.

- The air enters the body from nostrils then pass through nasal cavity to the pharynx, larynx, trachea, bronchi, bronchioles, then to the alveoli in the lungs.

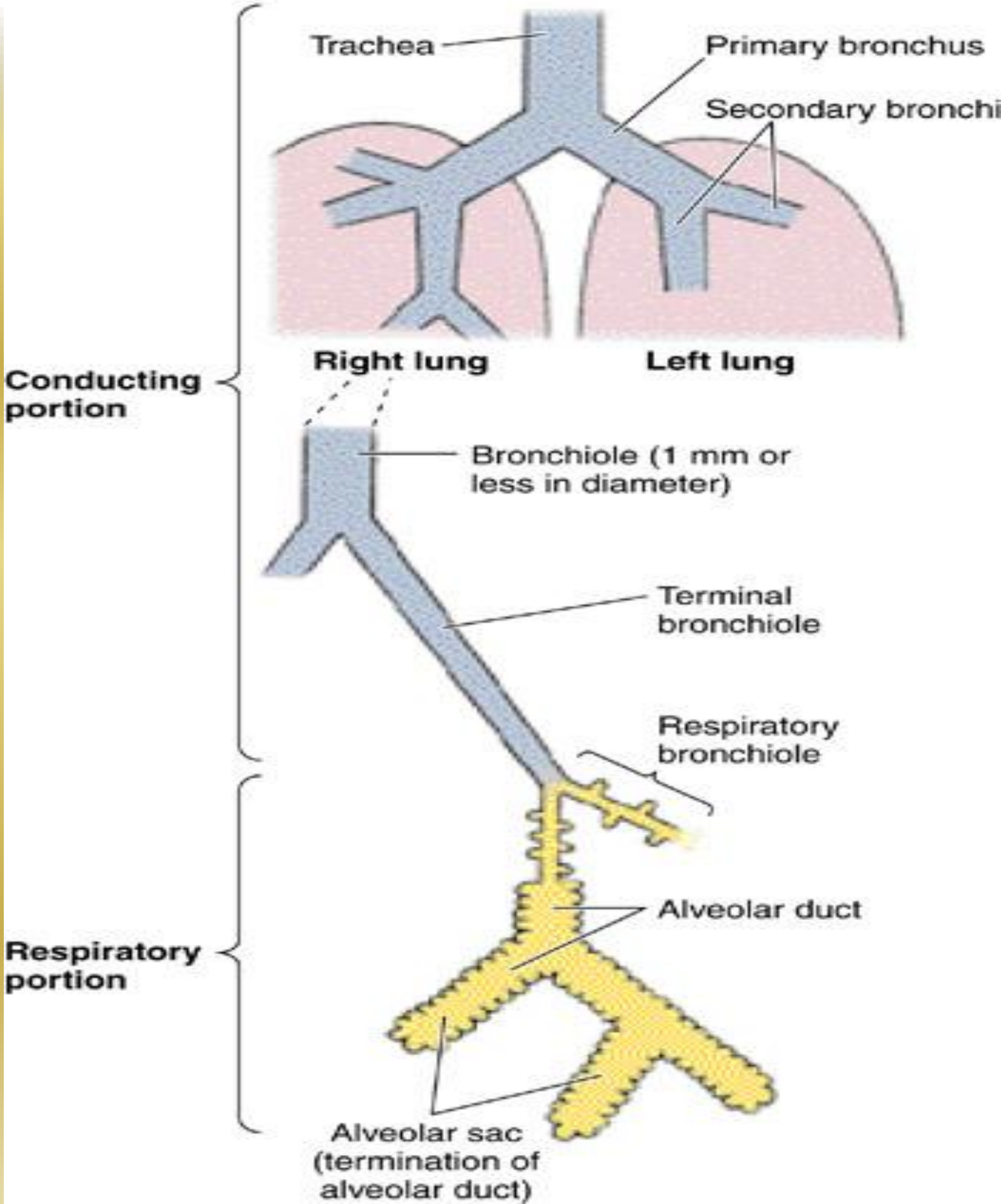
- **<u>Respiratory epithelium: </u>**Respiratory tract lined with ciliated psuedostratified columnar epithelium that contains a rich population of goblet cells.


nasal cavity
pharynx
larynx
trachea
bronchus
epiglottis
right lung
left lung
diaphragm
pleural
cavity

The respiratory system is divided into principle regions:

1. Conducting portion is consisting of the *nasal cavity, nasopharynx, larynx, trachea, bronchi, bronchioles, and terminal bronchioles.*

2. respiratory portion (<u>where gas exchange take place)</u> is consisting *of respiratory bronchioles, alveolar ducts and alveoli.*



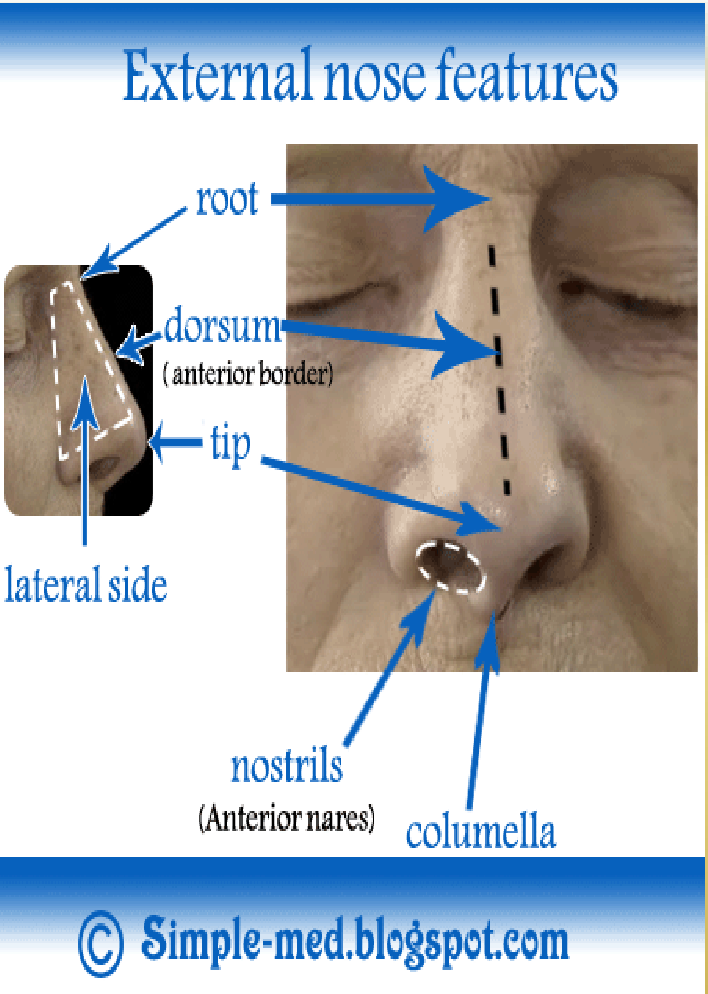
The Nose

- The nasal cavity is divided into two chambers by nasal septum,
- The nasal septum forms the medial wall of the nasal chamber.
- The anterior part of nasal septum is composed from **cartilage**, and the posterior part composed from bone.
- The lateral wall of the nasal cavity contains three prominent elevations called **conchae** (<u>superior concha</u>, <u>middle concha</u>, and <u>inferior choncha</u>). Therefore three air meatuses are formed for air passage, these are **<u>inferior,</u>** **<u>medile</u>**, and **<u>superior meatuses</u>**
- The inferior and middle conchae are lined by ***respiratory epithelium.***
- The superior chonchae are covered with specialized ***olfactory epithelium (for smell= olfection).***
- **Olfectory epithelium** a specialized area of mucous membrane in the superior chonchea located in the roof of nasal cavity.

•The external nares (nastrils) are guarded by numerous sebaceous, and sweet glands and long hair to prevent large air borne particles like insect to get in.

•The nasal cavity is lined by mucous membrane. The mucous membrane secret serous fluid which moistened the inhaled air.

•Nasal cavity rich in blood which warm the air.


External nose features
root
dorsum
(anterior border)
tip
lateral side
nostrils
(Anterior nares)
columella
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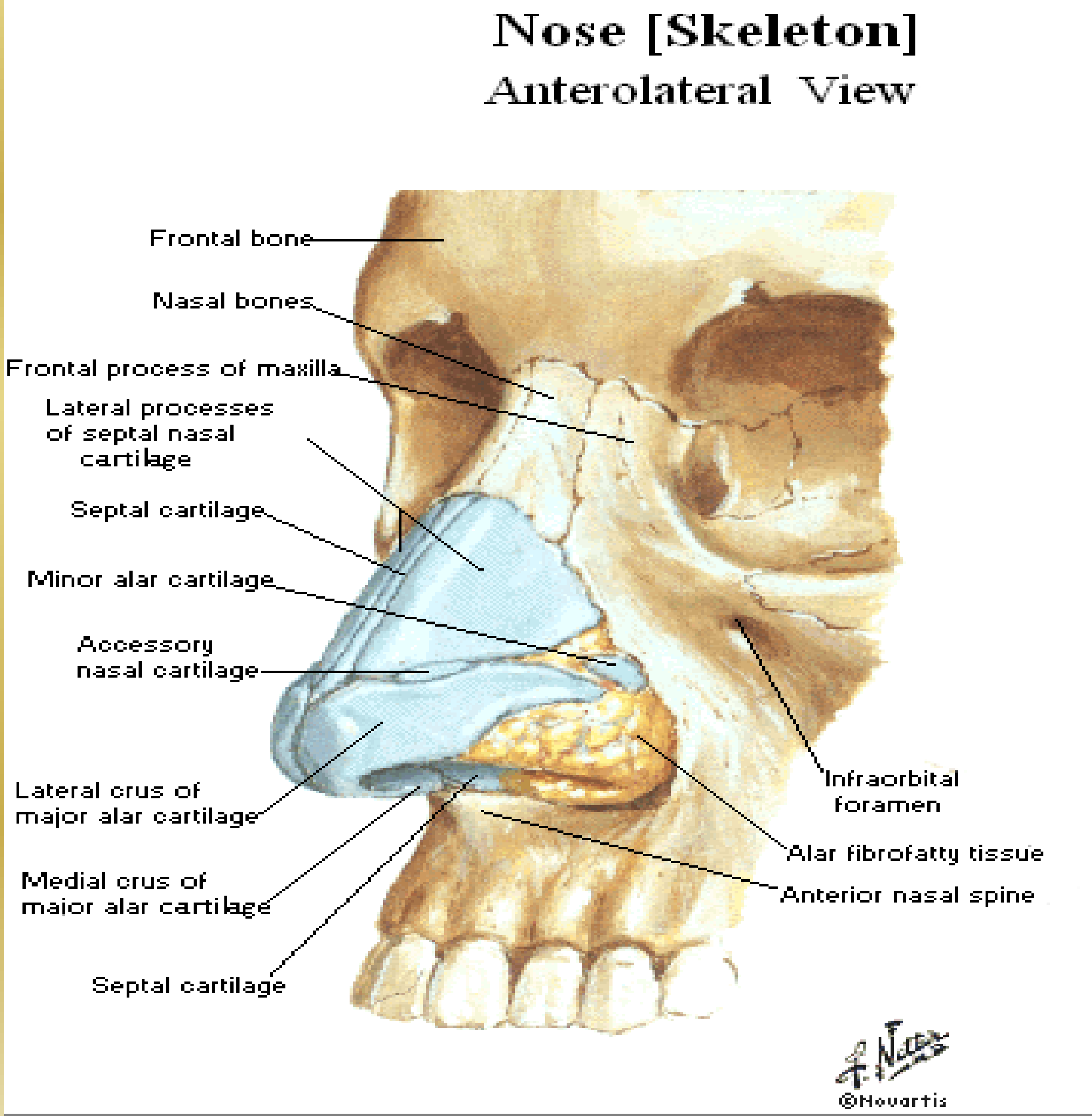
Nose [Skeleton]
Anterolateral View
Frontal bone
Nasal bones
Frontal process of maxilla
Lateral processes of septal nasal cartilage
Septal cartilage
Minor alar cartilage
Accessory nasal cartilage
Lateral crus of major alar cartilage
Medial crus of major alar cartilage
Septal cartilage
Infraorbital foramen
Alar fibrofatty tissue
Anterior nasal spine
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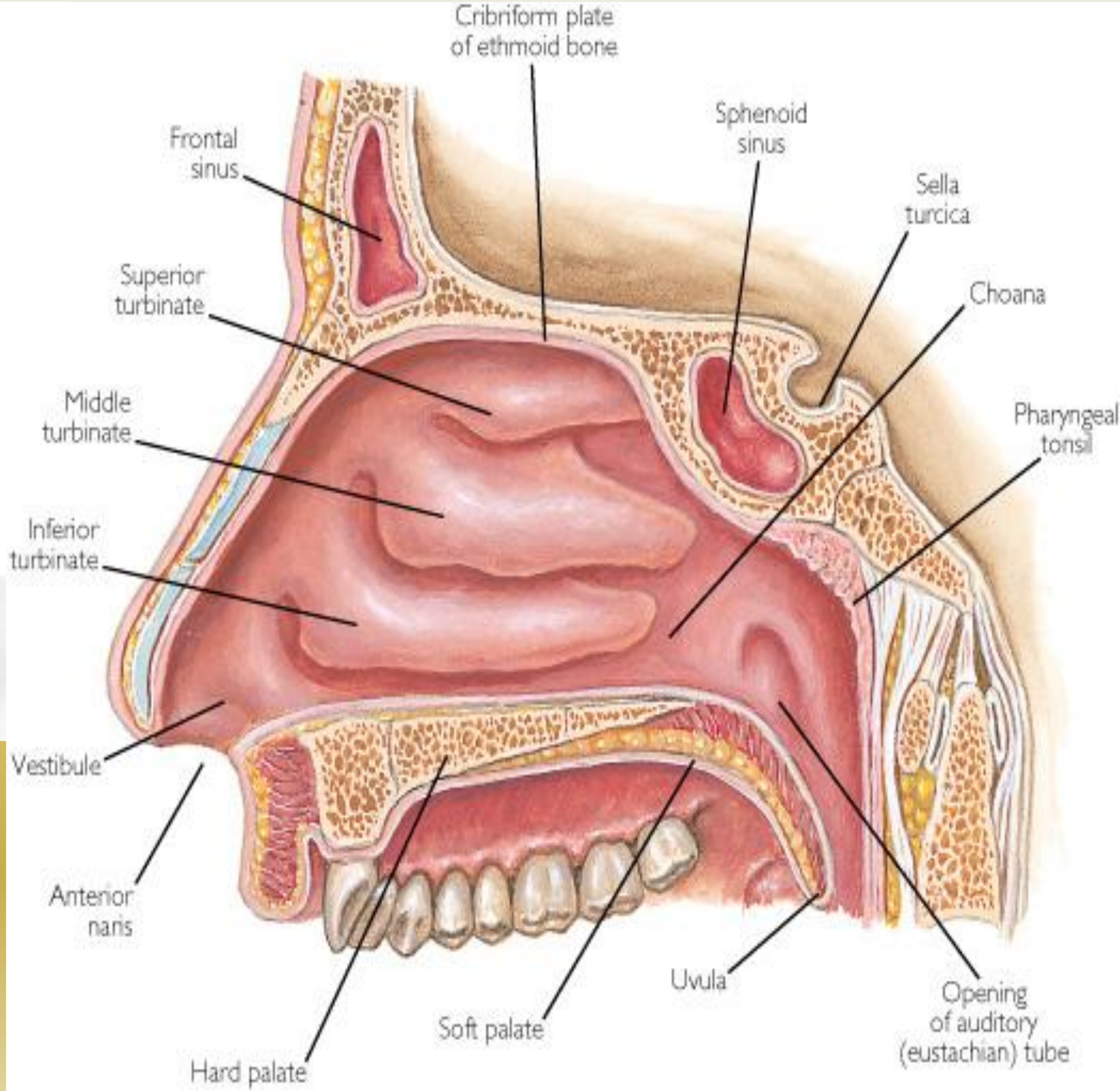
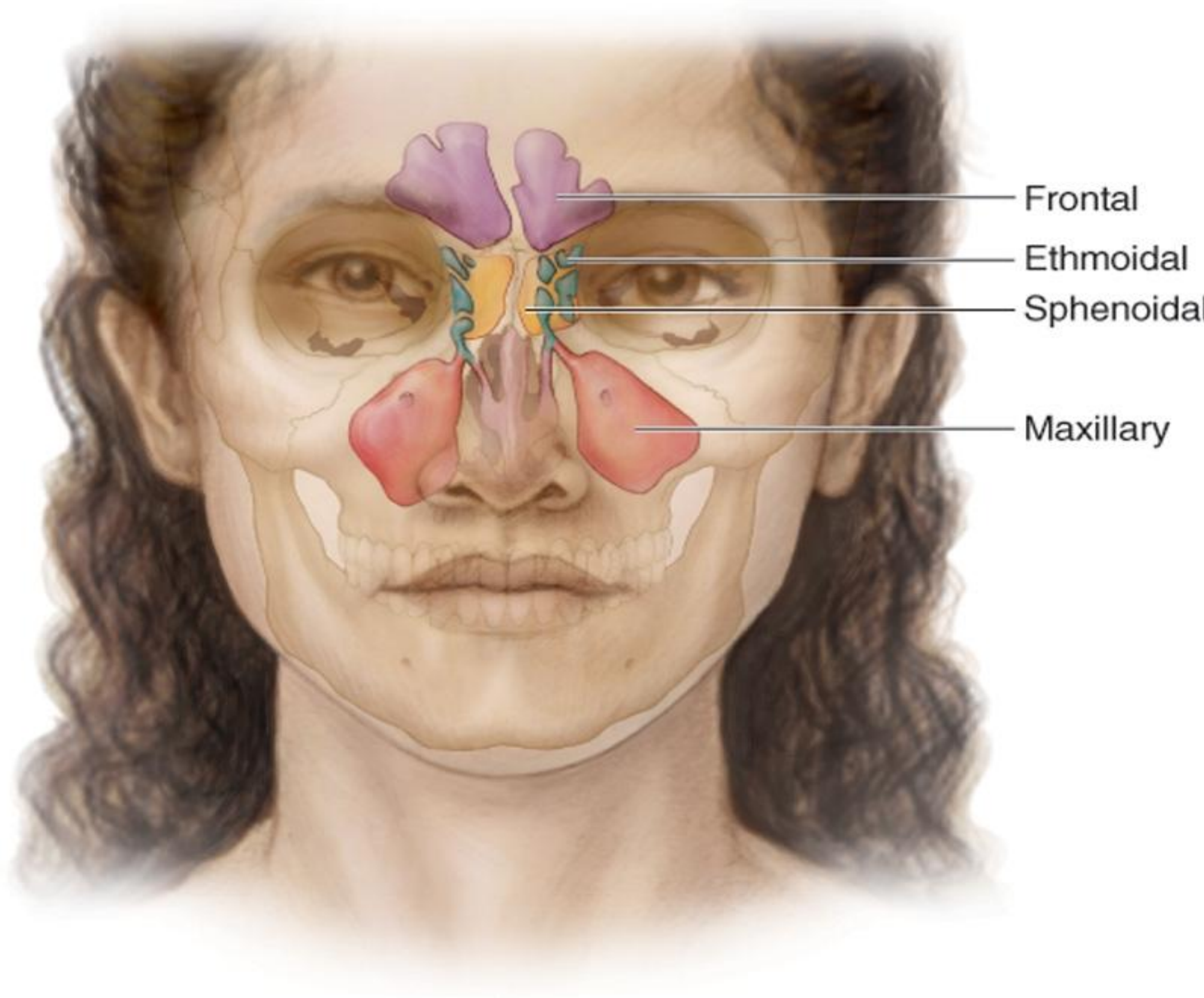

Cribriform plate of ethmoid bone
Frontal sinus
Sphenoid sinus
Sella turcica
Superior turbinate
Choana
Middle turbinate
Pharyngeal tonsil
Inferior turbinate
Vestibule
Anterior naris
Uvula
Soft palate
Opening of auditory (eustachian) tube
Hard palate

Functions of the Nose

- form a resonating cavity for noise.
- It is an olfectory organ for sense order.
- It is a part of respiratory system **(<u>it is function to filter, warm and moisten the inhaled air before reaches to the lungs).</u>**

Paranasal Sinuses (Air filled cavities)

- Sinuses are cavities in the skull.
- These sinus present in the **frontal bone** (called *frontal sinus)*, **ethmoid bone** (called *ethmoidal sinus*), **spenoid bone** (called *sphenoidal sinus*), **maxillary bone** (called *maxillary sinus*).
- Thery are lined with a **thinner respiratory epithelium** that contains few *goblet cells*. And the *lammina properia contains only small glands*.
- The paranasal sinuses communicate with the nasal cavity through small opening.
- Other opening in the nasal cavity is **lacrimal opening**.



Frontal
Ethmoidal
Sphenoidal
Maxillary

Functions of paranasal sinuses

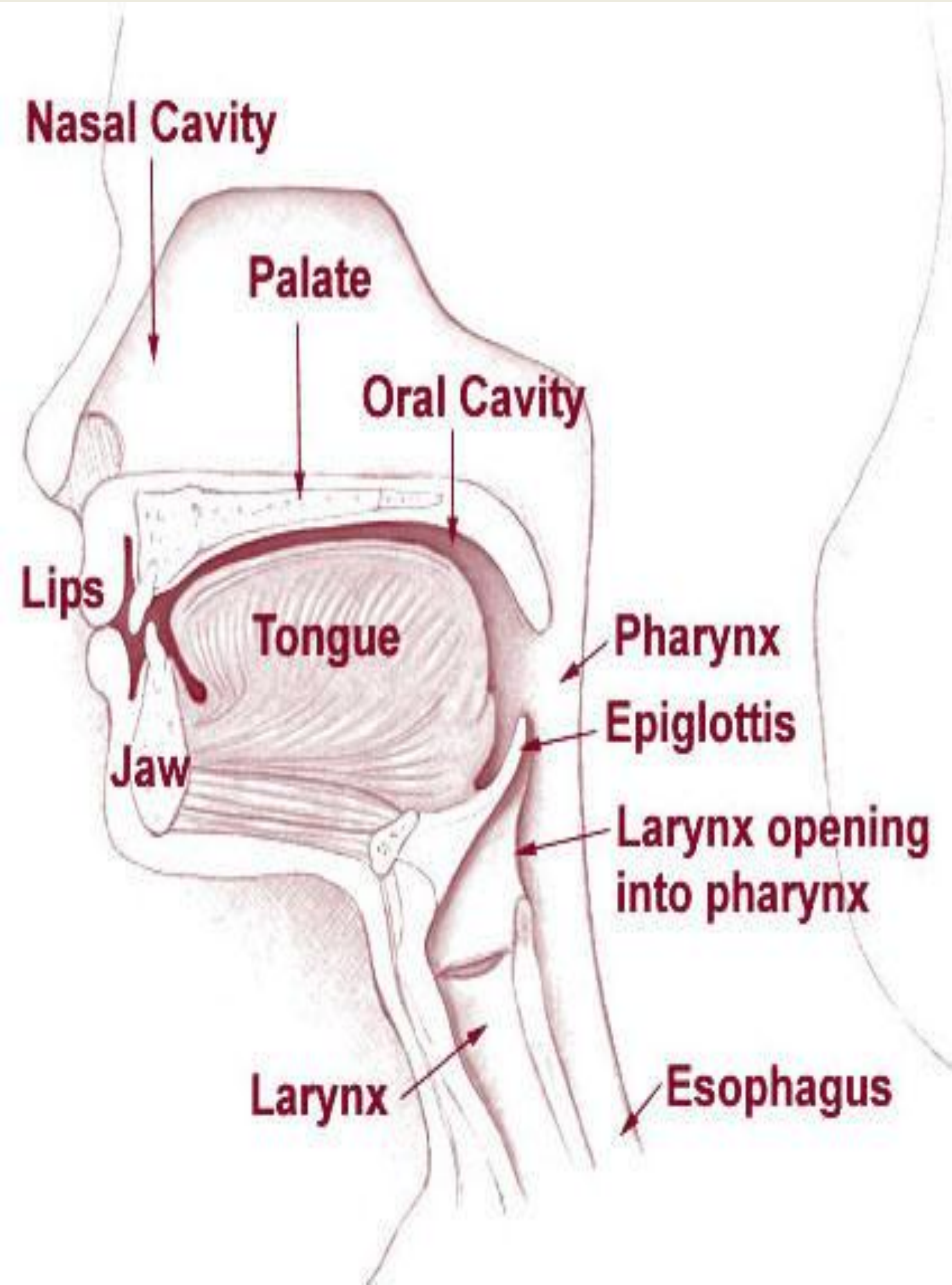
- Lighten weight of skull.
- Sound resonance.

pharynx

Posterior to the nasal cavity there is pharynx (*nasopharynx* which continuing caudally with *oropharynx* and then *laryngeopharynx*).

Function:

1. Air passage between nasal cavity and larynx.
2. Passage way for swallowed food and drink between oral cavity and esophagus.



Larynx

- It is irregular tube that connect the pharynx with trachea.
- It is also called voice box because it contains **vocal cords**.
- The structure of the larynx is mainly composed from **cartilages** and also **muscles** and **ligaments**.
- There are nine cartilages in the larynx

-*Thyroid cartilages* (pair) called Adam's apple

-*Artynoid cartilages* (pair)

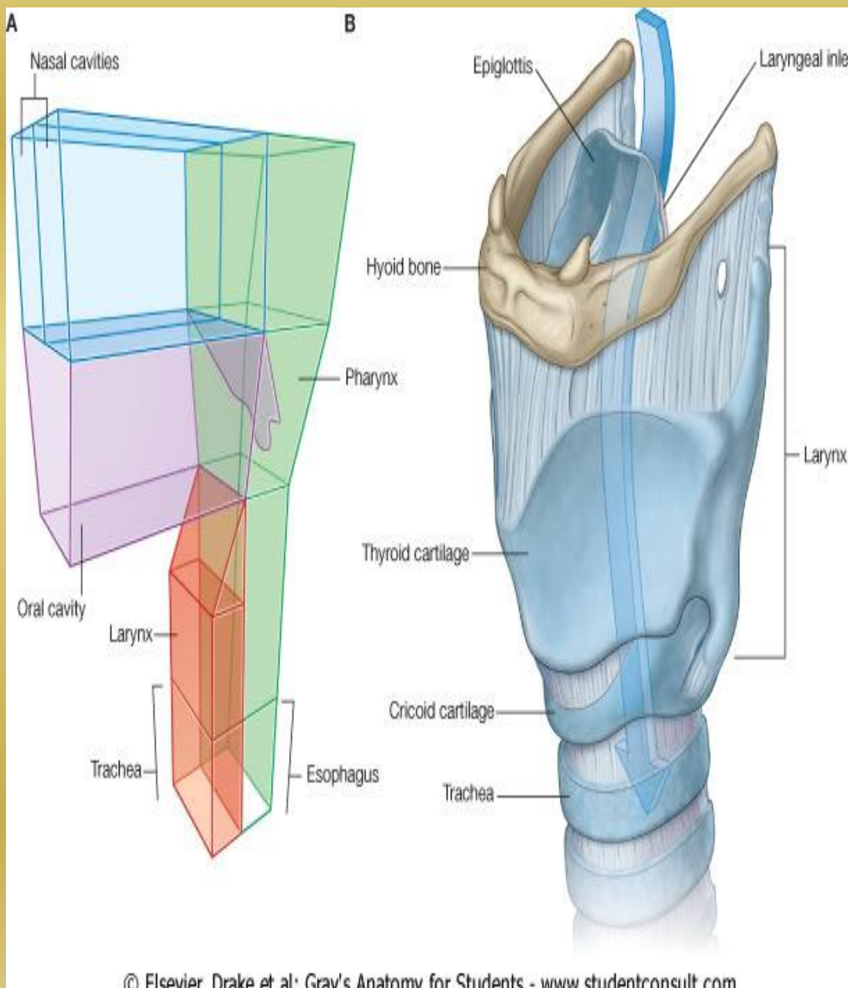
-*Cricoid* (single)

-*Epigllottis* (single)

-*Coneiform*

-*Corniculate*

- **Epiglottis** projects from rim of the larynx extends into the pharynx.
- Below the epiglottis, the mucosa forms 2 pairs of folds that extend into the lumen of the pharynx.


A
Nasal cavities
Oral cavity
Larynx
Trachea
Pharynx
Esophagus
B
Epiglottis
Laryngeal inlet
Hyoid bone
Larynx
Thyroid cartilage
Cricoid cartilage
Trachea
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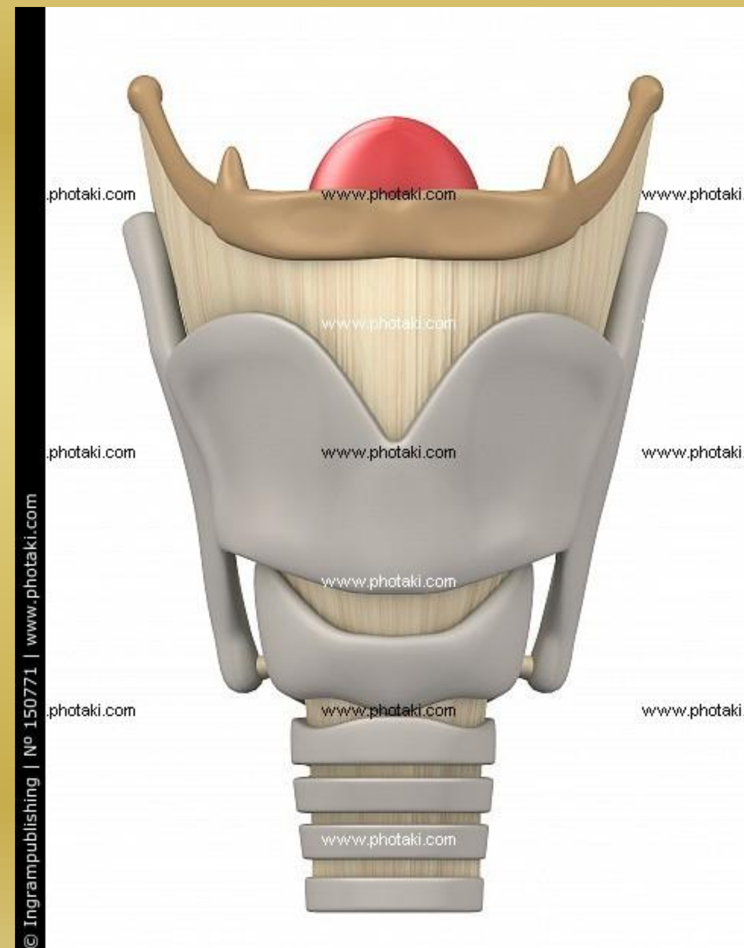
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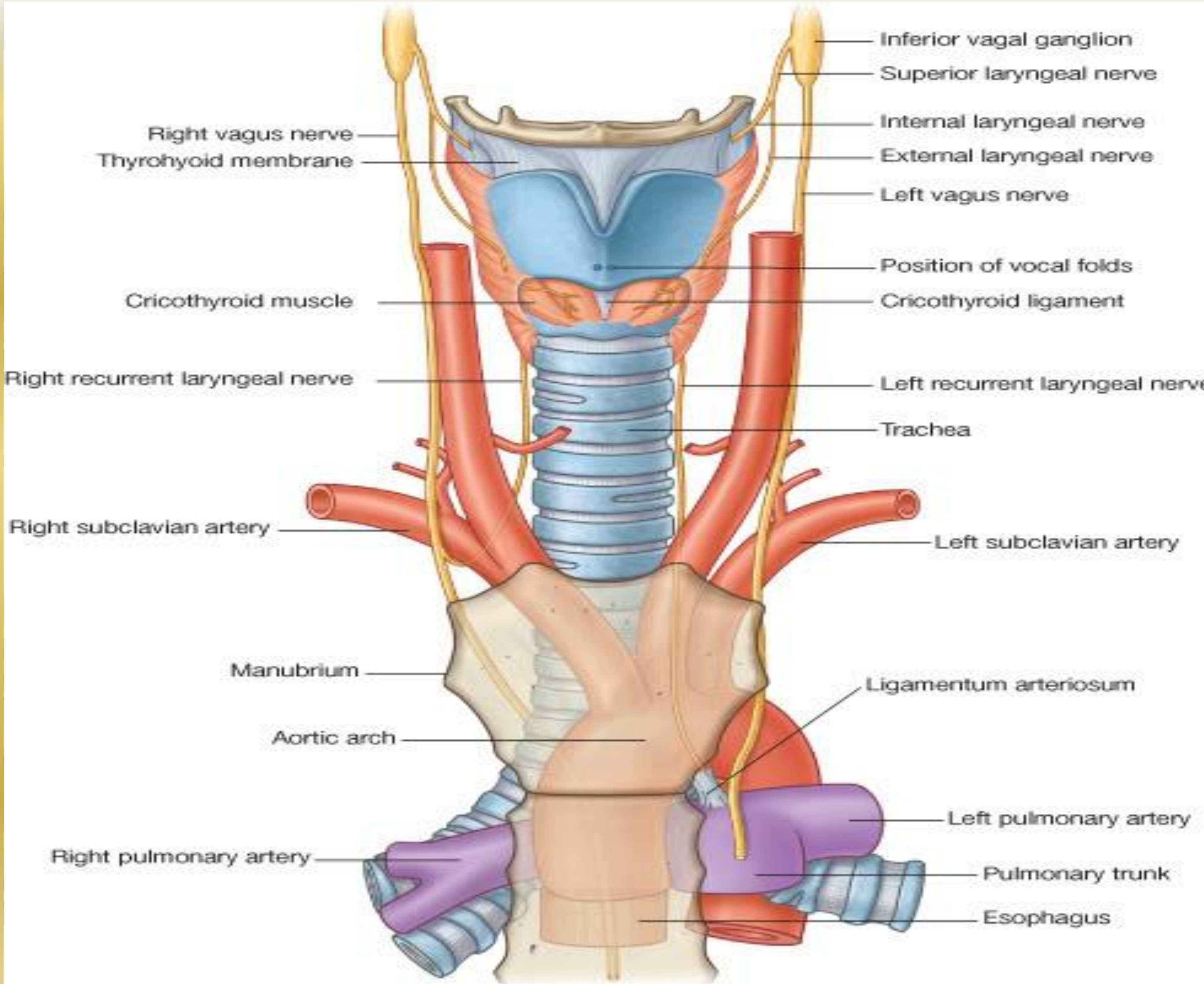
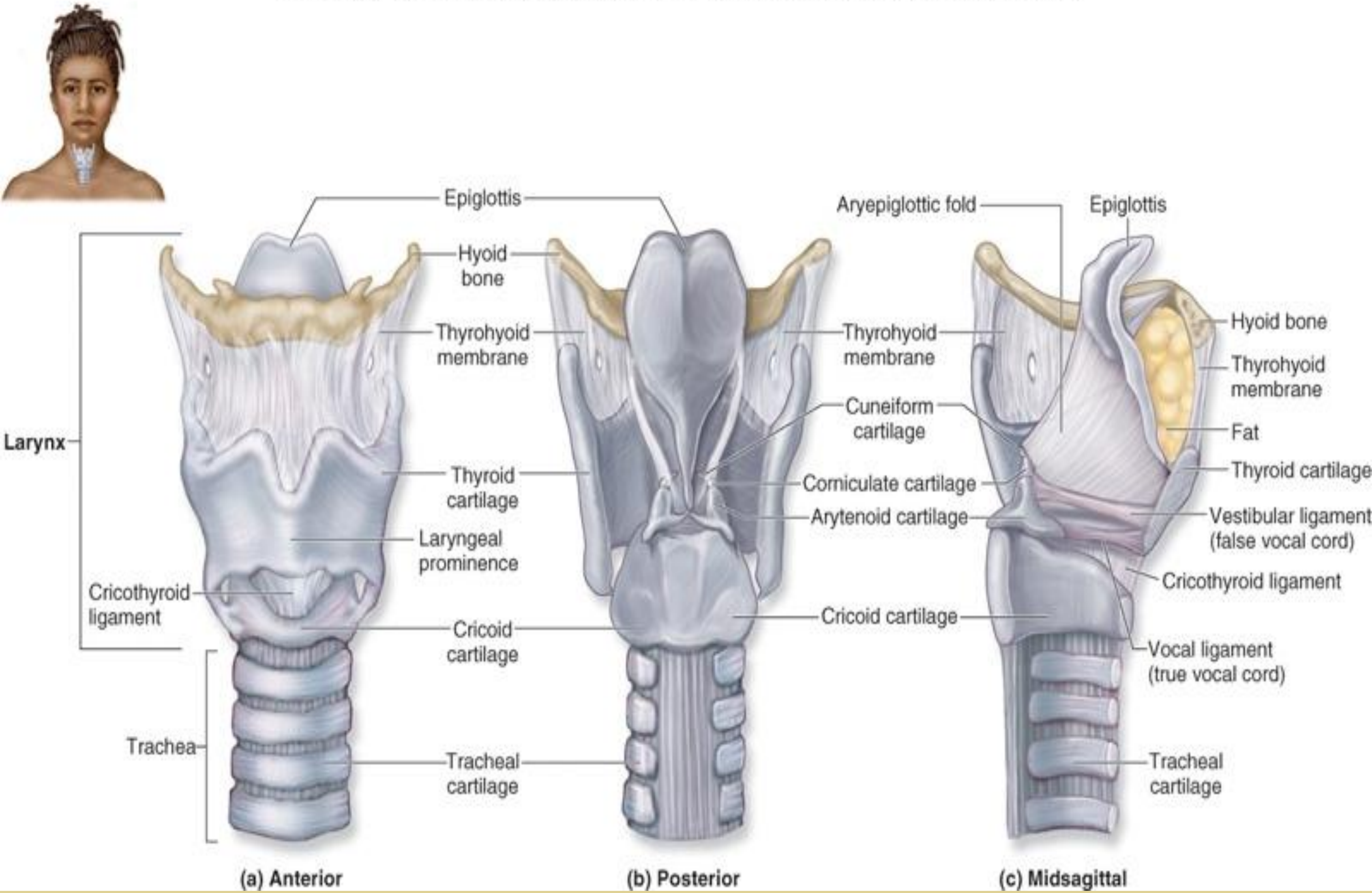

Inferior vagal ganglion
Superior laryngeal nerve
Internal laryngeal nerve
External laryngeal nerve
Left vagus nerve
Right vagus nerve
Thyrohyoid membrane
Position of vocal folds
Cricothyroid muscle
Cricothyroid ligament
Right recurrent laryngeal nerve
Left recurrent laryngeal nerve
Trachea
Right subclavian artery
Left subclavian artery
Manubrium
Ligamentum arteriosum
Aortic arch
Left pulmonary artery
Right pulmonary artery
Pulmonary trunk
Esophagus



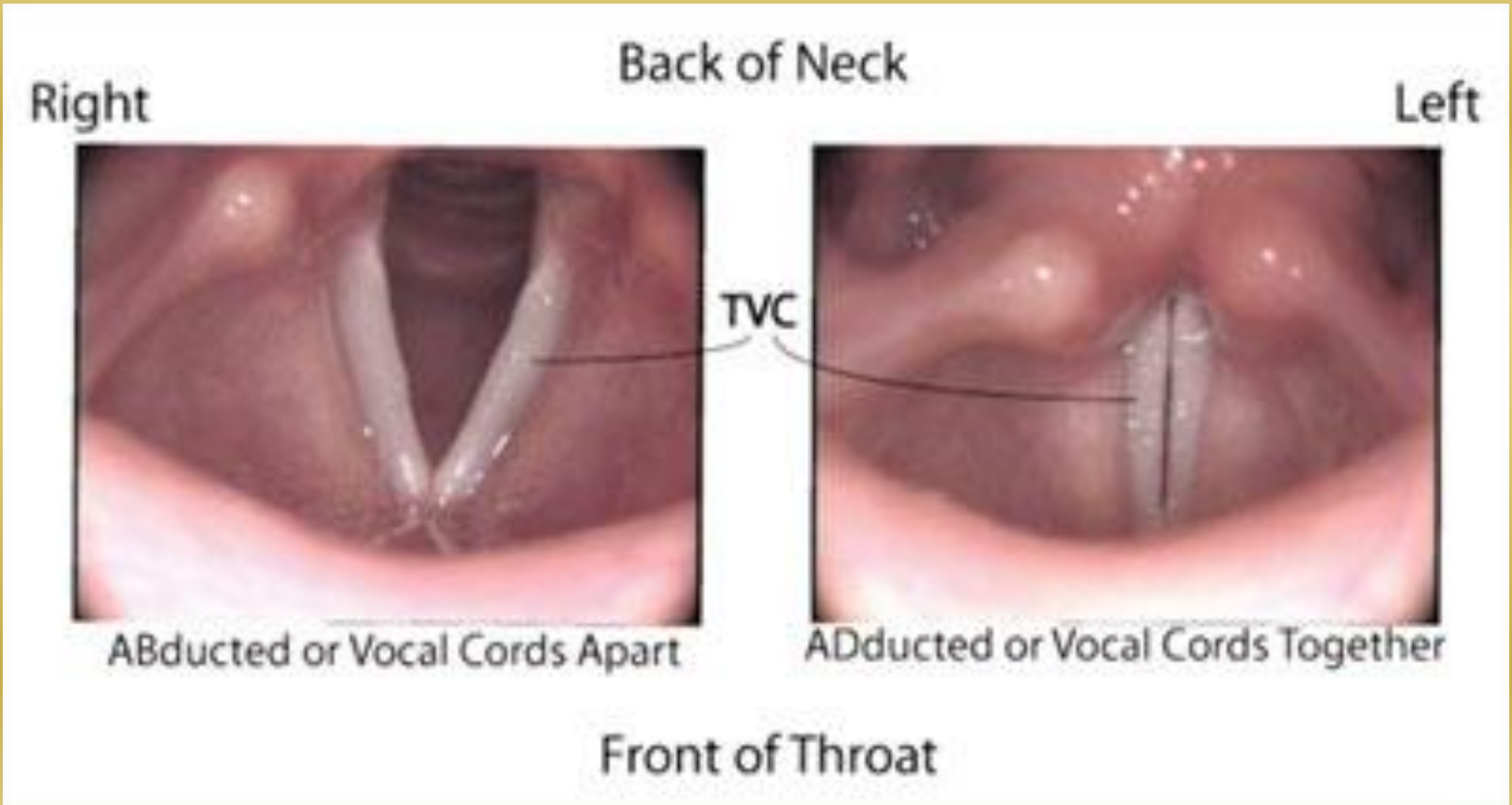
Larynx
Epiglottis
Hyoid bone
Thyrohyoid membrane
Thyroid cartilage
Laryngeal prominence
Cricothyroid ligament
Cricoid cartilage
Trachea
Tracheal cartilage
Thyrohyoid membrane
Cuneiform cartilage
Corniculate cartilage
Arytenoid cartilage
Cricoid cartilage
Aryepiglottic fold
Epiglottis
Hyoid bone
Thyrohyoid membrane
Fat
Thyroid cartilage
Vestibular ligament (false vocal cord)
Cricothyroid ligament
Vocal ligament (true vocal cord)
Tracheal cartilage
(a) Anterior
(b) Posterior
(c) Midsagittal

Functions of larynx

- Produce sound because it contains the vocal cords.
- Prevent food from entering the trachea.
- It passes air to the trachea.

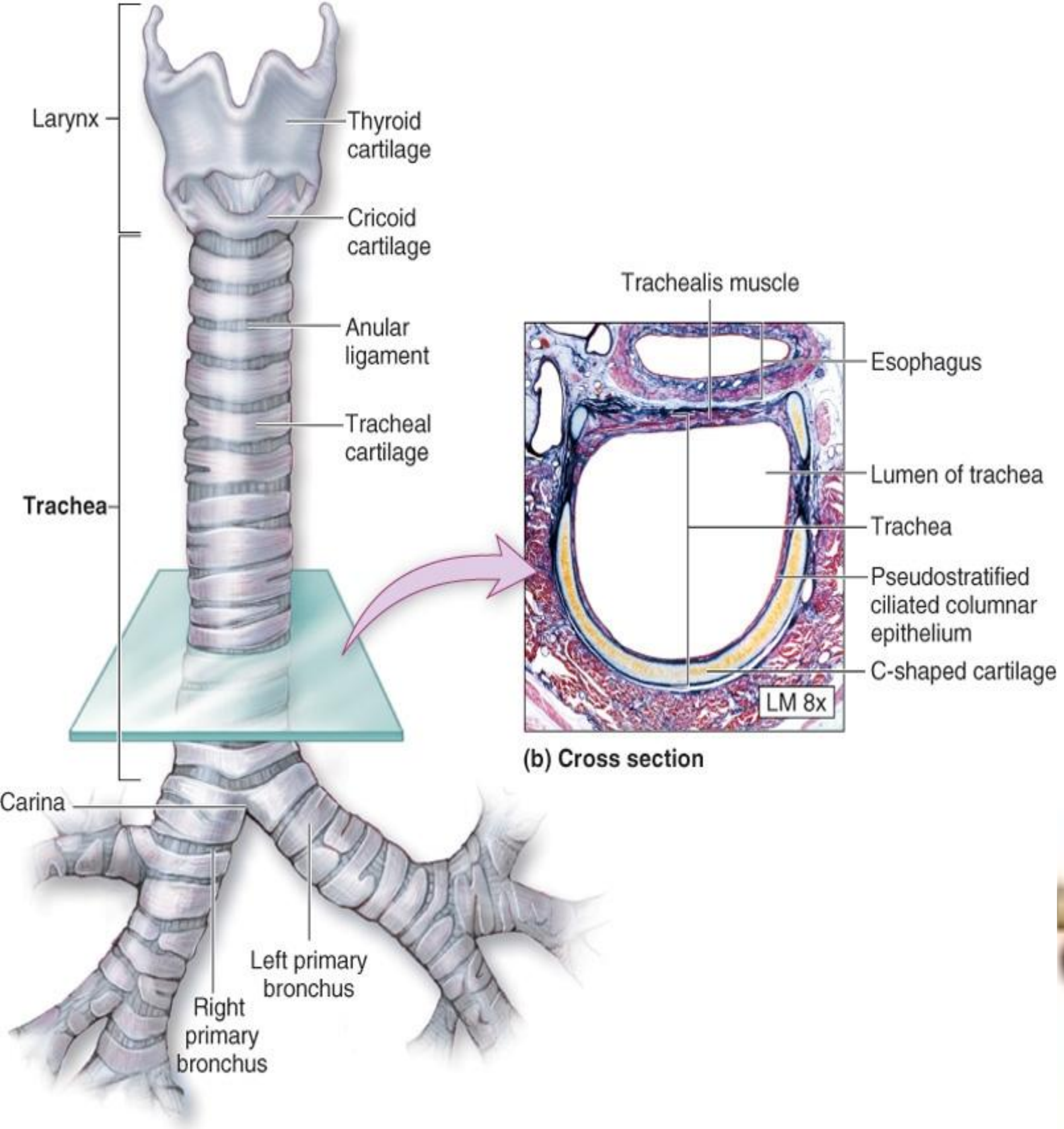
Vocal cords

- Vocal cords are folds of tissue, there are two types of vocal cords, true vocal cords and false vocal cords.
- True vocal cords make sound but false vocal cords don’t make sound.


Back of Neck
Right
Left
TVC
ABducted or Vocal Cords Apart
ADducted or Vocal Cords Together
Front of Throat

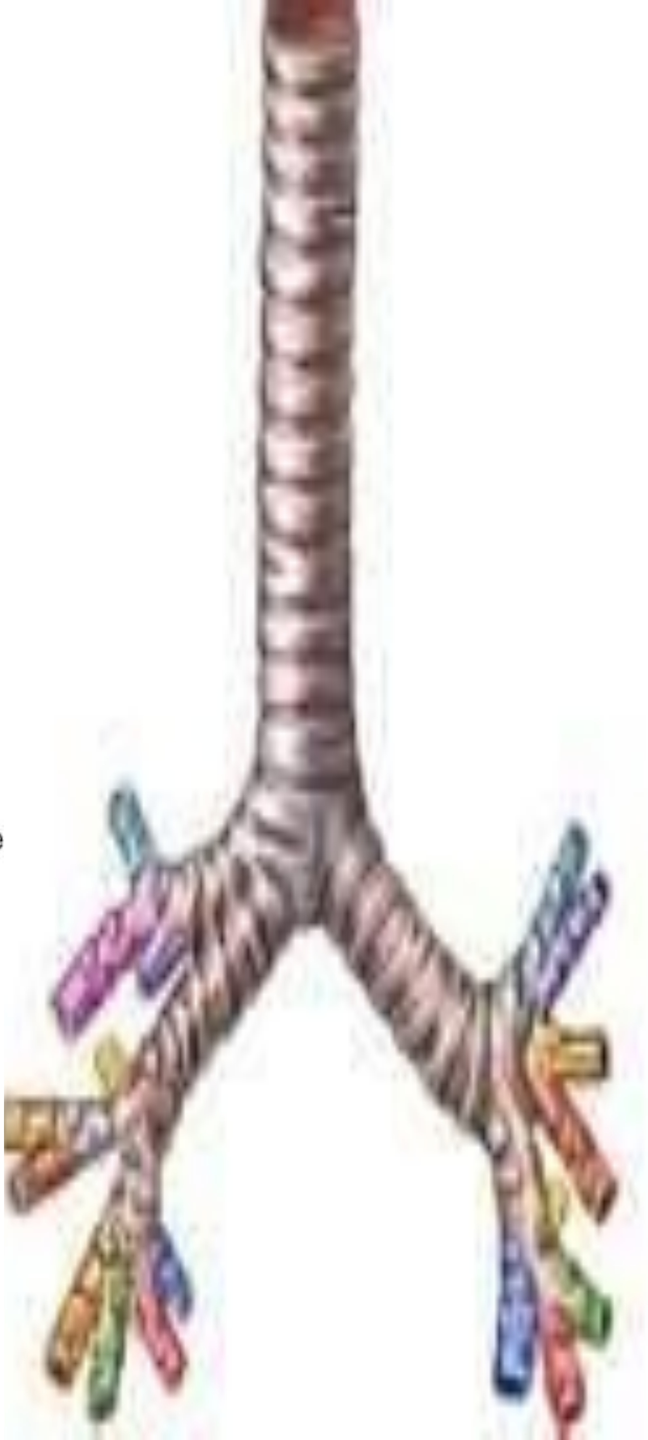
Trachea

- The trachea (windpipe) is lined with a typical ***respiratory mucosa***.
- In the lamina propria are (16-20) *C-shaped rings cartilage* that keep the tracheal lumen open and numerous *seromucous glands* that produce a more fluid mucus.



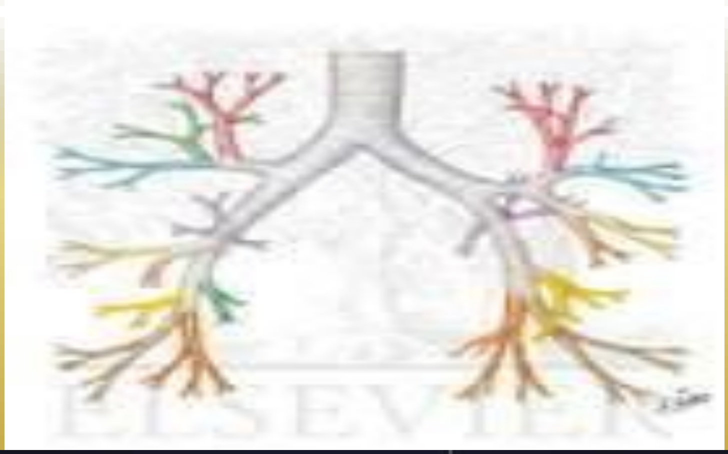
(b) Cross section

(a) Anterior view



Bronchial Tree

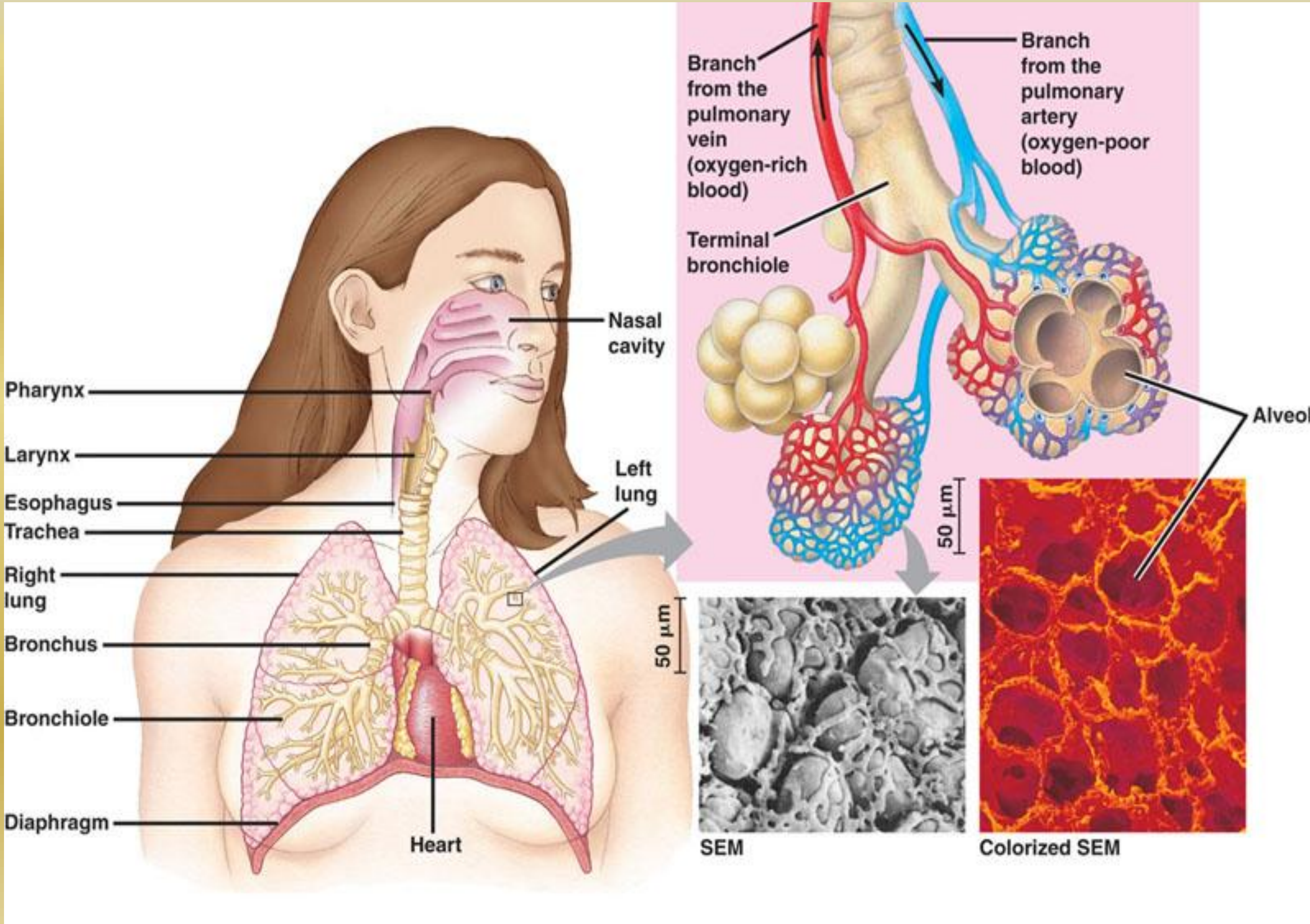
- The trachea divided into *two primary bronchi* that enter the lungs at the hilum.
- At each hilum, arteries are enter and veins and lymphatic vessels leave.
- After entering the lungs the *bronchi giving rise to 3 bronchi in the right lung, and 2 bronchi in the left lung each of which supplies a pulmonary lobe*.
- These lobe bronchi divide repeatedly giving rise to smaller bronchi
- The terminal branches are called bronchioles.
- Each bronchiole branches to form 5-7 terminal bronchioles.

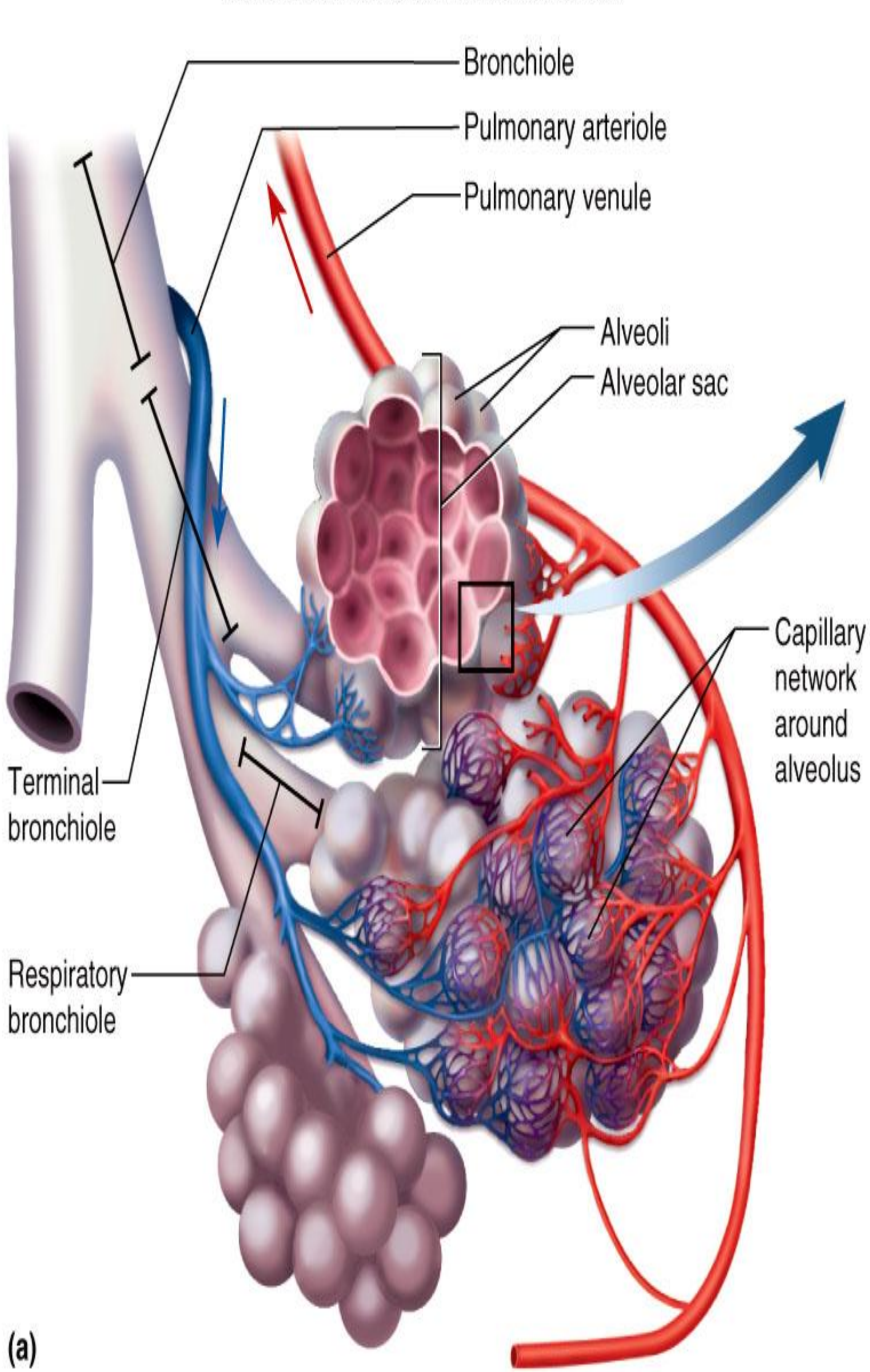


- **Bronchi** are lined with respiratory mucosa. And the walls contain cartilage and smooth muscle.
- **Bronchioles** is composed largely smooth muscle and elastic fibers and there is no cartilage.
- **Terminal bronchioles** subdivides into 2 or more **respiratory bronchioles.**

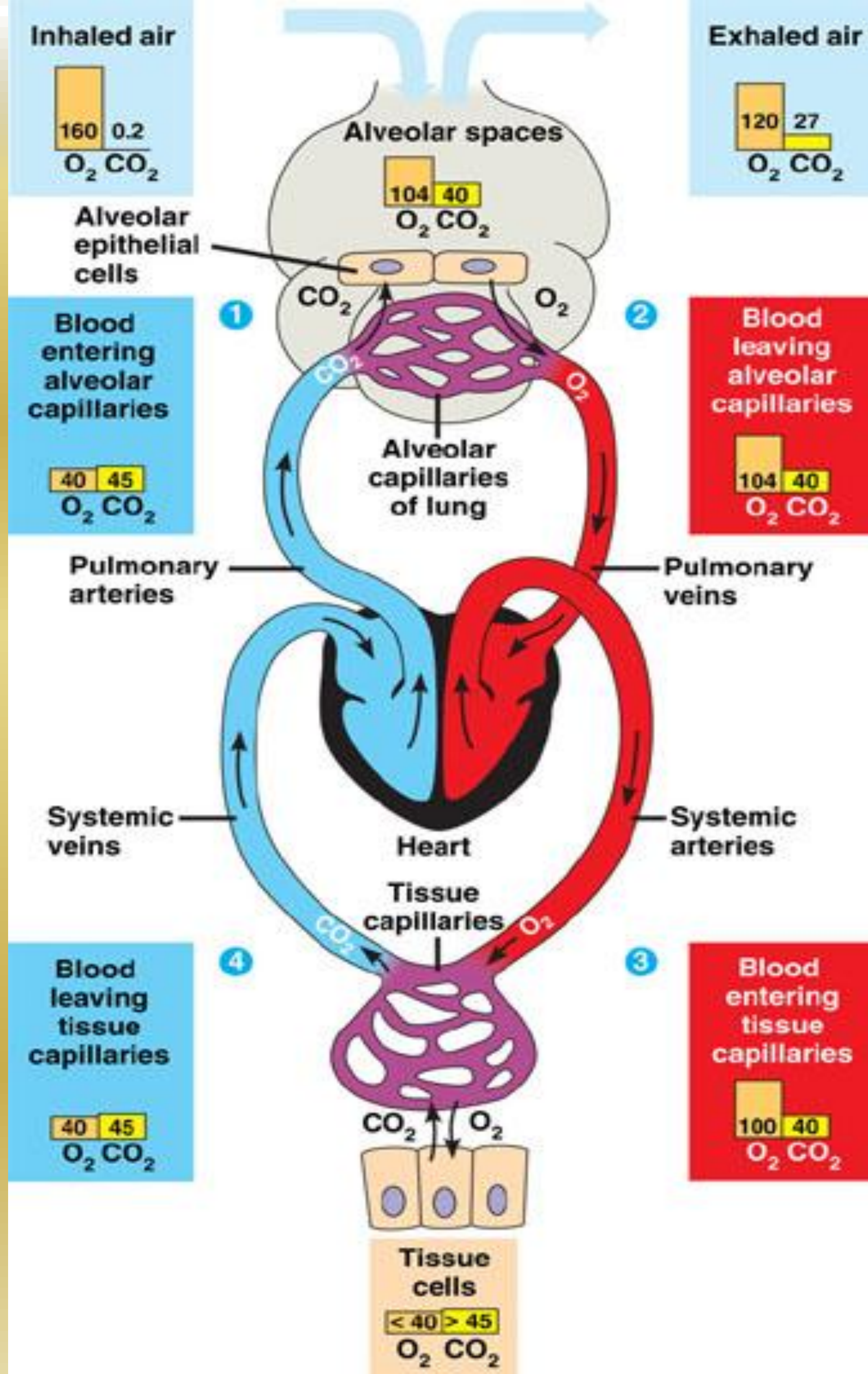
- **Alveolar ducts** and **then alveoli.**
- Both alveolar ducts and alveoli are lined by squamous epithelial cells and have elastic and reticular fibers within lamina properia of their walls.

-**Alveoli** are specialized sac like structures that make up the greater part of the lungs.
- Alveoli are the main sites for the principle function of the lungs (the exchange of O2 and CO2 between inspired air and blood).


Branch from the pulmonary vein (oxygen-rich blood)
Branch from the pulmonary artery (oxygen-poor blood)
Terminal bronchiole
Nasal cavity
Pharynx
Larynx
Esophagus
Trachea
Right lung
Left lung
Bronchus
Bronchiole
Diaphragm
Heart
Alveoli
50 µm
50 µm
SEM
Colorized SEM



Bronchiole
Pulmonary arteriole
Pulmonary venule
Alveoli
Alveolar sac
Capillary network around alveolus
Terminal bronchiole
Respiratory bronchiole
(a)

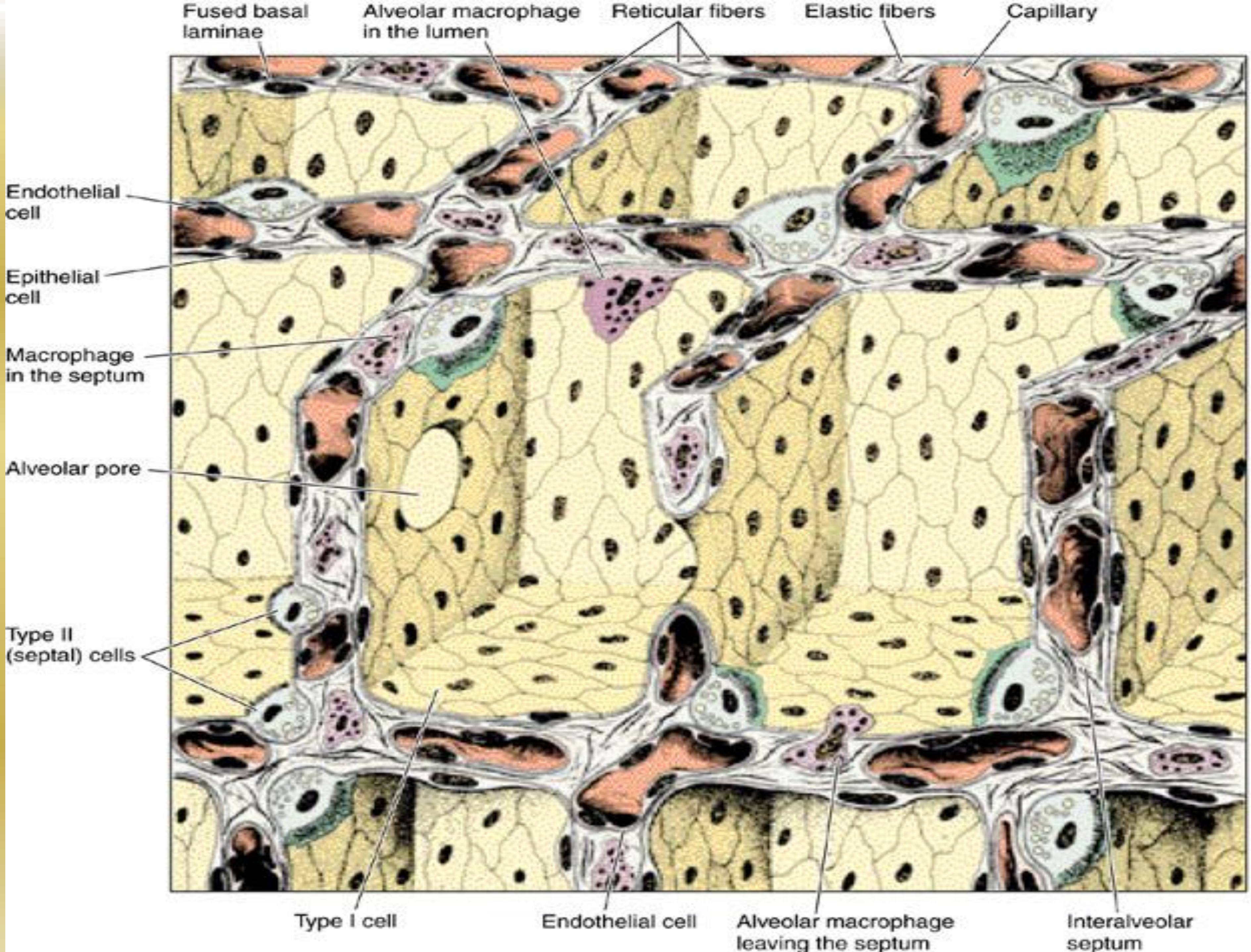


Inhaled air
160 0.2
O_2 CO_2
Exhaled air
120 27
O_2 CO_2
Alveolar spaces
104 40
O_2 CO_2
Alveolar epithelial cells
CO_2
O_2
1
Blood entering alveolar capillaries
40 45
O_2 CO_2
2
Blood leaving alveolar capillaries
104 40
O_2 CO_2
Alveolar capillaries of lung
Pulmonary arteries
Pulmonary veins
Systemic veins
Heart
Systemic arteries
Tissue capillaries
4
Blood leaving tissue capillaries
40 45
O_2 CO_2
3
Blood entering tissue capillaries
100 40
O_2 CO_2
CO_2
O_2
Tissue cells
< 40 > 45
O_2 CO_2

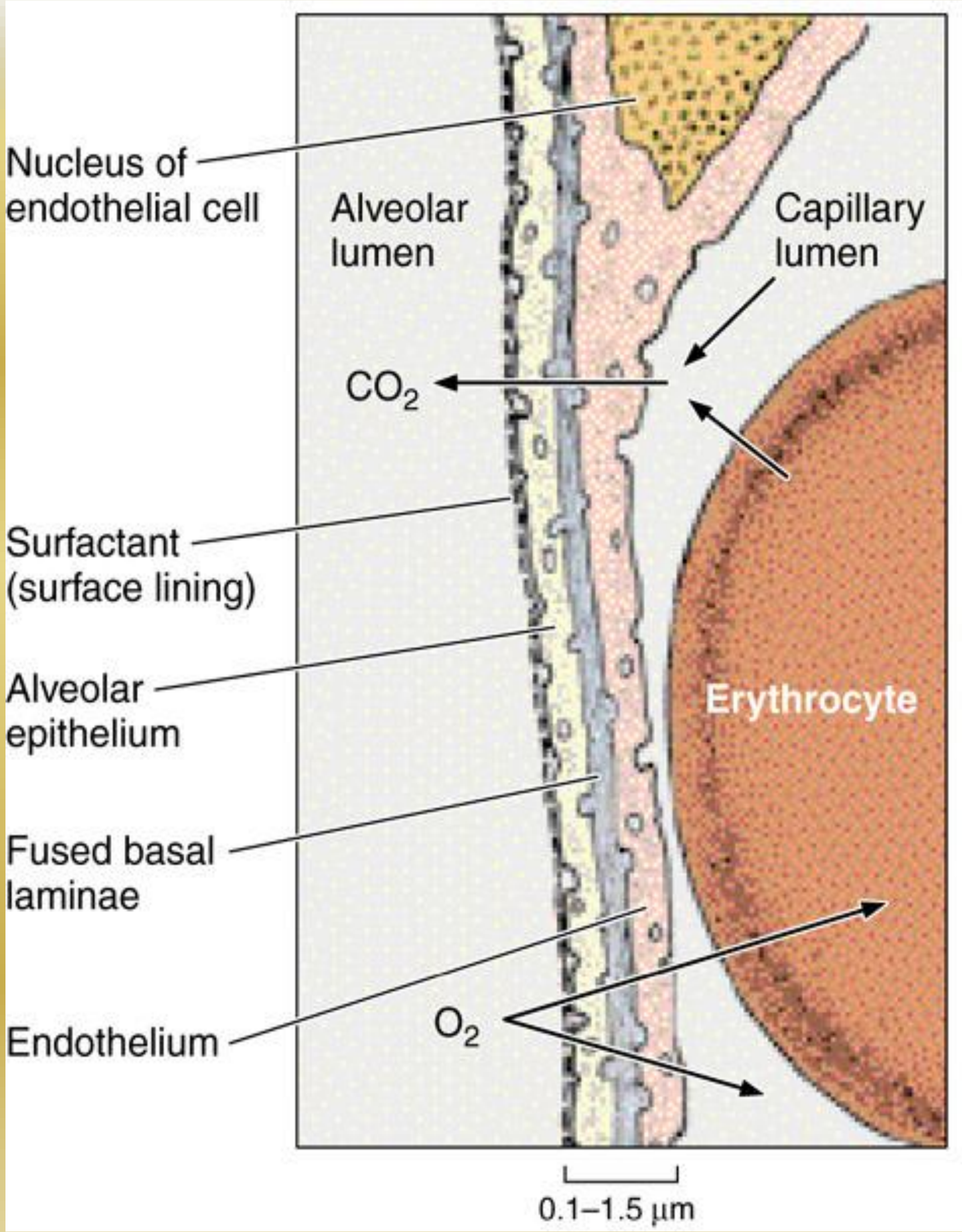
Respiratory membrane

- Thin wall between the inhalator gases within the alveolar lumen and blood capillaries consists of:

- Alveolar epithelium (squamous cell).
- Endothelial cells of capillaries.
- Fused basement membrane.


Fused basal laminae
Alveolar macrophage in the lumen
Reticular fibers
Elastic fibers
Capillary
Endothelial cell
Epithelial cell
Macrophage in the septum
Alveolar pore
Type II (septal) cells
Type I cell
Endothelial cell
Alveolar macrophage leaving the septum
Interalveolar septum

Portion of the interalveolar septum showing the blood-air barrier. To reach the erythrocyte, O2 traverses the surface lining, the alveolar epithelium cytoplasm, and the plasma. In some locations, there is loose interstitial tissue between the epithelium and the endothelium.



Lungs and pleural membrane

- **Right lung** has three lobs:

- Superior
- Middle lobe
- Inferior lobe

- **Left lung** has two lobs:

- Superior lobe
- Inferior lobe

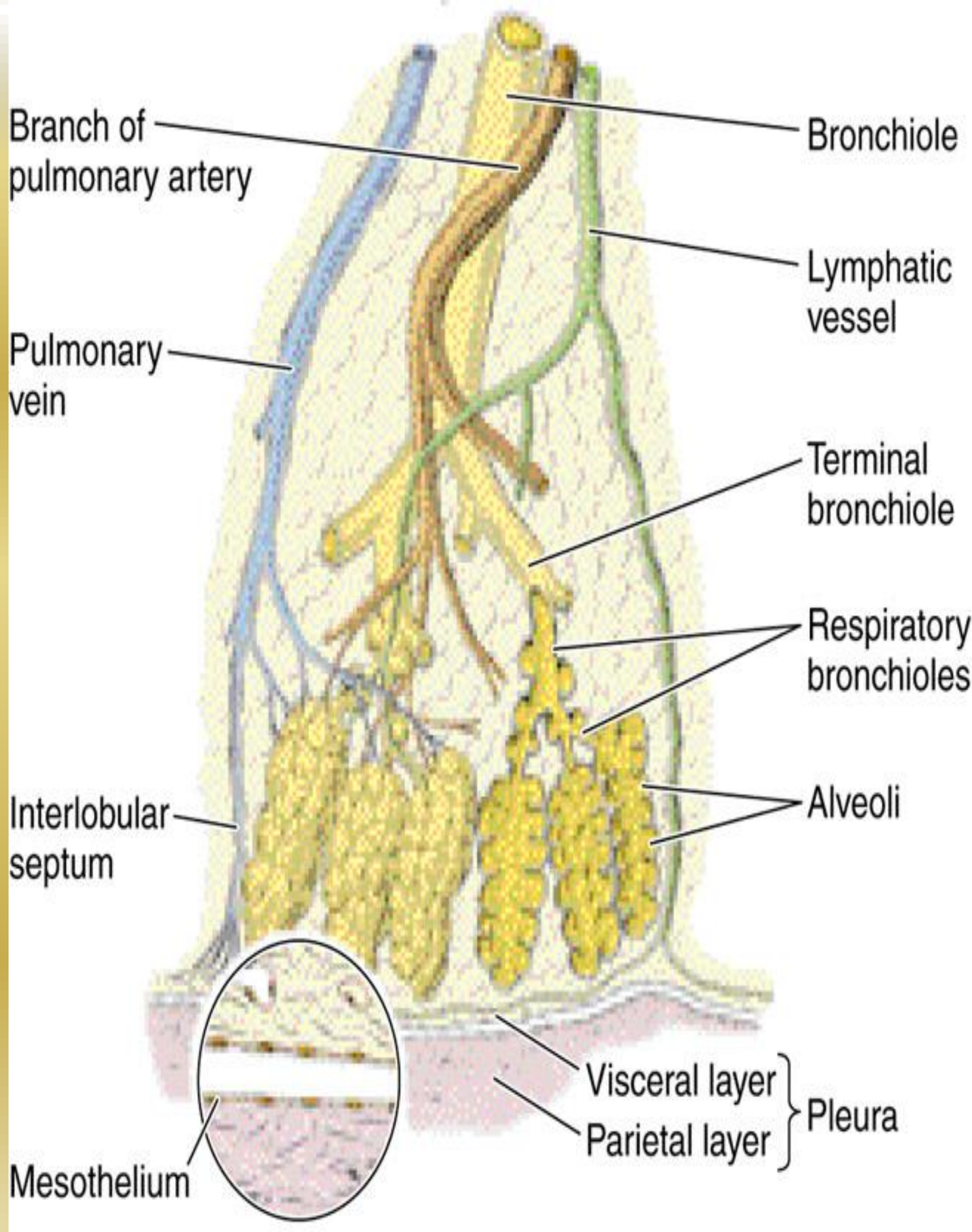
pleura

- Is the serous membrane covering the lungs.
- It consists of two layers:

  - ***Parietal layer***

  - ***Visceral layer***
- Both layers are composed of *mesothelial cells resting on a fine connective tissue layer that contains collagen and elastic fibers.*
- The space between parietal pleura and visceral pleura is called pleural cavity.
- **Pleural cavity** contains only a *small amount of liquid that act a lubricant, facilitating the smooth sliding of one surface over the other during respiratory movements.*

Blood and lymph circulation in a pulmonary lobule. Both vessels and bronchi are enlarged out of proportion in this drawing. In the interlobular septum, only one vein (on the left) and one lymphatic vessel (on the right) are shown, although both actually coexist in both regions. At the lower left, an enlargement of the pleura shows its mesothelial lining.



- The respiratory system exposes to a large number of insults like infectious agents and non infectious agents.
- Therefore respiratory system has defense mechanisms represented by:
  - abundant lymphoid tissues.
  - alveolar macrophage
  - mucous secretion and cilia in the respiratory epithelium.
  - cough reflex

Respiratory Cycle

1. Inspiration in which air is taken into the lungs.

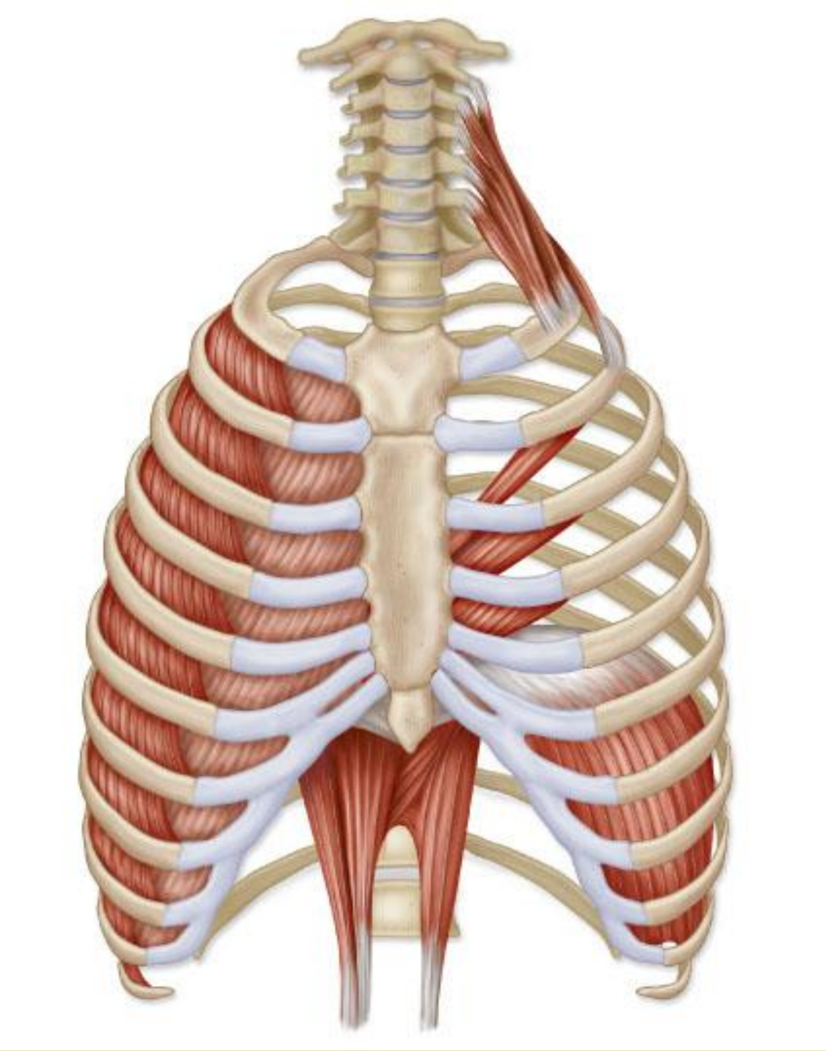
2. Expiration in which air is breath out.

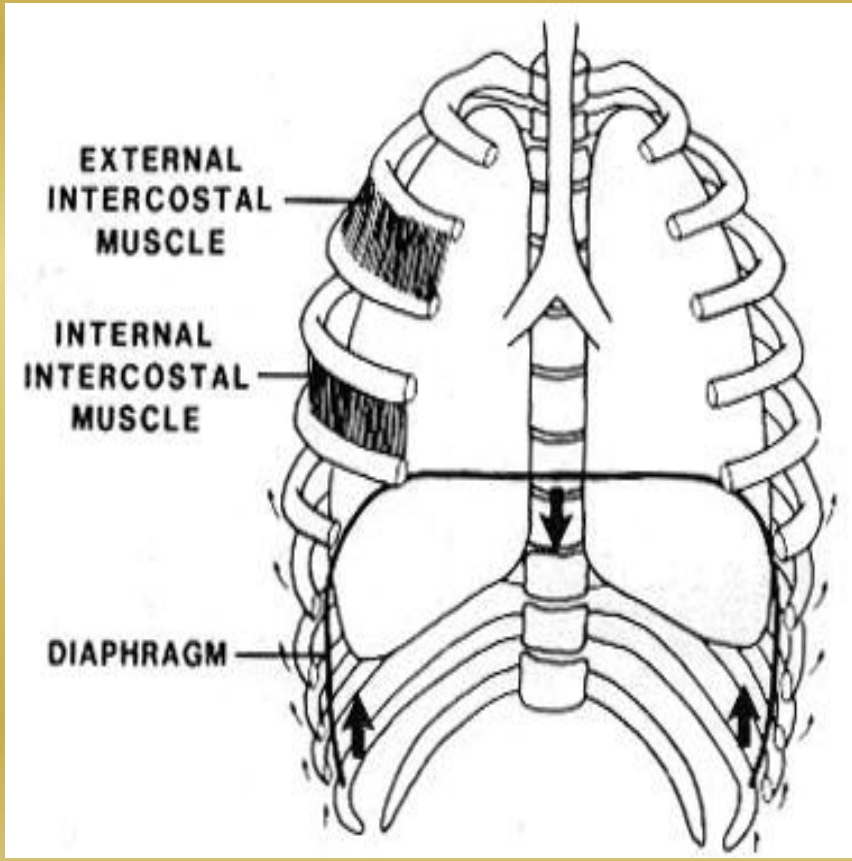
3. A short pause before the next inspiration.

Respiratory movements (mechanism of respiration)

- **Muscles of Respiration**

1. Diaphragm
2. Intercostal muscles (mainly external intercostal muscles and also internal intercostal muscles).
3. Neck muscles
4. Abdominal muscles



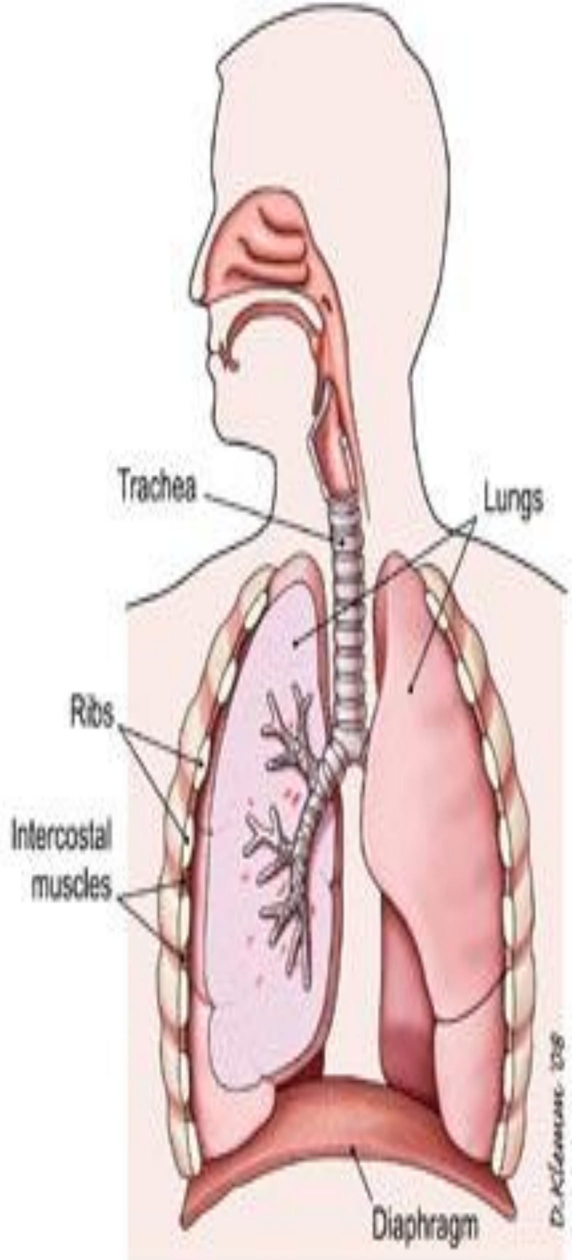

EXTERNAL
INTERCOSTAL
MUSCLE
INTERNAL
INTERCOSTAL
MUSCLE
DIAPHRAGM

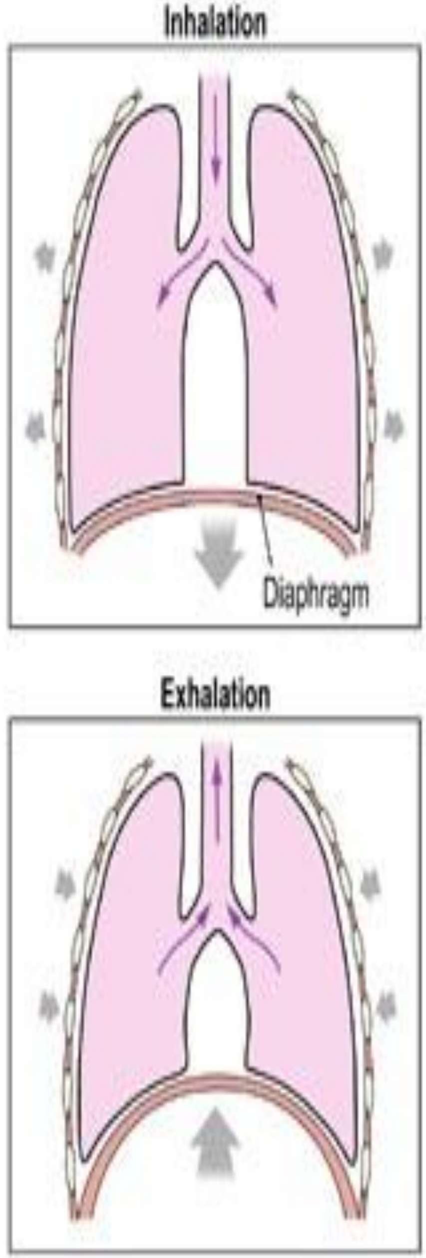
- **Inspiration**

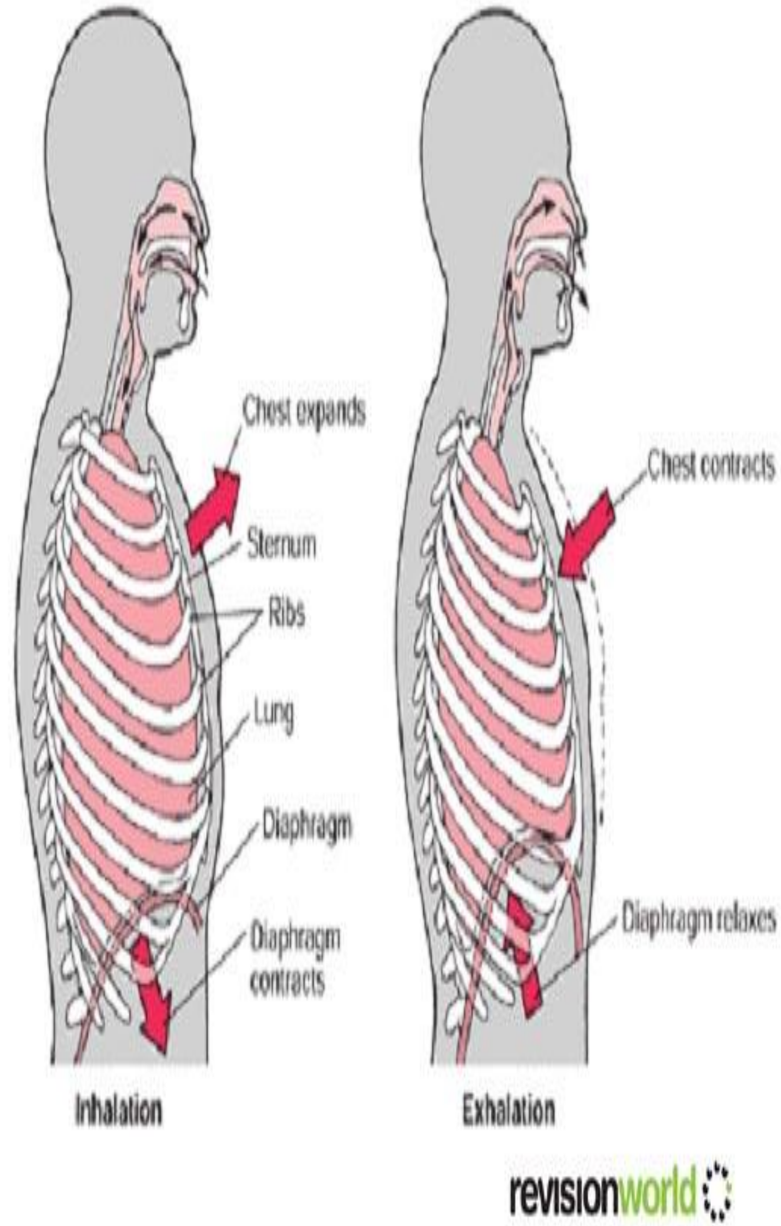
- During inspiration brain stem sends a massage to diaphragm to contract (so it moves dawn) and also external intercostal muscles contract.

- Contraction of diaphragm and external intercostal muscles lead to increase space of thoracic cavity and decrease pressure in the pulmonary cavity.

- Decrease pressure in pulmonary cavity leads lungs to expand that cause the air moves from atmosphere to the lungs.


Trachea
Lungs
Ribs
Intercostal muscles
Diaphragm
D.Klemme '08


Inhalation
Diaphragm
Exhalation

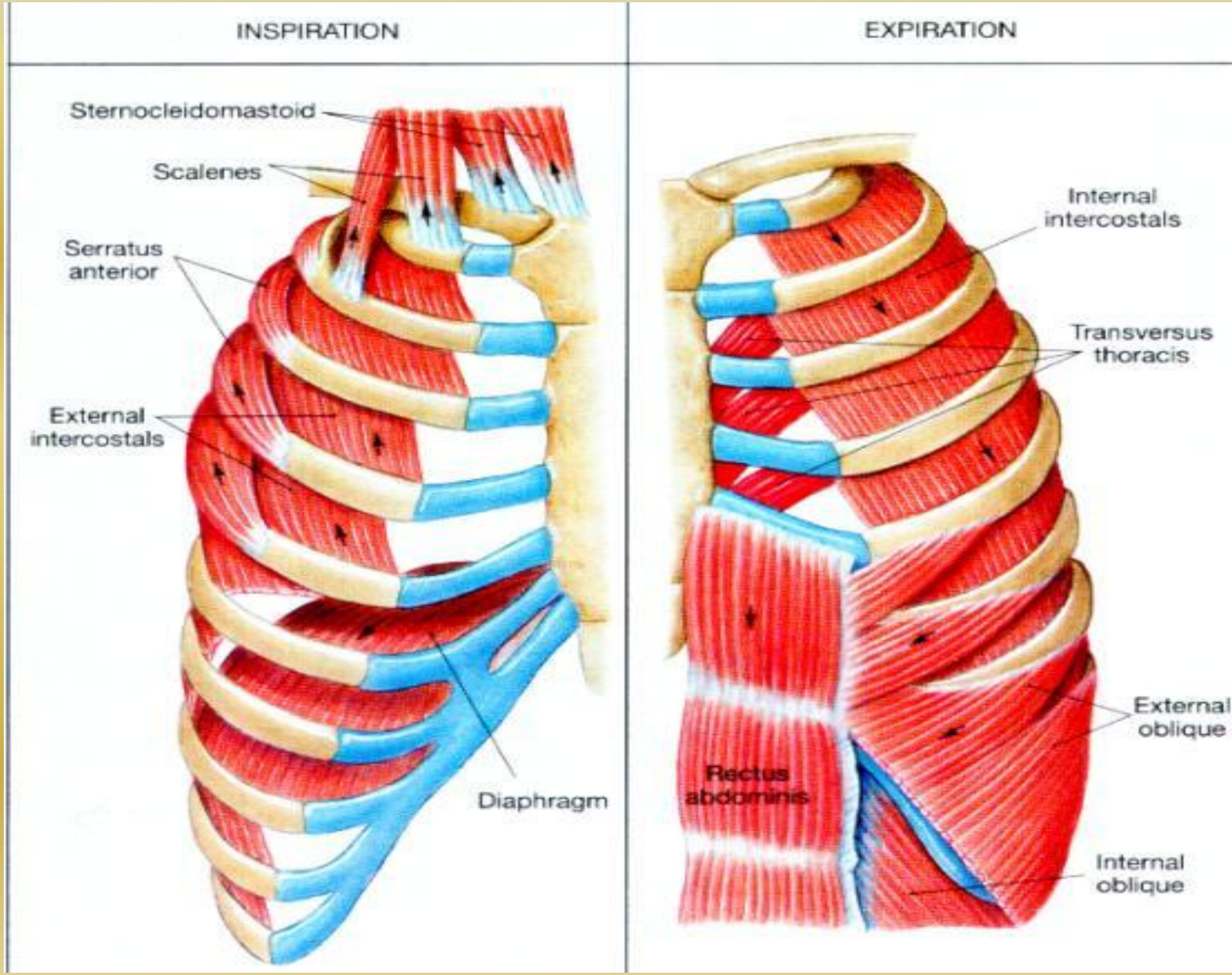

Chest expands
Sternum
Ribs
Lung
Diaphragm
Diaphragm contracts
Chest contracts
Diaphragm relaxes
Inhalation
Exhalation

- **Expiration**

- When the diaphragm and intercostal muscles relax the abdominal cavity push against thoracic cavity. That leads to increase pulmonary pressure.
- Increase pulmonary pressure leads air to leave lungs and get out.

Note: An important factor to prevent pulmonary collapse during expiration is the presence a phospholipid material called surfactant.

- Surfactant is a liquid material secreted by alveolar cells. It acts to decrease surface tension at alveolar level, lubrication and prevent alveolar collaps.


INSPIRATION
EXPIRATION
Sternocleidomastoid
Scalenes
Serratus
anterior
External
intercostals
Diaphragm
Internal
intercostals
Transversus
thoracis
External
oblique
Rectus
abdominis
Internal
oblique

Internal and external respiration

- External respiration: the exchange of gases between air in alveoli of the lungs and blood is called external respiration.

- Internal respiration: exchange of gases between blood and body cells is called internal respiration.

Transport of blood gases

- To understand how transport O_2 between blood and body cells we should know the following:

1. The atmosphere is a mixture of gases N_2 (79%), O_2 (21%), and CO_2 (0.04%). The pressure exerted by the atmosphere can be measured using barometer. At the sea level it is equal to that of column of 760mm of mercury.
2. Each gas exerts pressure proportional to its own concentration. The partial pressure of O_2in atmosphere in atmospheric air expressed as pO_2 is (2/100) x 760 = 160 mmHg.

Composition of atmosphere air and alveolar air

	pO_2	pCO_2	pN_2	pH_2O
Atmosphere air	**159**	**0.3**	**597**	**3.7**
Alveolar air	**104**	**40**	**569**	**47**
Expired air	**120**	**27**	**566**	**47**

- The pO_2 of deoxygenated blood circulating in the walls of alveoli is about 40 mmHg. The pO_2 of alveolar air is much higher (104 mmHg). Hence O_2 diffuses easily from alveolar air to blood.
- O_2 combines with hemoglobin to form oxyhemoglobin.
- pO_2 of arterial blood 100mmHg. In contrast pO_2 of tissue fluid is 40 mmHg. Hence oxygen readliy diffuses from blood to tissue.

Steps of Respiration

1. Ventilation: exchange of air between atmosphere and alveoli by *bulk flow*
2. Gas exchange of O_2 and CO_2 between alveolar air and blood (RBC contains Hb which has high affinity for O_2) in lung capillaries by *diffusion.*
3. Gas transport O_2 and CO_2 through pulmonary and systemic circulation by *bulk flow.*
4. Gas exchange of O_2 and CO_2 between blood in the tissue capillaries and cells in the tissue by *diffusion.*
5. Cellular respiration (utilization) of O_2 and production of CO_2.

Factors affecting the affinity of hemoglobin to O2

Hb decreases its affinity to O2

1. Fever
2. pH
3. Accumulation of 2,3 –Diphosphoglycerate (2,3- DPG)

Control of Respiration

- Respiration is controlled by the nervous system.
- in the brain the **respiratory center** presents in the **medulla** and **pons**.

- The respiratory center receives input from **chemoreceptors** (carotid body and aortic body).
- When CO_2 increases in the blood chemoreceptors send impulses to the respiratory center.

- The respiratory center sends impulses that increase the rate and depth of respiration so the CO_2 level returns to the normal.

Lung functions test

- We can assessment lung function by measure the ***pulmonary volume and capacity***, by using spirometry apparutus.
- **Tidal volume** is a volume of inspired or expired air under resting condition (in adult = 500ml.
- **Inspiratory reserve volume** is a volume of air inspired maximally after normal inspiration (3000ml).
- **Expiratory reserve volume** is a volume of air expirated forcelly after normal expiration (1200ml).
- **Residual volume** is a volume of air remains in the lungs after end forced expiration (1200ml).
- **Inspiratory capacity** is a maximum amount of air that can be inhaled after normal tidal expiration (tidal volume + inspiratory reserve)(3500ml).

- **Functional residual capacity** amount of air rmaining in the lungs after a normal tidal expiration (Residual volume + expiratory reserve volume) (2400ml).
- **Total lung capacity** is a maximum amount of air the lungs can contain (5900ml).

- **Pulmonary ventilation (volume/minute) =**

  Tidal volume X Respiratory rate

Respiratory Volumes and Capacities