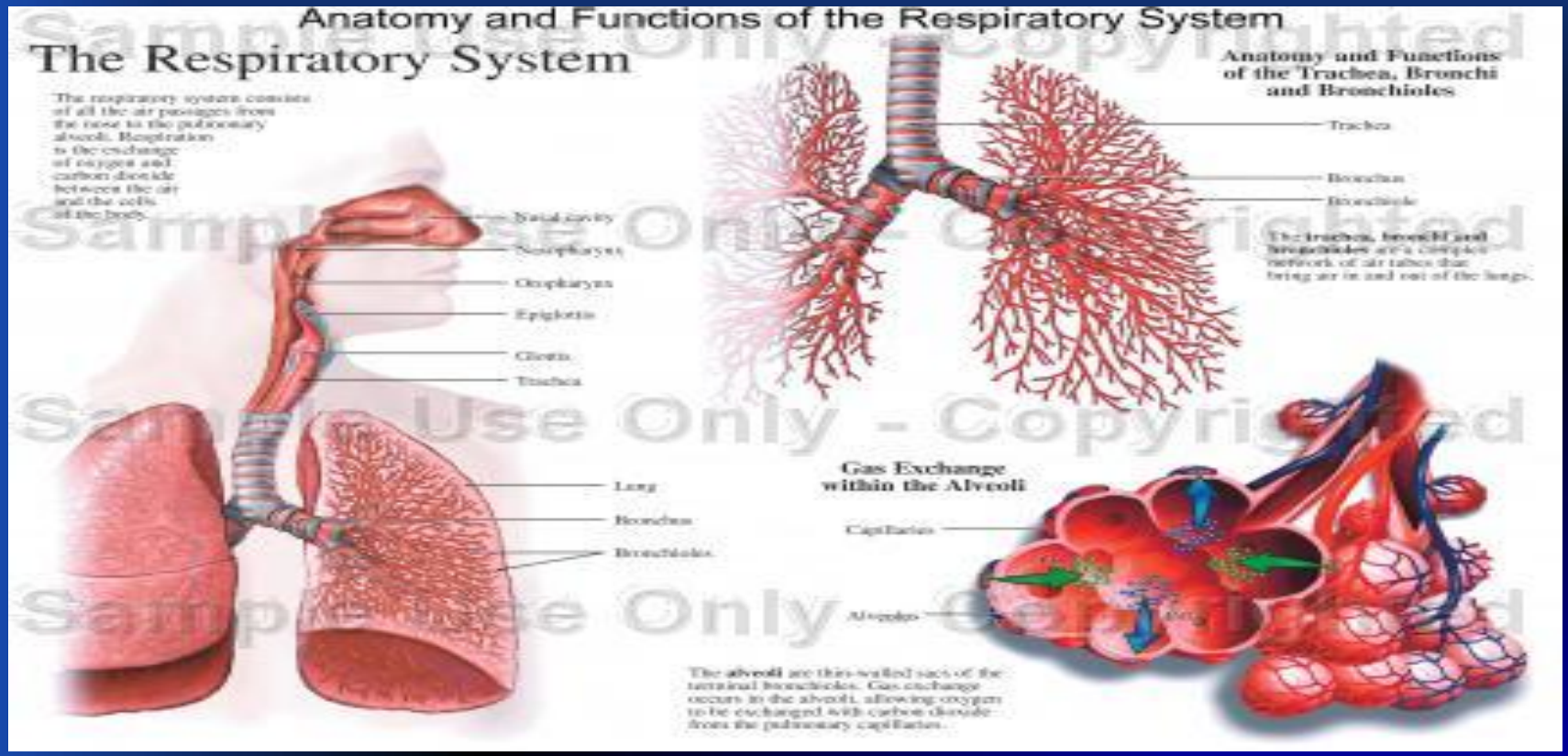
Respiratory Physiology



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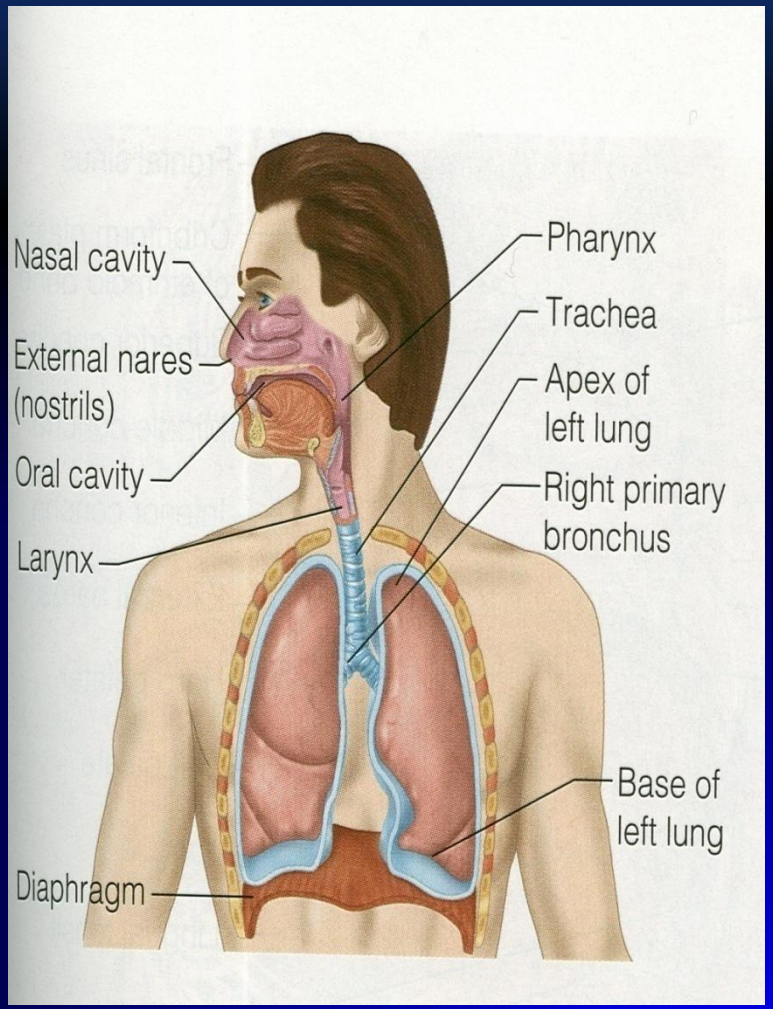
The main goal of respiration is to

1-provide oxygen to tissues

2- remove CO_2

Respiratory System consists of :-

- passages (airways)
- muscles
- centers



Functions and organization of the respiratory system

Learning Objectives

- **By the end of this lecture you will be able to:-**
- 1- Describe the structures and functions of the conductive and respiratory zones of airways.
- 2- Understand the difference between internal and external respiration.
- 3- Understand the functions of the respiratory system, including non- respiratory functions, like clearance mechanism by mucus and cilia, production of surfactant and its physiological significance.

Functions of the respiratory system include

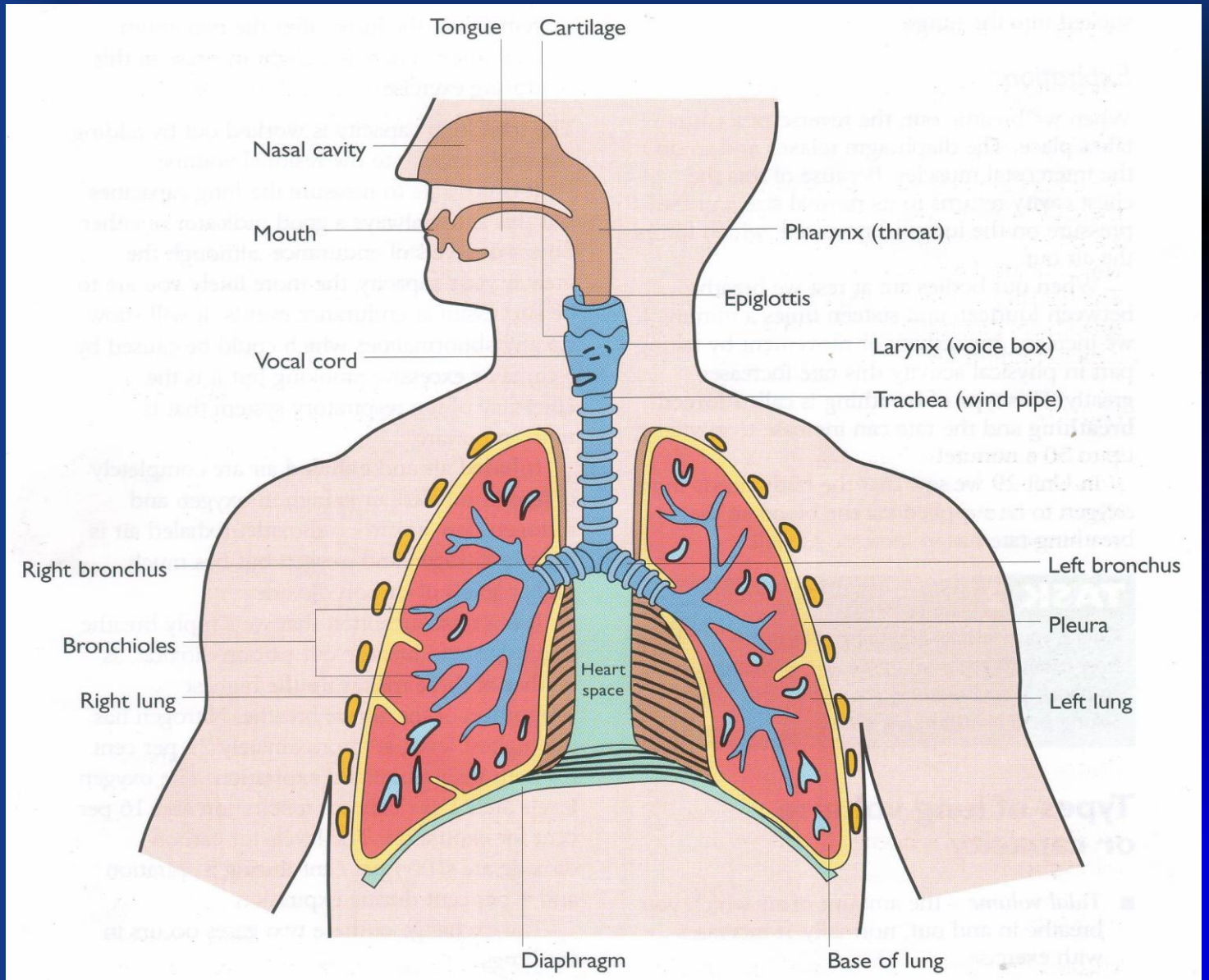
- Gas exchange (respiratory function),
- Phonation: is the production of sounds by the movement of air through the vocal cords.
- Pulmonary defense

- *Immunoglobulin A (IgA*) ,
- Alpha-1 antitrypsin
- *The pulmonary macrophages in the alveoli: engulf* smaller particles which pass through the muco-cilliary barrier filter.

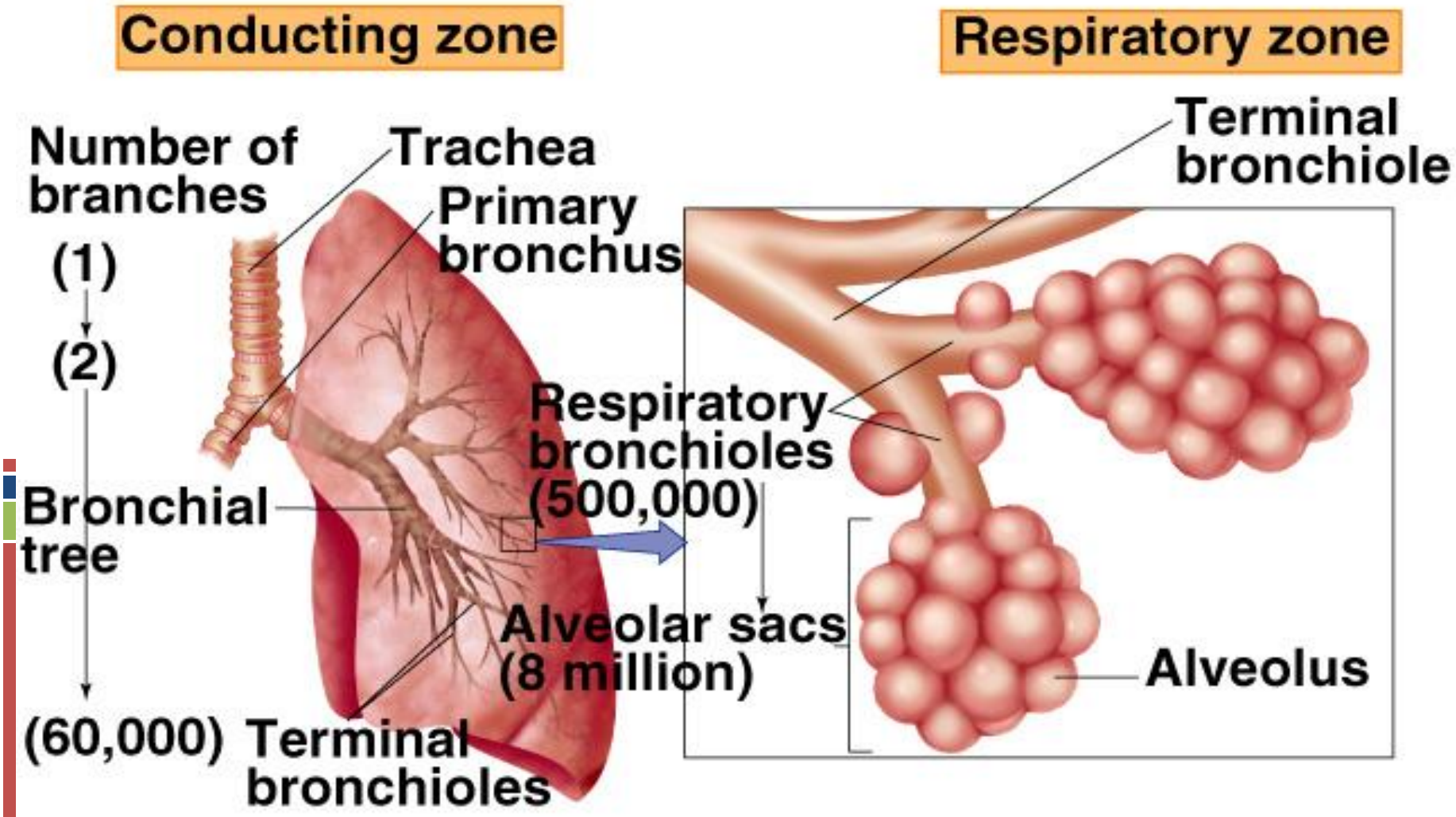
Cont..non respiratory functions of lung

- -Angiotensin I is converted to angiotensin II with the help of converting enzymes formed by the lungs
- Regulating the acid- base status of the body by washing out extra carbon dioxide from the blood.
- Secretion of important substances like surfactant .

Respiratory passages (airways)



Cont…Respiratory passages airways) can be divided into



I-Conducting Zone

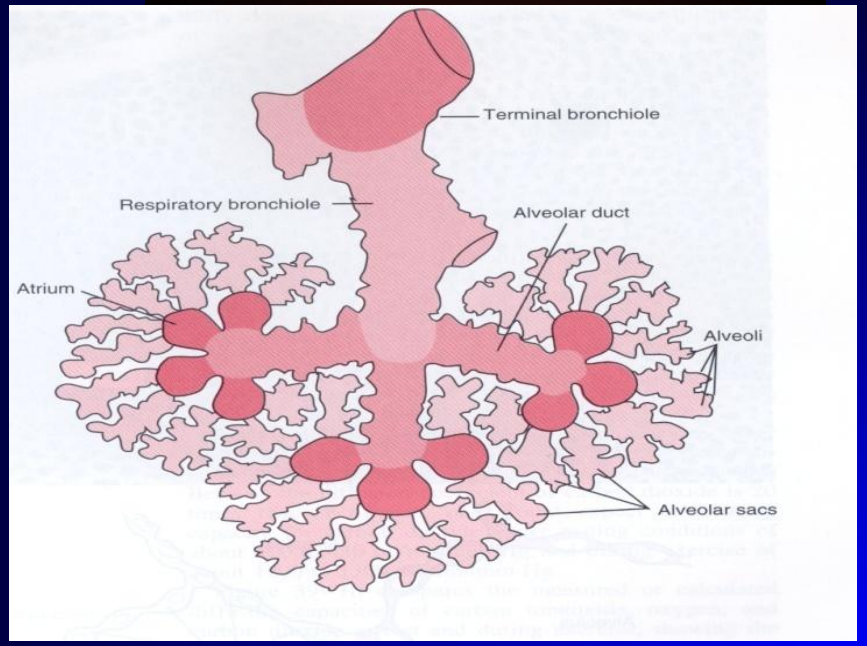
- All the structures air passes through before reaching the respiratory zone.
- Includes nose-nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles, terminal bronchioles.
- brings fresh air to the deeper part of the lungs.
- **help *warming - humidification - filtration* of inspired air**

II- Respiratory Zone (Respiratory unit)

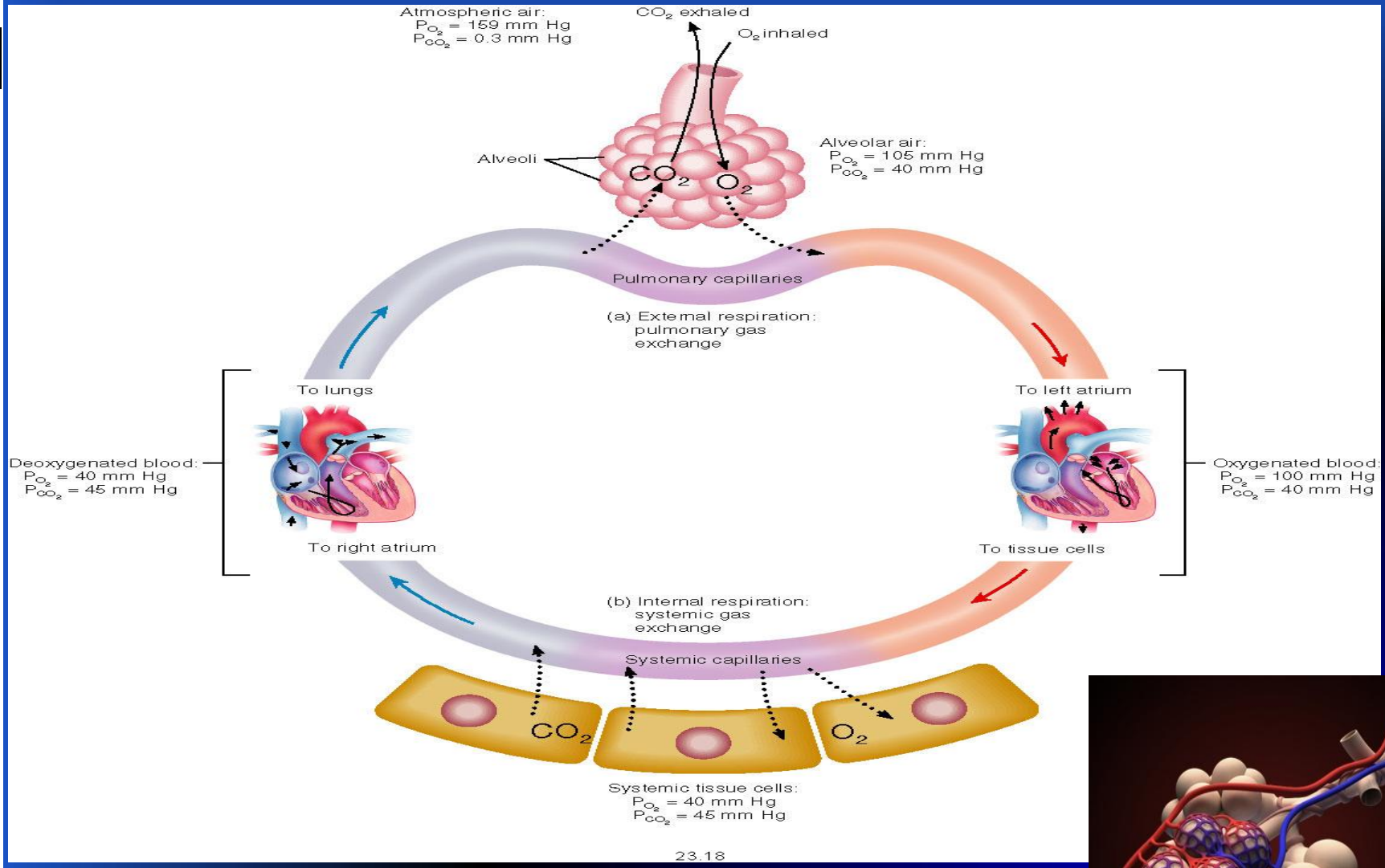
- Includes:

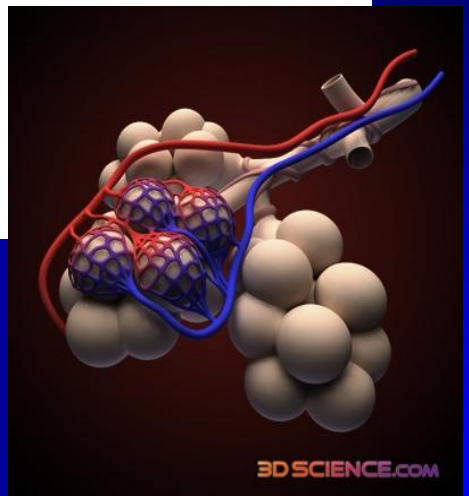
Respiratory bronchioles, alveolar ducts, alveolar sacs, alveoli

- **Function in gas exchange.**



Internal & External Respiration





External respiration

3 major functional events occurs during it:

- 1-Pulmonary ventilation: inward and outward movement of air between lung and atmosphere.
- 2- Diffusion of oxygen and CO2 between the alveoli and the pulmonary capillary blood
- 3- Transport of O2 & Co2 in the blood and body fluids to and from the cells

Respiration could be either

Resting : normal breathing during resting conditions

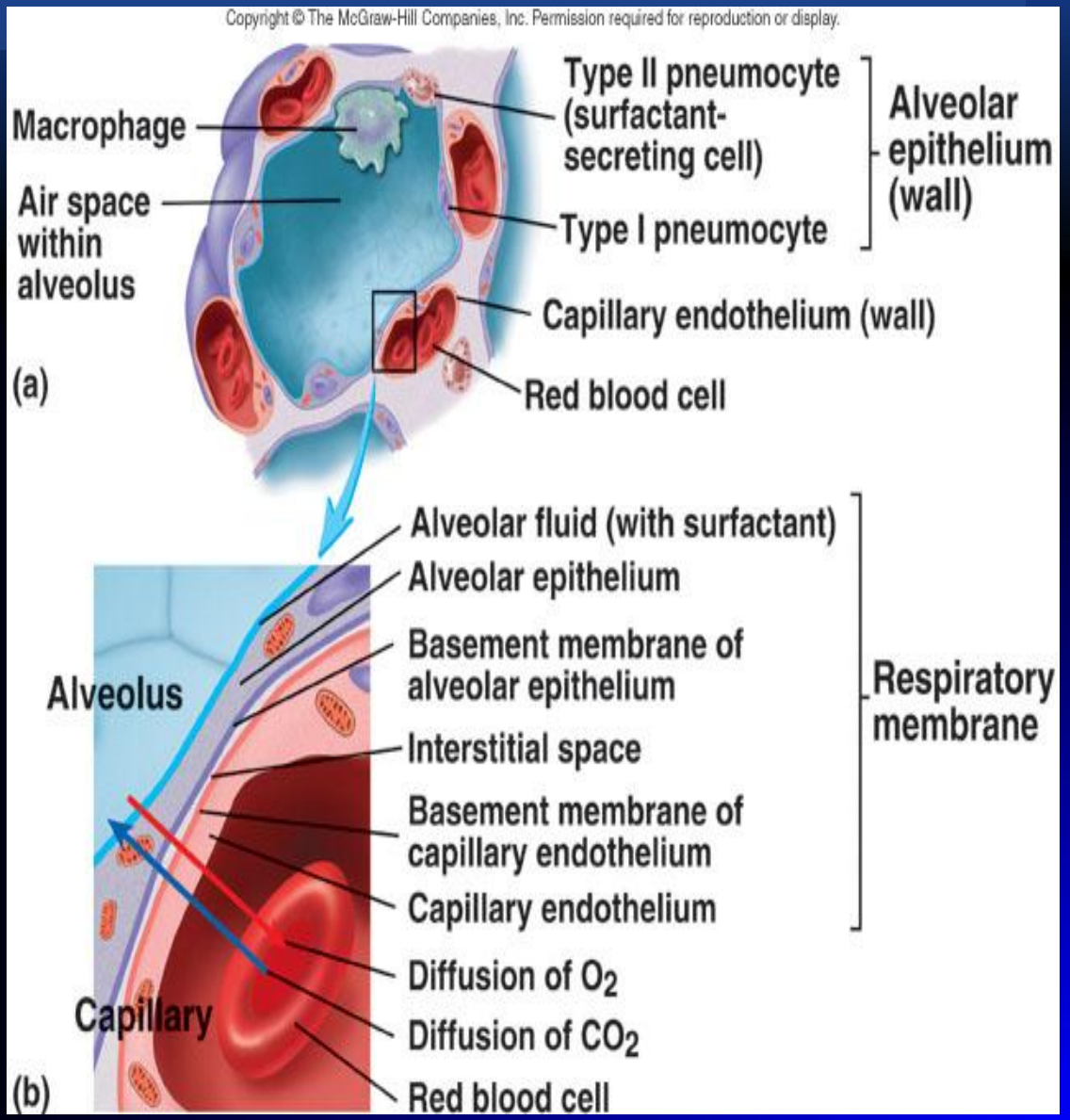
Forced (maximal): during exercise, in patients with asthma, allergy,…

Lining cells of the alveoli

Type I alveolar cells
(type I pneumocytes)

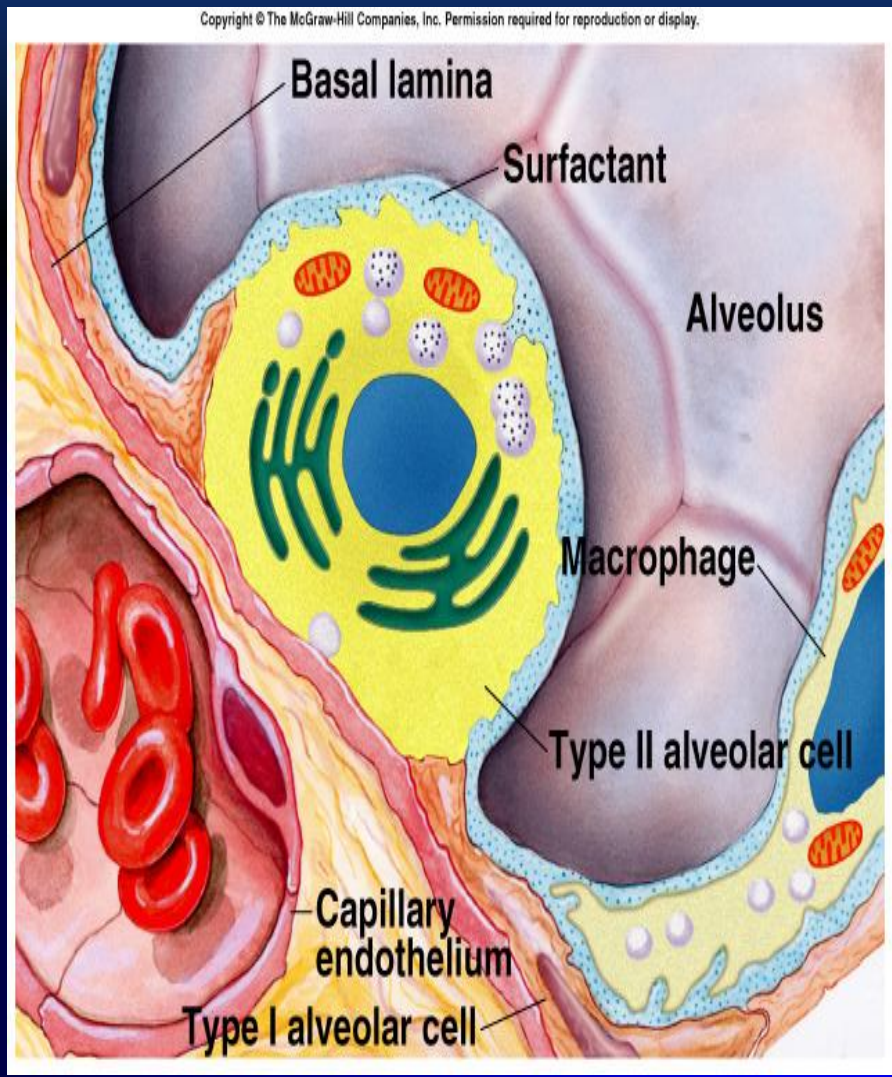
Type II alveolar cells
(type II pneumocytes)
(Secrete surfactant)

Alveolar macrophages



Surface Tension

- H_20 molecules at the surface are attracted to other H_20 molecules by attractive forces that resist distension called surface tension.
- Surface tension tends to oppose alveoli expansion
- Pulmonary surfactant reduces surface tension



surfactant

- Surfactant is a complex substance containing phospholipids and a number of apoproteins.
- Secreted by the Type II alveolar cells at wk 35 of intrauterine life from fetal alveoli.
- Surfactant reduces surface tension throughout the lung , decreases airway resistance and the work of breathing.

Functions of surfactant:

1- Prevents alveolar collapse.

2- Reduces the work of breathing, making respiration easier.

3- Keeps the alveoli dry. When surface tension force is higher, it sucks fluid into the alveolar spaces from the capillaries surrounding it.

Cont…surfactant

- Deficiency in premature babies cause respiratory distress syndrome of the new born (RDS). (hyaline membrane disease)

- Smoking in adult, Hypoxia or hypoxemia (low oxygen in the arterial blood) or both, decrease the secretion of surfactant and cause adult respiratory distress syndrome.

Innervations of lungs and bronchi

- is by autonomic nerves
- Sympathetic causes dilatation of the bronchi
- Parasympathetic causes constriction of the bronchi.
- Locally secreted factors *:histamine, Slow reacting substances of anaphylaxis (SRSA) by Mast cells, Due to allergy often cause bronchiolar constriction and increase airway resistance.*

Mechanics of pulmonary ventilation

Learning Objectives

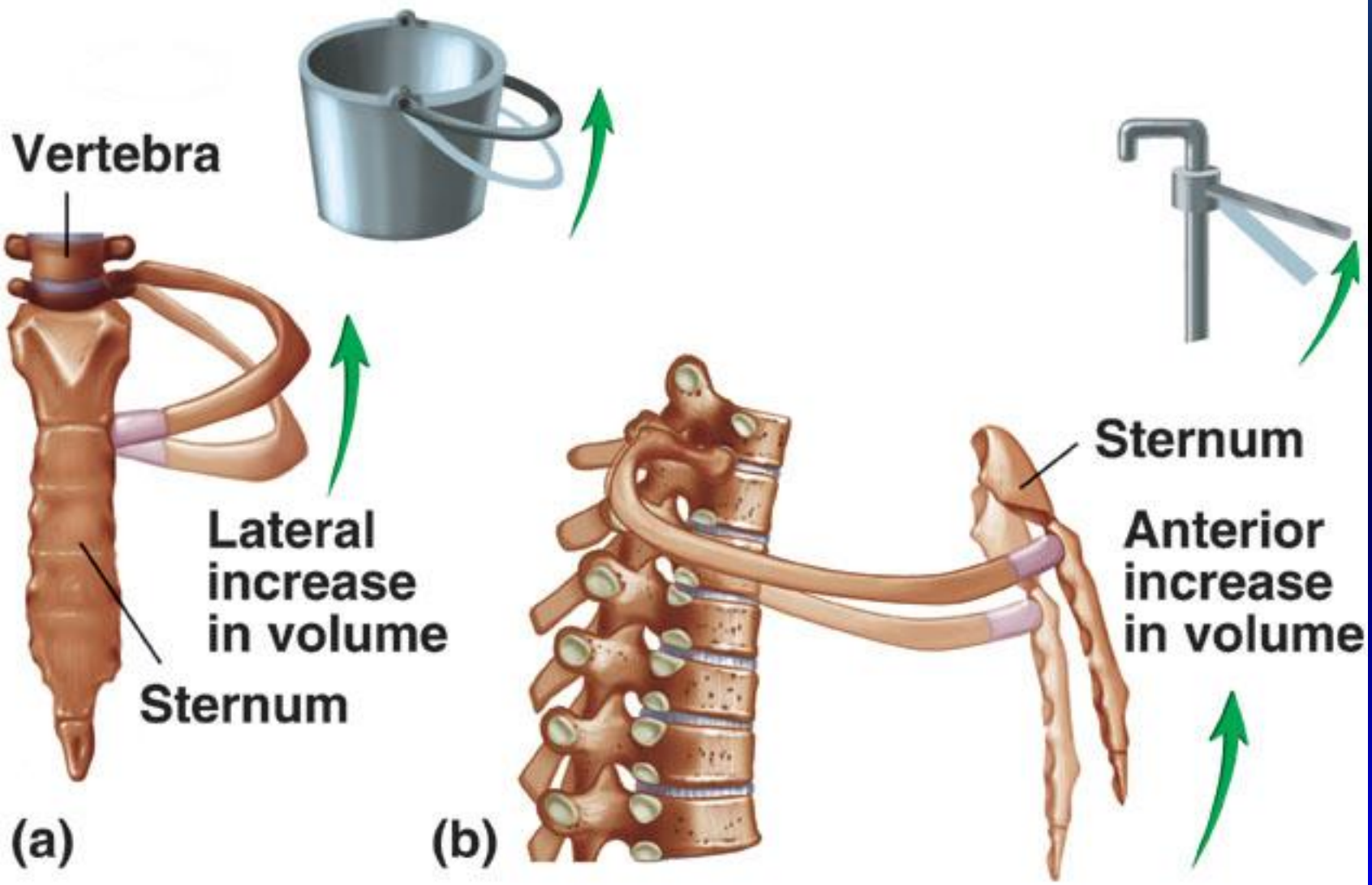
- By the end of this lecture you will be able to:

1- List the muscles of respiration and describe their roles during inspiration and expiration.

2- Understand the importance of the following pressures in respiration: Atmospheric, alveolar, intrapleural, and transpulmonary.

3- Explain why intrapleural pressure is always subatmospheric under normal conditions, and the significance of the thin layer of the intrapleural fluid surrounding the lung.

4- Define lung compliance and list the determinants of compliance.



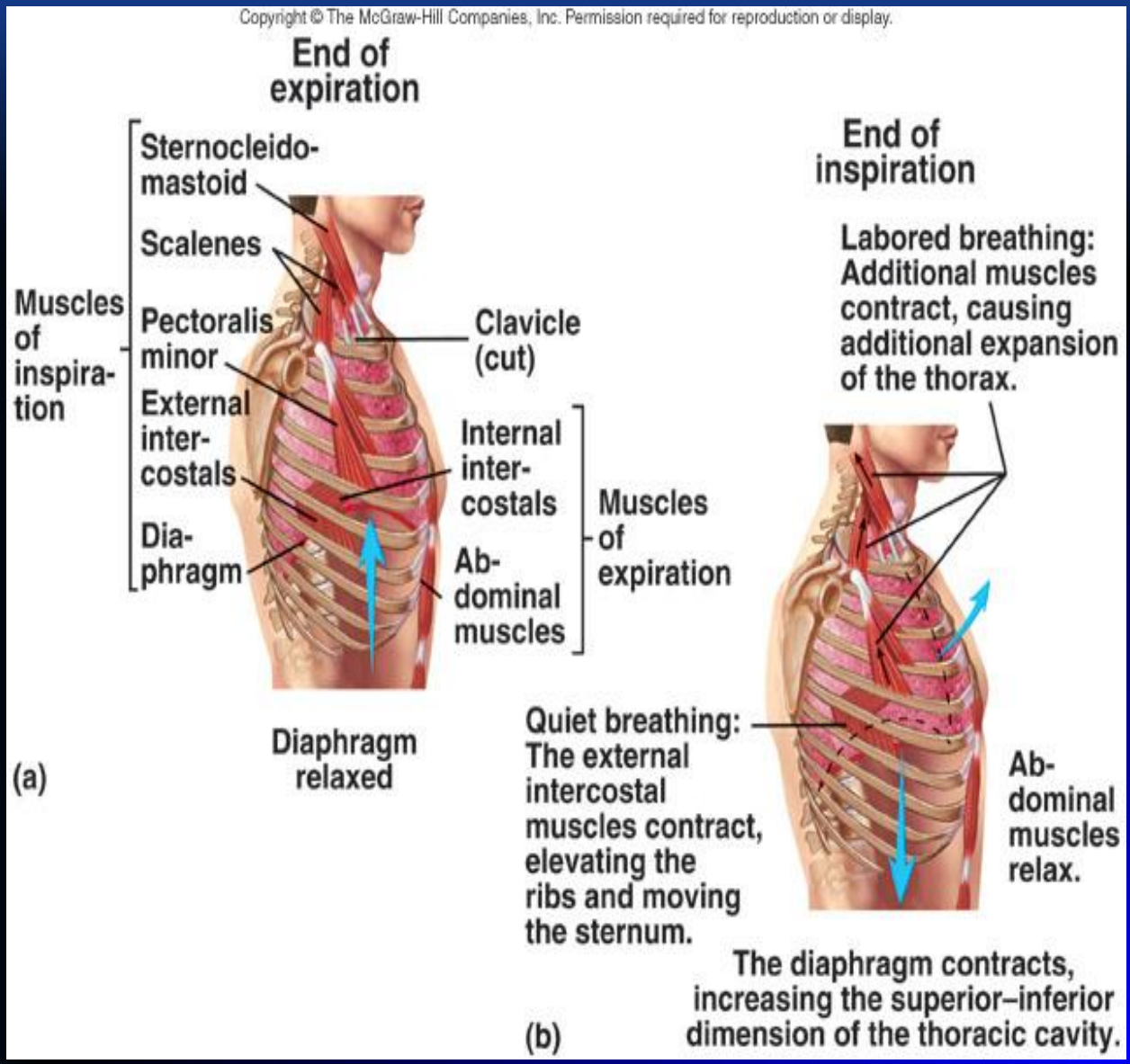
Respiratory muscles

Inspiratory muscles

(resting- forced)

Expiratory muscles

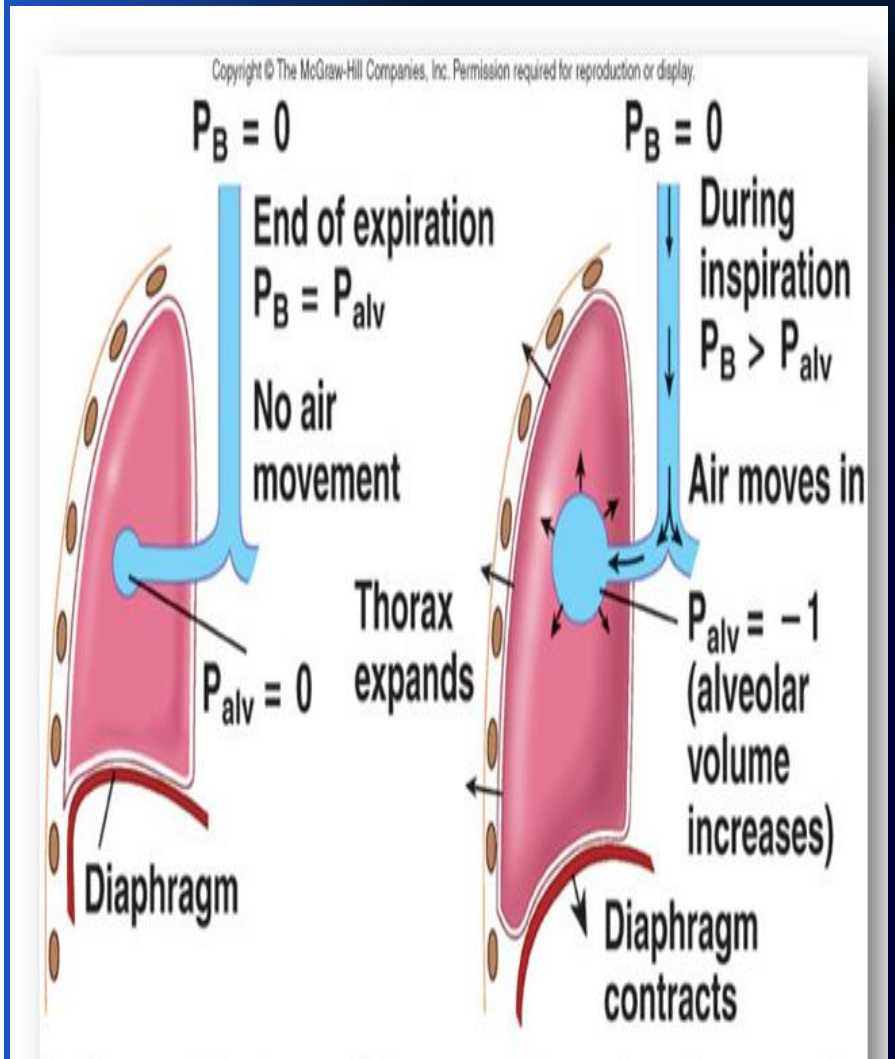
(forced expiration- muscles that depress the rib cage)

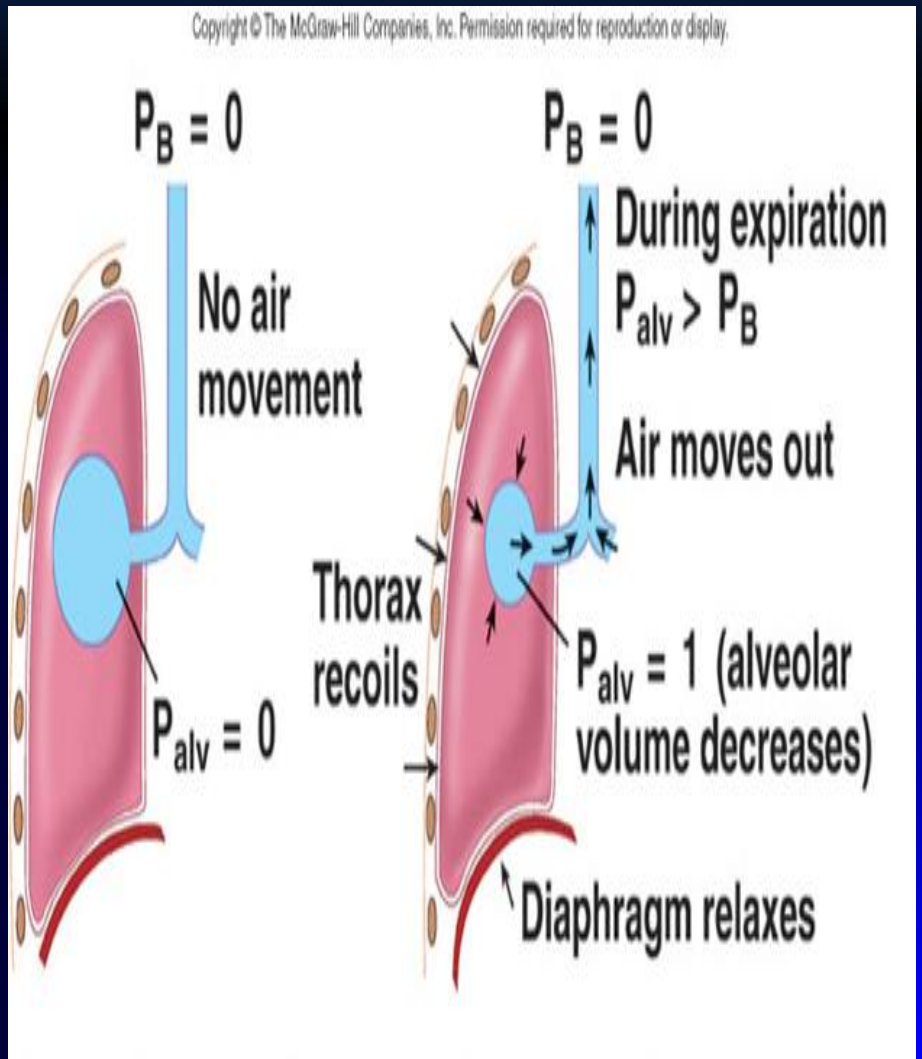


Deep Forceful Breathing

- Deep Inspiration
  - During deep forceful inhalation accessory muscles of inspiration participate to increase size of thoracic cavity
    - Sternocleidomastoid – elevate sternum
    - Scalenes – elevate first two ribs
    - Pectoralis minor – elevate 3rd–5th ribs
- Deep Expiration
  - Expiration during forceful breathing is active process
  - Muscles of exhalation increase pressure in abdomen and thorax
    - Abdominal muscles

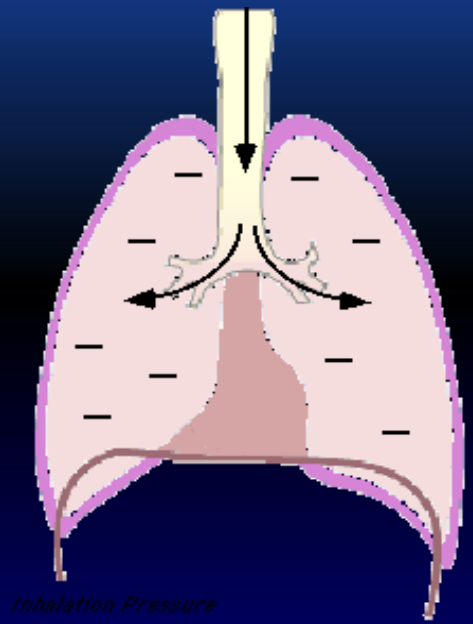
Air will flow from a region of high pressure to one of low pressure-- the bigger the difference, the faster the flow

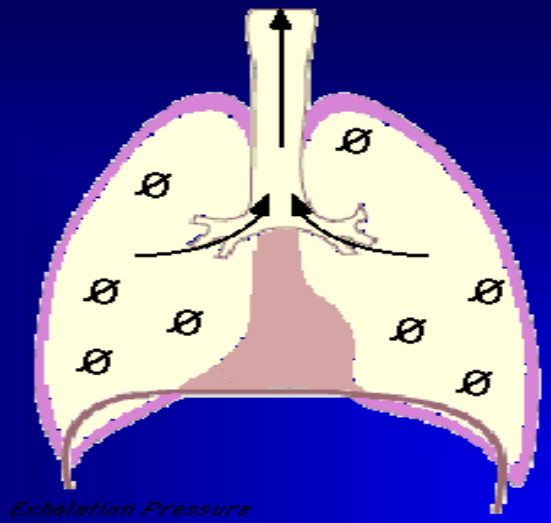




Pressure changes in the lungs during breathing

- 1-Intra-alveolar (intrapulmonary pressure
- *Between breathes = zero pressure*
- *During inspiration = (-1 mmHg), air (tidal volume) flow from outside to inside the lungs).*
- *At the end of inspiration= zero. air flow stops.*
- *During expiration=* (+1 mmHg) . air flow out of the Lungs





- 2-Intrapleural pressure (IPP):

Pressure in the pleural space

is negative with respect to atmospheric pressure at the end of normal expiration(-5cmH2o).

- Why negative??:

The lung's elastic tissue causes it to recoil, while that of the chest wall causes it to expand. Because of these 2 opposing forces the pressure in the pleural cavity becomes negative.

*The pleural space is a potential space, empty due to continuous suction of fluids by lymphatics.

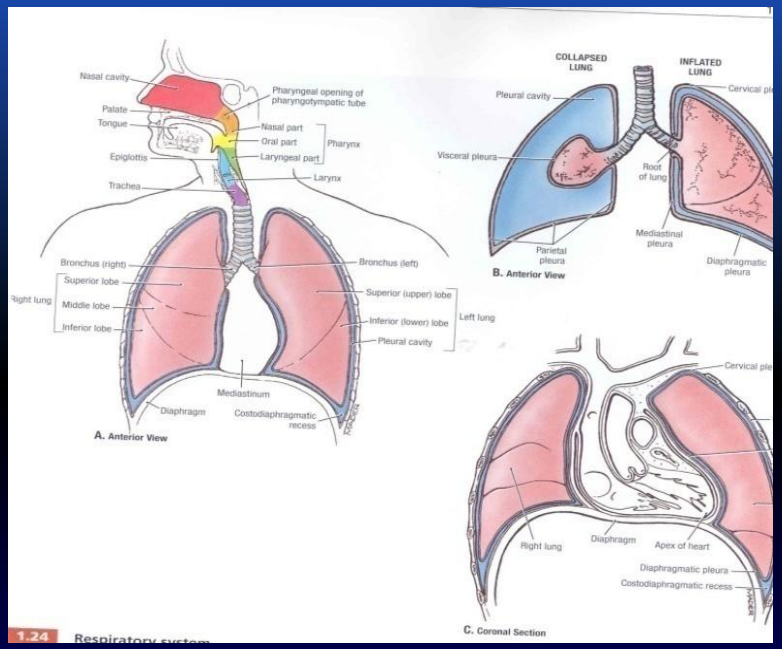
Values of IPP

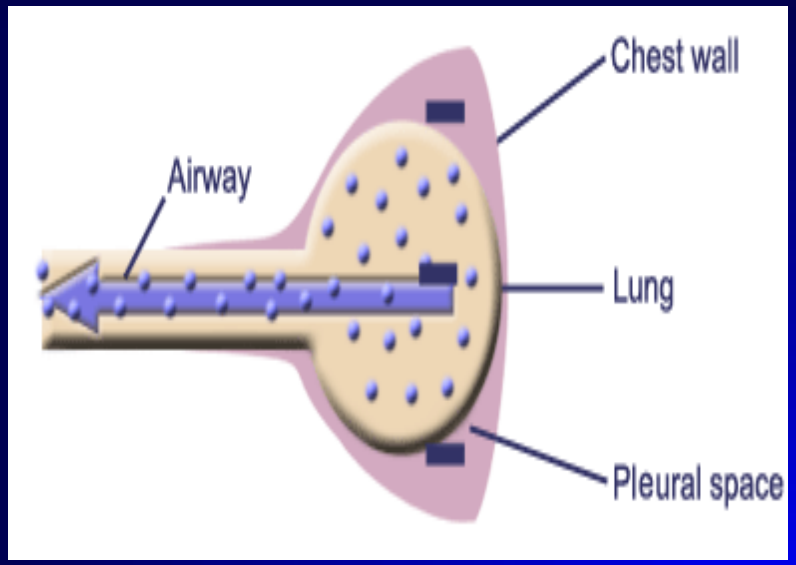
- -5 cm H2O during resting position between breathes, and it becomes more –ve (-7.5 cm H2O) during resting inspiration

- Forced ventilation

  Insp. :-20 to -40 cm H2O

  Exp. : + 30 cm H2O





3-Transpulmonary pressure (TPp) (Extending Pressure)

- *The difference between the alveolar pressure (Palv) and the pleural pressure(Ppl).*

$$TPp = Palv - Ppl$$

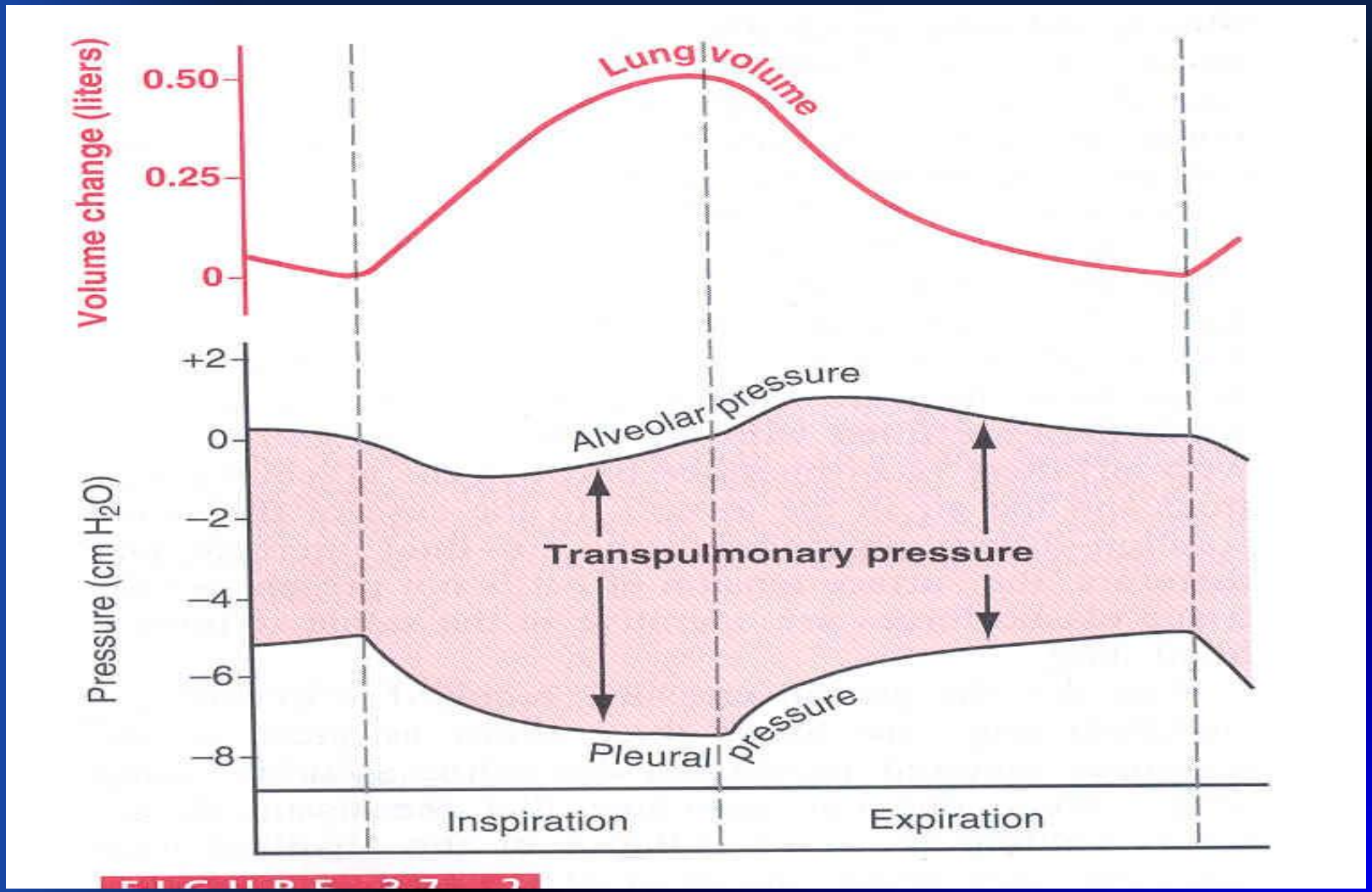
- *It is a measure of the elastic forces in the lungs that tend to collapse the lungs (**the recoil pressure).***

- It Keeps the lungs against the chest wall (prevent lung collapse).

- The bigger the volume of the lung the higher will be its tendency to recoil.

Volume change / pressure change

(Compliance of the lung) in a single respiratory cycle



Compliance of the lungs

- Is defined as, the ratio of change in the lung volume produced per unit change in distending pressure

- The extent to which the lungs expand for each unit increase in the transpulmonary pressure.

- CL= $\frac{\text{Volume change } (\Delta V)}{\text{Transpulmonary pressure change } (\Delta P)}$
- CL = $\frac{(\Delta V)}{(\Delta P)}$

Cont…compliance of lung

- For both lungs in adult = 200 ml of air /cm H20.
- For lungs and thorax together= 110 ml/cm H20.
- is reduced in pulmonary fibrosis , pulmonary edema, diseases of the chest wall (kyphosis, scoliosis)
- Emphysema increases the compliance of the lungs because it destroys the alveolar septal tissue rich with elastic fibers that normally opposes lung expansion.