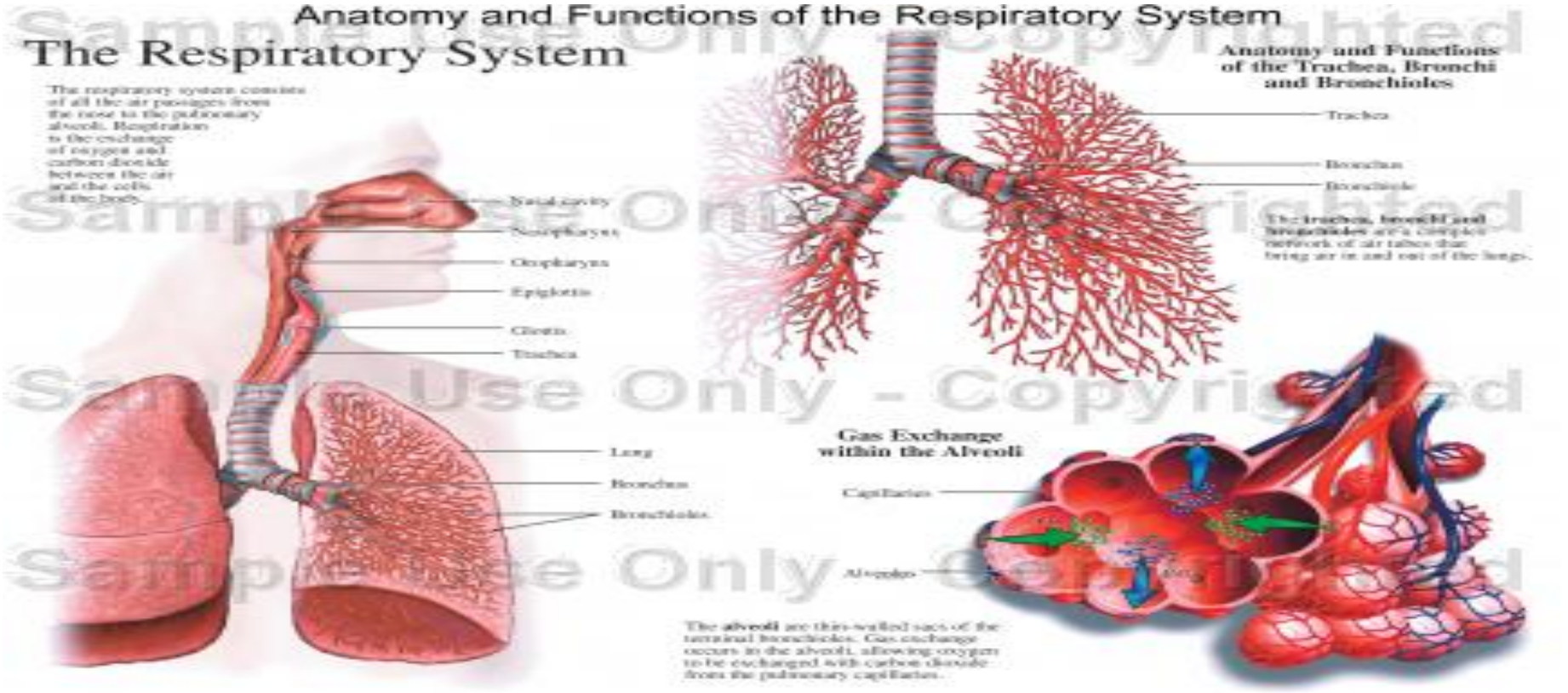
Respiratory Physiology



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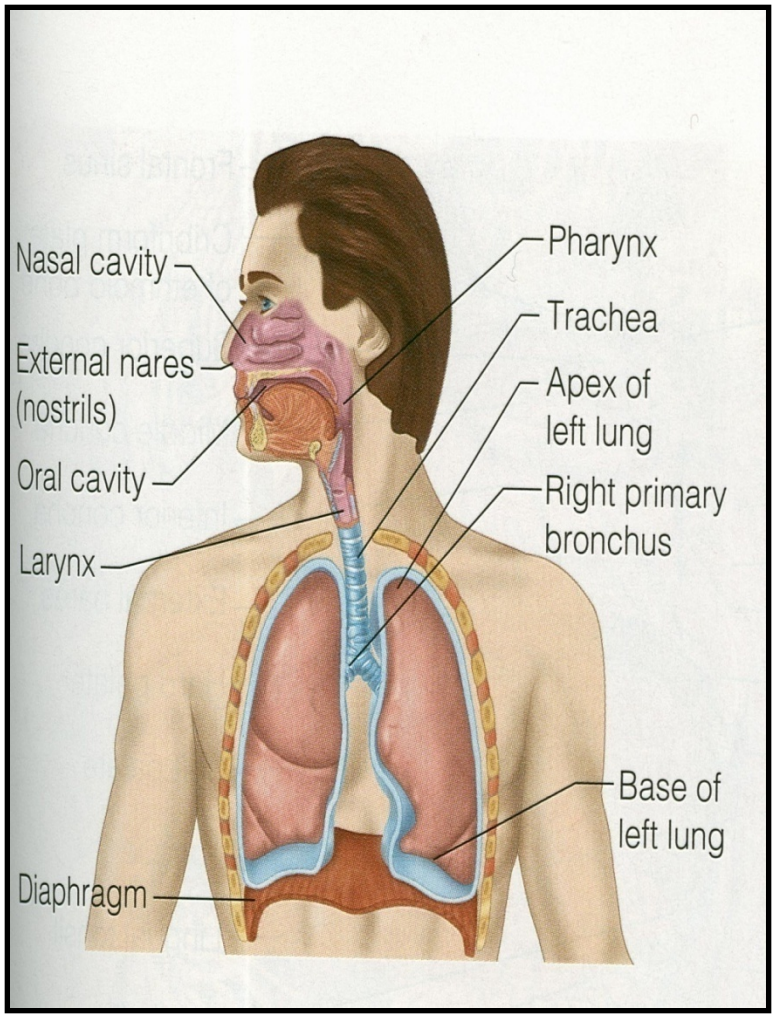
The main goal of respiration is to

1-Provide oxygen to tissues

2- Remove CO_2

Respiratory system consists of:

- passages (airways)
- muscles
- centers



Functions and organization of the respiratory system

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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.

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Functions of the respiratory system include

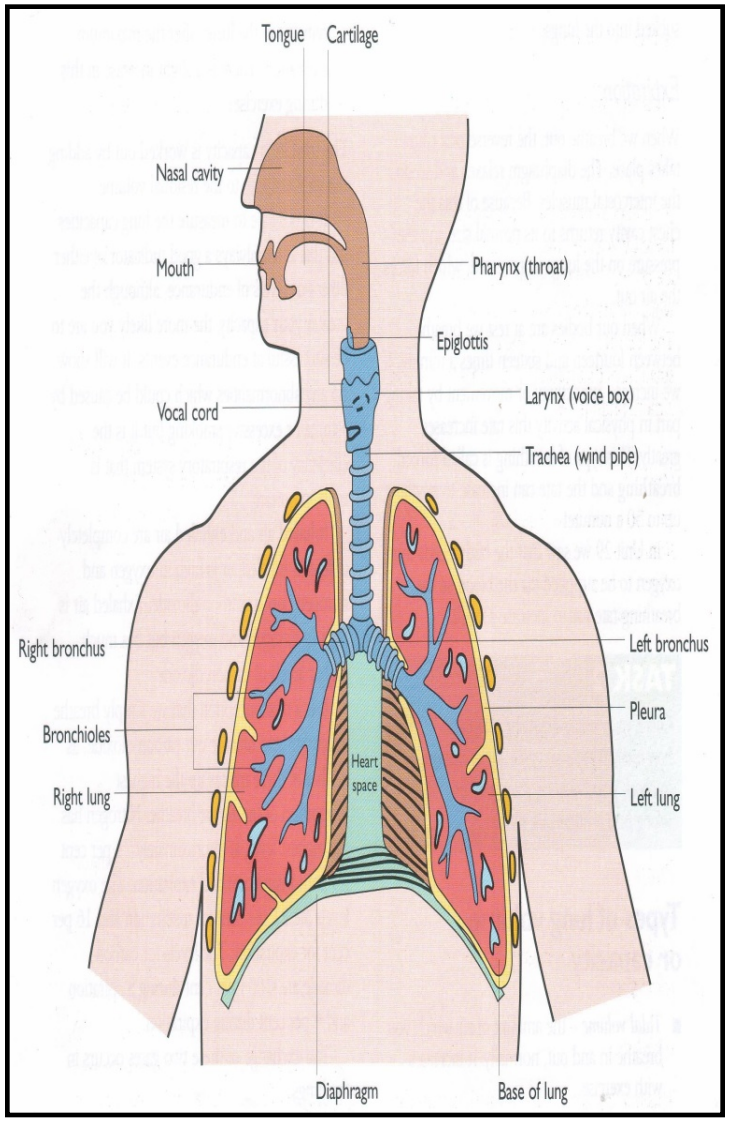
- Gas exchange (respiratory function).
- Phonation: is the production of sounds by the movement of air through the vocal cords.
- Pulmonary defense

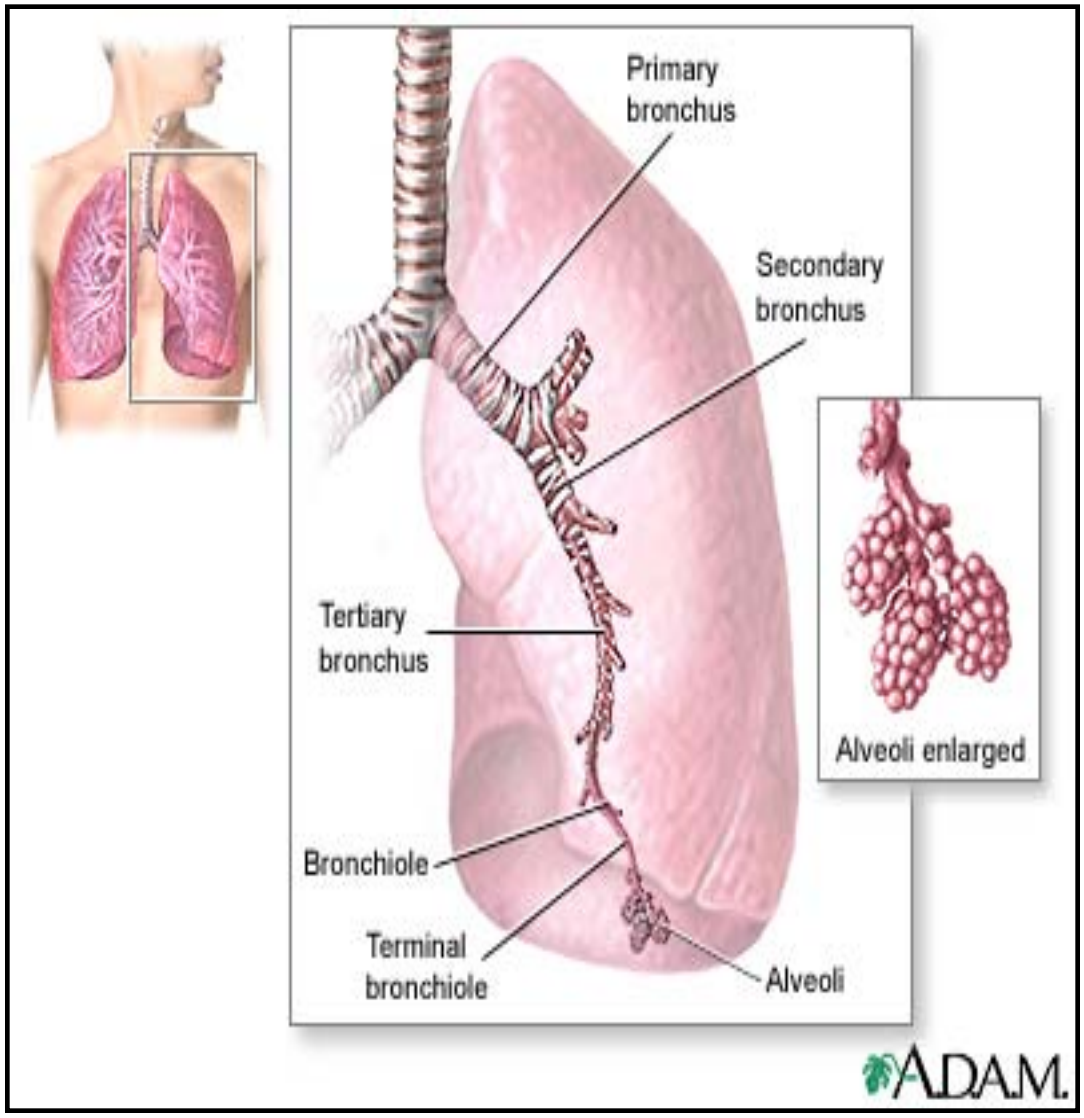
- Immunoglobulin A (IgA),
- Alpha-1 antitrypsin
- *The pulmonary macrophages in the alveoli: engulf* smaller particles which pass through the muco-cilliary barrier filter.

Cont..non respiratory functions of lung

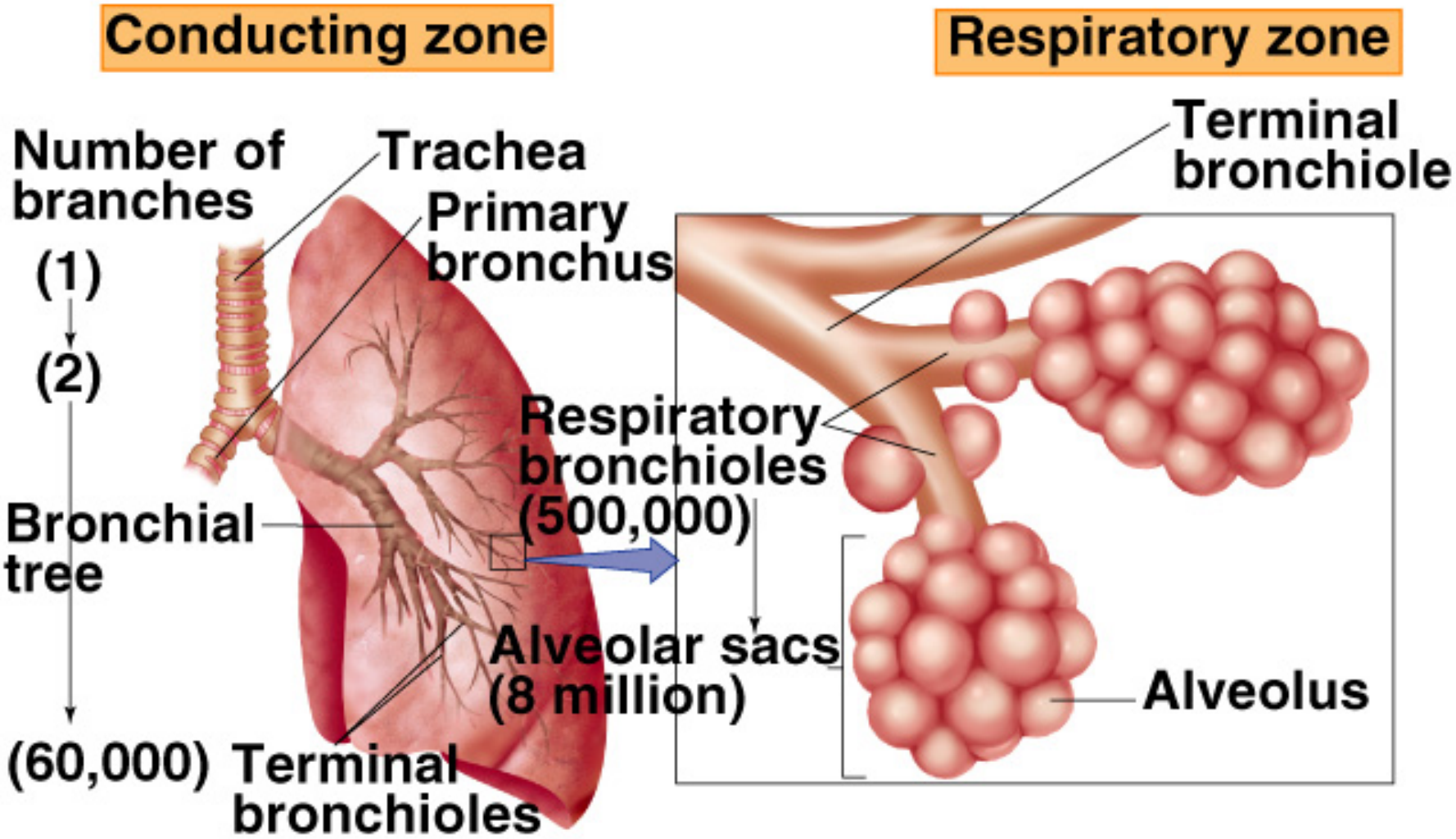
- Angiotensin I is converted to angiotensin II with the help of angiotensin converting enzyme formed by the lungs.
- Regulating the acid- base status of the body by washing out extra carbon dioxide from the blood.
- Secretion of important substances like surfactant .

Respiratory passages (airways)





Respiratory passages airways can be divided into



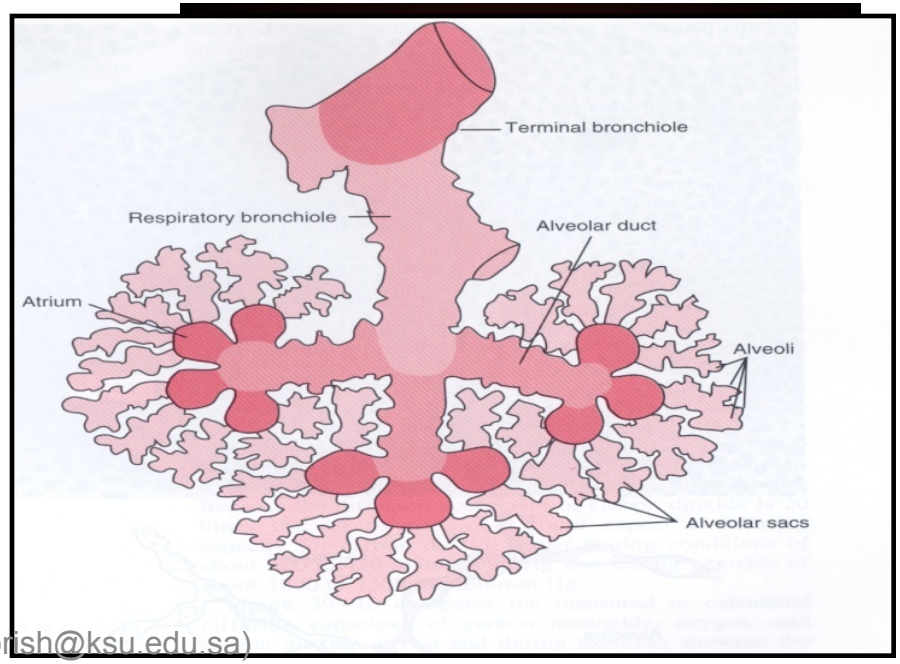
I- Conductive Zone

- Starts from nose to the end of terminal bronchioles.
- Help *warming, humidification, filtration* of inspired air.
- Contains the *olfactory receptors* for smell sensation.
- *Conducts the sound* during speech.
- Protective function by cough and sneezing reflexes.

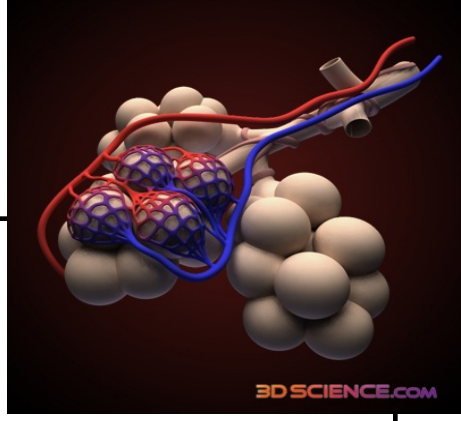
II- Respiratory Zone (Respiratory unit)

- Includes:

  Respiratory bronchioles, alveolar ducts, alveolar sacs, alveoli
- Function in gas exchange.



Internal & External Respiration



Atmospheric air:
P_{O_2} = 159 mm Hg
P_{CO_2} = 0.3 mm Hg

CO_2 exhaled

O_2 inhaled

Alveoli

Alveolar air:
P_{O_2} = 105 mm Hg
P_{CO_2} = 40 mm Hg

CO_2 O_2

Pulmonary capillaries

(a) External respiration:
pulmonary gas
exchange

To lungs

To left atrium

Deoxygenated blood:
P_{O_2} = 40 mm Hg
P_{CO_2} = 45 mm Hg

Oxygenated blood:
P_{O_2} = 100 mm Hg
P_{CO_2} = 40 mm Hg

To right atrium

To tissue cells

(b) Internal respiration:
systemic gas
exchange

Systemic capillaries

CO_2 O_2

Systemic tissue cells:
P_{O_2} = 40 mm Hg
P_{CO_2} = 45 mm Hg

23.18

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.

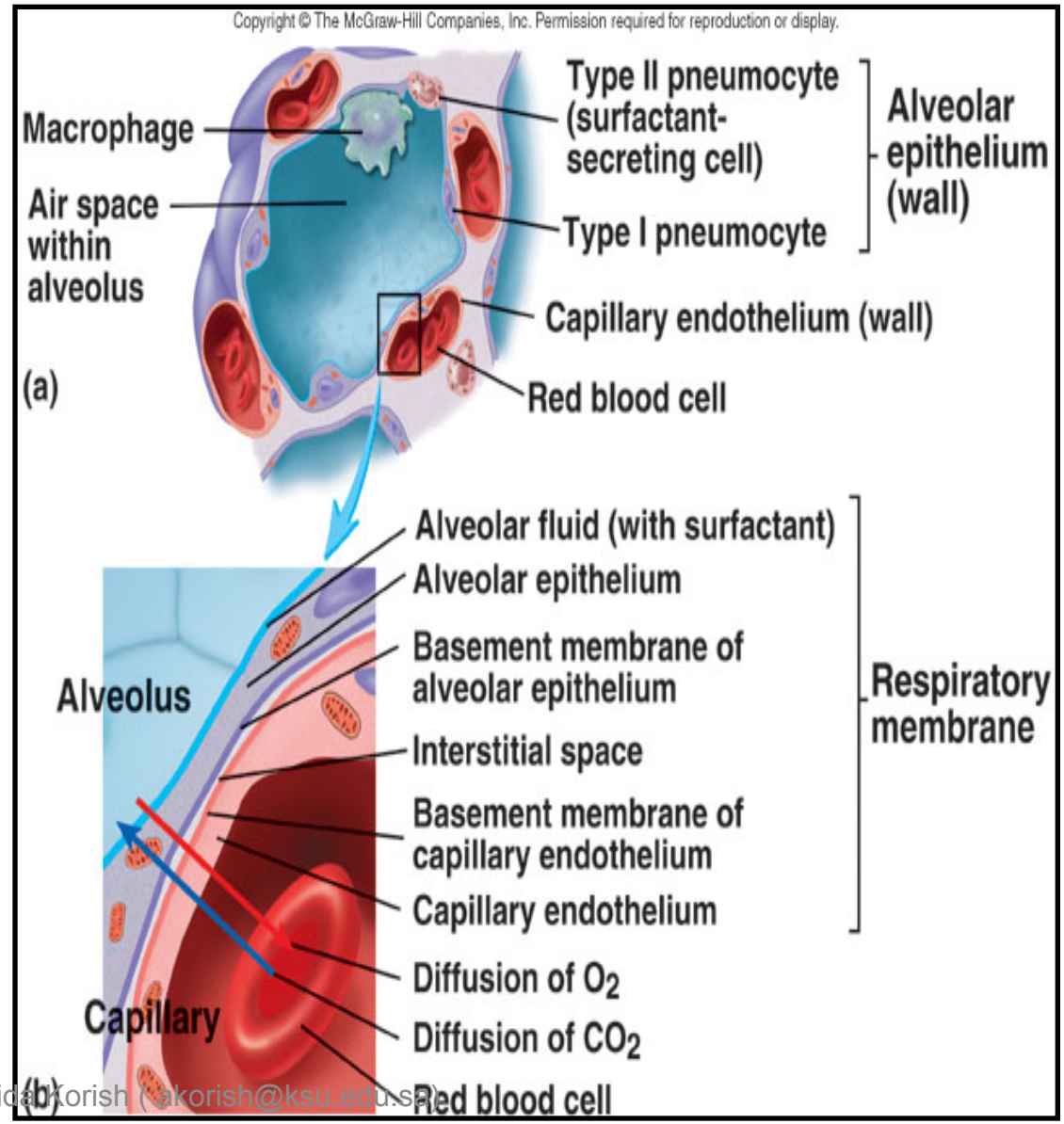
Forced (maximal): during exercise, in patients with asthma, allergy,…

Lining cells of the alveoli

1- Type I alveolar cells
(type I pneumocytes)

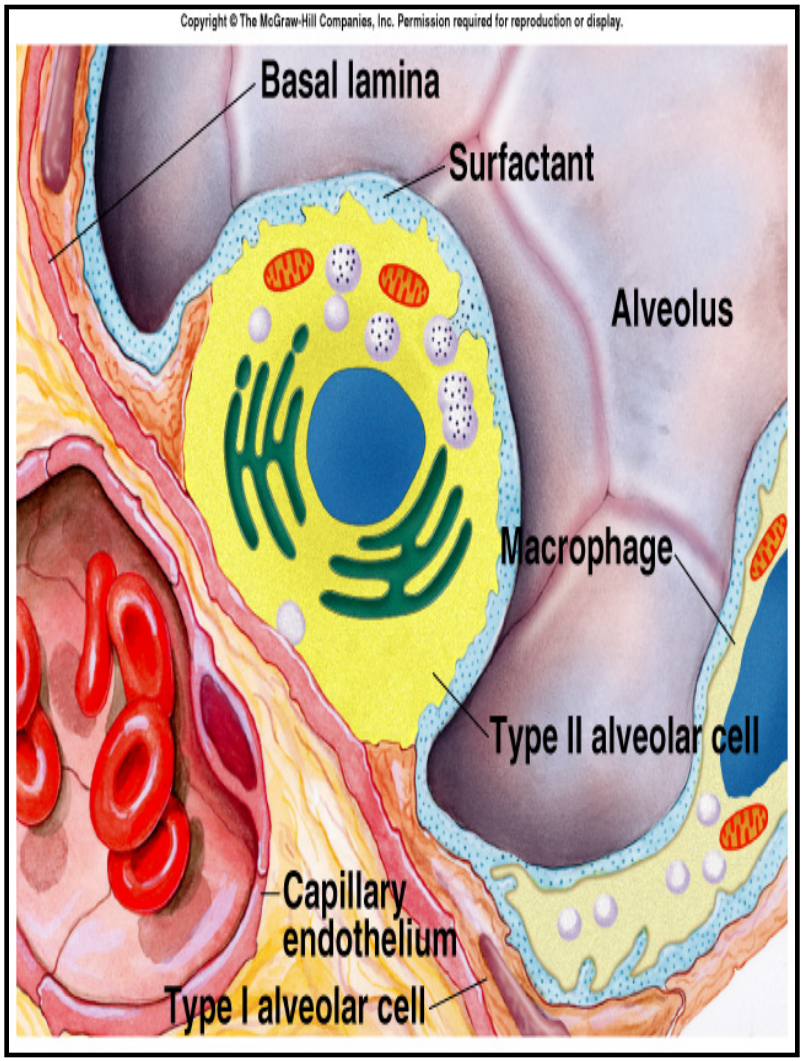
2- Type II alveolar cells
(type II pneumocytes)
(Secrete surfactant)

3- Alveolar macrophages



Surface Tension

- H_2O molecules at the surface are attracted to other H_2O 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. The earliest detection from fetal alveoli begins between 6-7th month but this could be delayed in others to wk 35 of intrauterine life.
- Surfactant reduces surface tension throughout the lung, prevents alveolar collapse, decreases airway resistance and the work of breathing.

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 stimulation causes dilatation of the bronchi
- Parasympathetic stimulation causes constriction of the bronchi.
- Locally secreted factors :histamine, slow reacting substances of anaphylaxis (SRSA) by mast cells, due to allergy (as in patients with asthma) often cause bronchiolar constriction and increase airway resistance.

Mechanics of pulmonary ventilation

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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.

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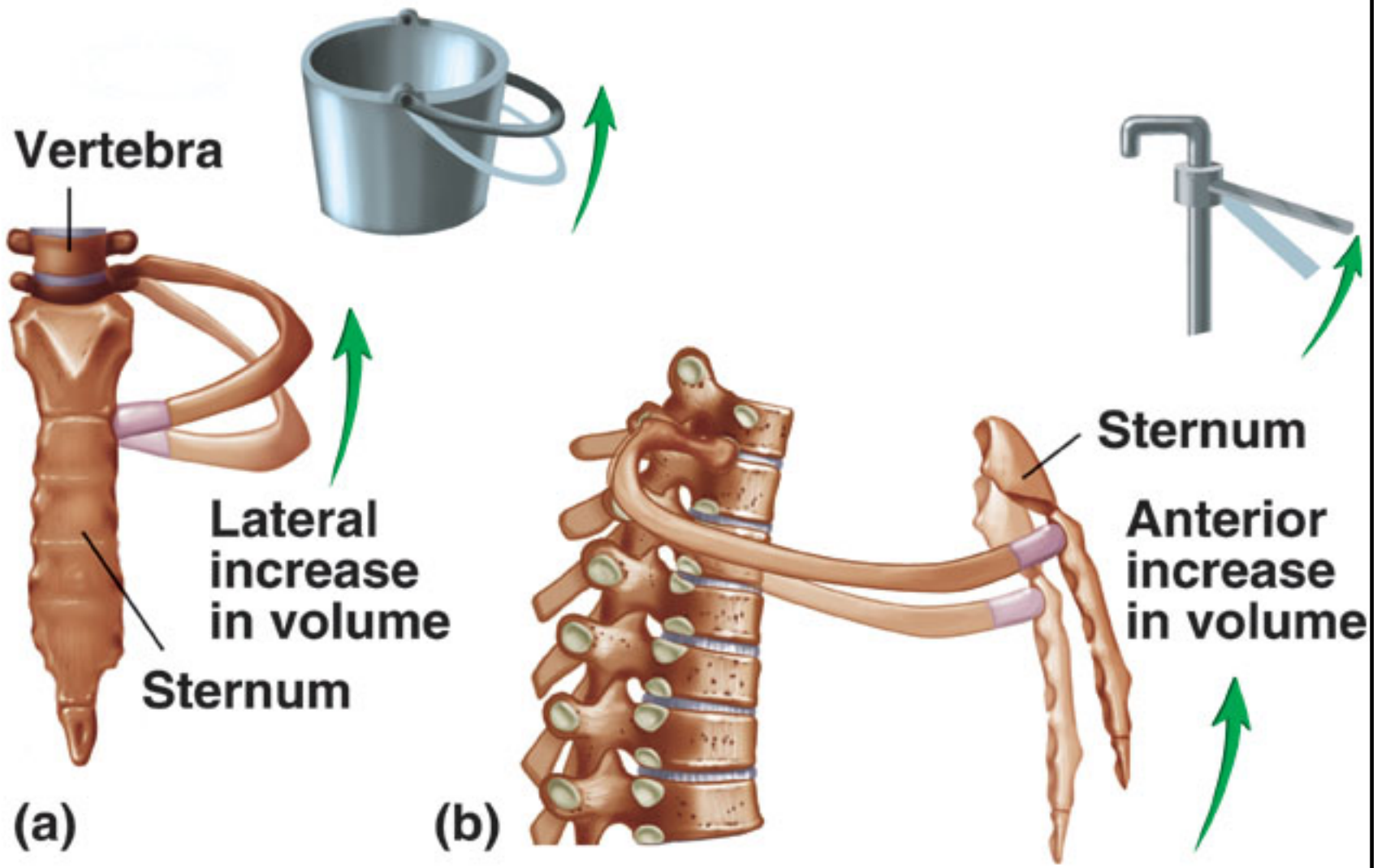
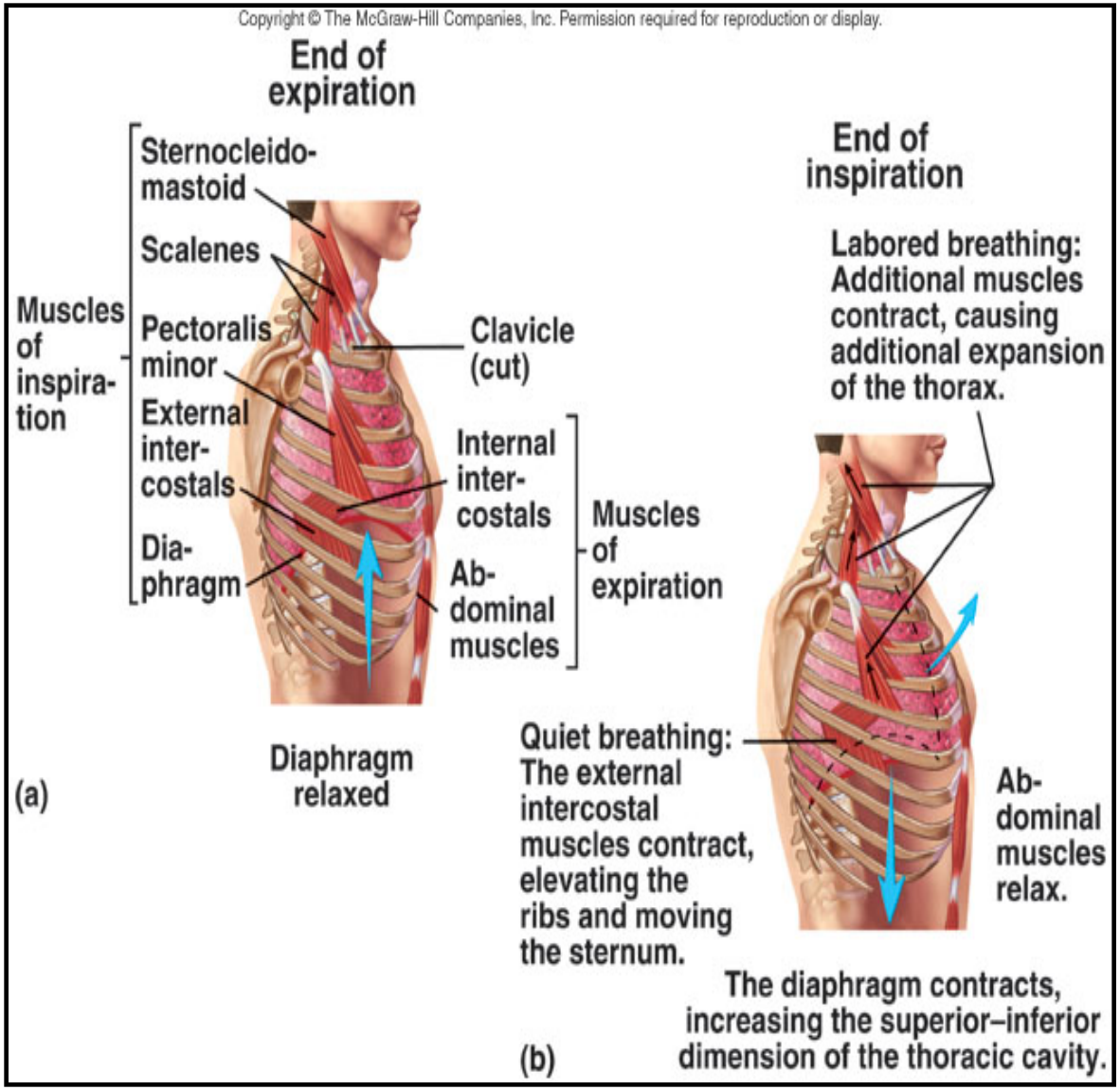


Respiratory muscles

Inspiratory muscles
(resting- forced)

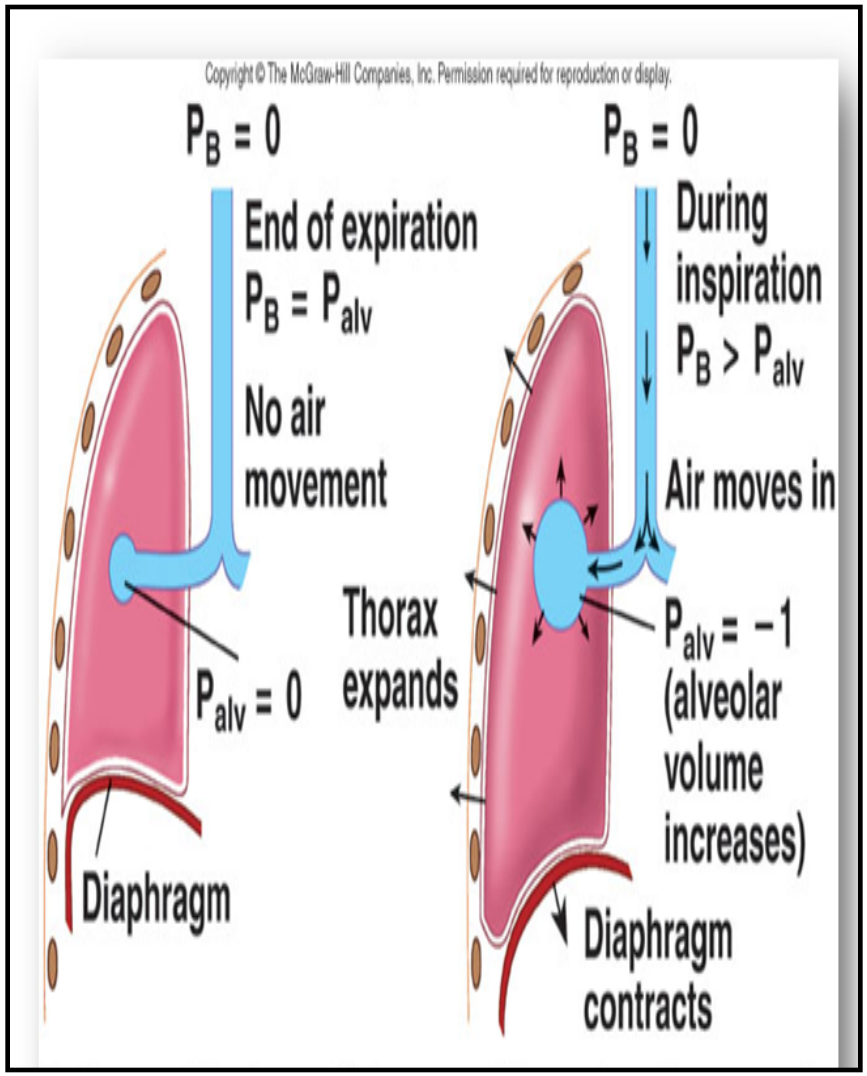
Expiratory muscles
(forced expiration- muscles that depress the rib cage)

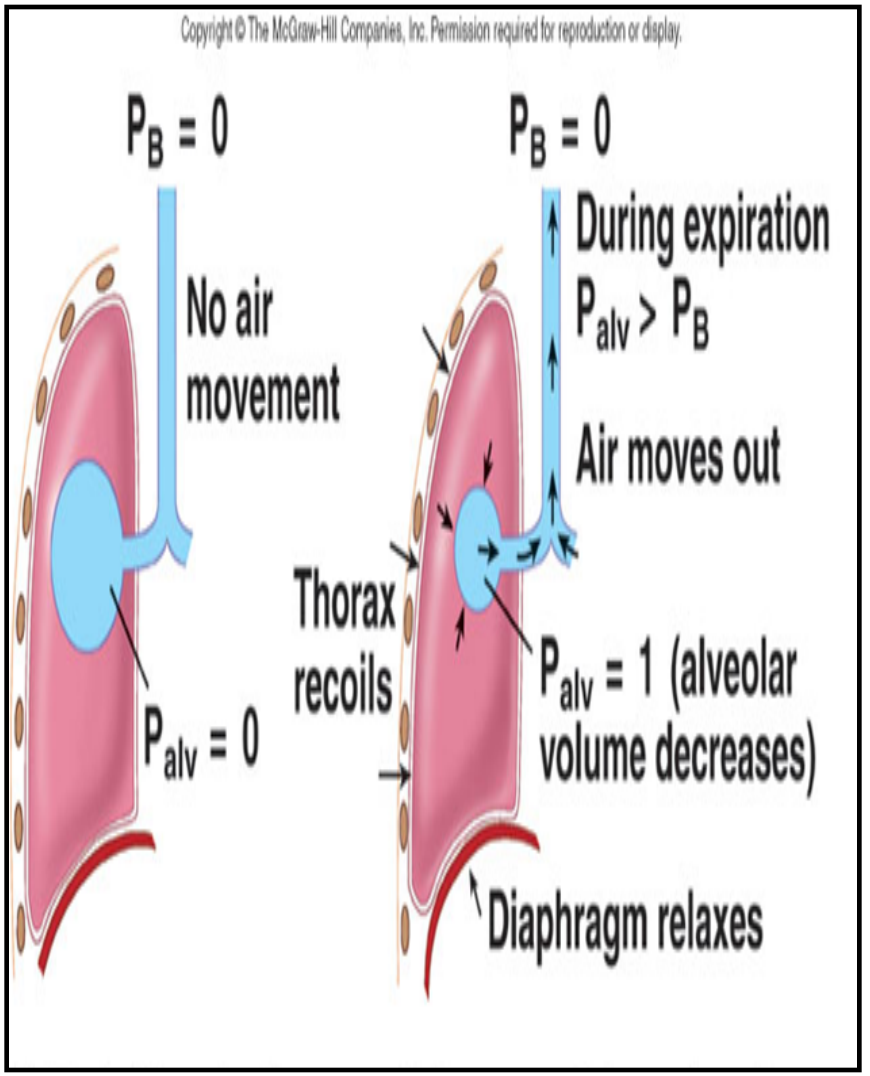


Deep Forceful Breathing

- Deep Inspiration
  - During deep forceful inhalation accessory muscles of inspiration participate to increase size of the thoracic cavity
    - Sternocleidomastoid – elevate sternum
    - Scalene – 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.
    - Internal intercostals.

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

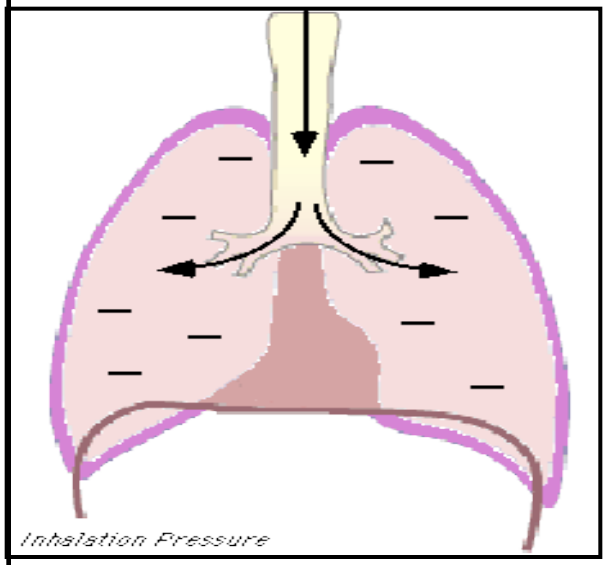
1-Intra-alveolar (intrapulmonary pressure

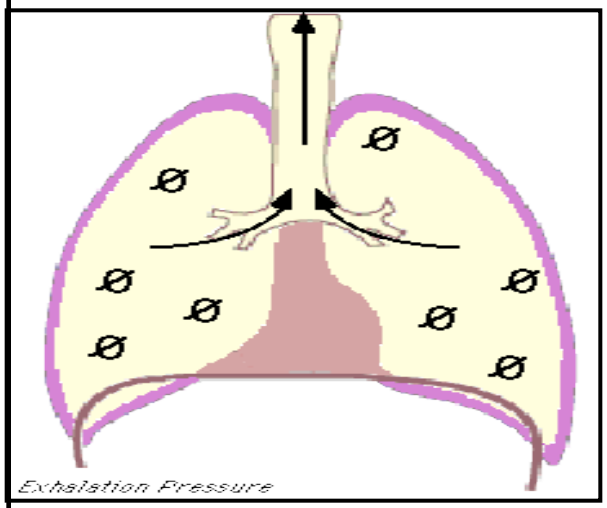
Between breathes = zero pressure

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





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- **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??:

1- 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.

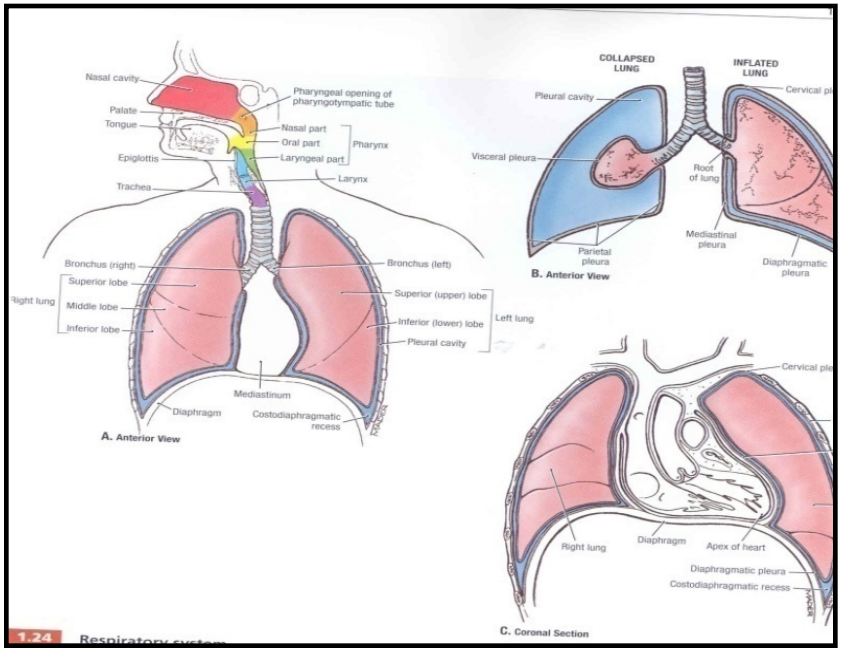
2-The pleural space is a potential space, empty due to continuous suction of fluids by lymphatic vessels.

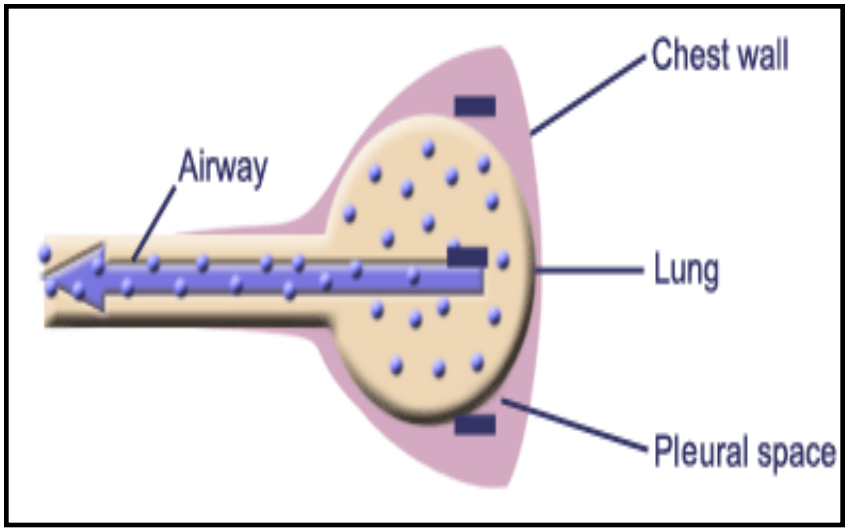
Values of IPP

- (-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





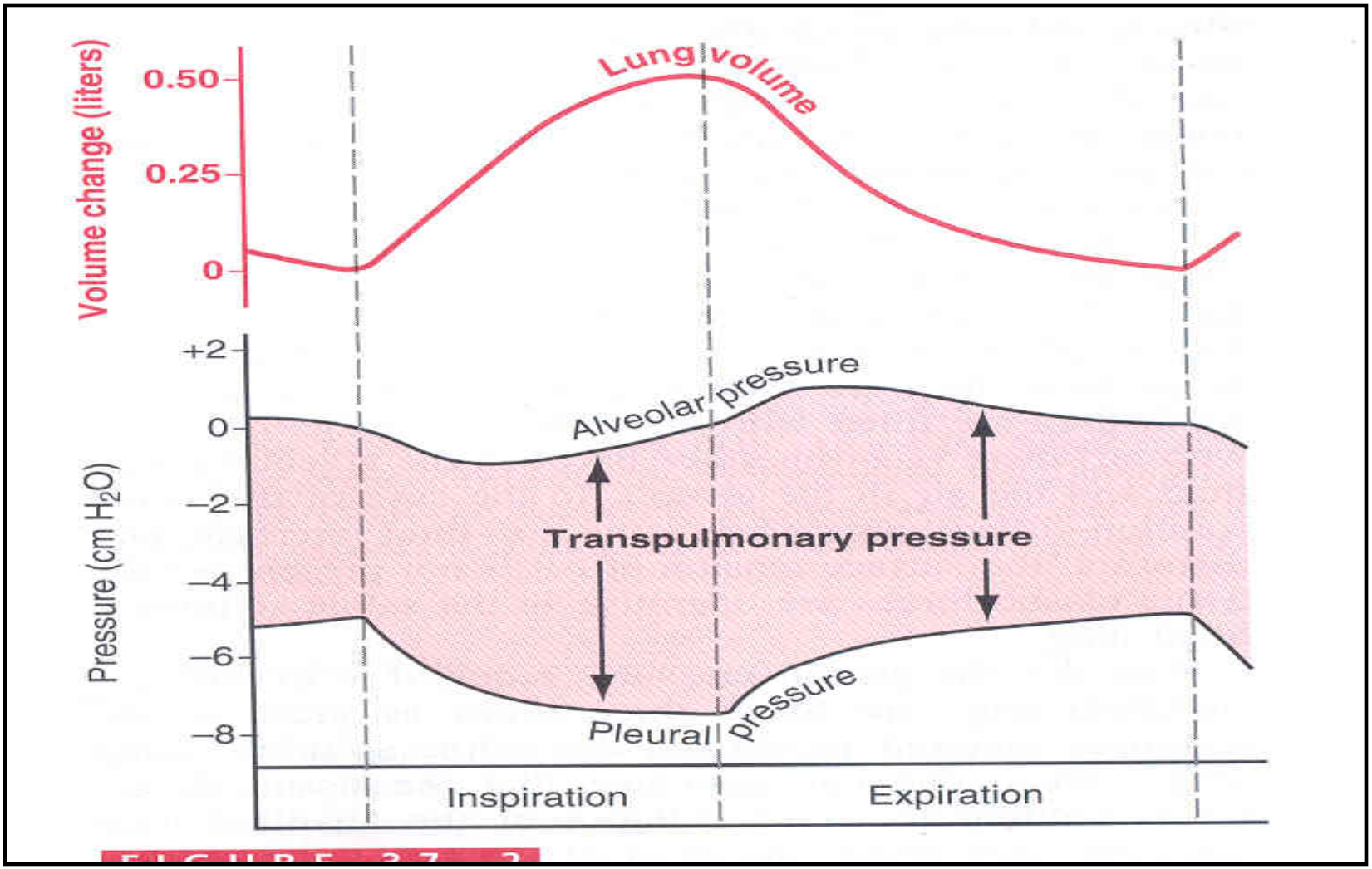
3-Transpulmonary pressure (TPp) (Extending Pressure)

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

$$TPp = \text{Palv-Ppl}$$

- *It is a measure of the elastic forces in the lungs that tend to collapse the lungs (**the recoil pressure).***
  - It prevents lung collapse.
- The bigger the volume of the lung the higher will be its tendency to recoil.

(Compliance of the lung) in a single respiratory cycle



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