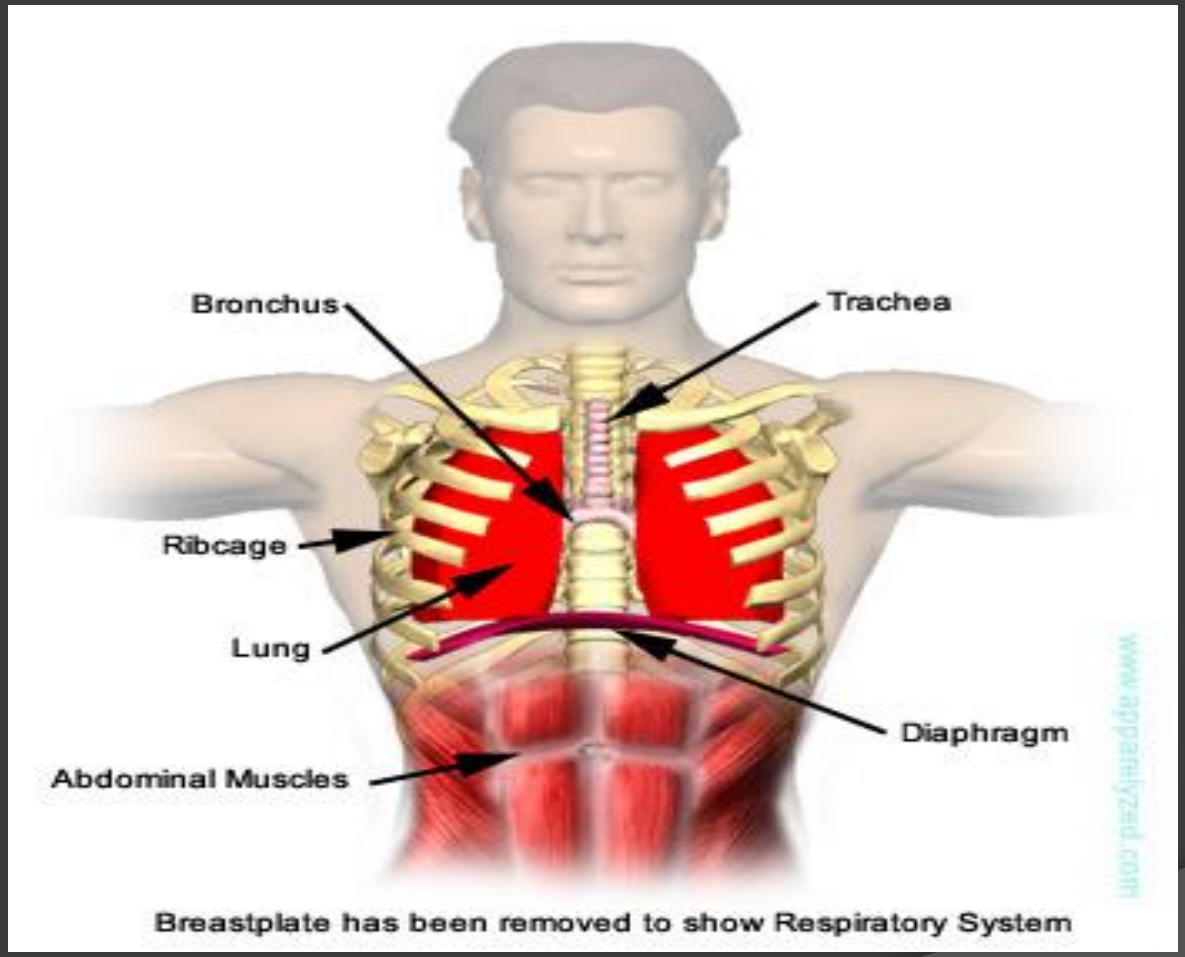
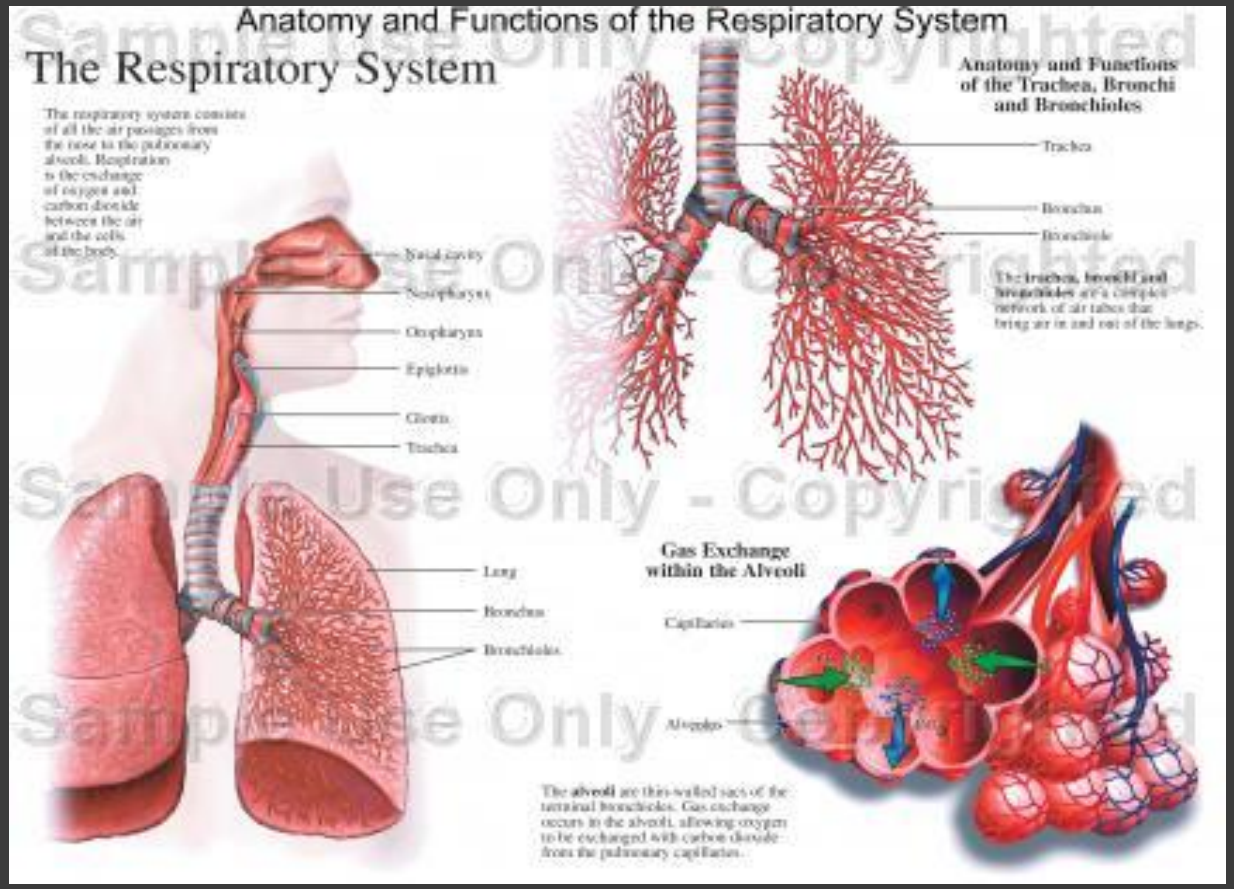
Respiratory Physiology





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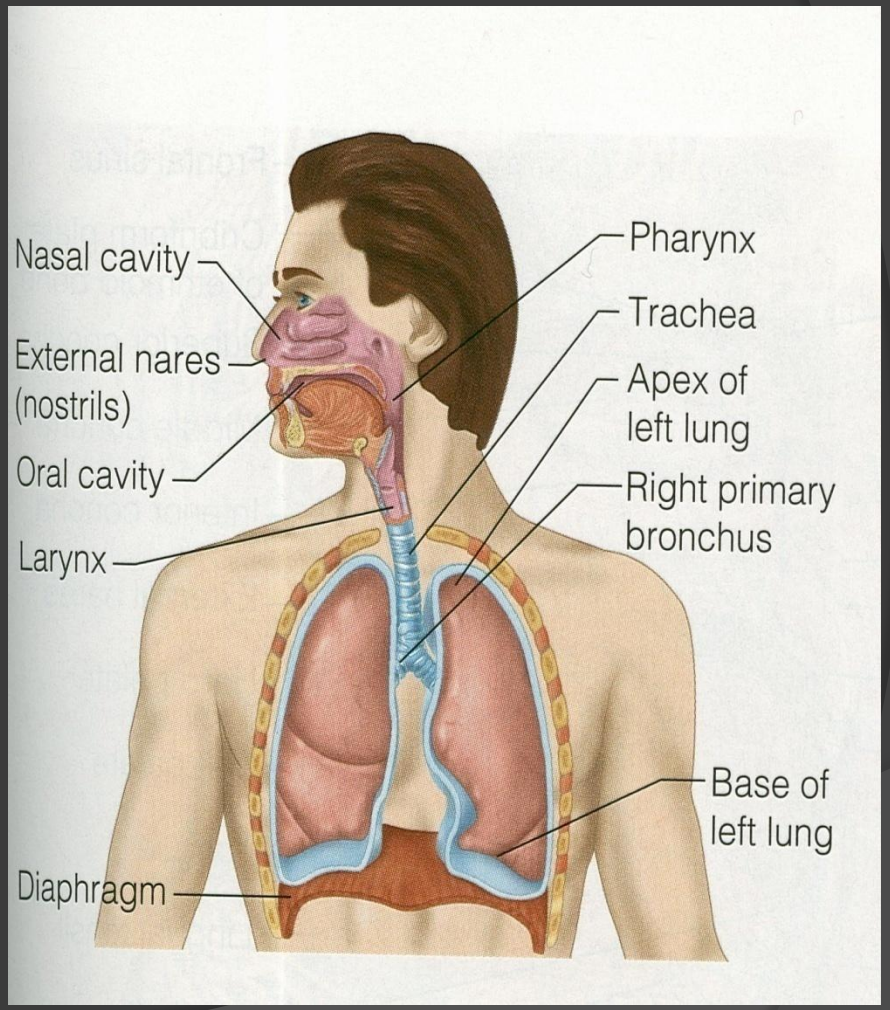
The Main goal of respiration is to

1-provide oxygen to tissues

2- remove CO_2



Functions and organization of the respiratory system

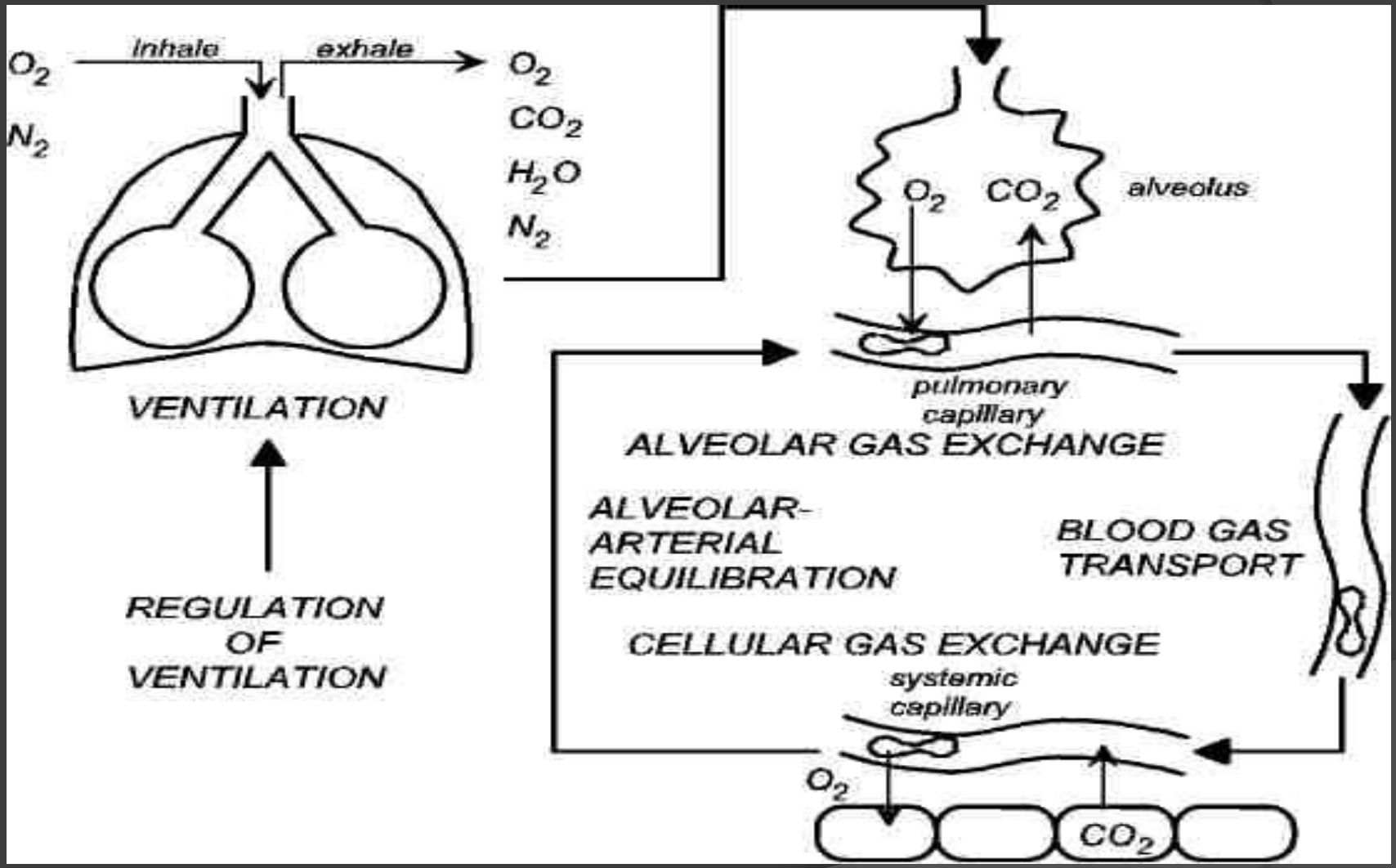
Learning Objectives

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

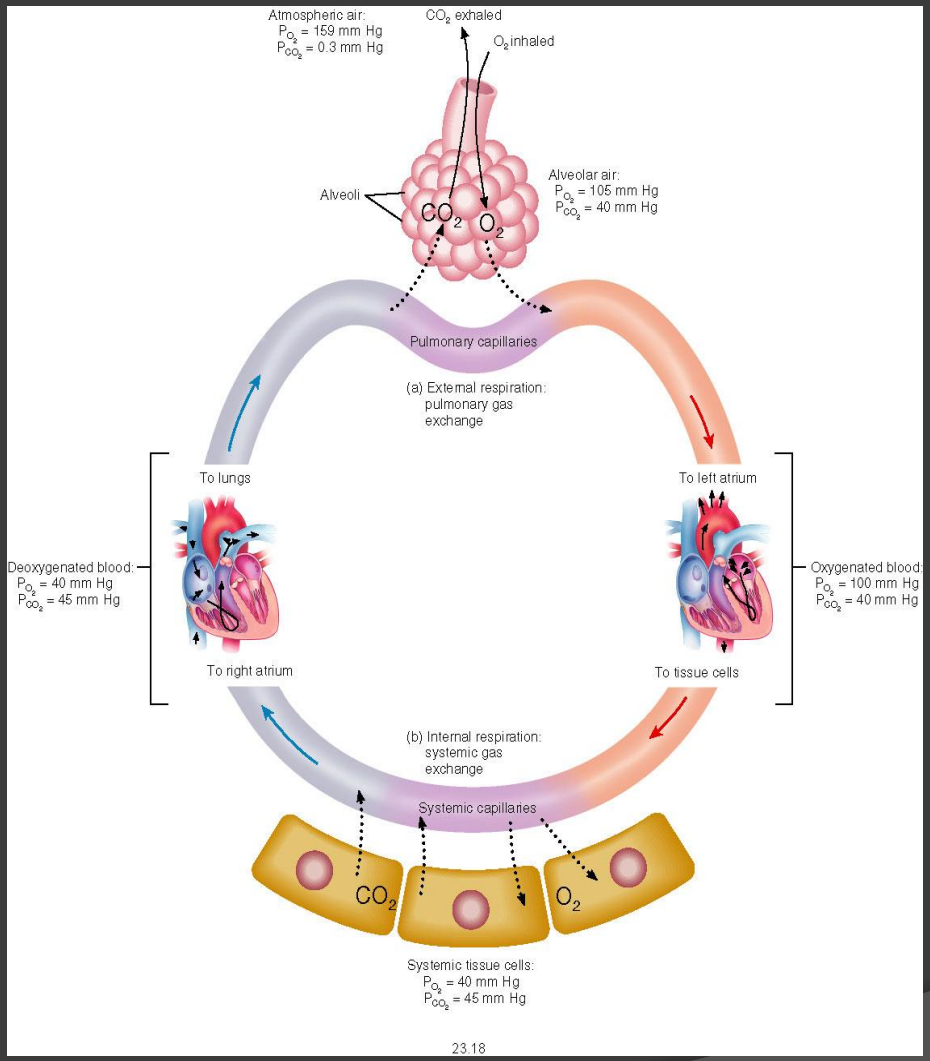
- 1- Understand the difference between internal and external respiration.

- 2- Describe the structures and functions of the conductive and respiratory zones.

- 3- Understand functions of the respiratory system, including non- respiratory functions, like clearance mechanism by mucus and cilia, production of surfactant and converting enzyme.


O_2
N_2
inhale
exhale
O_2
CO_2
H_2O
N_2
VENTILATION
REGULATION OF VENTILATION
O_2
CO_2
alveolus
pulmonary capillary
ALVEOLAR GAS EXCHANGE
ALVEOLAR-ARTERIAL EQUILIBRATION
BLOOD GAS TRANSPORT
CELLULAR GAS EXCHANGE
systemic capillary
O_2
CO_2

Internal & External Respiration



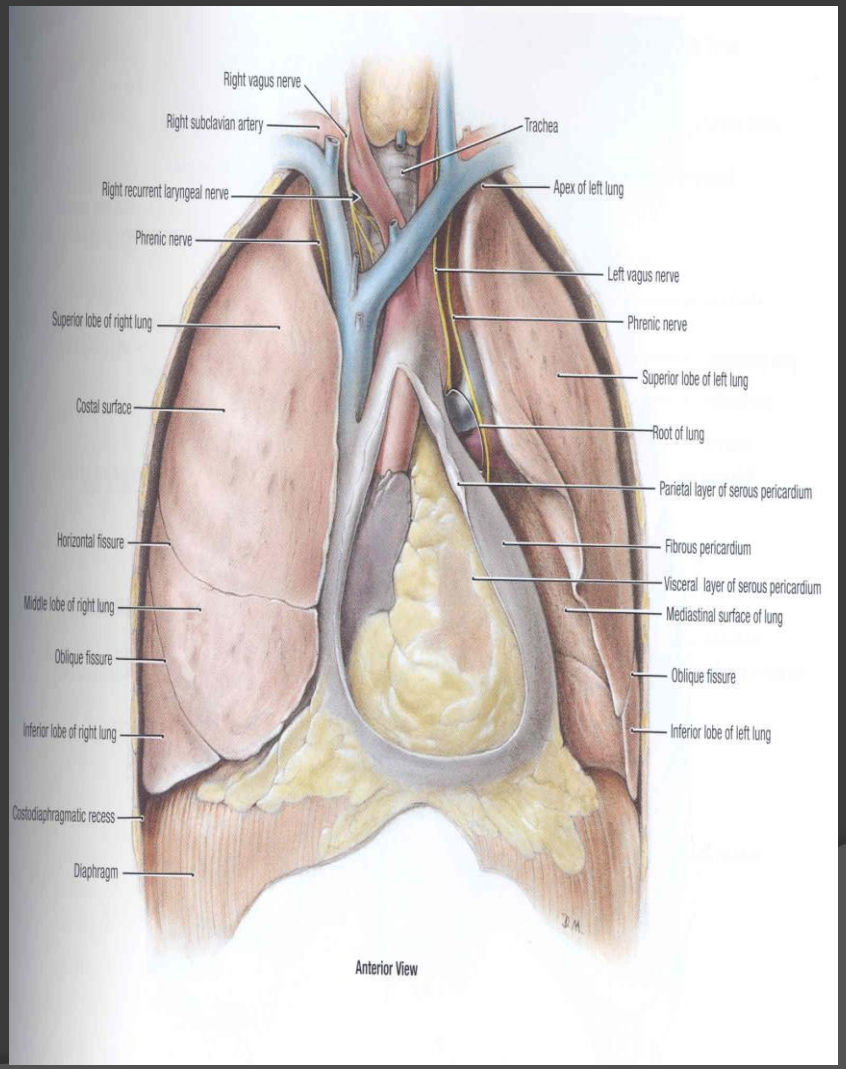
External respiration

3 major functional events

- 1-Pulmonary **ventilation**
- 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

The respiratory system is formed of

- **passages (airways)**
- **muscles**
- **centers**

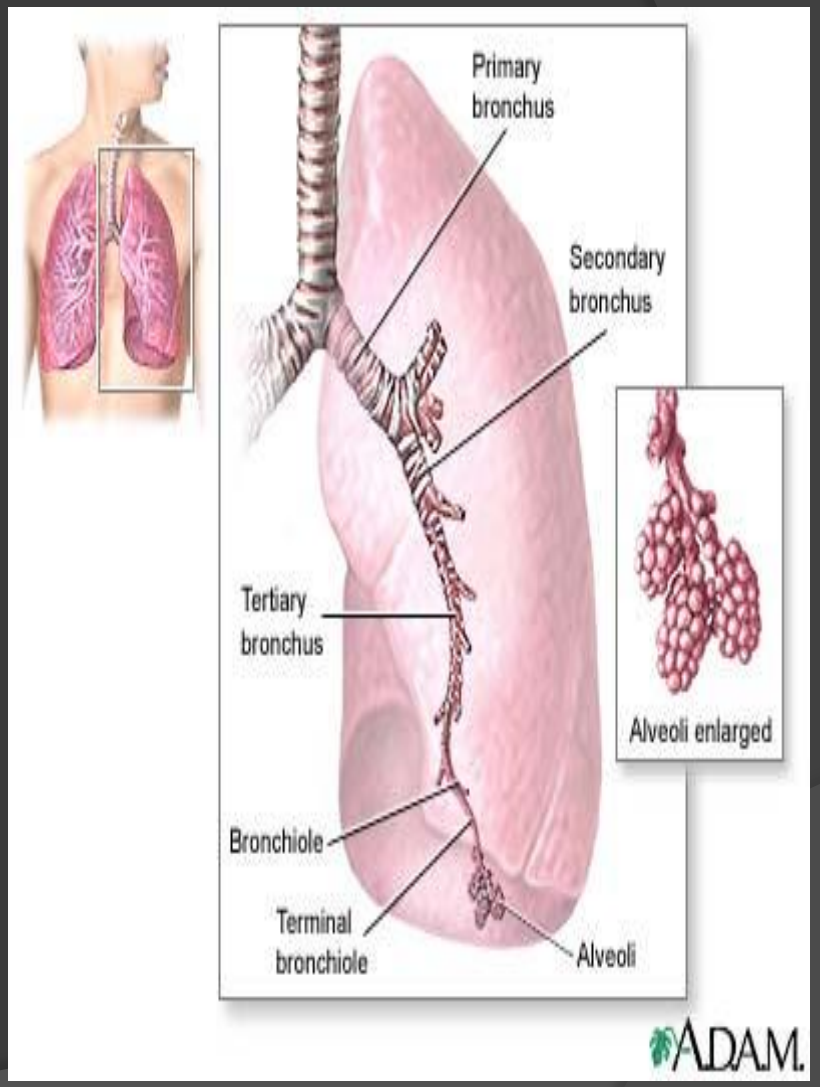


Respiratory passages (airways) can be divided into

- ***I-The conductive zone*:**
- brings fresh air to the deeper part of the lungs.

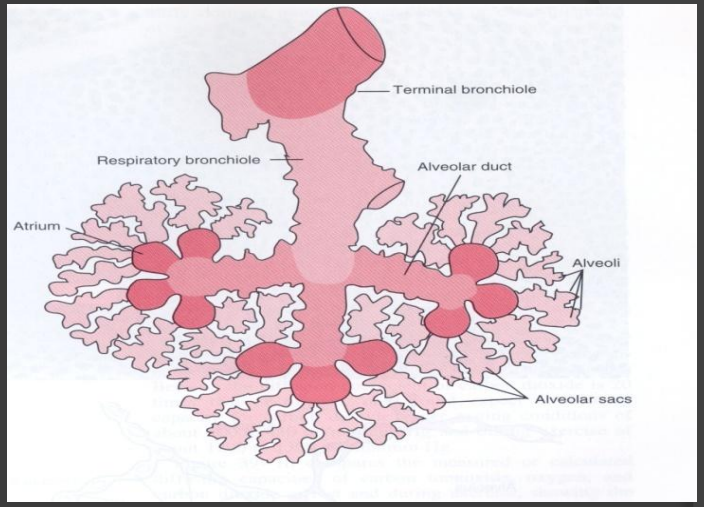
*help *warming - humidification - filtration* of inspired air

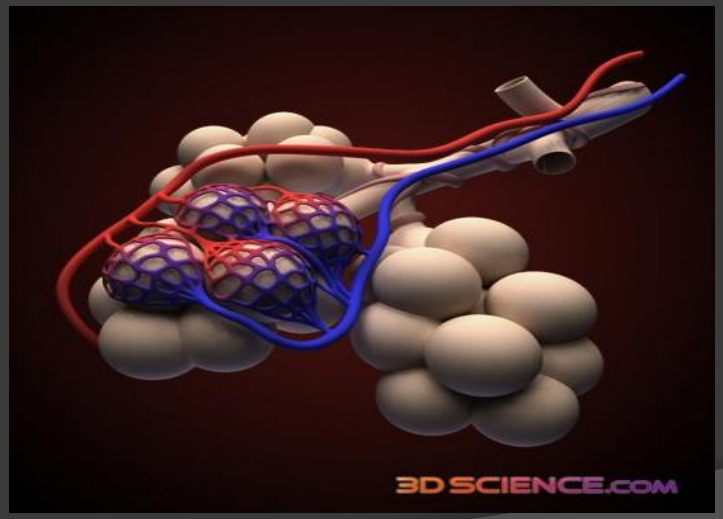
*contains the *olfactory receptors* and **conducts the sound* during the speech



II. Respiratory zone or gas exchanging part

- **(acini or primary lobule (respiratory unit).**





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 and
- *The macrophages phagocytose* smaller particles which pass through the mucocilliary barrier filter.

Cont..non respiratory functions of lung

- metabolism and handling of bioactive materials:
  -**Angiotensin I is converted to angiotensin II** with the help of converting enzymes formed by the lungs
- **Humidification;** this prevents dehydration of the epithelium , regulates body temperature ,regulate water balance by losing water in the form of vapor in expired air.
- **regulating the acid- base status** of the body by washing out extra carbon dioxide from the blood.
- Secretion of important substances like surfactant .

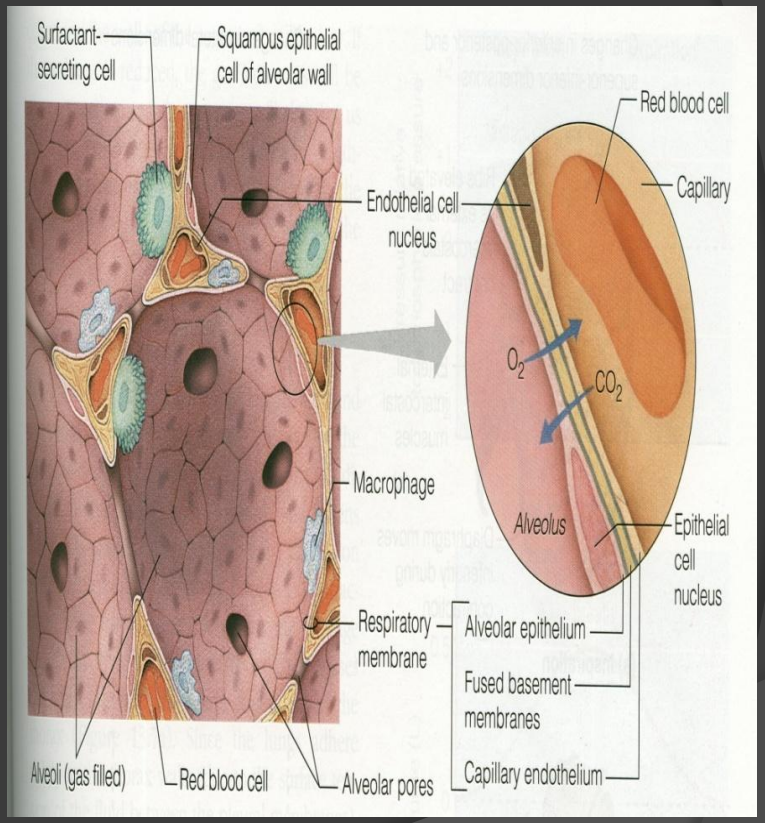
Lining cells of the alveoli

- Type I alveolar cells

  (share in the respiratory membrane for gas exchange)
- Type II alveolar cells

  (secrete surfactant)
- Macrophages

  (engulf foreign bodies)



surfactant

- Surfactant is a complex substance containing phospholipids and a number of apoproteins.
- This essential fluid is produced by the Type II alveolar cells, and lines the alveoli and smallest bronchioles.
- **Secreted at wk 35 of intrauterine life from fetal alveoli.**
- Surfactant reduces surface tension throughout the lung, thereby contributing to its general compliance

Surfactant


P II cell
Alveoli without surfactant
P
P
Alveoli with surfactant
D.Orlando ©1995

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.

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" dilatation of the bronchi
- Parasympathetic constriction of the bronchi.
- Locally secreted factors *(histamine, SRSA, by Mast cells, Due to allergy often cause bronchiolar constriction*

Mechanics of breathing

Learning Objectives

- **By the end of this lecture you should 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- Describe pneumothorax.
- 5- Describe the pressure and volume relationships in a single respiratory cycle.
- 6- Define lung compliance and list the determinants of compliance.
- 7- Describe the physiological significance of surfactant and provide an example of abnormal lung function due to a deficiency of surfactant.
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Mechanics of pulmonary ventilation:

- **Inspiration is an active process; resting expiration is a passive process due to the recoil tendency of the lung**

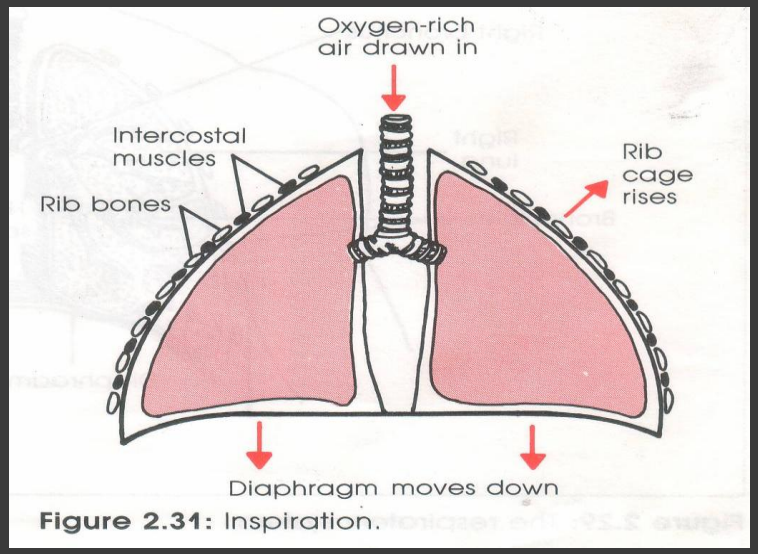


Figure 2.31: Inspiration.

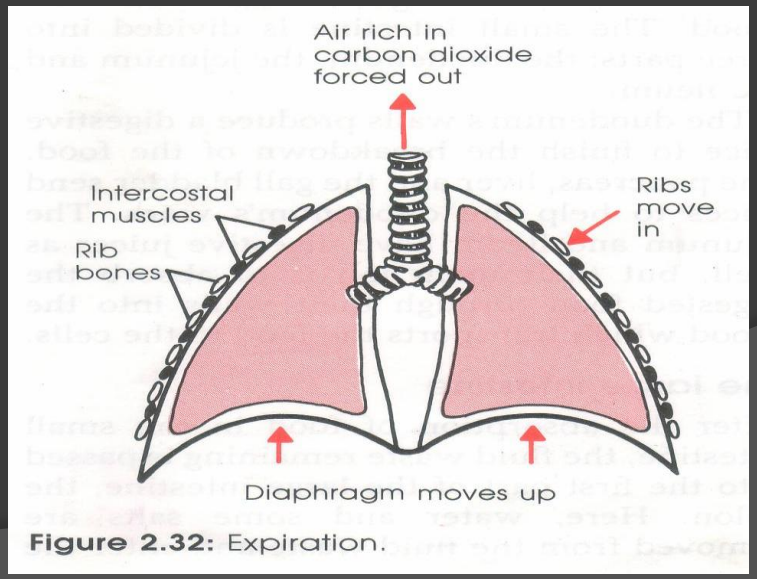
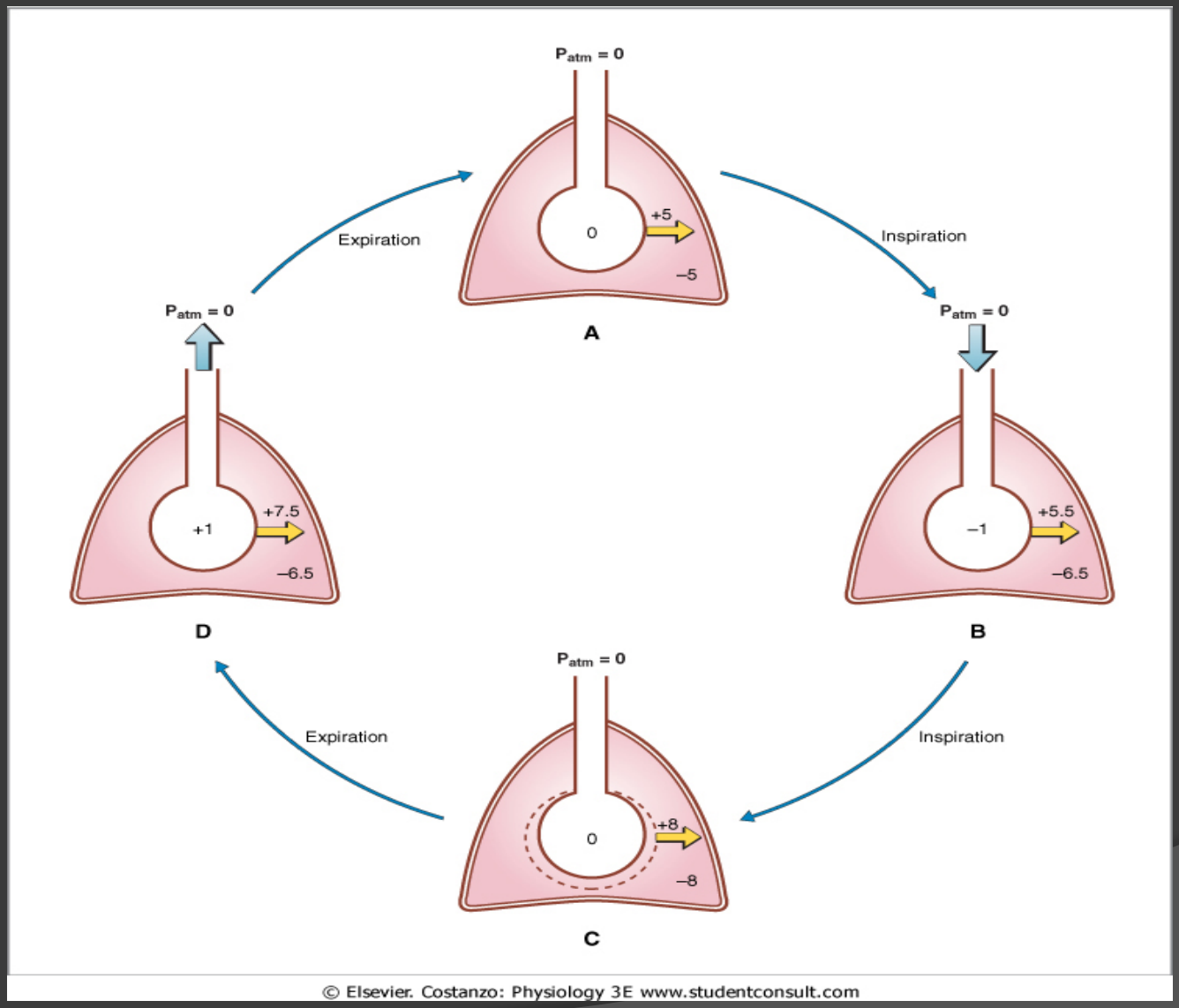


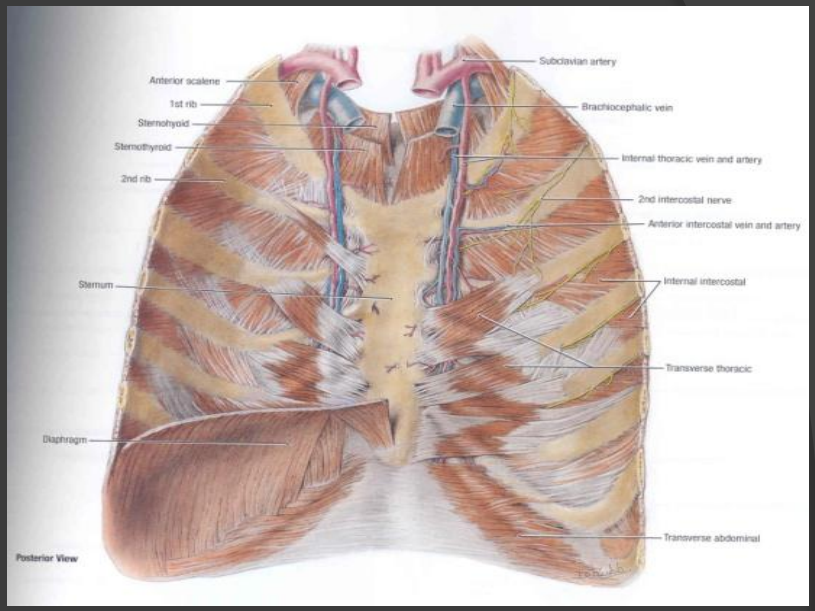
Figure 2.32: Expiration.

Cont.... Mechanics of ventilation

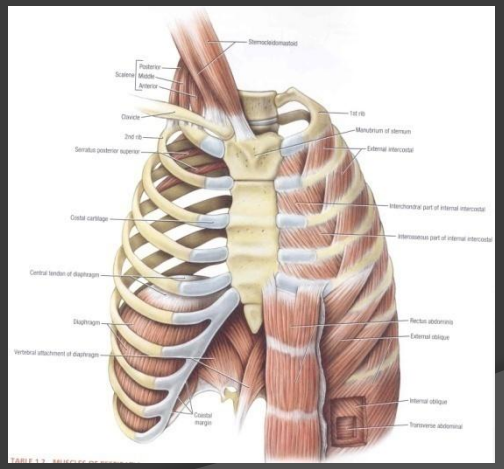


Respiratory muscles

- ***Inspiratory muscles***
  (resting- forced)

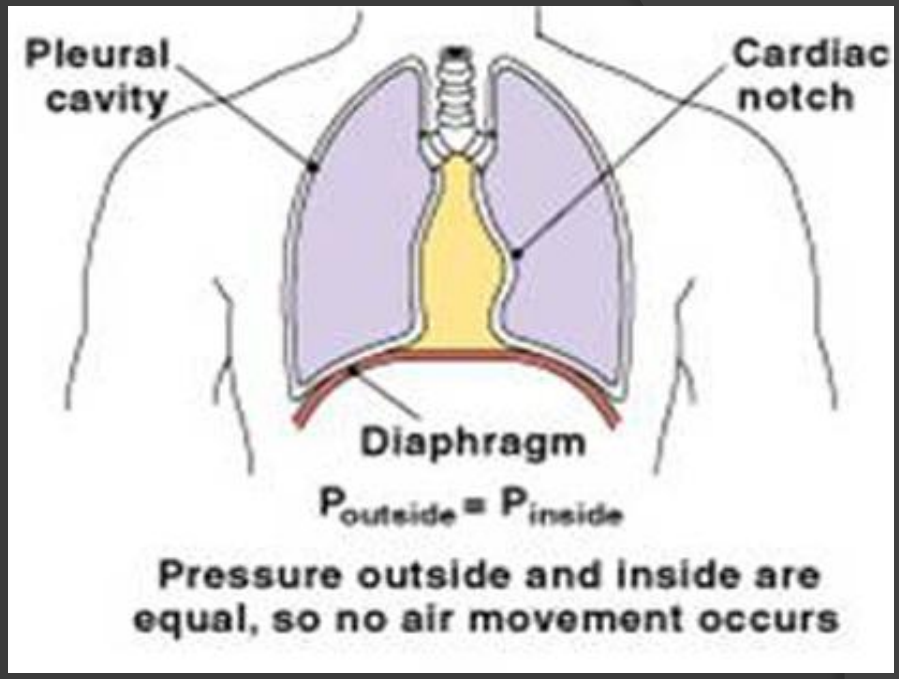


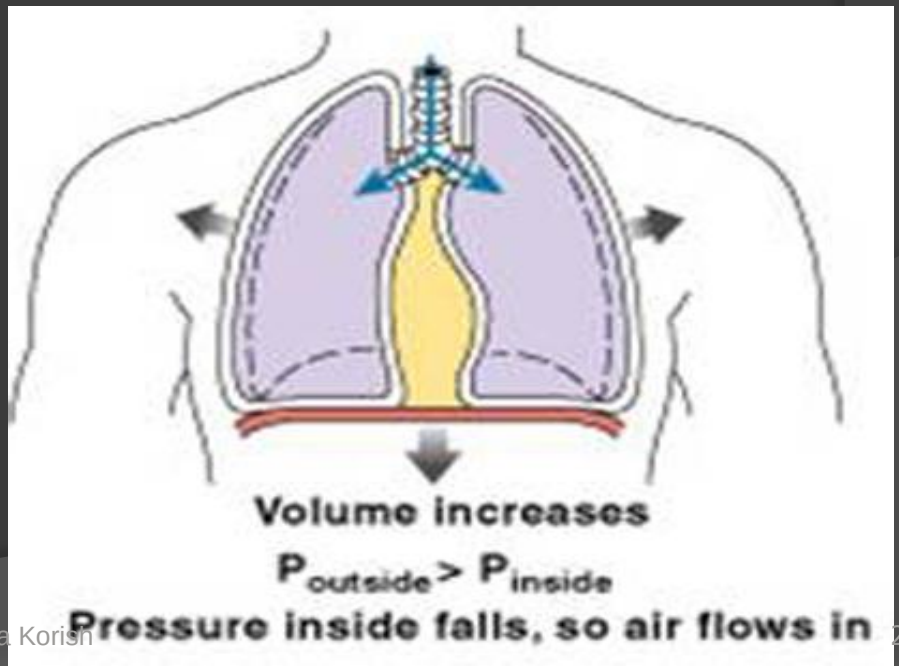
- ***Expiratory muscles***
  (forced expiration- muscles that depress the rib cage)



Inspiration

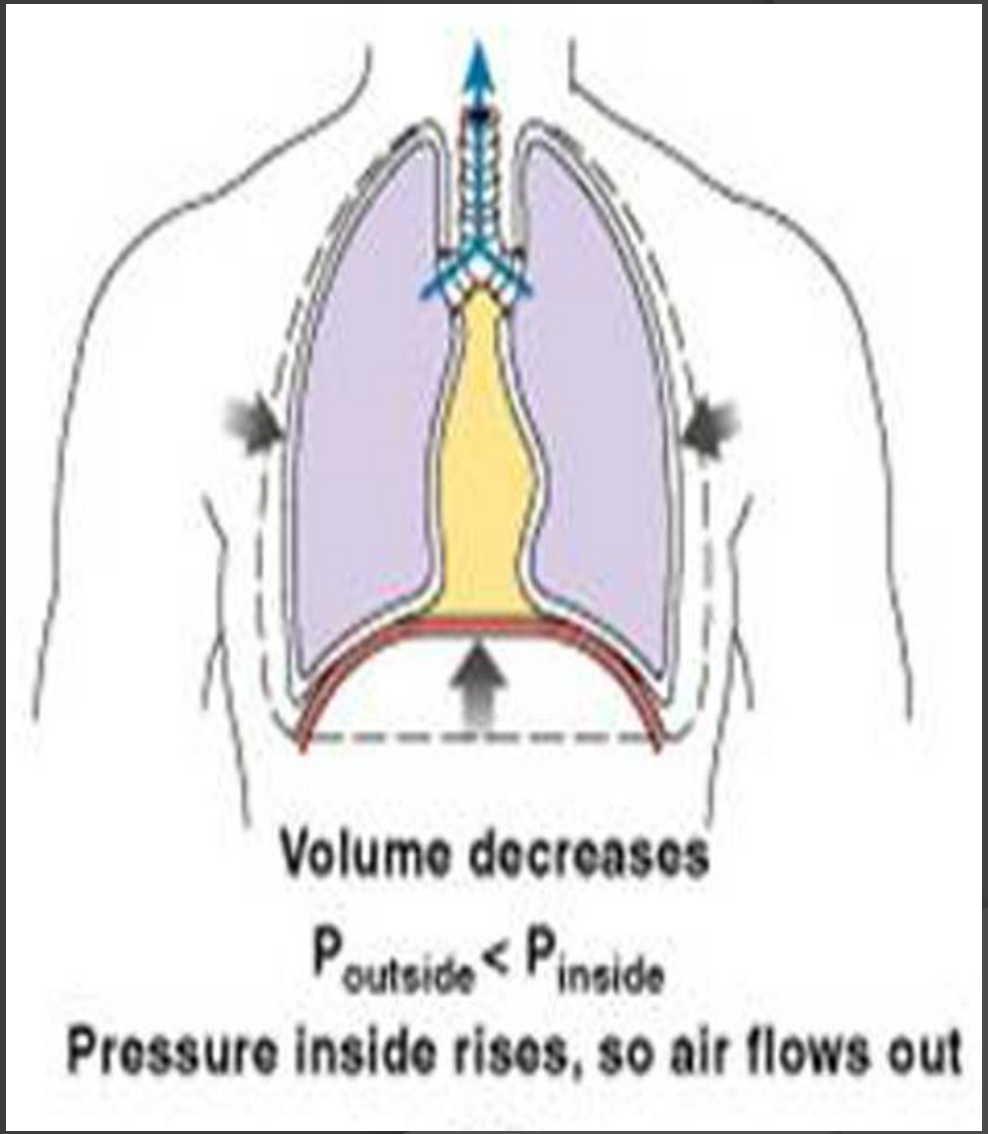
- Active process
  - During quiet breathing contraction of diaphragm and external intercostals expands thoracic cavity
  - Decreases pressure (Boyle's law – volume inversely related to pressure)
  - air flows down pressure gradient





Expiration

- Exhalation during quiet breathing is passive process
  - Elastic recoil of chest wall and lungs
  - Due to:
    - Recoil of elastic fibres
    - Inward pull of surface tension of alveolar fluid

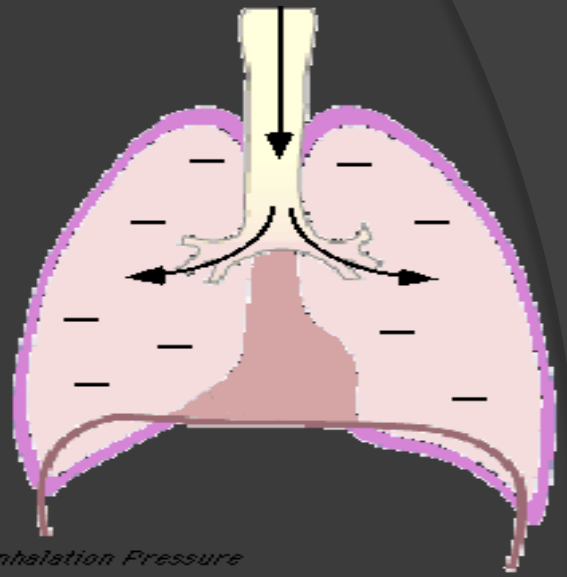


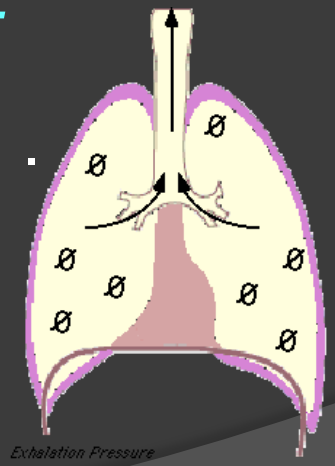
Deep Forceful Breathing

- 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
    - Internal intercostals

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, at .





- 2-Intrapleural pressure (IPP): *is negative with respect to atmospheric pressure at the end of normal expiration.*
- *The lung's elastic tissue causes it to retract, while that of the chest wall causes it to expand. Because of these 2 opposing forces the* ***pressure in the pleural cavity becomes negative.***
- It is a potential space, empty due to continuous suction of fluids by lymphatics.

Values of IPP

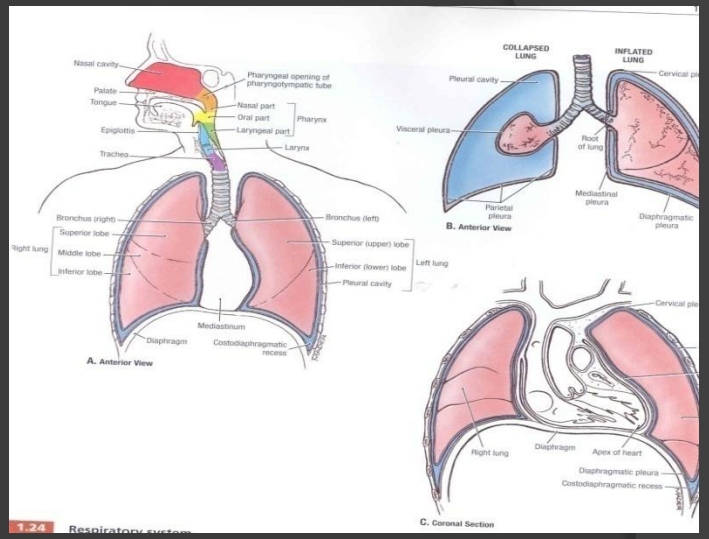
- -5 cm H2O during resting position between breathes, and it becomes more –ve (-7.5 cm H2O)
- *Quit ventilation*

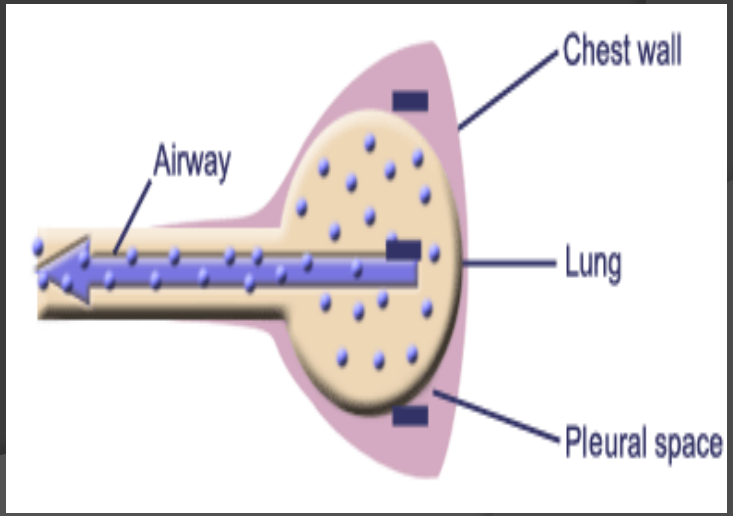
  Insp.: (-5 to -7.5)

  Exp. :1 cm H2O
- *Forced ventilation*

  Insp.:-20 to -40 cm H2O

  Exp.: + 30 cm H2O

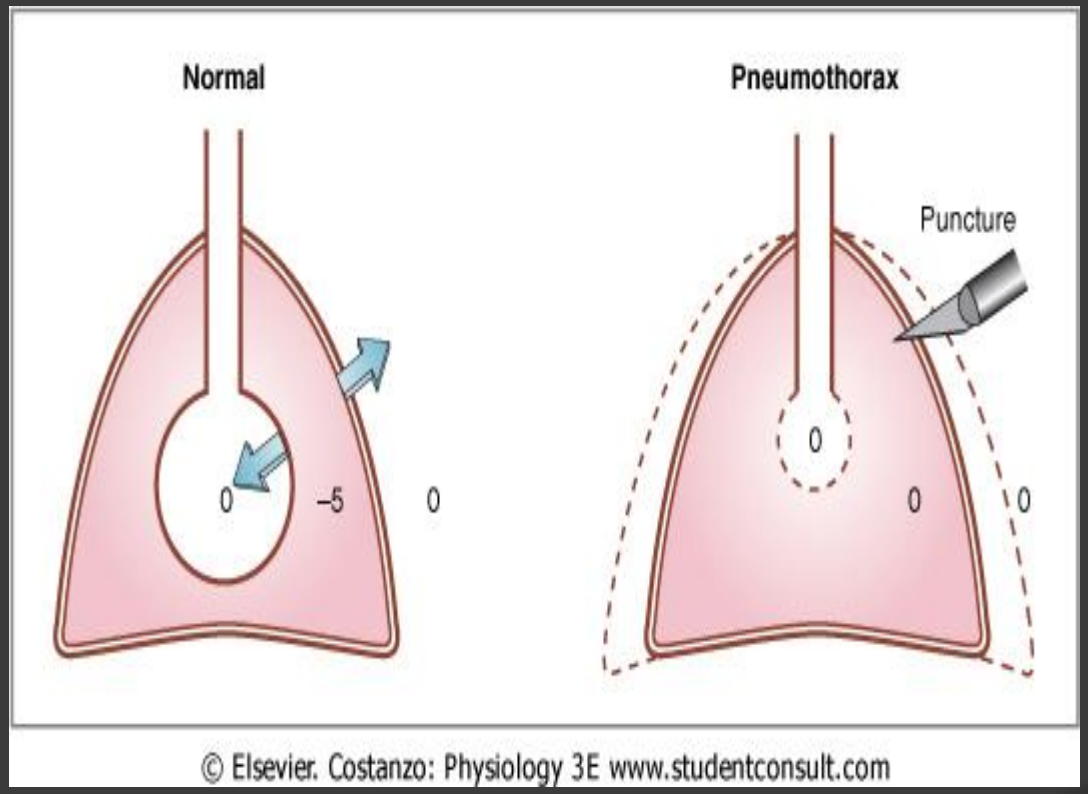




3-transpulmonary pressure

- *The difference between the alveolar pressure and the pleural pressure.*
- *TPp* = Palv-Ppl
- *It is a measure of the elastic forces in the lungs that tend to collapse the lungs called* ***the recoil pressure.***
- **Elastic Recoil of the Lung**
  Alveolar pressure minus pleural pressure (Palv-Ppl).
- Recoil tendency of the lung is highest at total lung capacity.

Pneumothorax

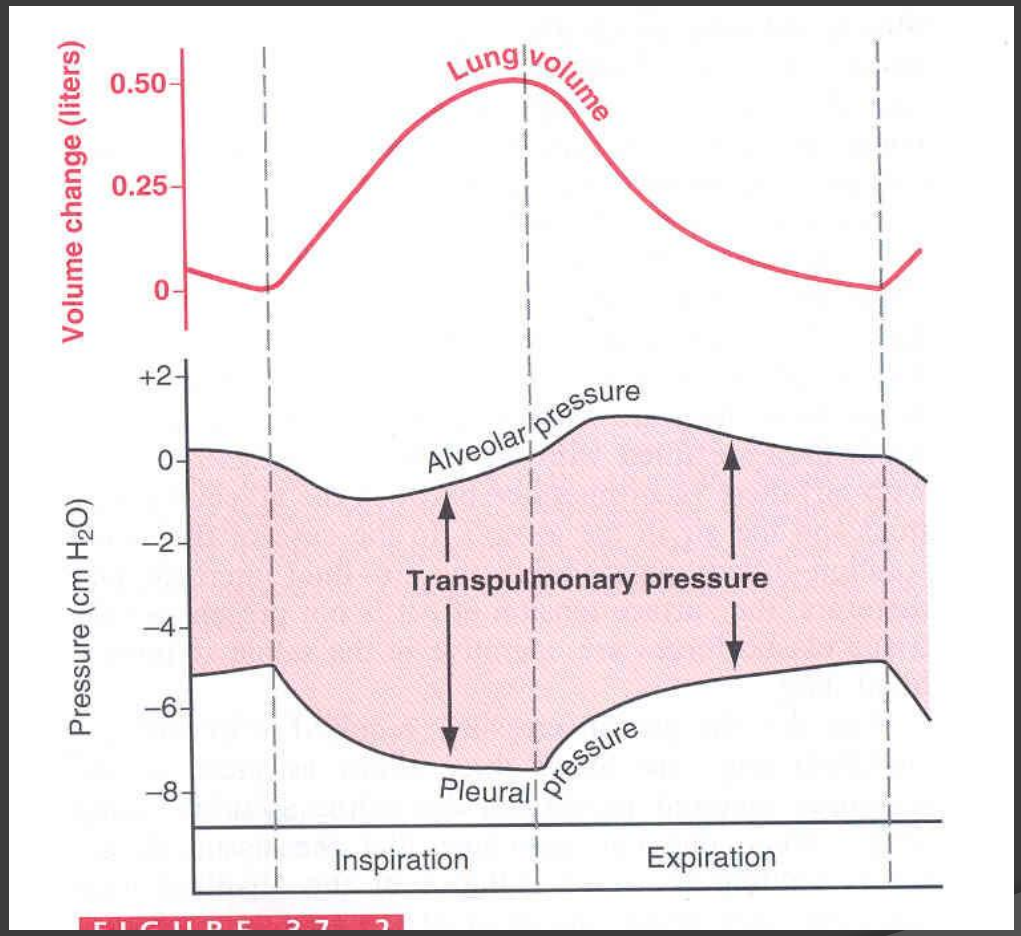


The elastic forces of the lungs.

This is divided into 2 parts

- the elastic forces of *the lung tissue itself*
- (caused by collagen and elastin fibers)
- (account for 1/3 of the total elastic forces of the lung).
- The elastic forces caused by *the surface tension* of the *fluid* lining the alveoli 2/3 of the total elastic forces of the lungs.

Volume change / pressure change
(Compliance of the lung) in a single respiratory cycle



Compliance of the lungs

- **The extent to which the lungs expand for each unit increase in transpulmonary pressure.**
- ***Is defined as, the ratio of change in the lung volume produced per unit change in distending 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 = 200ml of air /cm H20.
- Of the lungs and thorax together= 110ml/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 that normally opposes lung expansion.

Compliance diagram of the lungs: