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-Discuss the functions of the respiratory system, including non-respiratory functions, like the metabolic function, the protective functions, the production of surfactant and its physiological significance.

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

3-Distinguish the difference between internal and external respiration.

4- Identify the cells lining the alveoli and discuss their functions and the concept of surface tension.

5- Identify the innervation of the respiratory passages and the determinants of airway resistance.

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Functions of the respiratory system include

- **Respiratory function:** The main function is to provide O2 to the tissues and remove CO2 through Gas exchange.
- **Non respiratory functions:**

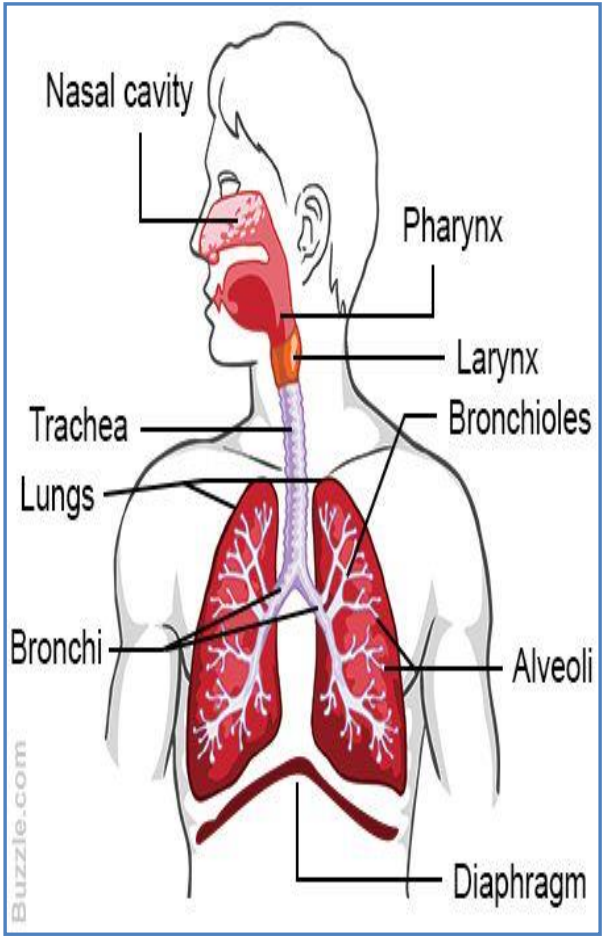
*1- **Olfaction**:* sense of small by the receptors in roof of nose.

*2- **Phonation**:* is the production of sounds by the movement of air through the vocal cords.

*3- **Pulmonary defense:*** The respiratory mucus membrane has muco-cilliary barrier filter, and it secretes:

✓Immunoglobulin A (Ig A)

✓Alpha-1 antitrypsin.



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Cont.. non respiratory functions of lung

- ✓ The pulmonary macrophages in the alveoli: engulf smaller foreign particles which pass through the mucocilliary barrier filter.
- ✓ *Cough reflex*: initiated by slight foreign bodies irritation of bronchi and trachea.
- ✓ *Sneezing reflex:* like the cough reflex, it applies to the nasal passageways instead of the lower respiratory passages.

***4- Activation of Angiotensin* I to angiotensin II** with the help of angiotensin converting enzyme (ACE) formed by the lungs.

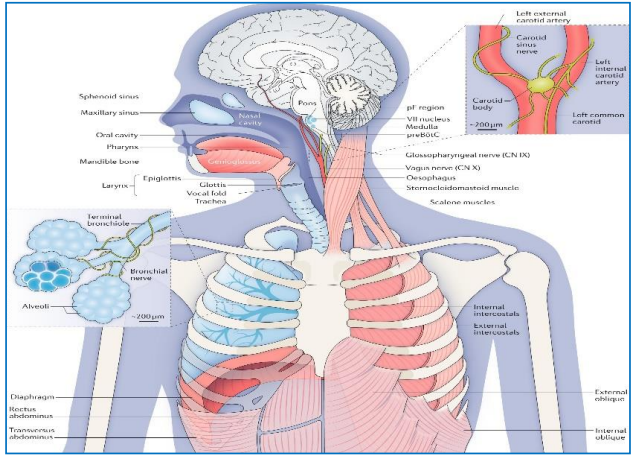
5- *Regulating* the acid-base status of the body by washing out extra carbon dioxide from the blood.

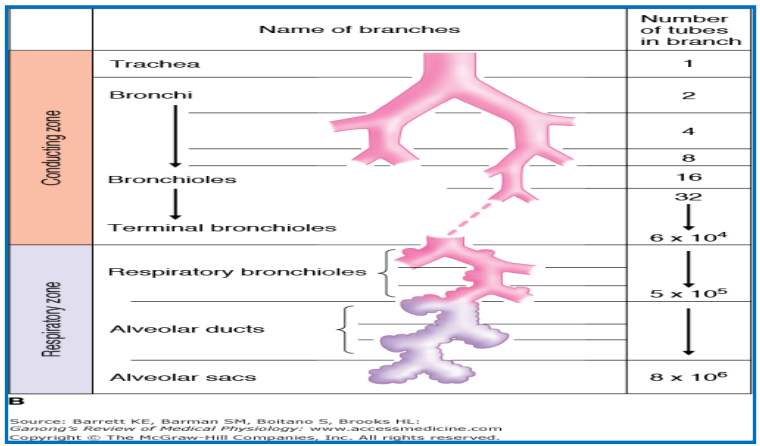
6- Secretion of important substances like surfactant**.**

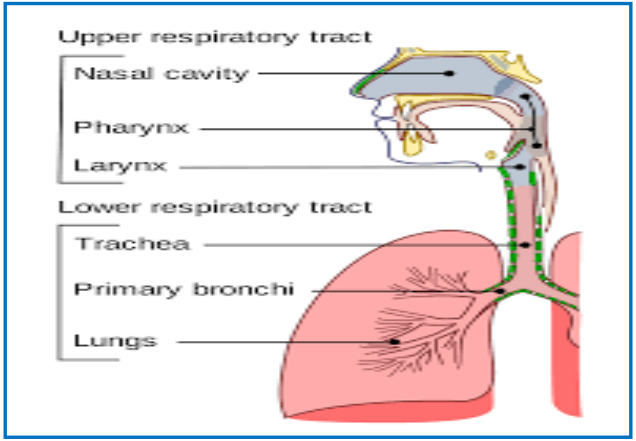
Organization of the respiratory system

Respiratory system consists of:

- Respiratory Passages (airways)
- Respiratory Muscles
- Respiratory Control Centers







I- Conductive Zone

- Starts from trachea 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.

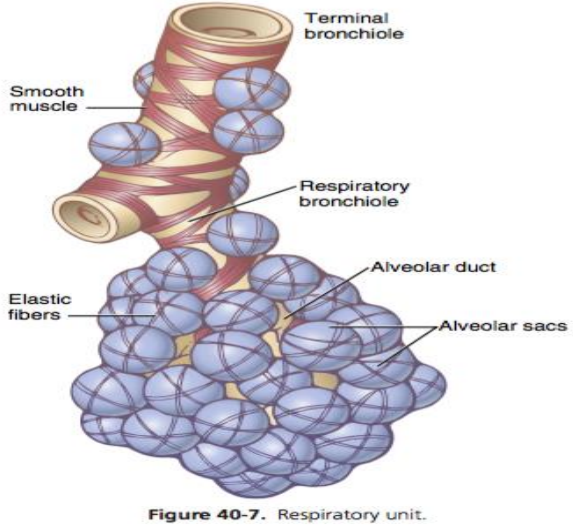


Figure 40-7. Respiratory unit.

External and Internal Respiration

External respiration:

The absorption of O2 and removal of CO2 from the body as a whole. ***4*** major functional events occur during it:

(1) Pulmonary ventilation.

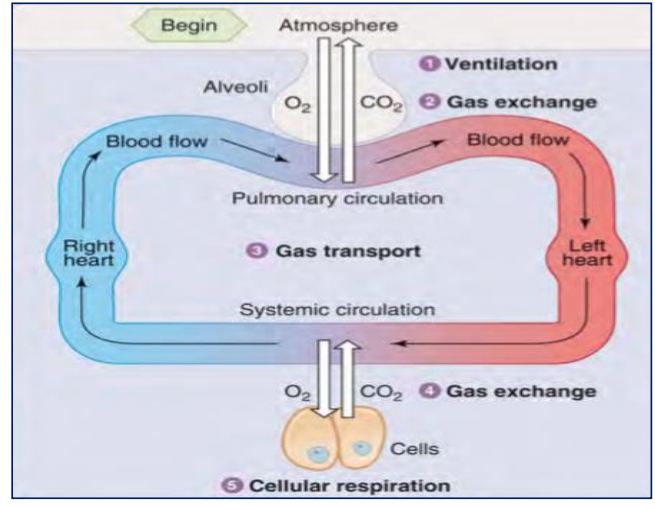
(2) Diffusion of (O2) and(CO2) between the alveoli and the blood.

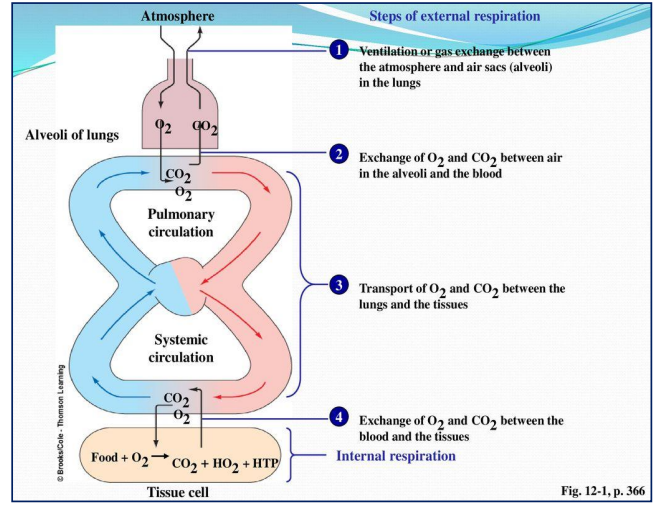
(3) Transport of Oxygen and carbon dioxide in the blood and body fluids to and from the body's tissue cells.

(4) Control of breathing.

Internal Respiration:

The utilization of O2 and production of CO2 by the cells. (Cellular respiration)





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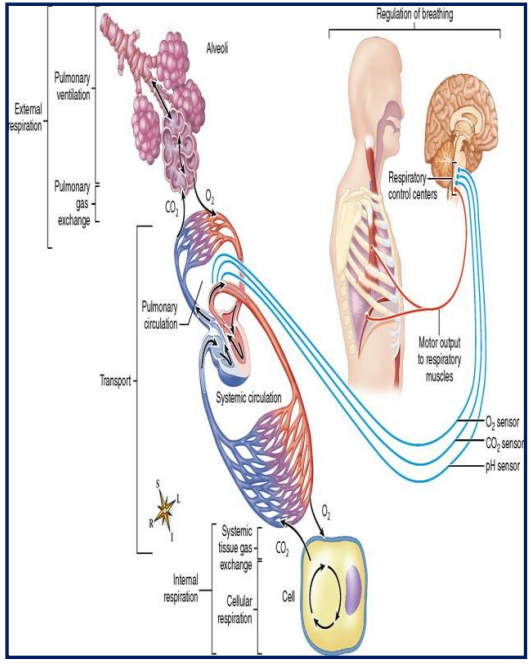
<u>Respiration (breathing) could be described as either:</u>

***Resting breathing*:** normal breathing during resting conditions.

Forced (maximal) breathing: *It occur* during exercise and in patients with bronchial asthma, allergy, other pulmonary diseases.



Lining cells of the alveoli

1- Type I alveolar epithelial cells

(type I pneumocytes)

*Participate in the respiratory membrane, across which gas exchange takes place.

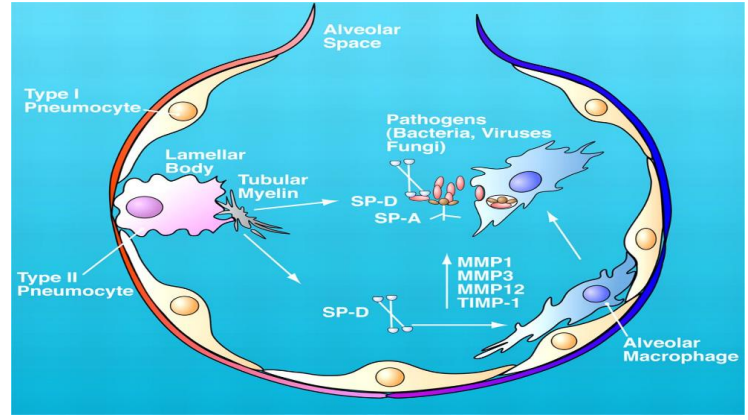
2- Type II alveolar epithelial cells (type II pneumocytes)

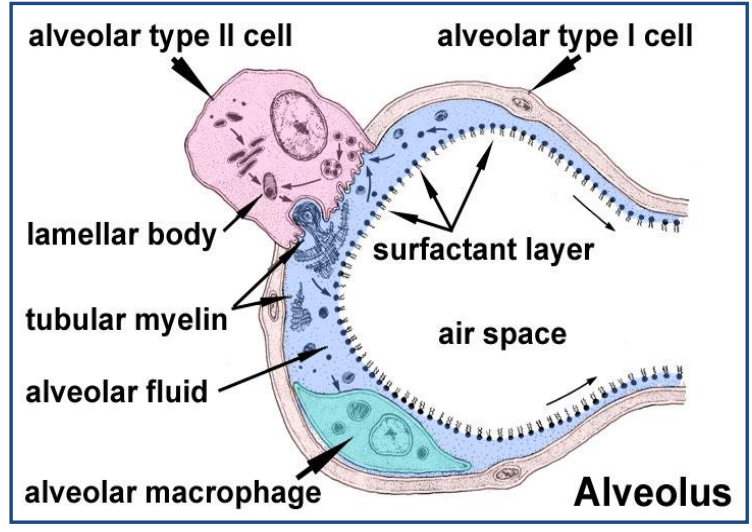
(10% of the surface area of alveoli)

*Secrete surfactant.

3- Alveolar macrophages

*Engulf the foreign bodies that reach the alveoli.



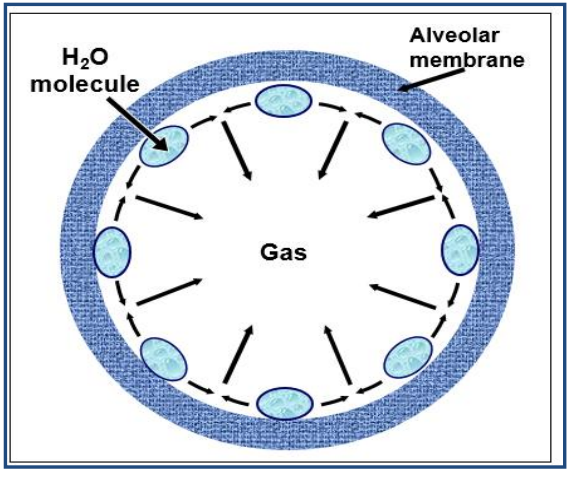


Surface Tension

H_2O molecules at the surface of alveoli are attracted to each other by attractive forces that resist distension called surface tension.

- Surface tension tends to oppose alveolar expansion.
- Pulmonary surfactant reduces the surface tension of the fluid lining the alveoli.
- Collapsing Pressure is caused by Surface tension of the fluid lining the alveoli and is indirectly related to the size of alveoli (law of LaPlace) .

$$\text{Pressure} = \frac{2 \times \text{Surface tension}}{\text{Radius of alveolus}}$$



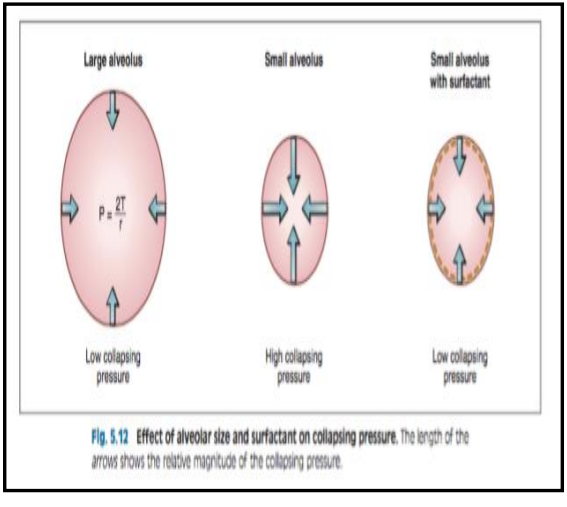
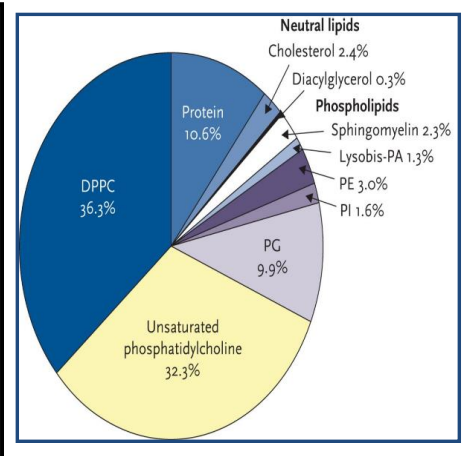
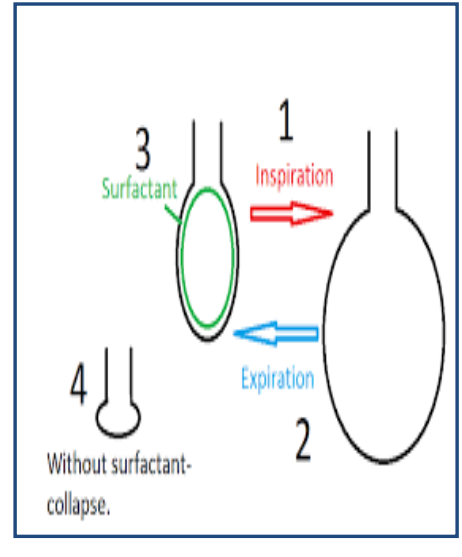


Fig. 5.12 Effect of alveolar size and surfactant on collapsing pressure. The length of the arrows shows the relative magnitude of the collapsing pressure.

Surfactant

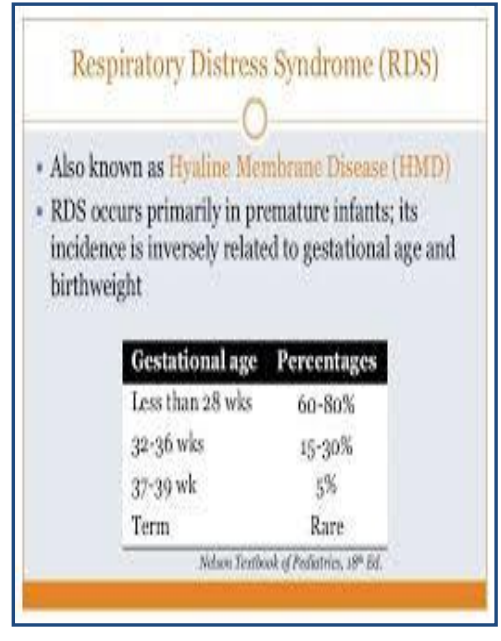
- Surfactant is a complex compound containing phospholipids especially. dipalmitoylphosphatidyl choline and a number of Apo proteins.
- The earliest detection of surfactant in fetal alveoli begins between 6-7th month (24-28 Wk) but could be delayed in others to wk 35 of intrauterine life.
- **Functions of surfactant:**
  - Reduces surface tension throughout the lung,
  - Reduces the effort (work of breathing) required by the respiratory muscles to expand the lungs
  - Prevents alveolar collapse,
  - Decreases airway resistance and keeps alveoli dry.





Surfactant deficiency

- Deficiency in premature babies causes respiratory distress syndrome of the new born (RDS) (hyaline membrane disease).
- Prevention: Corticosteroid injection to mothers expected to deliver prematurely. This will enhance surfactant maturation.
- After delivery they are given inhaled surfactant.
- Smoking in adults, hypoxia or hypoxemia, decrease the secretion of surfactant and cause adult respiratory distress syndrome.



Innervations of lungs and bronchi

- Is by autonomic nerves.
- Sympathetic stimulation releases epinephrine (adrenaline) causes dilatation of the bronchi.
- Parasympathetic stimulation releases acetyl choline causes constriction of the bronchi.
- Parasympathetic nerves are also activated by irritation of the epithelial membrane of the respiratory passageways by noxious gases, dust, cigarette smoke, or bronchial infection. Also, a bronchiolar constrictor reflex often occurs when micro emboli occlude small pulmonary arteries.
- Local Secretory Factors e.g *:* histamine, slow reacting substances of anaphylaxis (SRSA) secreted by the mast cells due to allergy (as in patients with asthma) often cause bronchiolar constriction and increased airway resistance leading to forced breathing.

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Resistance to Airflow in the Bronchial Tree

- The greatest amount of resistance to airflow occurs in some of the large bronchi and bronchioles near the trachea.

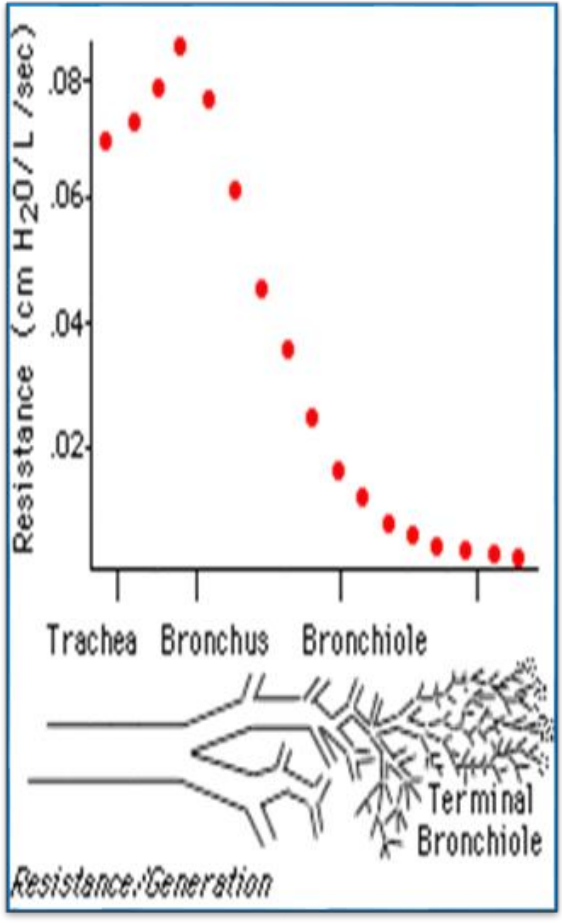
The reason for this high resistance is that there are relatively few of these large bronchi in comparison with the approximately 65,000 parallel terminal bronchioles,

- ***In some disease conditions***, the smaller bronchioles play a far greater role in determining airflow resistance because of their small size and because they are easily occluded by :

(1) Muscle contraction in their walls,

(2) Edema occurring in the walls, or

(3) Mucus collecting in the lumens of the bronchioles.



Airway resistance decreases as lung volume increases