

# Functions and organization of the respiratory system



**Dr. Aida Korish**  
**Associate Prof. Physiology**  
**KSU**

Dr.Aida Korish ( [akorish@ksu.edu.sa](mailto:akorish@ksu.edu.sa) )

# 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-Distinguish the difference between internal and external respiration.
- 3-Discuss the functions of the respiratory system, including non-respiratory functions, like clearance mechanism by mucus and cilia, production of surfactant and its physiological significance.

# What is the main goal of respiration?

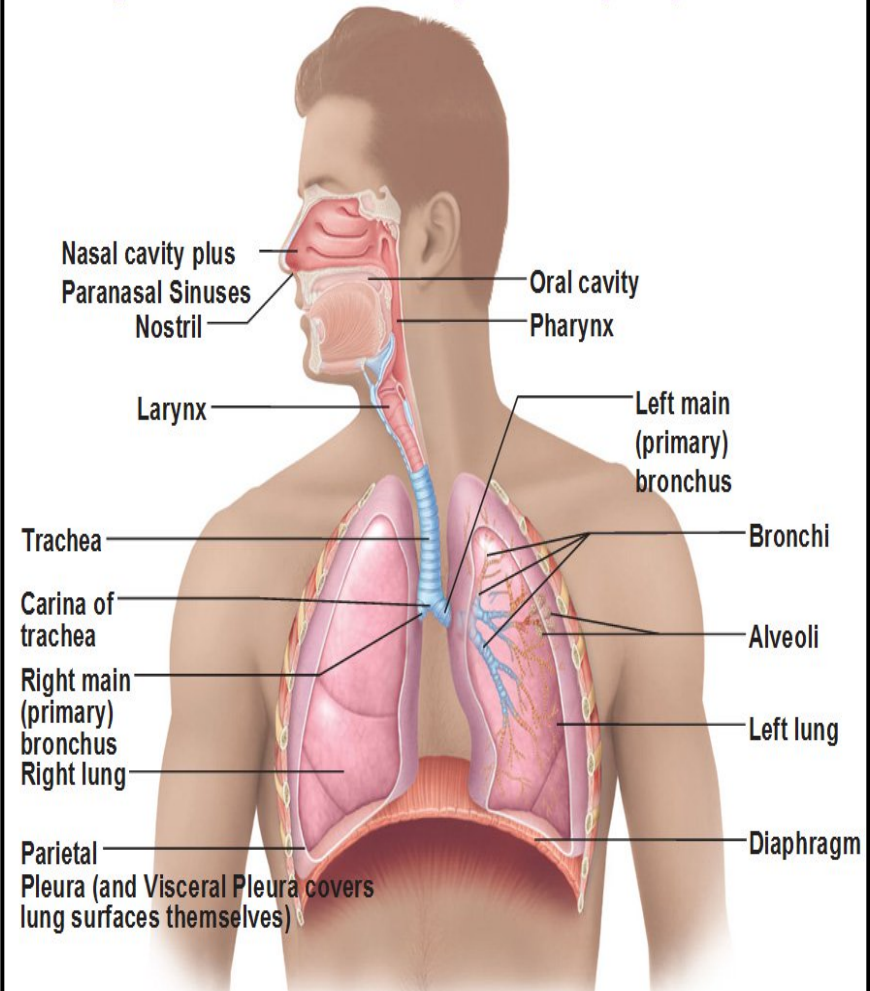
is to

- 1- Provide oxygen to tissues.
- 2- Remove CO<sub>2</sub> from the body.

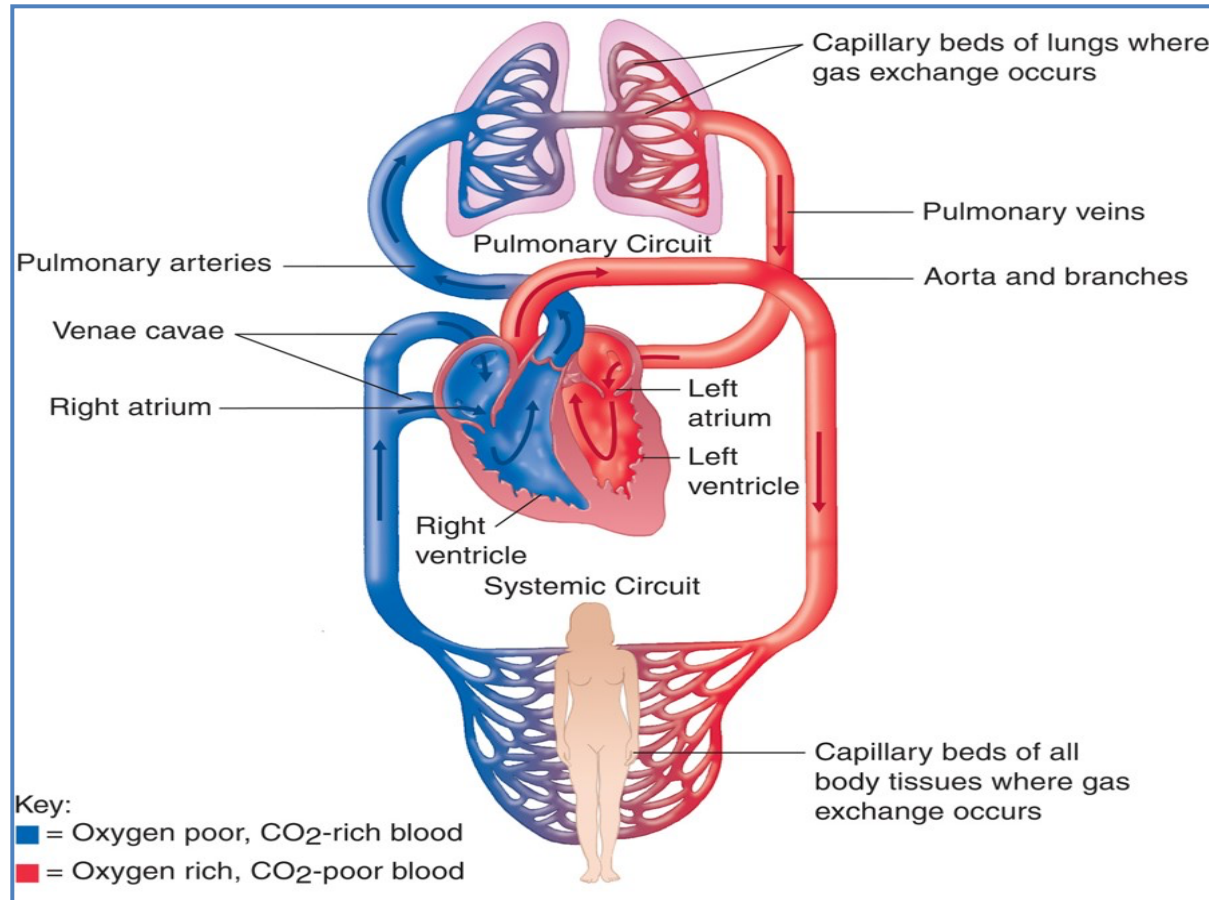
Respiratory system consists of:

- Passages (airways)
- Muscles
- Centers

## Organs of the Respiratory System



# Where gas exchange takes place?



## Functions of the respiratory system include

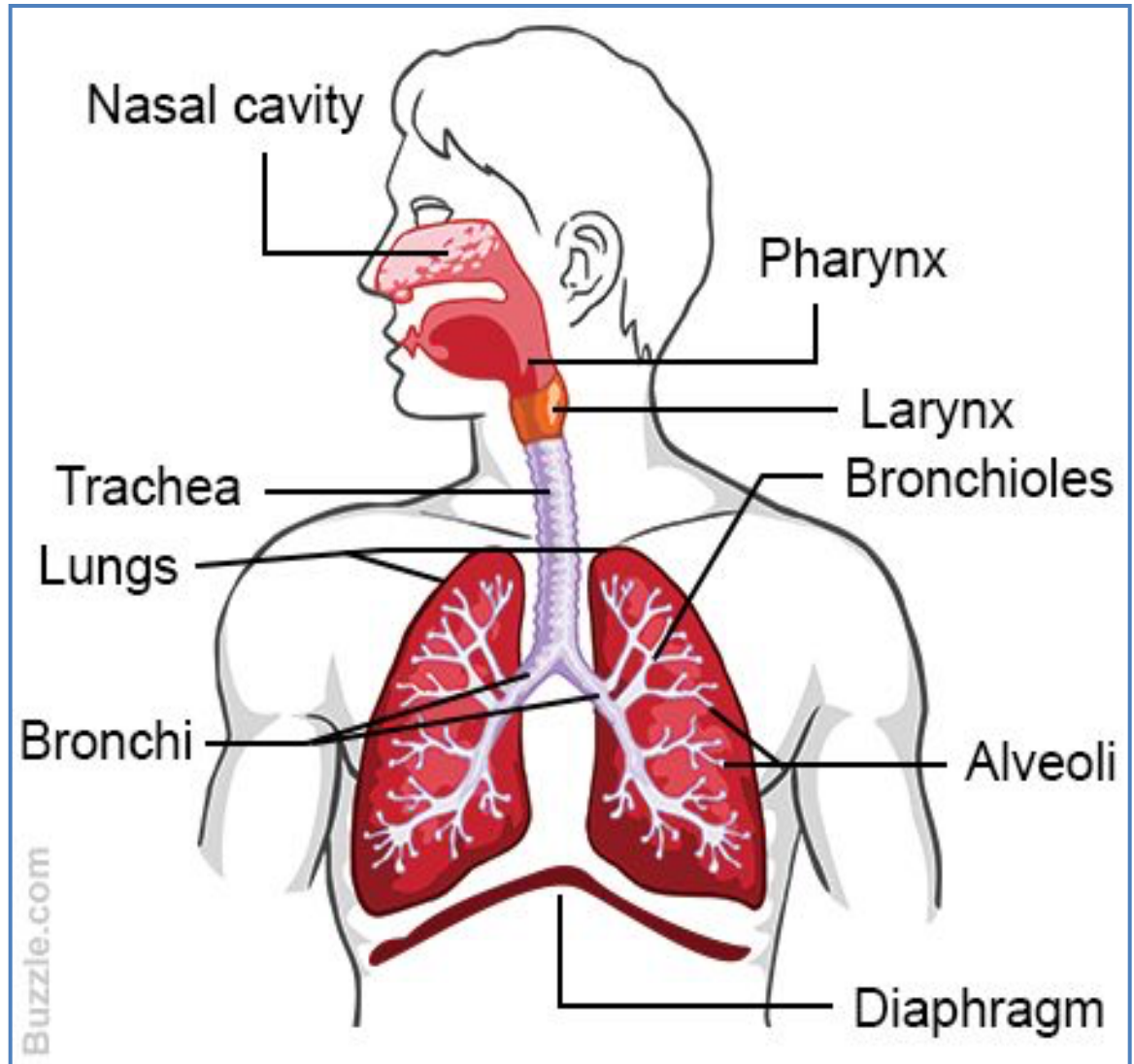
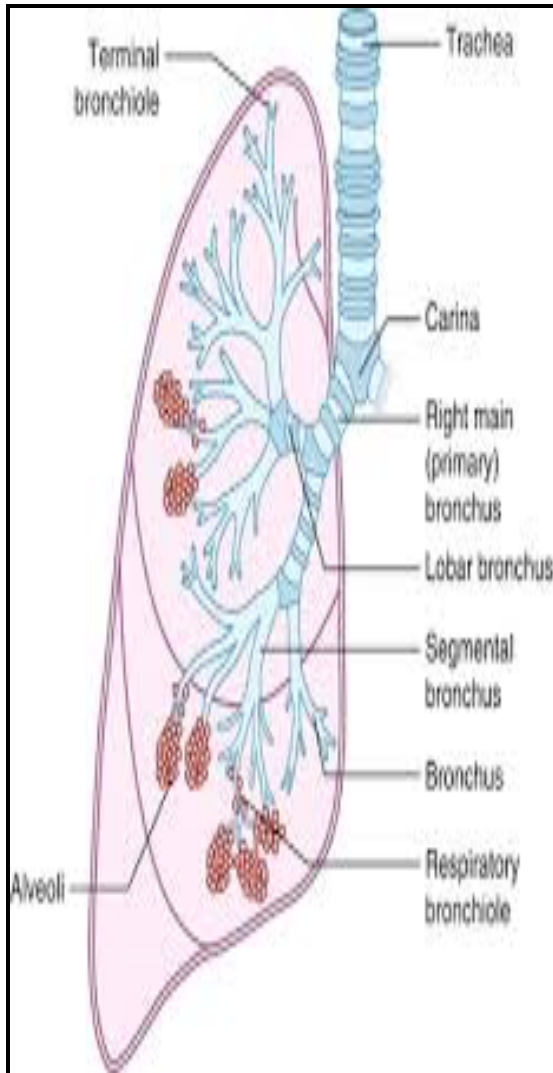
- Gas exchange (respiratory function).
- Phonation: is the production of sounds by the movement of air through the vocal cords.
- Pulmonary defense: the respiratory mucus membrane has muco-cilliary barrier filter and it produces
  - *Immunoglobulin A (Ig A),*
  - *Alpha-1 antitrypsin,*

*In addition, the pulmonary macrophages in the alveoli: engulf smaller foreign particles which pass through the muco-cilliary barrier filter.*

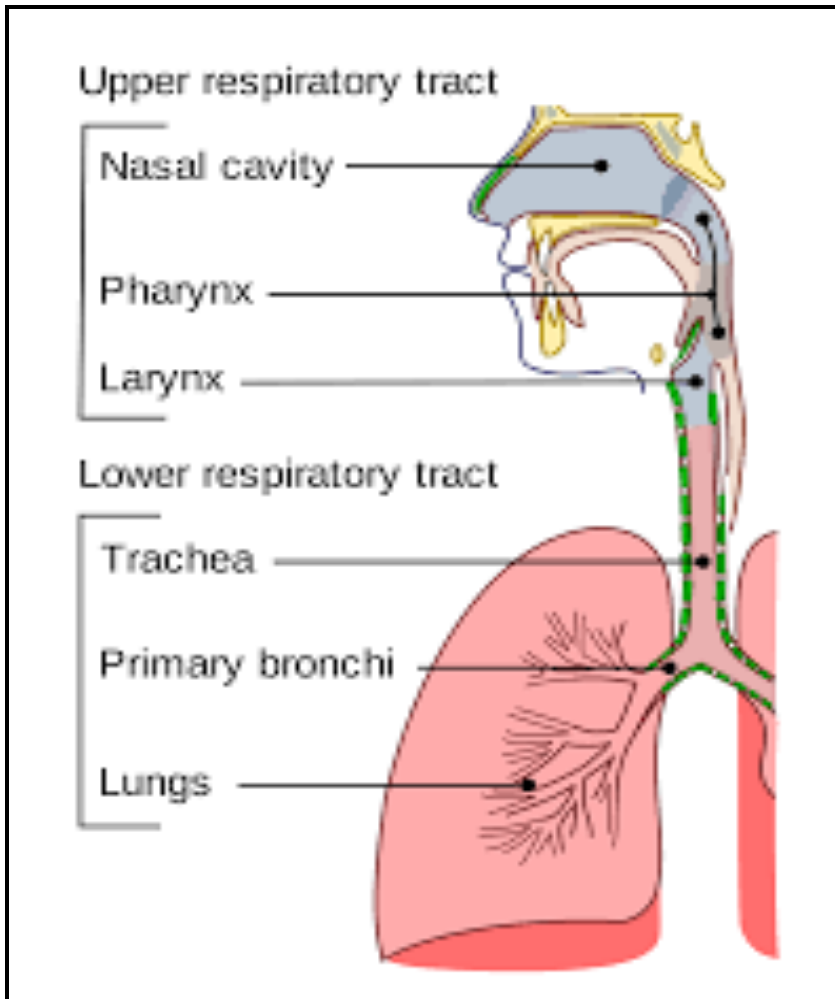
## Cont..non respiratory functions of lung

- 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)



# Organization of the respiratory system



	Name of branches	Number of tubes in branch
Conducting zone	Trachea	1
	Bronchi	2
		4
	Bronchioles	8
		16
	Terminal bronchioles	32
Respiratory zone	Respiratory bronchioles	$6 \times 10^4$
		$5 \times 10^5$
	Alveolar ducts	
	Alveolar sacs	$8 \times 10^6$

**B**

Source: Barrett KE, Barman SM, Boitano S, Brooks HL:  
*Ganong's Review of Medical Physiology*: www.accessmedicine.com  
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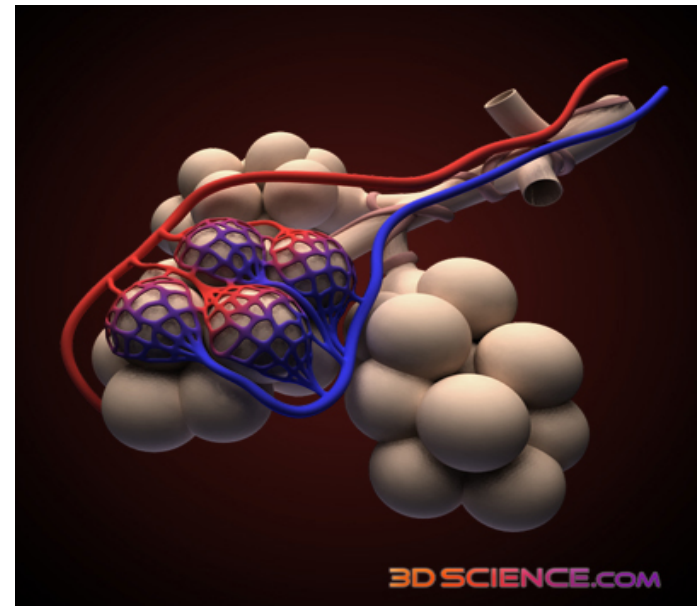


## I- Conductive Zone

- 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.



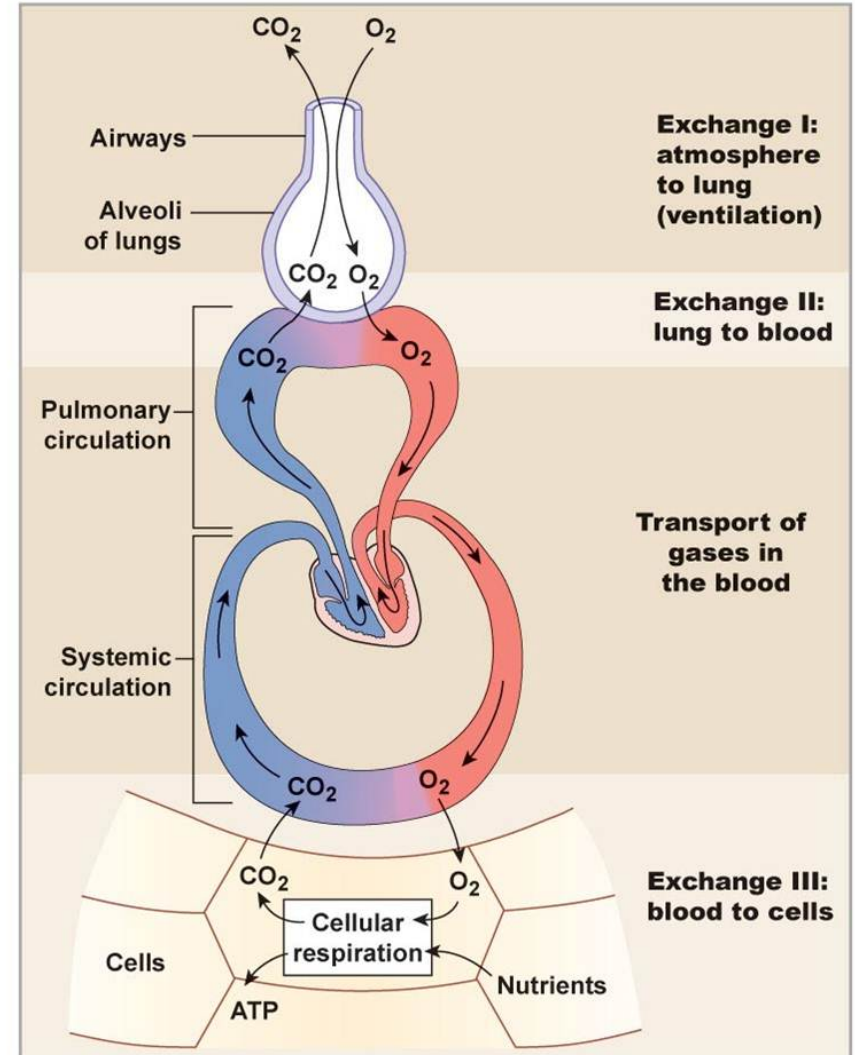
# External and Internal Respiration

## External respiration:

The absorption of O<sub>2</sub> and removal of CO<sub>2</sub> from the body as a whole.

## Internal Respiration:

The utilization of O<sub>2</sub> and production of CO<sub>2</sub> by the cells.



**The four major components of respiration are**

1- **Pulmonary *ventilation***, which means the inflow and outflow of air between the atmosphere and the lung alveoli;

2- **Diffusion of oxygen ( $O_2$ ) and carbon dioxide ( $CO_2$ ) between the alveoli and the blood;**

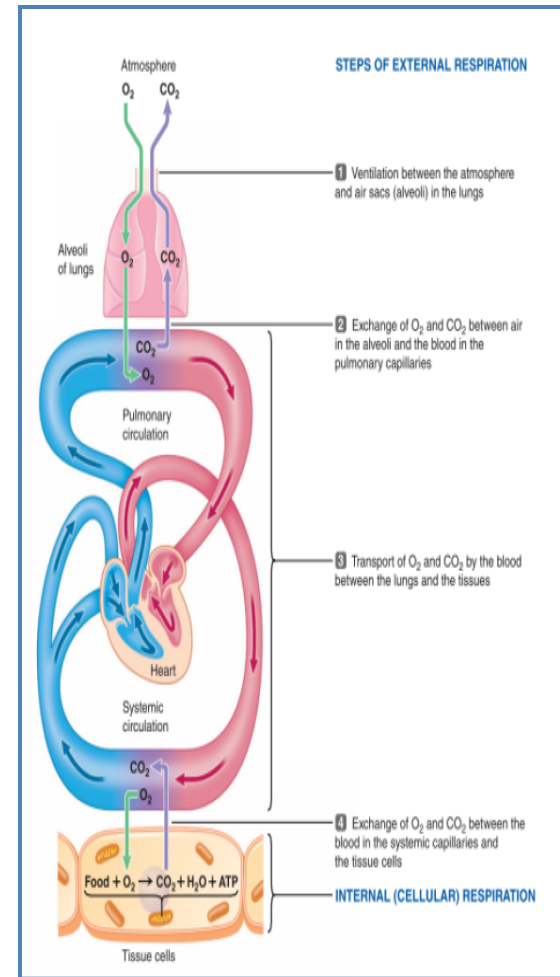
3 -**Transport of oxygen and carbon dioxide in the blood and body fluids to and from the body's tissue cells;** and

4- **Regulation of ventilation** and other facets of respiration.

Respiration (breathing) could be either:

**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.

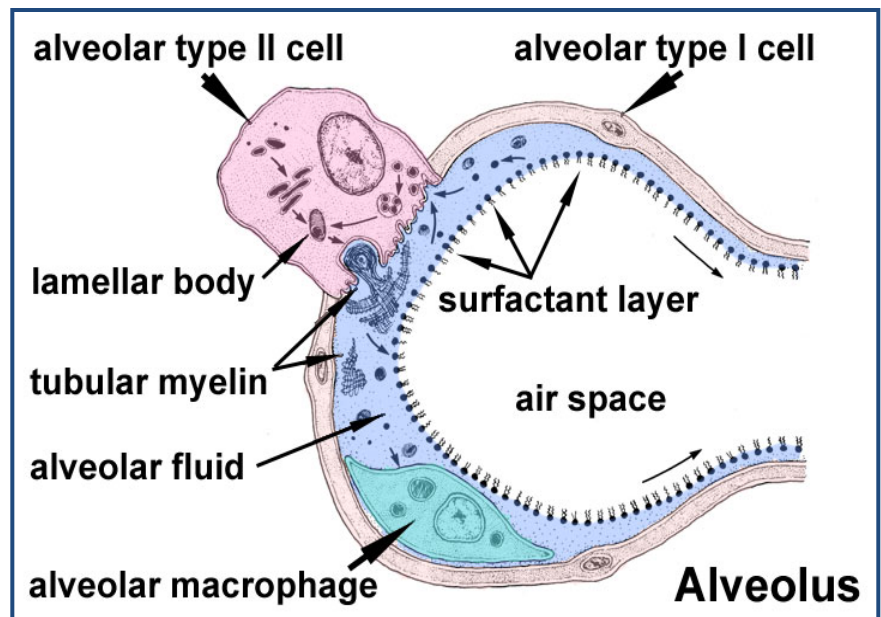
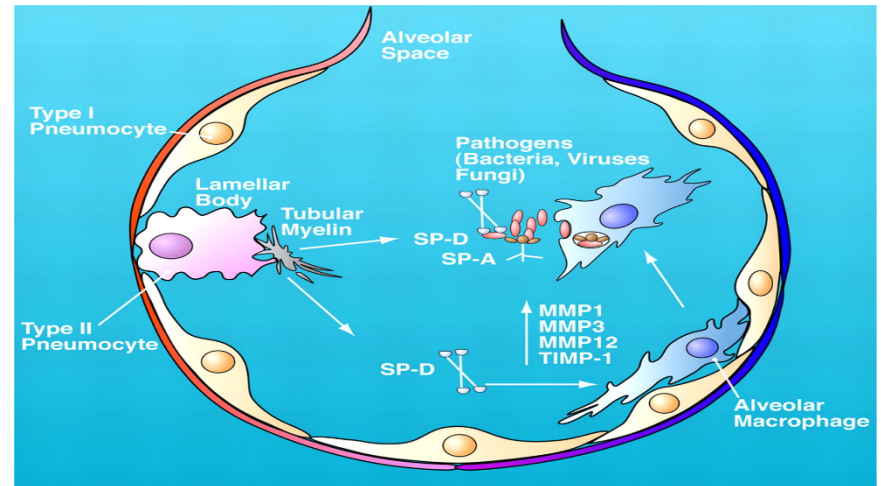
2- Type II alveolar epithelial cells

( 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<sub>2</sub>O 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 alveoli expansion.
- Pulmonary surfactant reduces the surface tension of the fluid lining the alveoli.
- Collapsing Pressure is Caused by Surface Tension and is indirectly related to the size of alveoli ( law of LaPlace ) .

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

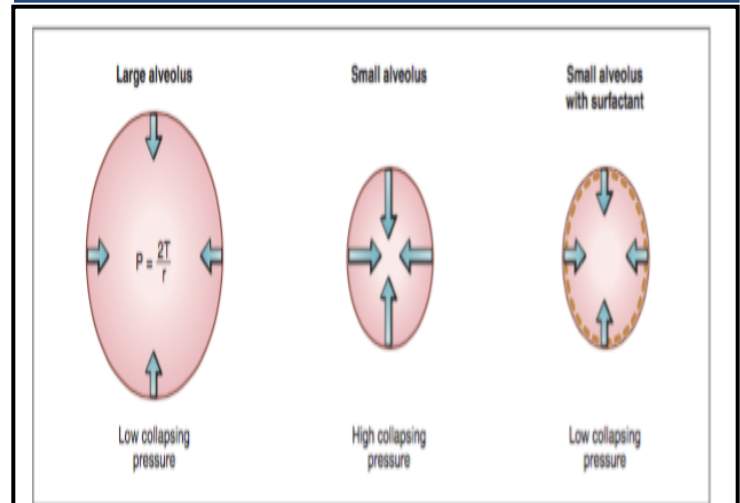
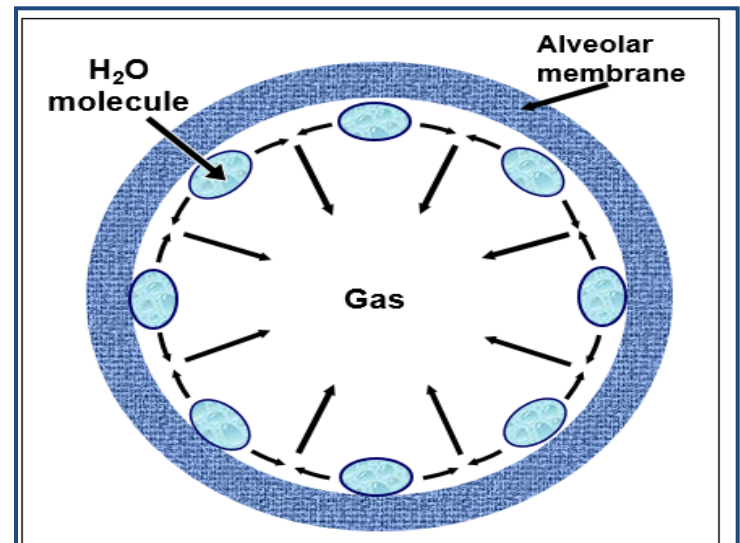
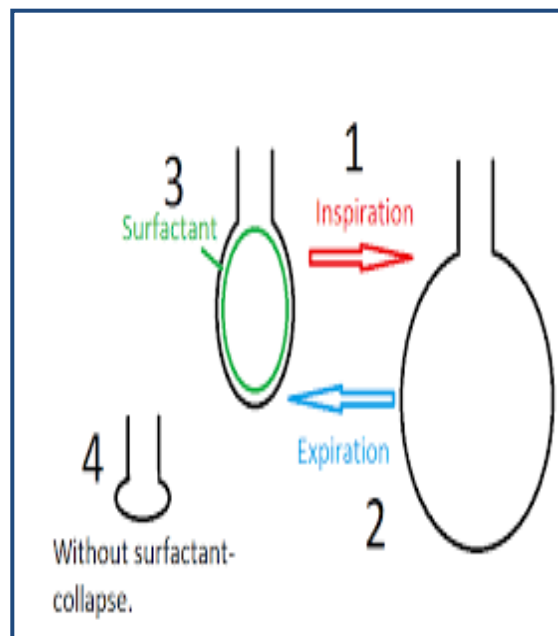
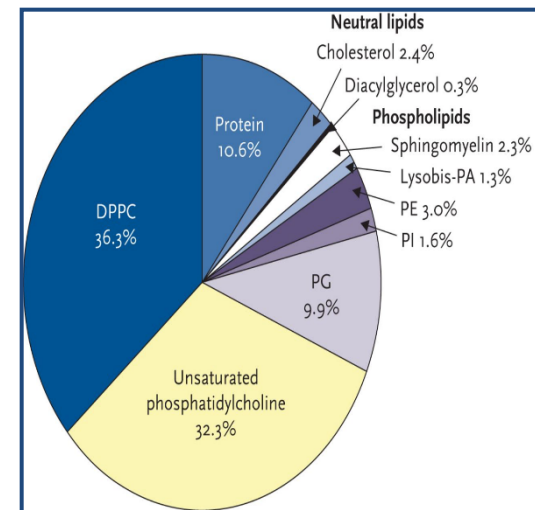


Fig. 5.12 Effect of alveolar size and surfactant on collapsing pressure. The length of the arrows shows the relative magnitude of the collapsing pressure.

# Surfactant

- Surfactant is a complex compound containing phospholipids esp. dipalmitoylphosphatidyl choline and a number of Apo proteins.
- The earliest detection of surfactant from fetal alveoli begins between 6-7<sup>th</sup> month but this could be delayed in others **to wk 35 of** intrauterine life.
- Surfactant ***reduces surface tension*** throughout the lung, ***reducing the effort required*** by the respiratory muscles to expand the lungs, ***prevents alveolar collapse***, ***decreases airway resistance*** and ***decreases work of breathing***.



# Surfactant deficiency

- Deficiency in premature babies causes respiratory distress syndrome of the newborn (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.

**Respiratory Distress Syndrome (RDS)**

- Also known as **Hyaline Membrane Disease (HMD)**
- RDS occurs primarily in premature infants; its incidence is inversely related to gestational age and birthweight

Gestational age	Percentages
Less than 28 wks	60-80%
32-36 wks	15-30%
37-39 wk	5%
Term	Rare

Nelson Textbook of Pediatrics, 18<sup>th</sup> Ed.

# 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.
- Locally secreted factors :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.
- The same irritants that cause parasympathetic constrictor reflexes of the airways—smoke, dust, sulfur dioxide, and some of the acidic elements in smog—may also act directly on the lung tissues to initiate local, non-nervous reactions that cause obstructive constriction of the airways.



# Resistance to Airflow in the Bronchial Tree

- The greatest amount of resistance to airflow occurs in some of the larger bronchioles and bronchi near the trachea. The reason for this high resistance is that there are relatively few of these larger 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

