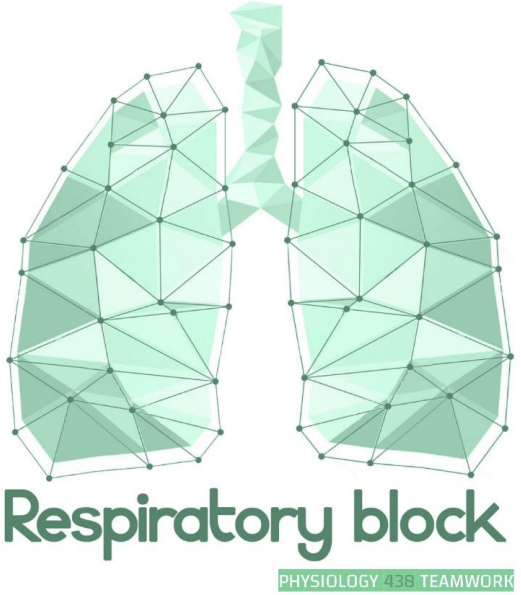
Functional organization of the respiratory system



- Red: important
- Black: in male / female slides
- Pink: in female slides only
- Blue: in male slides only
- Yellow:dr's notes
- Gray: extra information
- Textbook: Guyton + Linda

Editing file

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Objectives

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

2-Distinguish the difference between internal and external respiration.

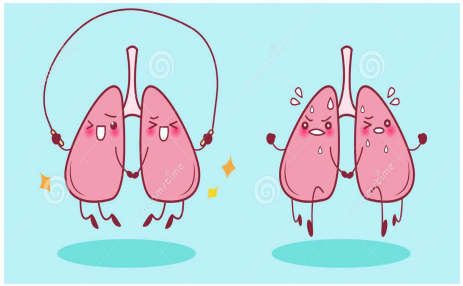
3-Discuss the functions of the respiratory system, including non-respiratory functions, like clearance mechanism by mucus and cilia, production of surfactant and its physiological significance.

The main goal of respiration is to

1- Provide oxygen to tissues

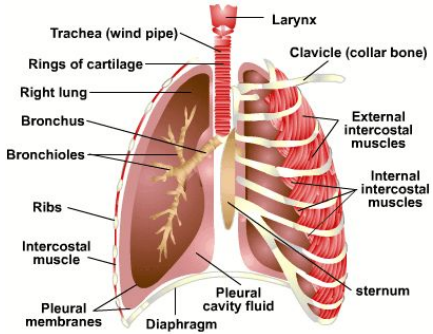
2- Remove CO_2 from the body

The body needs to get rid of CO_2 (Acid) because it will participate in production of H^+ which will decrease the PH (very dangerous) so our body will try to maintain alkalosis state



Respiratory system consists of:

- Passages (airways)
- Muscles
- Centers: located underneath the medulla. Its main function is to regulate and control the rate or speed of involuntary respiration.

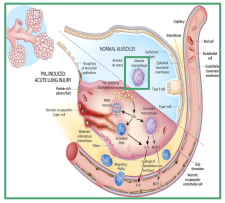


Functions of the respiratory system include

01 Gas exchange (respiratory function)

02 Pulmonary defense: the respiratory mucous membrane has muco-ciliary barrier filter and it produces Immunoglobulin A (IgA) and Alpha-1 antitrypsin.

Trypsin is a protalinc enzyme that digest proteins. Bacteria produce this enzyme, so the muco-ciliary barrier produces antitrypsin to protect the body proteins from bacteria



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

03 Phonation: is the production of sounds by the movement of air through the vocal cords.

04 Converting of Angiotensin I to Angiotensin II by Angiotensin Converting Enzyme (ACE). The enzyme is formed by the lungs

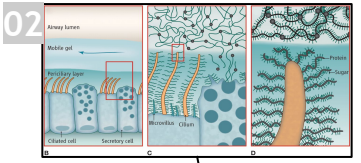
Angiotensin is a peptide hormone that causes vasoconstriction and an increase in blood pressure (regulation of B.P), Produced by kidney

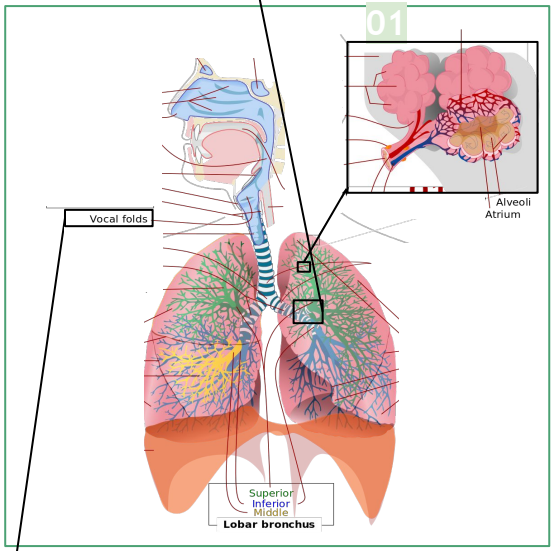
05 Regulating the acid- base status of the body by washing out extra carbon dioxide from the blood.

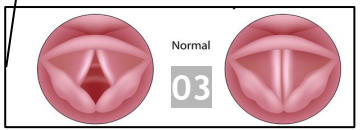
06 Secretion of important substances like surfactant.

Surfactant: also called surface-active agent, when added to a liquid, reduces its surface tension, thereby increasing its spreading and wetting properties.

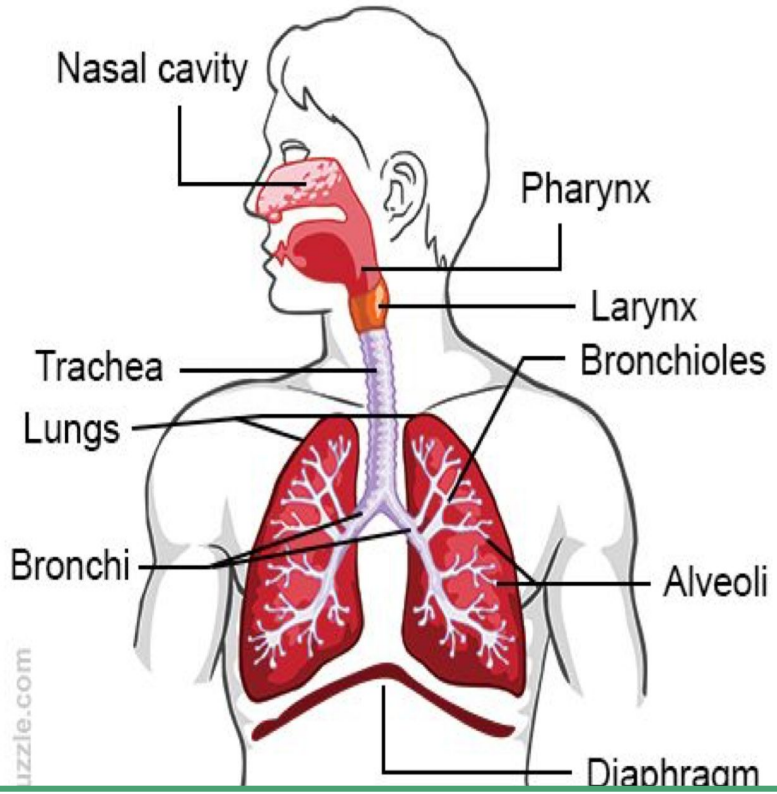
—Will be discussed later in this lecture







Respiratory passages (airways)



- Nostrils
- Nasal cavity
- Pharynx
- Larynx
- Trachea
- Thoracic cavity
- Alveoli

Respiratory passages airways can be divided into

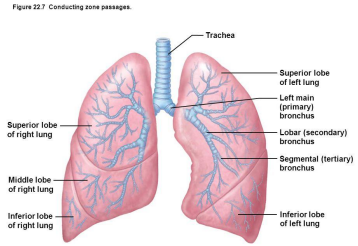
Conductive Zone

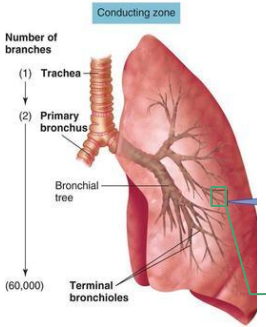
- Starts from nose to the end of terminal bronchioles.
- Help warming, humidification and filtration of inspired air.
- Contains the olfactory receptors for smell sensation.
- Conducts the sound during speech.
- Protective function by cough and sneezing reflexes.

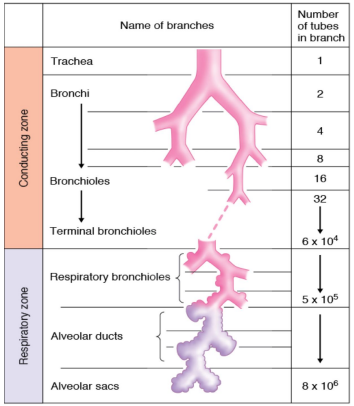
Respiratory Zone (unite)

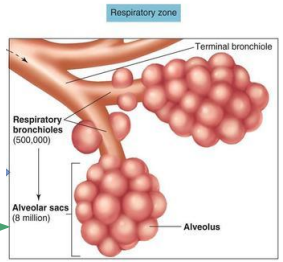
Includes:

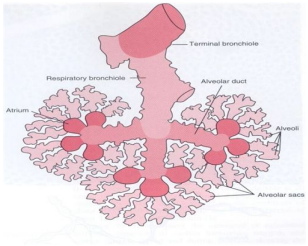
- Respiratory bronchioles, alveolar ducts, alveolar sacs and alveoli.
- Function in gas exchange.





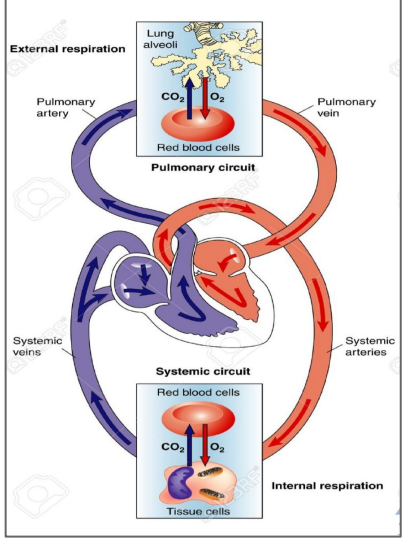


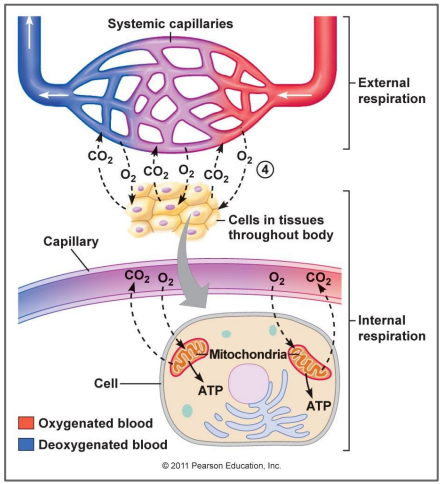




External & Internal respiration

External respiration	Internal respiration
is the process of gas exchange between the alveolar air and the pulmonary capillary blood.	is the process of gas exchange between the blood in the systemic capillaries and the tissues.





External & Internal respiration

3 major functional events occurs during it:

1

Pulmonary ventilation

inward and outward movement of air between lung and atmosphere.

2

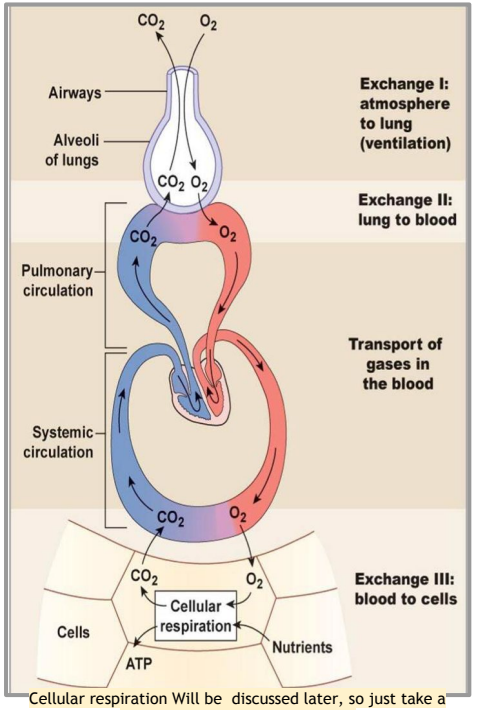
Diffusion

of oxygen and CO_2 between the alveoli and the pulmonary capillary blood.

3

Transport

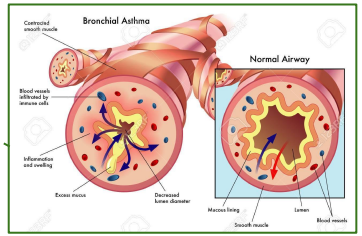
of O_2 & CO_2 in the blood and body fluids to and from the cells.



Cellular respiration Will be discussed later, so just take a small look and know the big idea

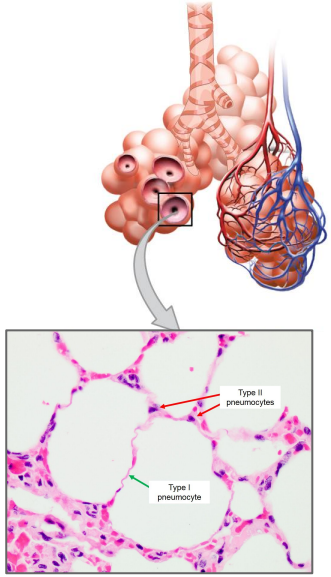
Respiration could be either:

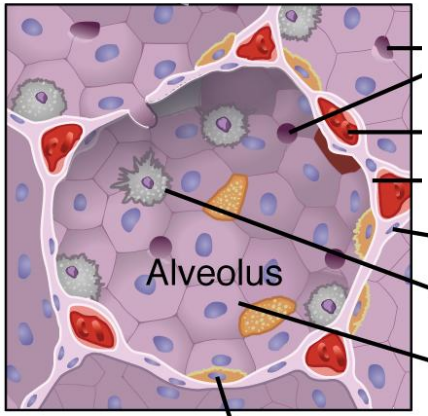
- Resting (minimal): normal breathing during resting conditions.
- Forced (maximal): normally during exercise and in patients with bronchial asthma, allergy,other pulmonary diseases.



During forced respiration we use more muscles than normal respiration.
(More details in the Anatomy lectures)

Lining cells of the alveoli





Type I alveolar cell

Macrophage

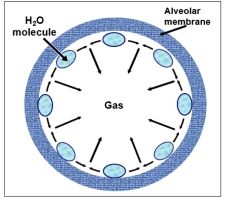
Type II alveolar cell (a)

Type I alveolar epithelial cells (type I pneumocytes)
- Participate in the respiratory membrane, across which gas exchange takes place.

Alveolar macrophages - Engulf the foreign bodies that reach the alveoli.

Type II alveolar epithelial cells (type II pneumocytes)10% of the surface area of alveoli
- Secrete surfactant.

Surface Tension



From Guyton

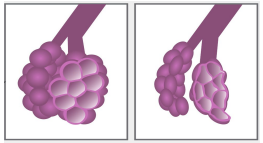
Principle of Surface Tension. let us see what happens on the inner surfaces of the alveoli. Here, the water surface is attempting to contract. This results in an attempt to force the air out of the alveoli through the bronchi and, in doing so, causes the alveoli to try to collapse. The net effect is to cause an elastic contractile force of the entire lungs, which is called the surface tension elastic force.

Surface Tension: When H_2O molecules at the surface of alveoli are attracted to each other by attractive forces that resist distension.

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

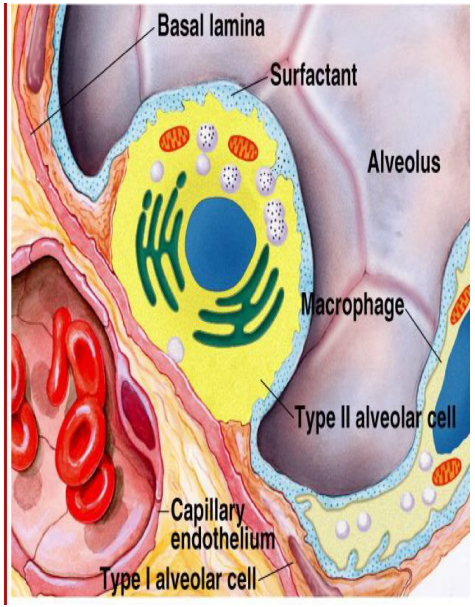
this pressure is pushing inward that causes lung recoil

Less Radius of alveoli more surface tension



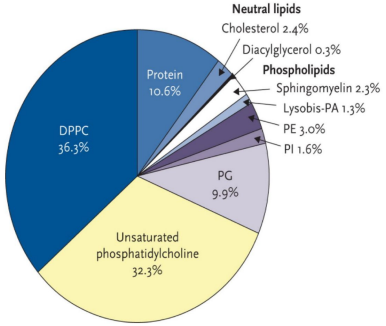
- Surface tension tends to oppose alveoli expansion.
- Pulmonary surfactant reduces the surface tension of the fluid lining the alveoli.
- Collapsing Pressure is Caused by Surface Tension and is indirectly related to the size of alveoli (law of LaPlace) .

As the surface tension increases, the collapsing pressure increases.



Helpful video

Surfactant



- Surfactant is a complex compound containing phospholipids especially, dipalmitoylphosphatidylcholine and number of Apoproteins.
- The earliest detection of surfactant from fetal alveoli begins between 6-7th month but this could be delayed in others to weak 35 of intrauterine life.

Function of surfactant:

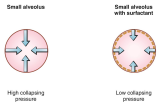
01 Reduces surface tension throughout the lung

Between the H_2O molecules there are hydrogen bonds which make the surface tension Surface tension is pulling the alveoli in that cause lung recoil, sometimes surface tension become very high which lead to alveoli collapsing (that's why we have type II pneumocytes that produce surfactant)

02 Reducing the effort required by the respiratory muscles to expand the lungs

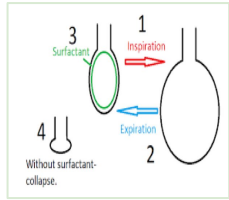
03 Prevents alveolar collapse

Surfactant help us to prevent collapsing of alveoli (collapsing of alveoli will need a lot of energy to return to its normal state)



04 Decreases airway resistance

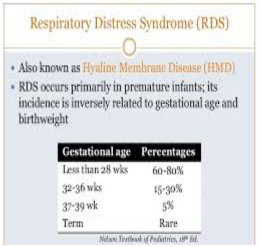
05 Decreases work of breathing.



06 Keep the alveoli dry

deficiency in surfactant increases recoil, the body accommodates by decreasing IP pressure(Intrapleural pressure) . this decrease in pressure will promote capillary filtration, leading to pulmonary edema.

Surfactant deficiency

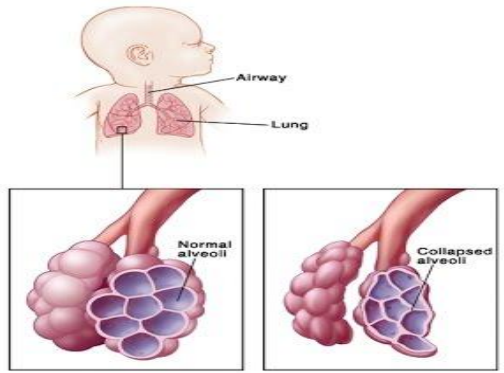


- Deficiency of surfactant in premature babies causes Respiratory Distress Syndrome of the newborn (RDS)
- (hyaline membrane disease)

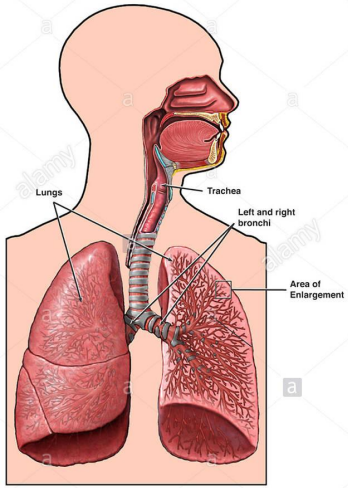
occurs in infants whose lungs have not yet fully developed. So, the more premature the baby is, the higher the chance of RDS after birth.

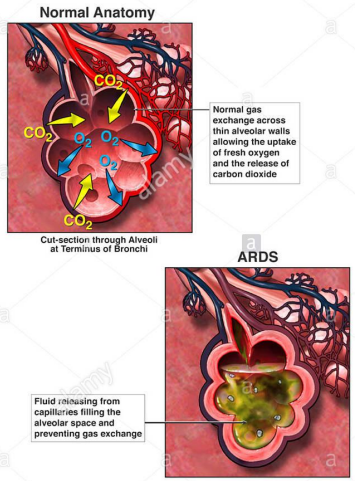
Prevention: Corticosteroid injection to mothers expected to deliver prematurely. This will enhance surfactant maturation.

• After delivery they are given inhaled surfactant.



- Smoking in adults, hypoxia or hypoxemia (low oxygen in the arterial blood) or both, decrease the secretion of surfactant and cause adult Respiratory Distress Syndrome (RDS)





Male's slides only

Neonatal Respiratory Distress Syndrome

- Infants born before week 24 will never have surfactant.

➔ Without surfactant, small alveoli will increase surface tension and that will increase pressures, eventually alveoli will collapse **(atelectasis)**.

- Collapsed alveoli are not ventilated,

therefore cannot participate in gas exchange.

Innervations of lungs and bronchi

- Is by autonomic nerves because breathing is not under our control

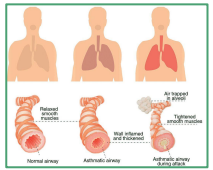
Sympathetic stimulation	ParaSympathetic stimulation
releases epinephrine	releases acetylcholine
➔ **dilatation** of the bronchi. to allow more air into the lungs, which will increase oxygenation of the blood and keep up with the increased flow of blood through the lungs due to the increased heart rate.	➔ **constriction** of the bronchi.

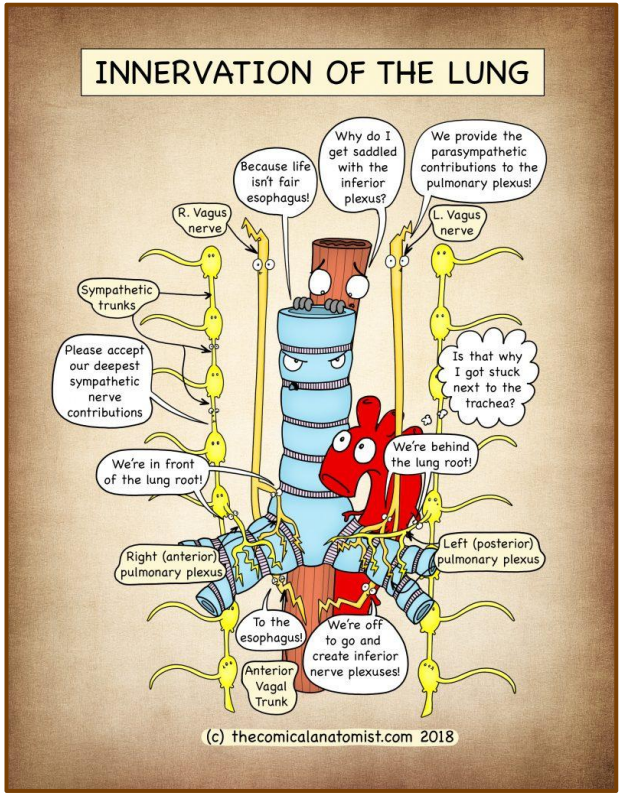
Locally secreted factors

- 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).

IgA will stick on the surface of mast cells and then will produce antibodies after they get attached again they will explode and histamine + SRSA are inside the mast cell, so they will release and that will lead to allergy and respiratory diseases





Quiz

You didn't understand why we choose this answer? Click here to read the explanations

1- Which of the following would be expected to increase the measured airway resistance?

A. Stimulation of parasympathetic nerves to the lungs
B. Low lung volumes
C. Release of histamine by mast cells
D. All of the above

2- muco-cilliary barrier produces:

A. T-lymphocyte
B. Mast cell
C. Alpha-1 antitrypsin
D. None of above

3-the function of type II pneumocytes is:

A. Engulf the foreign bodies that reach the alveoli
B. Participate in the respiratory membrane
C. Secrete surfactant
D. All of above

4- the relationship between surfactant and surface tension:

A. proportional relationship
B. inverse relationship
C. No relationship

SAQ

1- what is the Lining cells of the alveoli ?

2- what is the functions of the respiratory system ?

Answers

1)A- Type I alveolar epithelial cells (type I pneumocytes)
B-Type II alveolar epithelial cells (type II pneumocytes)
C-Alveolar macrophages

2) slide n.4

Key answers:
1-D 2-C 3-C 4- B

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