#424956
Topic: Pulmonary volumes and capacities

Define vital capacity. What is its significance?

Solution

Vital capacity is the maximum volume of air that can be exhaled after a maximum inspiration. It is about 3.5 – 4.5 litres in the human body. It promotes the act of supplying fresh air and getting rid of foul air, thereby increasing the gaseous exchange between the tissues and the environment.

#424957
Topic: Pulmonary volumes and capacities

State the volume of air remaining in the lungs after a normal breathing.

Solution

The volume of air remaining in the lungs after a normal expiration is known as functional residual capacity (FRC). It includes expiratory reserve volume (ERV) and residual volum (RV). ERV is the maximum volume of air that can be exhaled after a normal expiration. It is about 1000 mL to 1500 mL. RV is the volume of air remaining in the lungs after maximum expiration. It is about 1100 mL to 1500 mL.

$\therefore$ FRC = ERV + RV

$\cong$ 1500 + 1500

$\cong$ 3000 mL

The functional residual capacity of the human lungs is about 2500 – 3000 mL.

#424958
Topic: Process of respiration

Diffusion of gases occurs in the alveolar region only and not in the other parts of respiratory system. Why?

Solution

Each alveolus is made up of highly permeable and thin layers of squamous epithelial cells. Similarly, the blood capillaries have layers of squamous epithelial cells. Oxygen-rich air enters the body through the nose and reaches the alveoli. The deoxygenated (carbon dioxide-rich) blood from the body is brought to the heart by the veins. The heart pump it to the lungs for oxygenation. The exchange of O_2 and CO_2 takes place between the blood capillaries surrounding the alveoli and the gases present in the alveoli.
Thus, the alveoli are the sites for gaseous exchange. The exchange of gases takes place by simple diffusion because of pressure or concentration differences. The barrier between the alveoli and the capillaries is thin and the diffusion of gases takes place from higher partial pressure to lower partial pressure. The venous blood that reaches the alveoli has the lower partial pressure of O_2 and higher partial pressure of CO_2 as compared to alveolar air. Hence, oxygen diffuses into the blood. Simultaneously, carbon dioxide diffuses out of blood and into the alveoli.

#424959
Topic: Process of respiration

What are the major transport mechanisms for CO_2? Explain.

Solution

Plasma and red blood cells transport carbon dioxide. This is because they are readily soluble in water.

(1) Through plasma :

About 7% of CO_2 is carried in a dissolved state through the plasma. Carbon dioxide combines with water and forms carbonic acid.

$$CO_2 + H_2O \longrightarrow \underset{\text{(Carbonic acid)}}{H_2CO_3}$$

Since the process of forming carbonic acid is slow, only a small amount of carbon dioxide is carried this way.

(2) Through RBCs :

About 20 – 25% of CO_2 is transported by the red blood cells as carbaminohaemoglobin. Carbon dioxide binds to the amino groups on the polypeptide chains of haemoglobin and forms a compound known as carbaminohaemoglobin.

(3) Through sodium bicarbonate :

About 70% of carbon dioxide is transported as sodium bicarbonate. As CO_2 diffuses into the blood plasma, a large part of it combines with water to form carbonic acid in the presence of the enzyme carbonic anhydrase. Carbonic anhydrase is a zinc enzyme that speeds up the formation of carbonic acid. This carbonic acid dissociates into bicarbonate and hydrogen ions (H+).

$$CO_2 + H_2O \xrightarrow{\text{Carbonic anhydrase}} H_2CO_3$$

$$H_2CO_3 \xrightarrow[\text{anhydrase}]{\text{Carbonic}} HCO_3^- + H^+$$

#424960

Topic: Pulmonary volumes and capacities

What will be the pO_2 and pCO_2 in the atmospheric air compared to those in the alveolar air?

(i) pO_2 lesser, pCO_2 higher

(ii) pO_2 higher, pCO_2 lesser

(iii) pO_2 higher, pCO_2 higher

(iv) pO_2 lesser, pCO_2 leser

Solution

pO_2 higher will be higher and pCO_2 will be lesser in the atmospheric air as compared to those in the alveolar air.

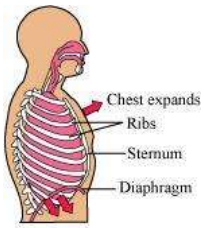
The partial pressure of oxygen in atmospheric air is higher than that of oxygen in alveolar air. In atmospheric air, pO_2 is about 159 mm Hg. In alveolar air, it is about 104 mm Hg. The partial pressure of carbon dioxide in atmospheric air is lesser than that of carbon dioxide in alveolar air. In atmospheric air, pCO_2 is about 0.3 mm Hg. In alveolar air, it is about 40 mm Hg.

#424963

Topic: Process of respiration

Explain the process of inspiration under normal conditions.

Solution



Diaphragm contracts

The movement of air into and out of the lungs is carried out by creating a pressure gradient between the lungs and the atmosphere. Inspiration is the process of taking air into the lungs and it can occur if there is negative pressure within the lungs (intra-pulmonary pressure). Inspiration begins with the contraction of diaphragm which increases the volume of thoracic chamber in the antero-posterior axis. The contraction of external inter-costal muscles lifts up the ribs and the sternum causing an increase in the volume of the thoracic chamber in the dorso-ventral axis. As a result of increase in thoracic volume causes pulmonary volume increases and intra-pulmonary pressure decreases creating negative pressure which forces the air from outside to move into the lungs, a process called inspiration.

#424964

Topic: Control of breathing

How is respiration regulated?

Solution

The respiratory rhythm centre present in the medulla region of the brain is primarily responsible for the regulation of respiration. The pneumotaxic centre can alter the function performed by the respiratory rhythm centre by signalling to reduce the inspiration rate.

The chemosensitive region present near the respiratory centre is sensitive to carbon dioxide and hydrogen ions. This region then signals to change the rate of expiration for eliminating the compounds.

The receptors present in the carotid artery and aorta detect the levels of carbon dioxide and hydrogen ions in the blood. As the level of carbon dioxide increases, the respirato centre sends nerve impulses for the necessary changes.

#424967

Topic: Pulmonary volumes and capacities

What is the effect of pCO_2 on oxygen transport?

Solution

pCO_2 plays an important role in the transportation of oxygen. At the alveolus, the low pCO_2 and high pO_2 favours the formation of haemoglobin. At the tissues, the high pCO and low pO_2 favours the dissociation of oxygen from oxyhaemoglobin. Hence, the affinity of haemoglobin for oxygen is enhanced by the decrease of pCO_2 in blood. Therefo oxygen is transported in blood as oxyhaemoglobin and oxygen dissociates from it at the tissues.

#424970

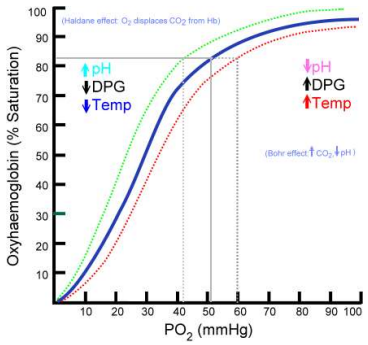
Topic: Process of respiration

Define oxygen dissociation curve. Can you suggest any reason for its sigmoidal pattern?

Solution

The oxygen dissociation curve is a graphical representation of the percentage of saturation of oxyhaemoglobin at various partial pressures of oxygen.

In the lungs, the partial pressure of oxygen is high. Hence, haemoglobin binds to oxygen and forms oxyhaemoglobin. Tissues have a low oxygen concentration. Therefore, at tl tissues, oxyhaemoglobin releases oxygen to form haemoglobin. The sigmoid shape of the dissociation curve is because of the binding of oxygen to haemoglobin. As the first oxygen molecule binds to haemoglobin, it increases the affinity for the second molecule of oxygen to bind. Subsequently, haemoglobin attracts more oxygen.



#424973

Topic: Pulmonary volumes and capacities

Distinguish between

(a) IRV and ERV

(b) Inspiratory capacity and Expiratory capacity

(c) Vital capacity and total lung capacity

Solution

(a)

Inspiratory reserve volume (IRV)	Expiratory reserve volume (ERV)
1. It is the maximum volume of air that can be inhaled after a normal inspiration.	1. It is the maximum volume of air that can be exhaled after a normal expiration.
2. It is about 2500 – 3500 mL in the human lungs.	2. It is about 1000 – 1100 mL in the human lungs.

(b)

Inspiratory capacity (IC)	Expiratory capacity (EC)
1. It is the volume of air that can be inhaled after a normal expiration.	1. It is the volume of air that can be exhaled after a normal inspiration.
2. It includes tidal volume and inspiratory reserve volume. IC = TV + IRV	2. It includes tidal volume and expiratory reserve volume. EC = TV + ERV

(c)

Vital capacity (VC)	Total lung capacity (TLC)
1. It is the maximum volume of air that can be exhaled after a maximum inspiration. It includes IC and ERV.	1. It is the volume of air in the lungs after maximum inspiration. It includes IC, ERV, and residual volume.
2. It is about 4000 mL in the human lungs.	2. It is about 5000 – 6000 mL in the human lungs.

#424975

Topic: Pulmonary volumes and capacities

Distinguish between inspiratory capacity and expiratory capacity.

Solution

	Inspiratory capacity (IC)	Expiratory capacity (EC)
1	It is the volume of air that can be inhaled after a normal expiration.	It is the volume of air that can be exhaled after a normal inspiration.
2	It includes tidal volume and inspiratory reserve volume.	It includes tidal volume and expiratory reserve volume.
3	IC = TV + IRV	EC = TV + ERV

#424976

Topic: Pulmonary volumes and capacities

Distinguish between vital capacity and total lung capacity.

Solution

	Vital capacity (VC)	Total lung capacity (TLC)
1.	It is the maximum volume of air that can be exhaled after a maximum inspiration. It includes IC and ERV.	It is the volume of air in the lungs after maximum inspiration. It includes IC, ERV, and residual volume.
2	It is about 4000 mL in the human lungs.	It is about 5000 – 6000 mL in the human lungs.

#424977

Topic: Pulmonary volumes and capacities

What is a tidal volume? Find out the tidal volume (approximate value) for a healthy human in an hour.

Solution

Tidal volume is the volume of air inspired or expired during normal respiration.

It is about 6000 to 8000 mL of air per minute.

The hourly tidal volume for a healthy human can be calculated as :

Tidal volume = 6000 to 8000 mL/minute

Tidal volume in an hour = 6000 to 8000 mL × (60 min)

= 3.6 × 105 mL to 4.8 × 105 mL

Therefore, the hourly tidal volume for a healthy human is approximately 3.6 × 105 mL to 4.8 × 105 mL.

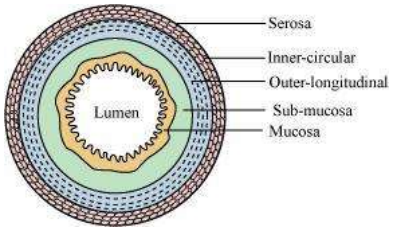
#424984

Topic: Respiratory organs

What are the basic layers of the wall of alimentary canal?

Solution

The walls of the alimentary canal are made up of four layers. These are as follows:



(i) The outermost layer of the human alimentary canal is known as serosa. It is composed of a thin layer of secretory epithelial cells, with some connective tissues underneath.

(ii) A thin layer of smooth muscles arranged into an outer longitudinal layer and an inner circular layer is known as muscularis.

(iii) Sub-mucosa is a layer of loose connective tissues, containing nerves, blood, and lymph vessels. It supports the mucosa.

(iv) Mucosa is the innermost lining of the lumen of the alimentary canal. It is mainly involved in absorption and secretion.