What is Gas Exchange in Respiration?

Worksheet

In the alveoli, oxygen diffuses from the high-pressure air into the lower-pressure capillary blood, while carbon dioxide diffuses the opposite way - from blood into air - both moving down their own partial pressure gradients across a thin, moist membrane.

Questions

1. According to Fick's Law, the rate of gas diffusion is directly proportional to:

A) Membrane thickness
B) Surface area and pressure gradient
C) Distance alone
D) Blood volume

2. Why does pulmonary fibrosis reduce gas exchange efficiency?

A) It increases alveolar surface area
B) It thickens the diffusion membrane, increasing T
C) It increases the pressure gradient
D) It removes capillaries entirely

3. Where does oxygen have the highest partial pressure in the respiratory system?

A) Freshly inhaled air in the alveoli
B) Deoxygenated blood entering the pulmonary artery
C) Body tissue cells
D) Systemic veins

4. Emphysema destroys alveolar walls. Per Fick's Law, this primarily reduces gas exchange by decreasing:

A) Pressure gradient (P)
B) Surface area (A)
C) Diffusion coefficient (D) alone
D) Blood flow rate

5. Compare gas exchange in healthy lungs (alveolar surface area 70 m) versus lungs damaged by emphysema (40 m), with pressure gradient and thickness unchanged.

6. In pulmonary fibrosis, the respiratory membrane thickens from about 0.5 m to 2 m. How does this affect diffusion rate?

7. At high altitude, the O2 partial pressure gradient between alveolar air and blood drops from about 60 mmHg (sea level) to 20 mmHg. Predict the effect on diffusion rate, and how the body compensates.

8. Define: Where does gas exchange occur in the lungs?

9. Define: What is Fick's Law of diffusion?

10. Define: Which direction do O2 and CO2 diffuse in the alveoli?

Answer Key

1. B) Surface area and pressure gradient - Rate = (DAP)/T - rate increases with surface area (A) and pressure gradient (P), and decreases with thickness (T).

2. B) It thickens the diffusion membrane, increasing T - Scar tissue thickens the respiratory membrane, and since rate is inversely proportional to thickness, diffusion slows considerably.

3. A) Freshly inhaled air in the alveoli - Freshly inhaled alveolar air has the highest O2 partial pressure, which is what drives diffusion into the blood.

4. B) Surface area (A) - Destroyed alveolar walls merge smaller air sacs into fewer, larger ones, drastically cutting total surface area (A).

5. Fick's Law: Rate is directly proportional to surface area (A) Healthy: A = 70 m high diffusion rate Emphysema: A = 40 m (alveolar walls destroyed) rate drops to about 57% of normal This is why emphysema patients experience breathlessness even with normal P

6. Fick's Law: Rate is inversely proportional to thickness (T) Thickness increases 4 (0.5 2 m) Diffusion rate drops to about 1/4 of normal This explains the reduced blood oxygenation seen in pulmonary fibrosis

7. Fick's Law: Rate is directly proportional to P P falls from 60 to 20 mmHg - roughly a 3 decrease Diffusion rate falls proportionally The body compensates over days to weeks by increasing breathing rate and red blood cell production (acclimatization)

8. In the alveoli - tiny air sacs with thin walls and a huge total surface area, surrounded by capillaries.

9. Rate = (D A P) / T - diffusion rate rises with surface area and pressure gradient, and falls with membrane thickness.

10. O2 diffuses from alveolar air into the blood; CO2 diffuses from the blood into the alveolar air - both down their own pressure gradients.