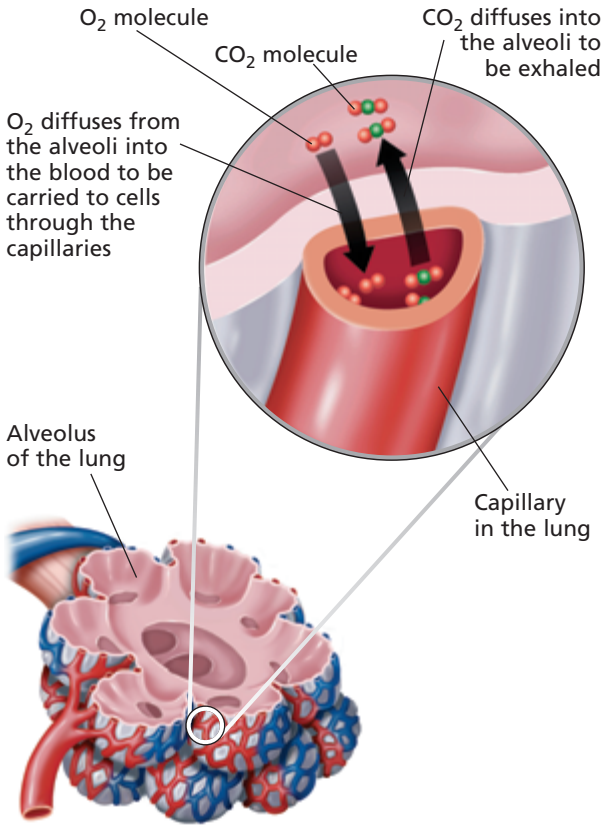
Exchange of CO_2 and O_2 in the Lungs

Why does CO_2 leave the blood as it passes through the lung's capillaries, and why does O_2 enter the blood? The exchange is caused by the difference in concentrations of CO_2 and O_2 in the blood and in the atmosphere. Oxygen is 21% of the atmosphere. Although the amount of CO_2 varies from place to place, it averages about 0.033% of the atmosphere. Thus, O_2 is about 640 times more concentrated in the atmosphere than is CO_2.

Substances tend to diffuse from regions of higher concentration toward regions of lower concentration. Thus, when blood reaches the capillaries of the lung, O_2 from the air diffuses into the blood, where its pressure is only 40 mm Hg, while CO_2 diffuses out of the blood, where its pressure is 45 mm Hg, and into the air. The diagram below summarizes the process.



The pressure of O_2 in the blood entering the lung is much lower than it is in the atmosphere. As a result, O_2 diffuses into the blood. The opposite situation exists for CO_2, so it diffuses from the blood into the air. Note that blood leaving the lung still contains a significant concentration of CO_2.

Acidosis and Alkalosis

In humans, blood is maintained between pH 7.3 and 7.5. The pH of blood is dependent on the concentration of CO_2 in the blood. Look again at this equilibrium system.

$$CO_2(aq) + 2H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$$

Notice that the right side of the equation contains the H_3O^+ ion, which determines the pH of the blood. If excess H_3O^+ enters the blood from tissues, the reverse reaction is favored. Excess H_3O^+ combines with HCO_3^- to produce more CO_2 and H_2O. If the H_3O^+ concentration begins to fall, the forward reaction is favored, producing additional H_3O^+ and HCO_3^-. To keep H_3O^+ in balance, adequate amounts of both CO_2 and HCO_3^- must be present. If something occurs that changes these conditions, a person can become very ill and can even die.

Hyperventilation occurs when a person breathes too rapidly for an extended time. Too much CO_2 is eliminated, causing the reverse reaction to be favored, and H_3O^+ and HCO_3^- are used up. As a result, the person develops a condition known as alkalosis because the pH of the blood rises to an abnormal alkaline level. The person begins to feel lightheaded and faint, and, unless treatment is provided, he or she may fall into a coma. Alkalosis is treated by having the victim breathe air that is rich in CO_2. One way to accomplish this is to have the person breathe with a bag held tightly over the nose and mouth. Alkalosis is also caused by fever, infection, intoxication, hysteria, and prolonged vomiting.

The reverse of alkalosis is a condition known as acidosis. This condition is often caused by a depletion of HCO_3^- ions from the blood, which can occur as a result of kidney dysfunction. The kidney controls the excretion of HCO_3^- ions. If there are too few HCO_3^- ions in solution, the forward reaction is favored and H_3O^+ ions accumulate, which lowers the blood's pH. Acidosis can also result from the body's inability to expel CO_2, which can occur during pneumonia, emphysema, and other respiratory disorders. Perhaps the single most common cause of acidosis is uncontrolled diabetes, in which acids normally excreted in the urinary system are instead retained by the body.