saturated with water vapour, and contains more carbon dioxide and less oxygen. Saturation with water vapour provides 6.3 kPa (47 mmHg) thus reducing the partial pressure of all the other gases present. Gaseous exchange between the alveoli and the bloodstream (*external respiration*) is a continuous process, as the alveoli are never empty, so it is independent of the respiratory cycle. During each inspiration only some of the alveolar gases are exchanged.

Diffusion of gases

Exchange of gases occurs when a difference in partial pressure exists across a semipermeable membrane. Gases move by diffusion from the higher concentration to the lower until equilibrium is established (p. 25). Atmospheric nitrogen is not used by the body so its partial pressure remains unchanged and is the same in inspired and expired air, alveolar air and in the blood.

External respiration  10.9

This is exchange of gases by diffusion between the alveoli and the blood in the alveolar capillaries, across the respiratory membrane. Each alveolar wall is one cell thick and is surrounded by a network of tiny capillaries (the walls of which are also only one cell thick). The total area of respiratory membrane for gas exchange in the lungs is about equivalent to the area of a tennis court. Venous blood arriving at the lungs has travelled from all the tissues of the body, and contains high levels of CO_2 and low levels of O_2. Carbon dioxide diffuses from venous blood down its concentration gradient into the alveoli until equilibrium with alveolar air is reached. By the same process, oxygen diffuses from the alveoli into the blood. The relatively slow flow of blood through the capillaries increases the time available for gas exchange to occur. When blood leaves the alveolar capillaries, the oxygen and carbon dioxide concentrations are in equilibrium with those of alveolar air (Fig. 10.24A).

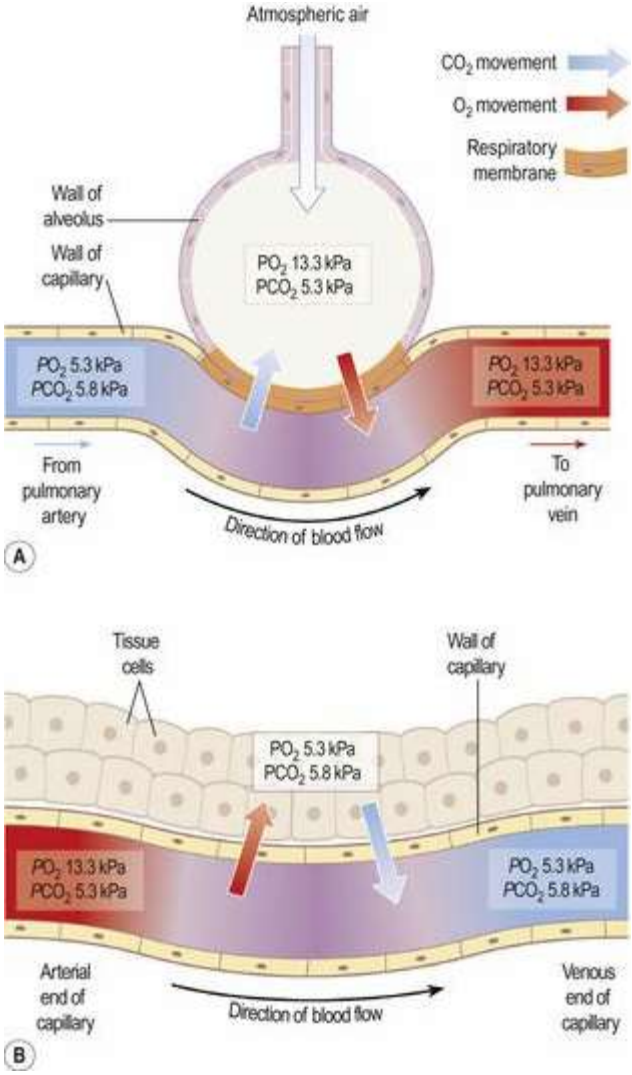

Figure 10.24 **A.** External respiration. **B.** internal respiration.

Internal respiration 10.10

This is exchange of gases by diffusion between blood in the capillaries and the body cells. Gas exchange does not occur across the walls of the arteries carrying blood from the heart to the tissues, because their walls are too thick. PO_2 of blood arriving at the capillary bed is therefore the same as blood leaving the lungs. Blood arriving at the tissues has been cleansed of its CO_2 and saturated with O_2 during its passage through the lungs, and therefore has a higher PO_2 and a lower PCO_2 than the tissues. This creates concentration gradients between capillary blood and the tissues, and gas exchange therefore occurs (Fig. 10.24B). O_2 diffuses from the bloodstream through the capillary wall into the tissues. CO_2 diffuses from the cells into the extracellular fluid, then into the bloodstream towards the venous end of the capillary.

Figure 10.25 summarises the processes of internal and external respiration. 10.11

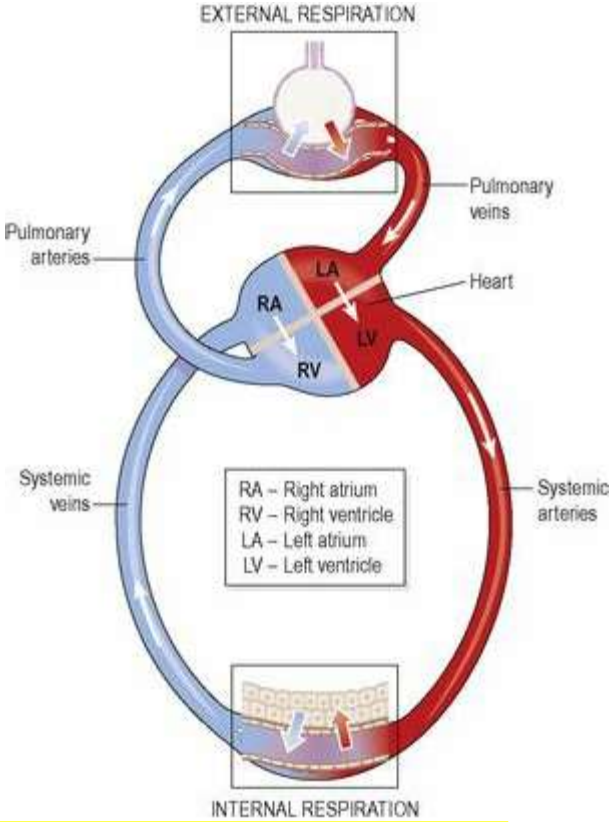

Figure 10.25 Summary of external and internal respiration.

Transport of gases in the bloodstream

Oxygen and carbon dioxide are carried in the blood in different ways.

Oxygen

Oxygen is carried in the blood in:

hemical combination with haemoglobin (see Fig. 4.5, p. 59) as *oxyhaemoglobin* (98.5%)

olution in plasma water (1.5%).

Oxyhaemoglobin is unstable, and under certain conditions readily dissociates releasing oxygen. Factors that increase dissociation include low O_2 levels, low pH and raised temperature (see Ch. 4). In active tissues there is increased production of carbon dioxide and heat, which leads to increased release of oxygen. In this way oxygen is available to tissues in greatest need. Whereas oxyhaemoglobin is bright red, deoxygenated blood is bluish-purple in colour.

Carbon dioxide

Carbon dioxide is one of the waste products of metabolism. It is excreted by the lungs and is transported by three mechanisms:

s bicarbonate ions (HCO_3^-) in the plasma (70%)

ome is carried in erythrocytes, loosely combined with haemoglobin as *carbaminohaemoglobin* (23%)