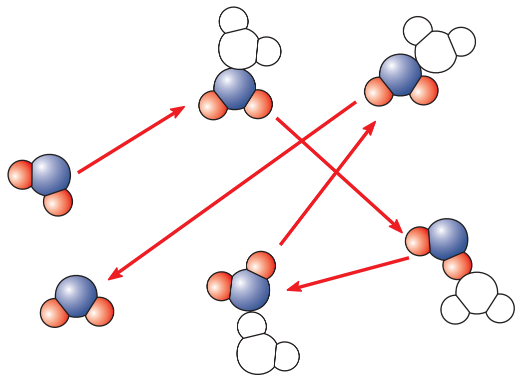

Figure 1.8 The thermal motion of molecules causes them to collide with each other continuously and change direction.

The rate of diffusion increases with area and concentration gradient

Transport by diffusion is only efficient over very short distances

time, end up in the right half (b). At any given point in time, the probability that each individual molecule will move to the right is exactly the same as the probability that it will move to the left. Because there are initially more dissolved molecules in the left compartment, there will initially be more particles at any given time passing from left to right than in the opposite direction. When the number of dissolved molecules in each half of the tank is identical, the number of dissolved molecules crossing the imaginary dividing wall in each direction will be equal (c). Fick's law describes the transport rate (Q) of a substance by diffusion:

$$Q = DA\frac{C_1 - C_2}{L}$$

D is the diffusion coefficient, which is a characteristic of a substance diffusing in a specific medium at a particular temperature. A is the cross-sectional area over which the substance is diffusing. C1 and C2 are the concentrations of the substance at two locations separated by the distance L, giving a concentration gradient of $(C_1 - C_2)/L$ for the substance.

Fick's law states that the rate of transport by diffusion increases when the cross-sectional diffusion area and the concentration gradient for the substance are increased. For a given concentration difference, the rate of diffusion is inversely related to the distance over which diffusion occurs. In biological systems, the transport rates of diffusion tend to be optimized by maximizing the area and minimizing the distance over which diffusion takes place.

Diffusion is an efficient mechanism for transport of dissolved substances over very short distances. Neurons communicate by means of chemical transmitter substances that diffuse from one cell to the next in special contact regions, called synapses (p. 113). The distance between the cell membranes in a synapse is approximately 20 nm (0.000 02 mm). In a matter of less than 100 µs (0.000 1 s), diffusion allows

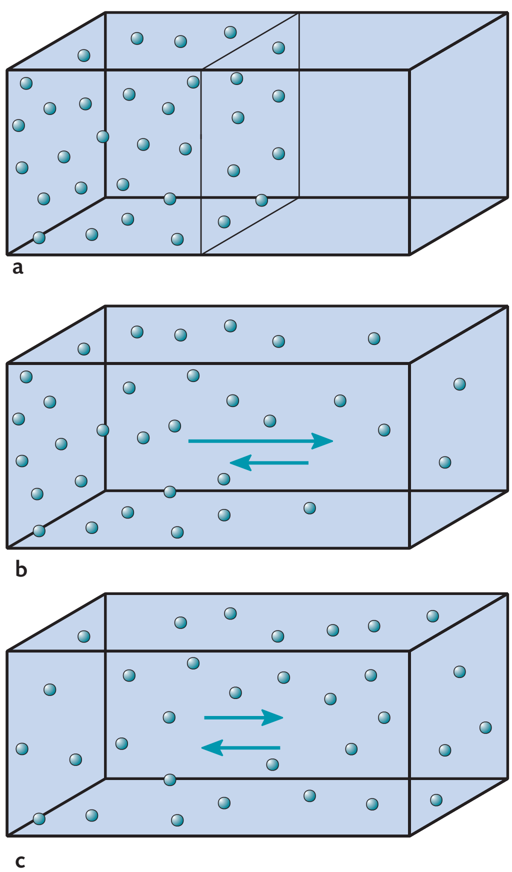

Figure 1.9 Diffusion of a dissolved substance. **a** A volume of water is divided in two by means of a dividing wall. A dissolved substance is evenly distributed in the left half. **b** The dividing wall is removed and dissolved molecules move by thermal motions to the right half. The movements are random and some of the molecules move back to the left half. Because there are more dissolved molecules in the left half, more molecules initially cross the midline from left to right than in the opposite direction. Consequently, there is a net transport of dissolved substance by diffusion from left to right. **c** The diffusion has led to an even distribution of the dissolved substance in the entire volume. In this situation, the same number of molecules crosses the midline in each direction over a given period of time, and there is no net transport of substance from one half to the other.