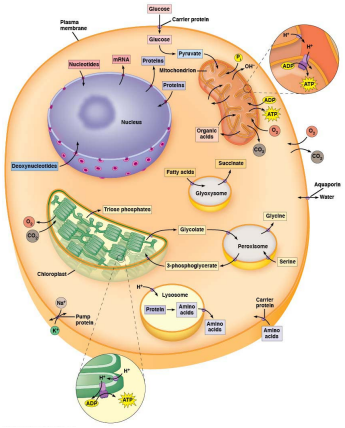
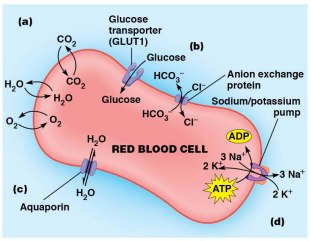


Table 8-1 Comparison of Simple Diffusion, Facilitated Diffusion, and Active Transport

Properties	Simple Diffusion	Facilitated Diffusion	Active Transport
Solutes transported			
	Small polar (H_2O, glycerol)	Small polar (H_2O, glycerol)	
	Small nonpolar (O_2, CO_2)	Large polar (glucose)	Large polar (glucose)
	Large nonpolar (oils, steroids)	Ions (Na^+, K^+, Ca^{2+})	Ions (Na^+, K^+, Ca^{2+})
Thermodynamic properties			
Direction relative to electrochemical gradient	Down	Down	Up
Metabolic energy required	No	No	Yes
Intrinsic directionality	No	No	Yes
Kinetic properties			
Membrane protein required	No	Yes	Yes
Saturation kinetics	No	Yes	Yes
Competitive inhibition	No	Yes	Yes

(a) Simple diffusion. Oxygen, carbon dioxide, and water diffuse directly across the plasma membrane in response to their relative concentrations inside and outside the cell. No transport protein is required.

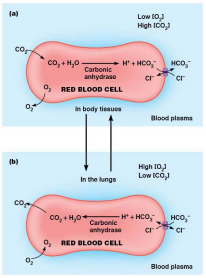
(b) Facilitated diffusion using carrier proteins. GLUT1 transports glucose into the erythrocyte, where the glucose concentration is lower. An anion exchange protein transports chloride (Cl^-) and bicarbonate (HCO_3^-) in opposite directions.



(c) Facilitated diffusion using channel proteins. Aquaporin channel proteins can facilitate the rapid inward or outward movement of water depending on the relative solute concentration on opposite sides of the membrane.

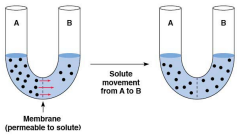
(d) Active transport using ATP-requiring pumps. Driven by the hydrolysis of ATP, the Na^+/K^+ pump moves sodium ions outward and potassium ions inward, establishing an electrochemical potential across the plasma membrane for both ions.

(a) In the capillaries of body tissues (low $[O_2]$ and high $[CO_2]$ relative to the erythrocytes), O_2 is released by hemoglobin within the erythrocytes and diffuses outward to meet tissue needs. CO_2 diffuses inward and is converted to bicarbonate by carbonic anhydrase in the cytosol. Bicarbonate ions are transported outward by the anion exchange protein, accompanied by the inward movement of chloride ions to maintain charge balance. Carbon dioxide therefore returns to the lungs as bicarbonate ions.

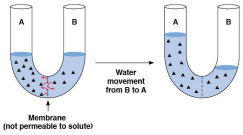


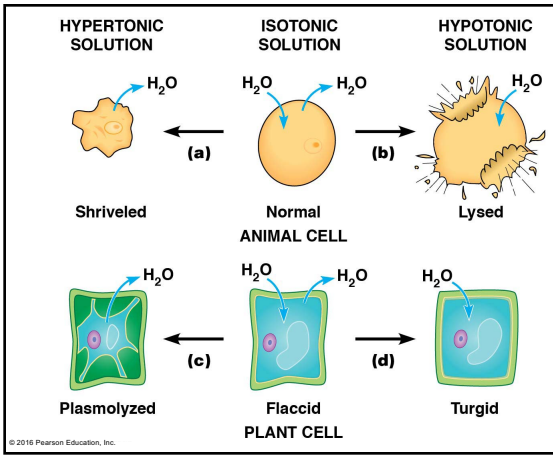
(b) In the capillaries of the lungs (high $[O_2]$ and low $[CO_2]$ relative to the erythrocytes), O_2 diffuses inward and binds to hemoglobin. Bicarbonate moves inward from the blood plasma, accompanied by an outward movement of chloride ions. Incoming bicarbonate is converted into CO_2, which diffuses out of the erythrocytes and into the cells lining the capillaries of the lungs. The CO_2 is now ready to be expelled from the body.

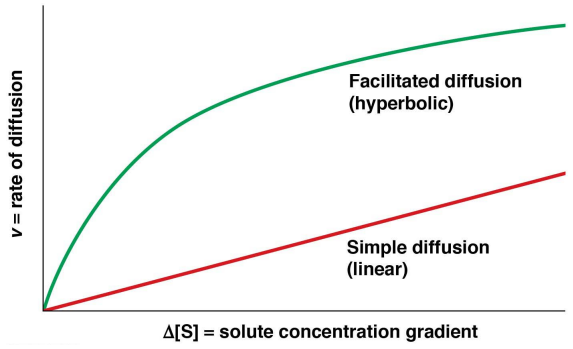
(a) Simple diffusion takes place when the membrane separating chambers A and B is permeable to molecules of dissolved solute, represented by the black dots. Net movement of solute molecules across the membrane is from chamber A to B (high to low solute concentration). Equilibrium is reached when the solute concentration is the same in both chambers.



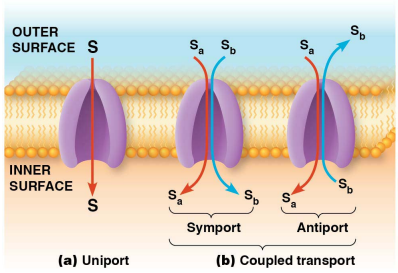
(b) Osmosis occurs when the membrane between the two chambers is not permeable to the dissolved solute, represented by the black triangles. Because solute cannot cross the membrane, water diffuses from chamber B, where the solute concentration is lower (more water), to chamber A, where the solute concentration is higher (less water). At equilibrium, the solute concentration will be equal on both sides of the membrane.



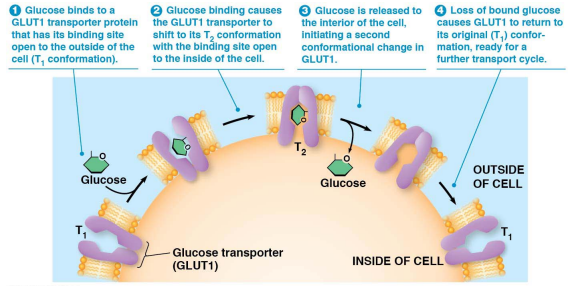




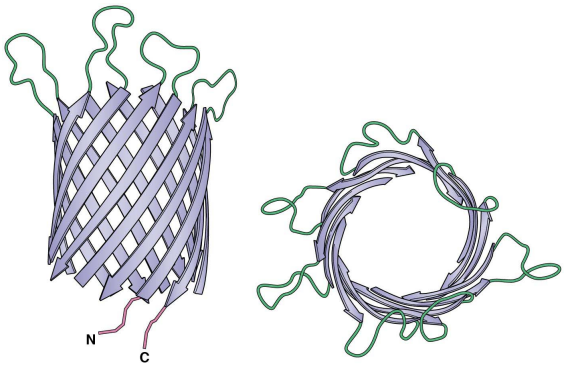
7



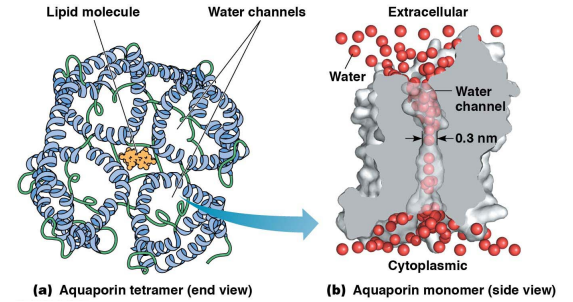
8



9



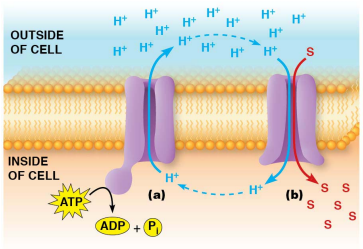
10



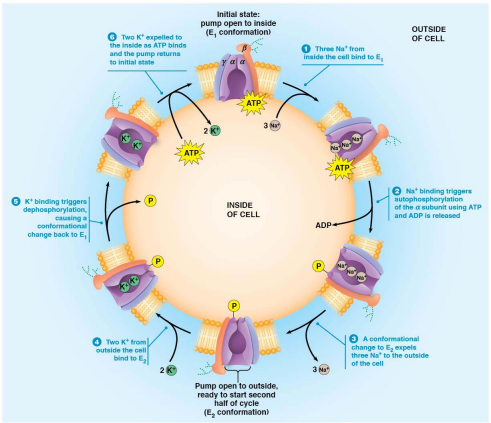
11

(a) Direct active transport involves a transport system coupled to an exergonic chemical reaction, most commonly the hydrolysis of ATP. As shown here, ATP hydrolysis drives the outward transport of protons, thereby establishing an electrochemical potential for protons across the membrane.

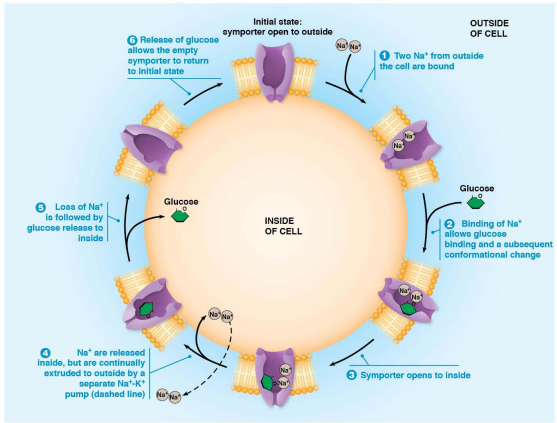
(b) Indirect active transport involves the coupled transport of a solute S and ions—protons, in this case. The exergonic inward movement of protons provides the energy to move the transported solute, S, against its concentration gradient or electrochemical potential.



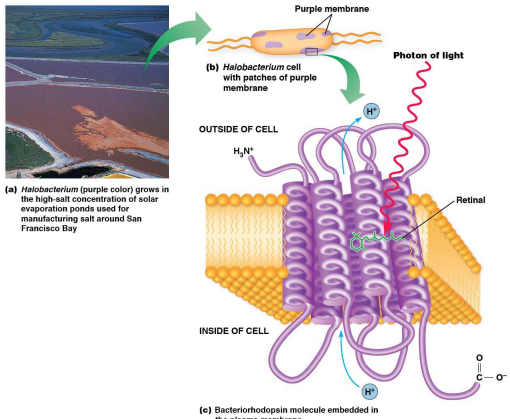
12



13



14



15