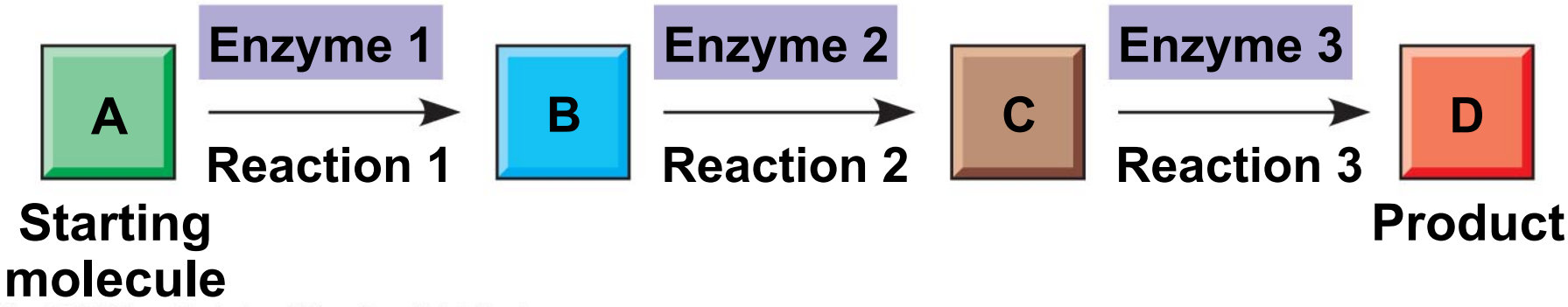
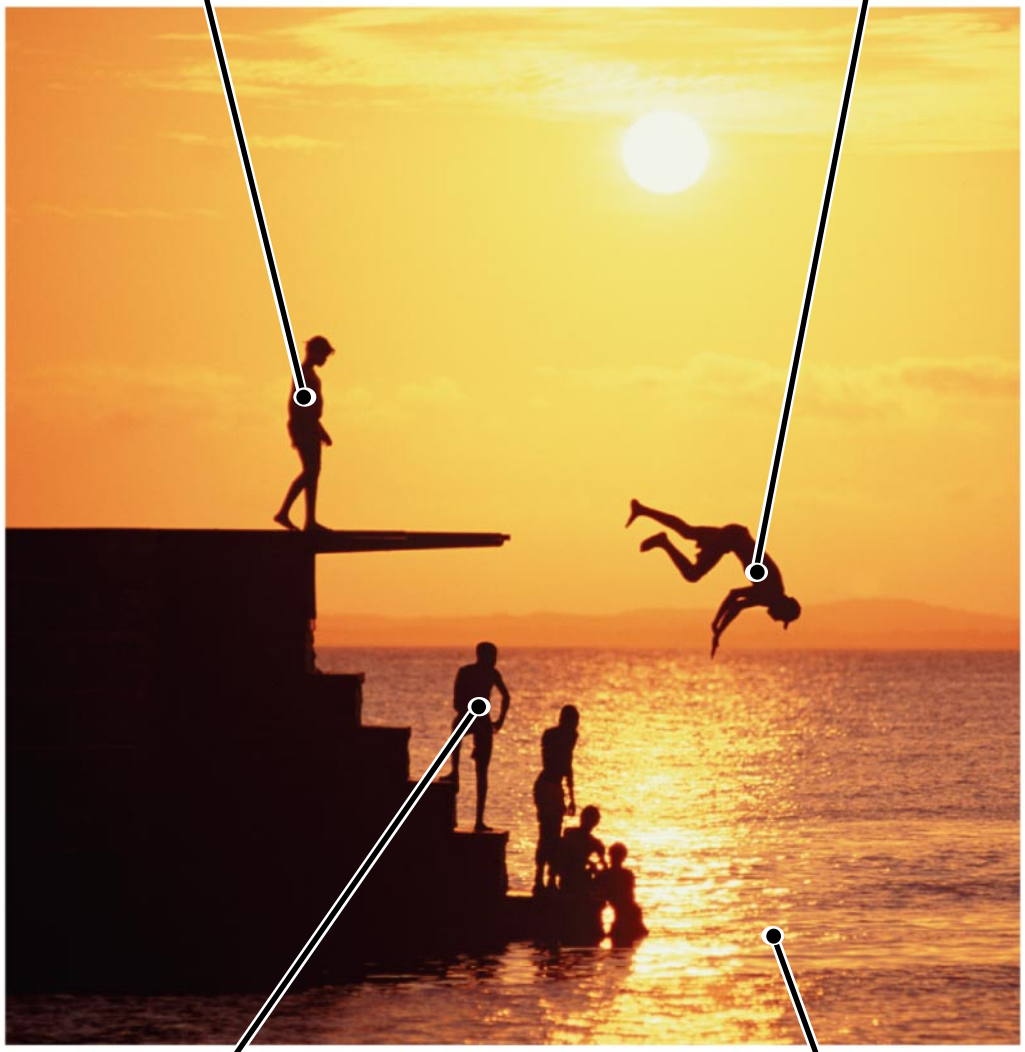


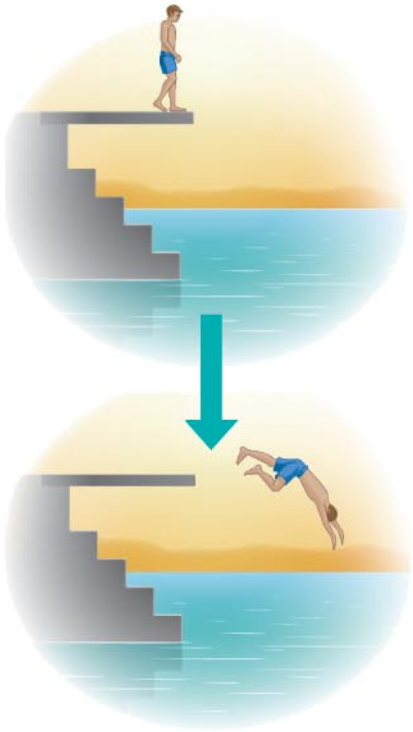


(a) First law of thermodynamics **(b) Second law of thermodynamics**

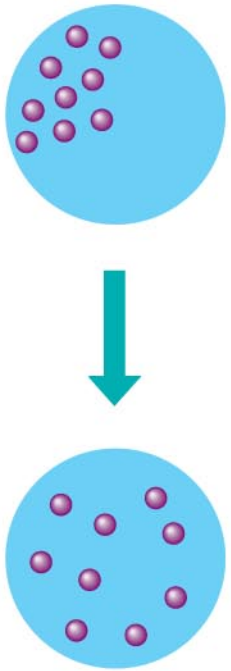
- More free energy (higher *G*)
- Less stable
- Greater work capacity

In a spontaneous change
- The free energy of the system decreases ($\Delta G < 0$)
- The system becomes more stable
- The released free energy can be harnessed to do work

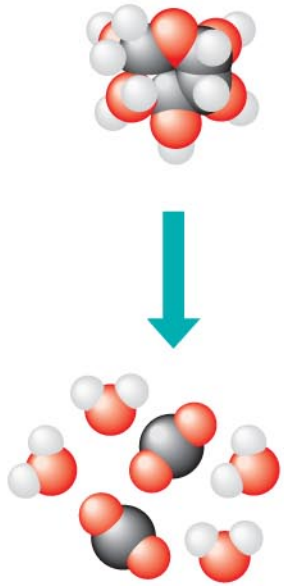
- Less free energy (lower *G*)
- More stable
- Less work capacity



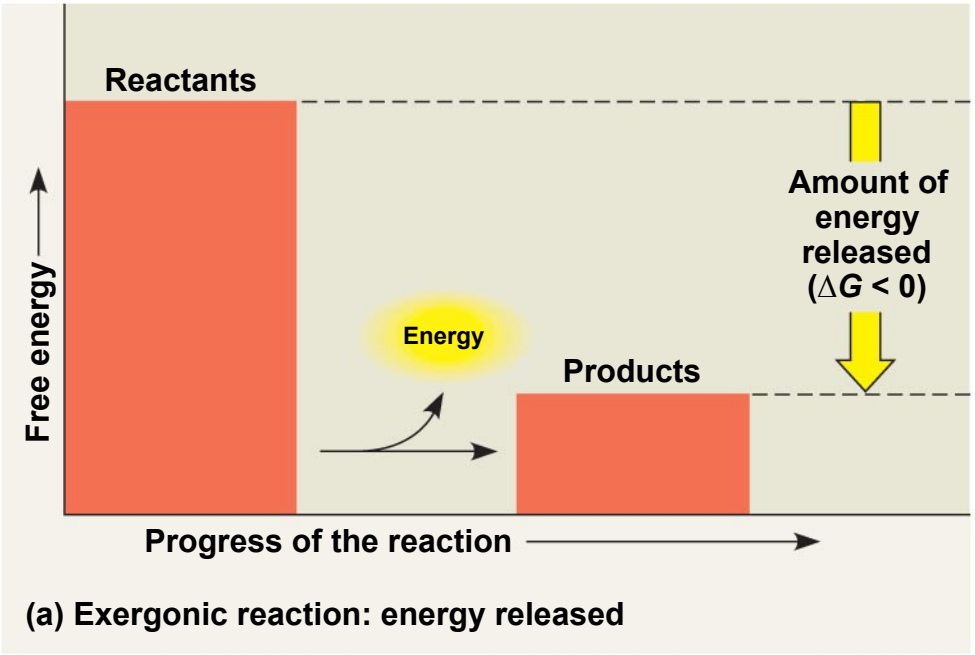
(a) Gravitational motion



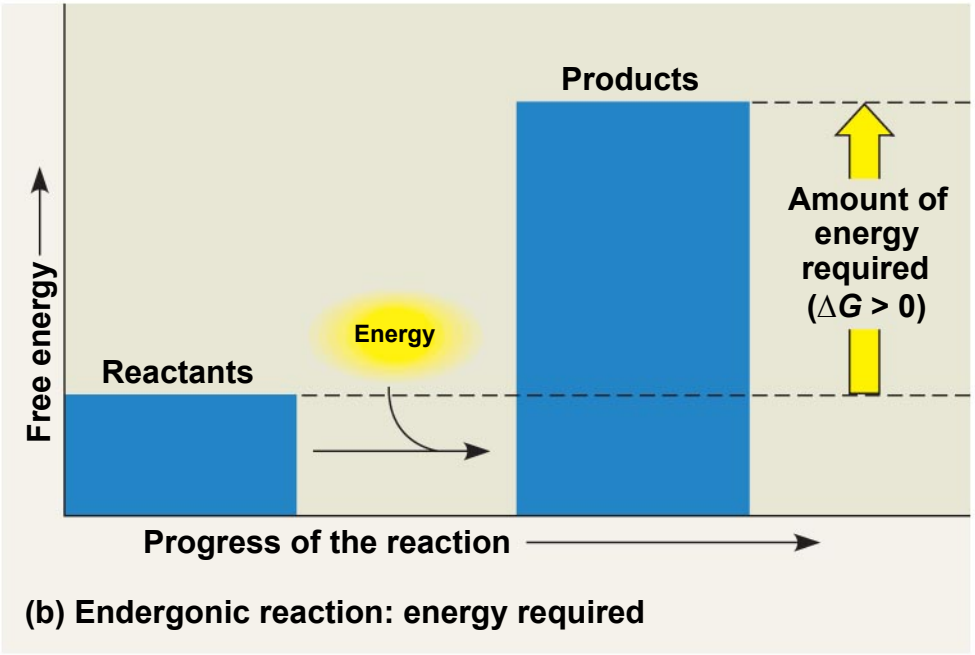
(b) Diffusion



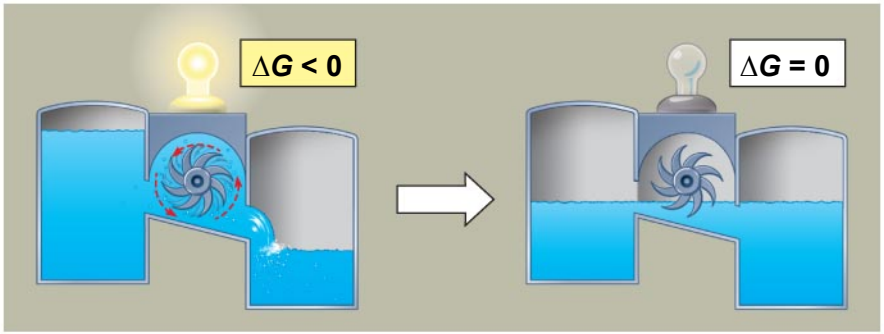
(c) Chemical reaction



(a) Exergonic reaction: energy released

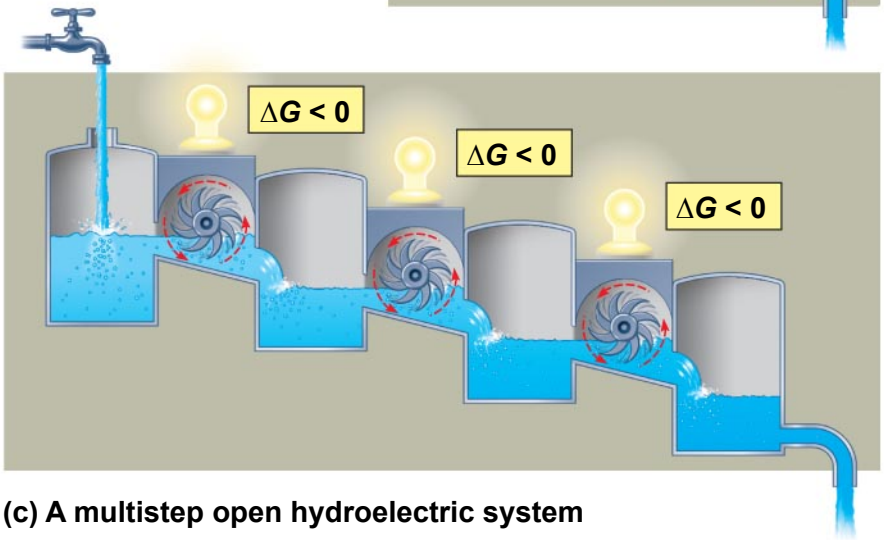


(b) Endergonic reaction: energy required

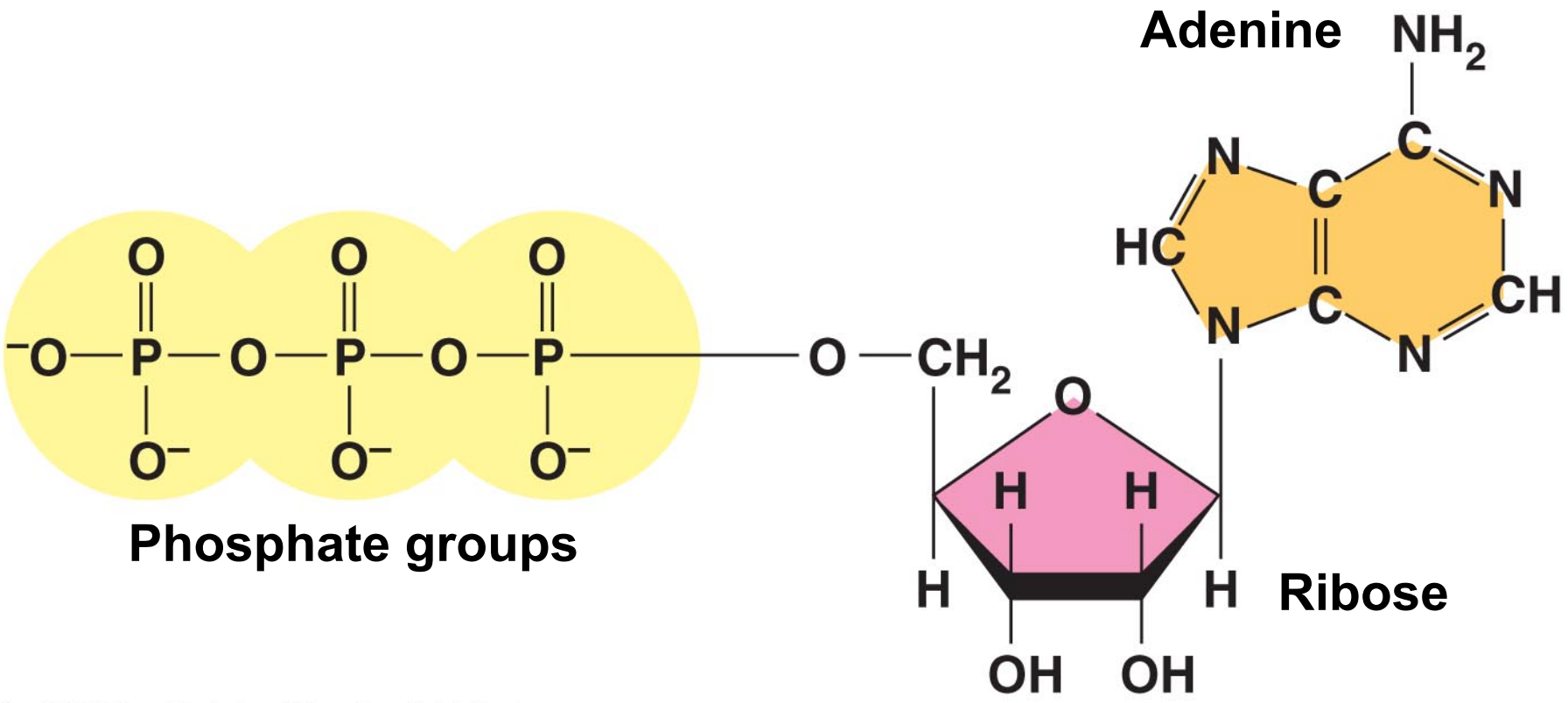


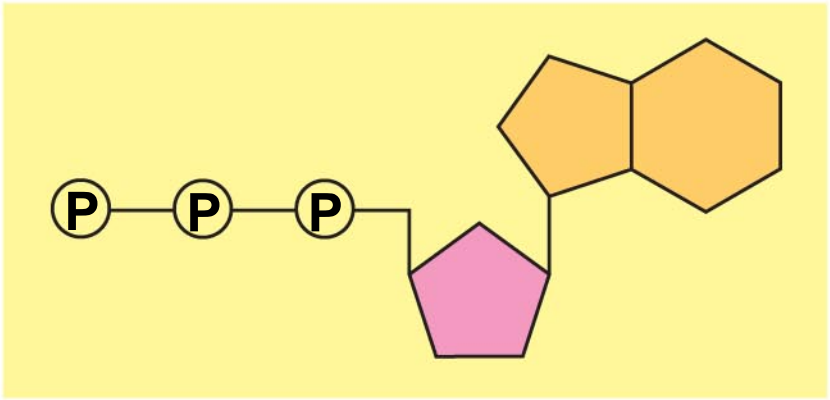
(a) An isolated hydroelectric system

(b) An open hydroelectric system

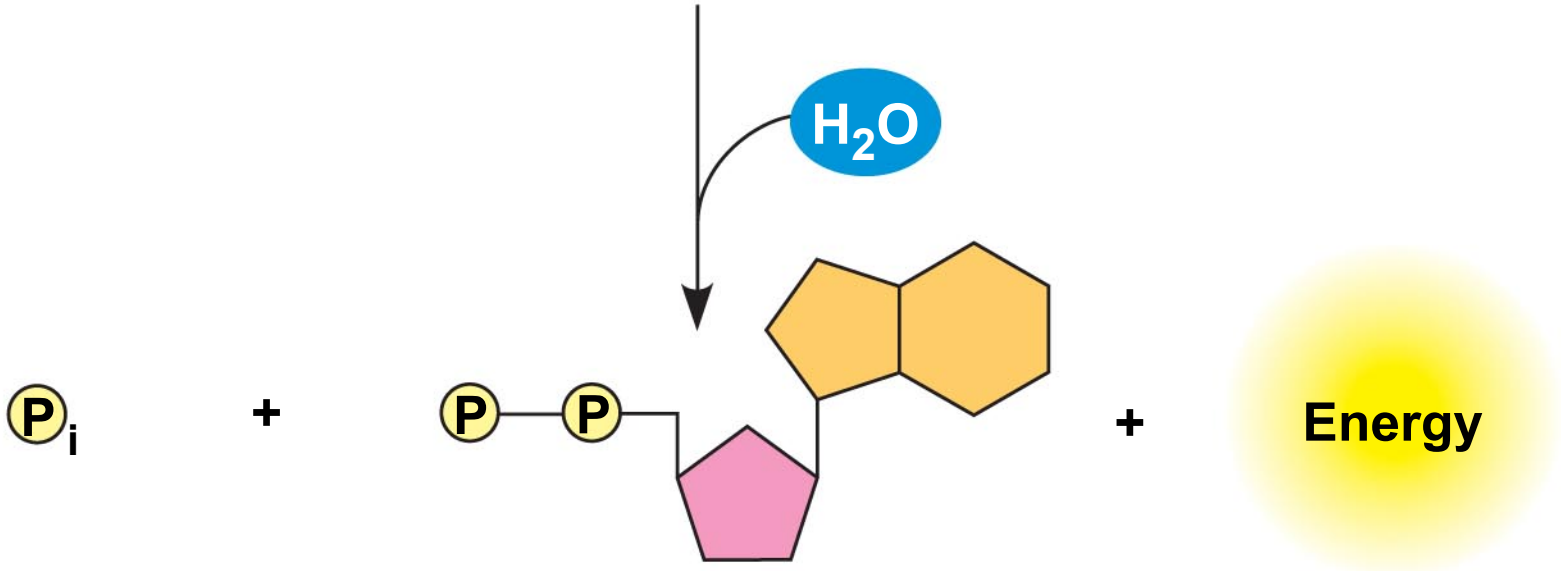


(c) A multistep open hydroelectric system

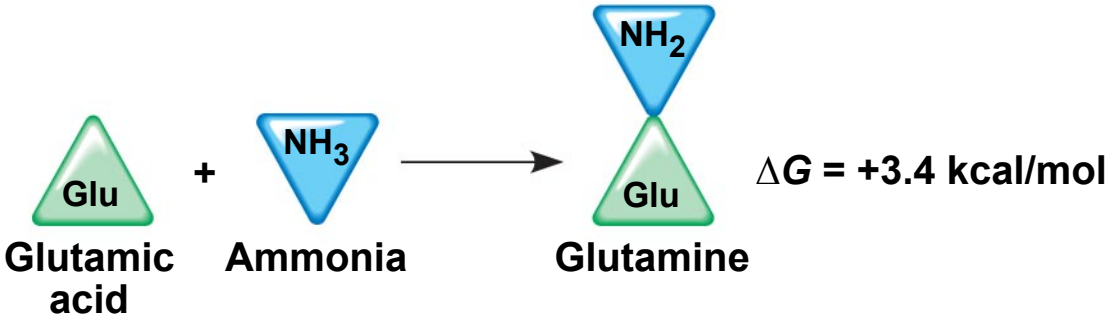




Adenosine triphosphate (ATP)



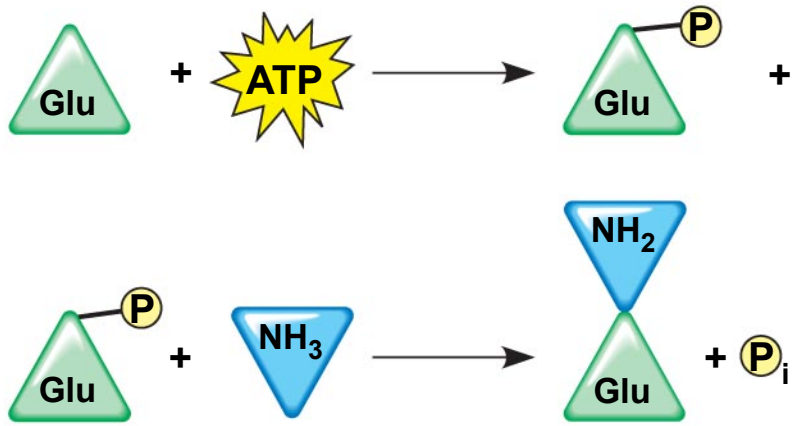
Inorganic phosphate **Adenosine diphosphate (ADP)**



(a) Endergonic reaction

1 ATP phosphorylates glutamic acid, making the amino acid less stable.

2 Ammonia displaces the phosphate group, forming glutamine.



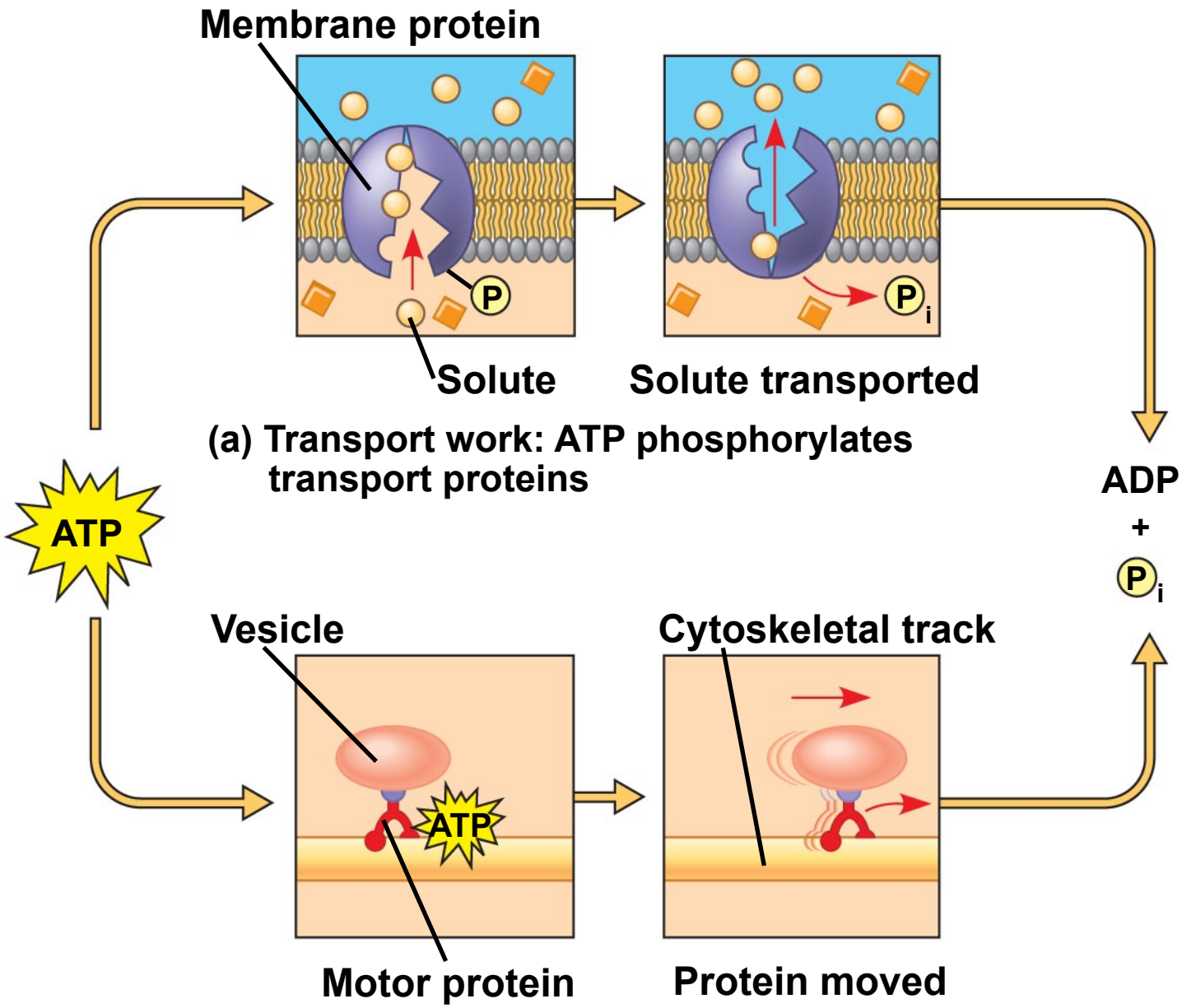
(b) Coupled with ATP hydrolysis, an exergonic reaction

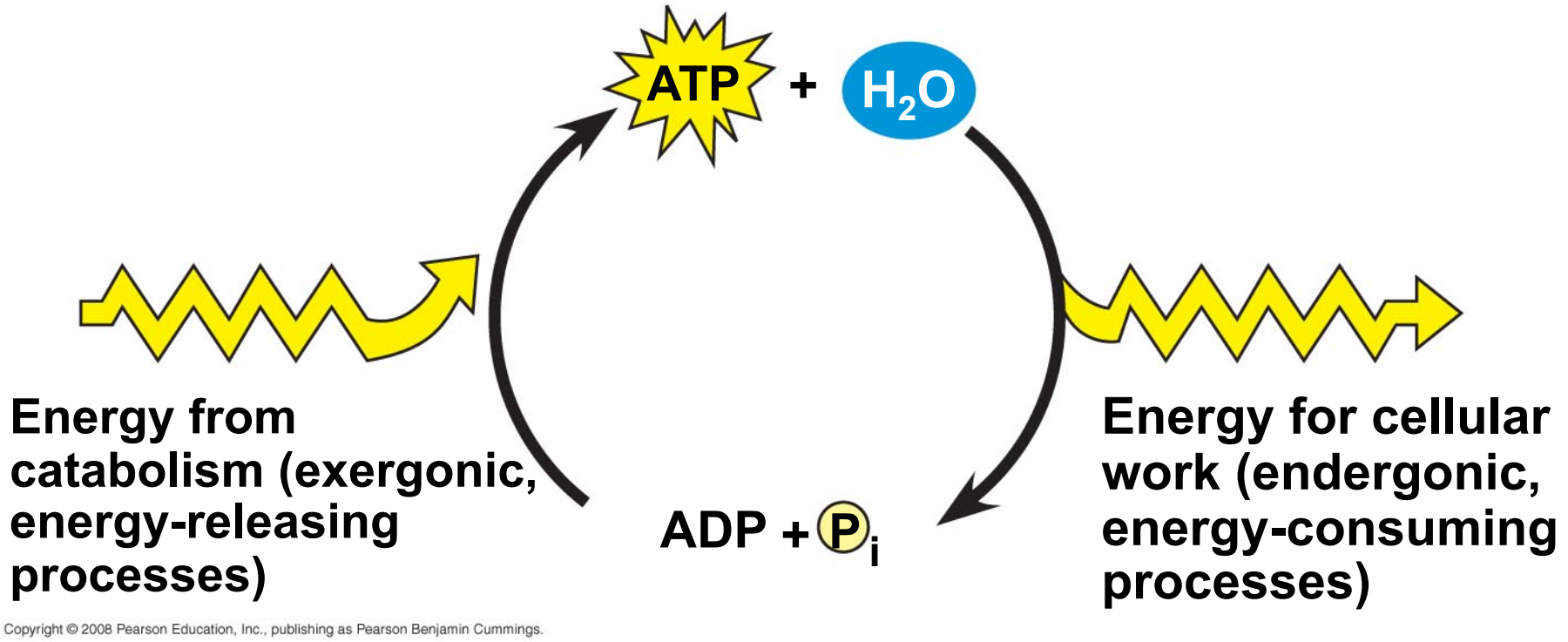
$Glu + NH_3 \longrightarrow Glu—NH_2$ $\quad \Delta G = +3.4$ kcal/mol

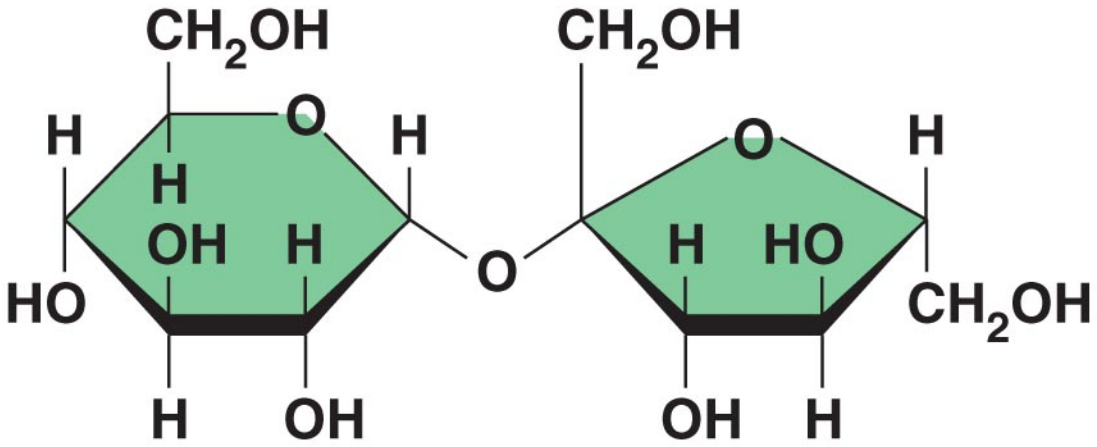
$ATP \longrightarrow ADP + P_i$ $\quad \Delta G = -7.3$ kcal/mol

Net $\Delta G = -3.9$ kcal/mol

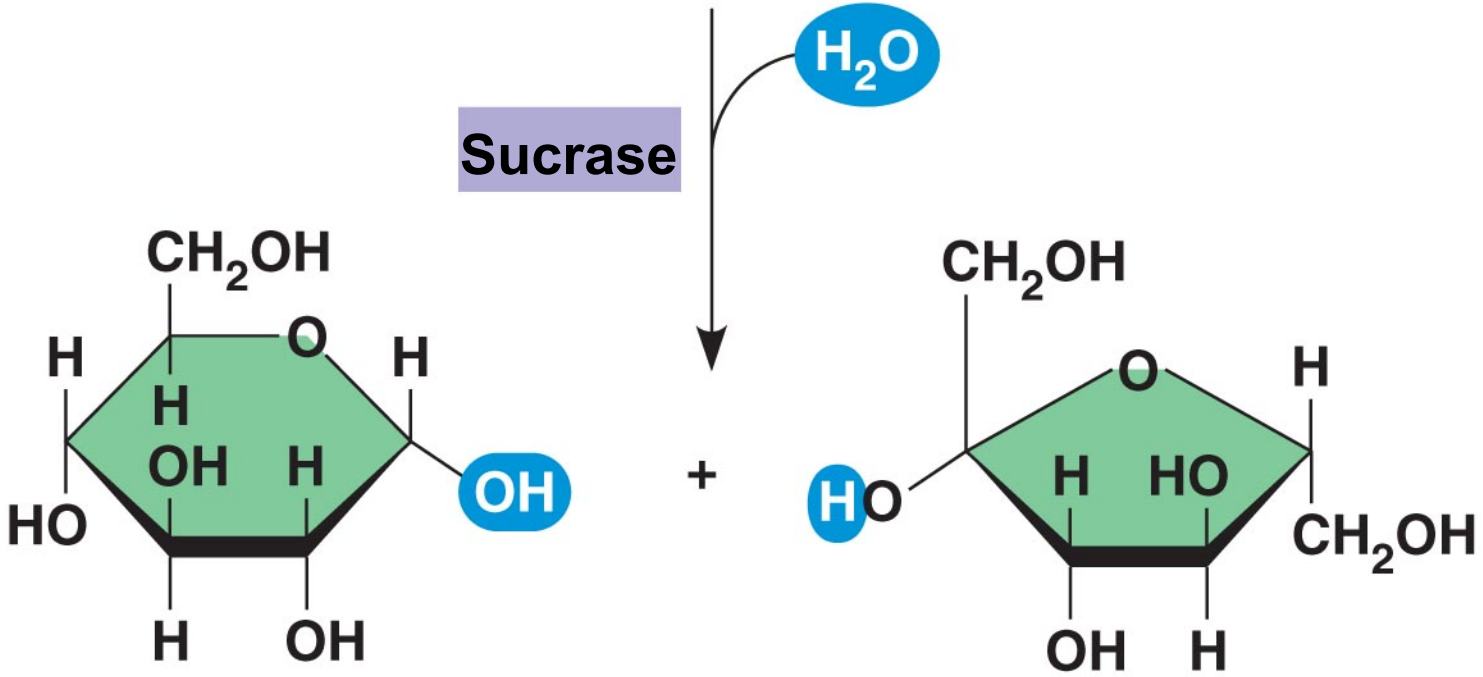
(c) Overall free-energy change



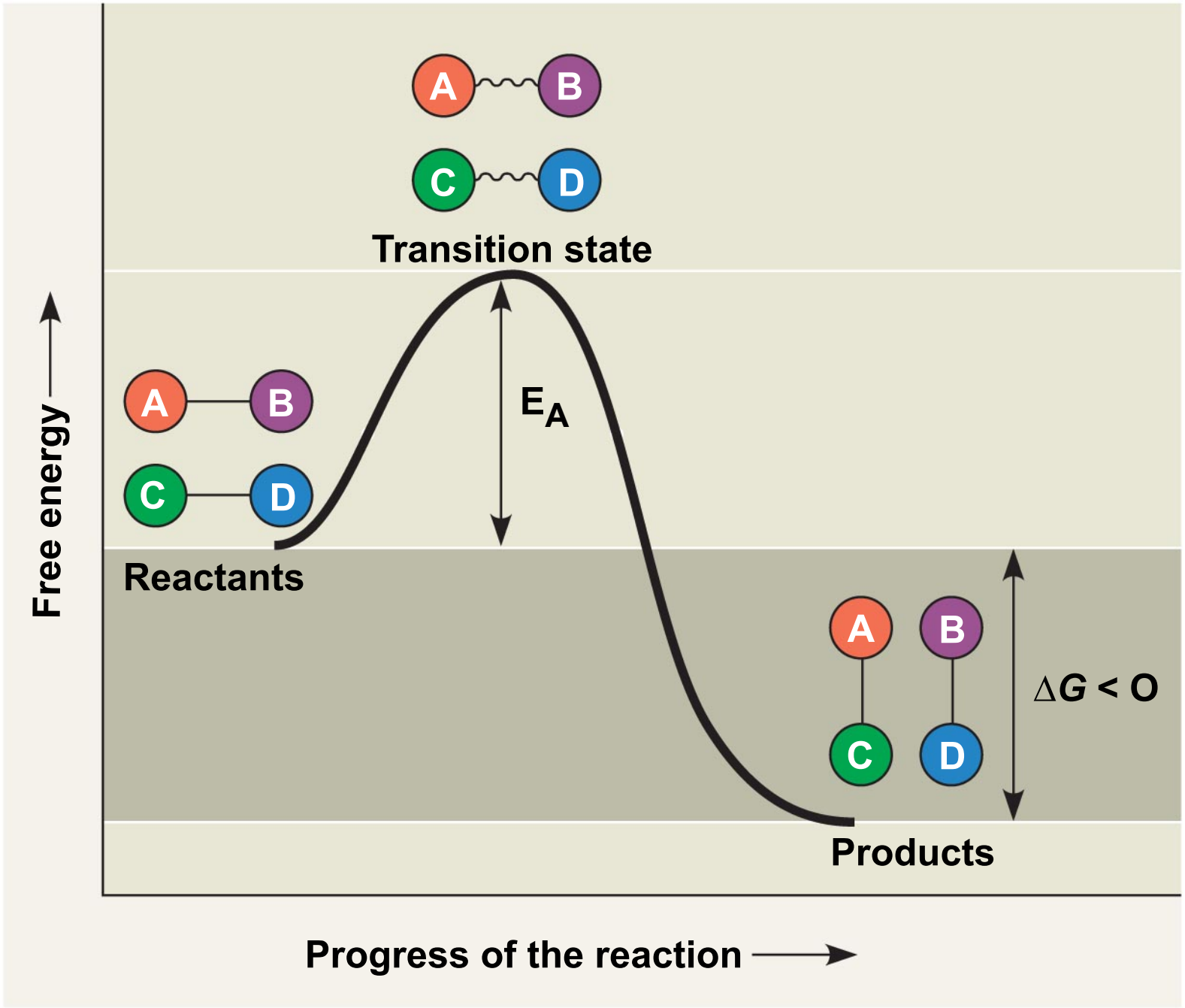


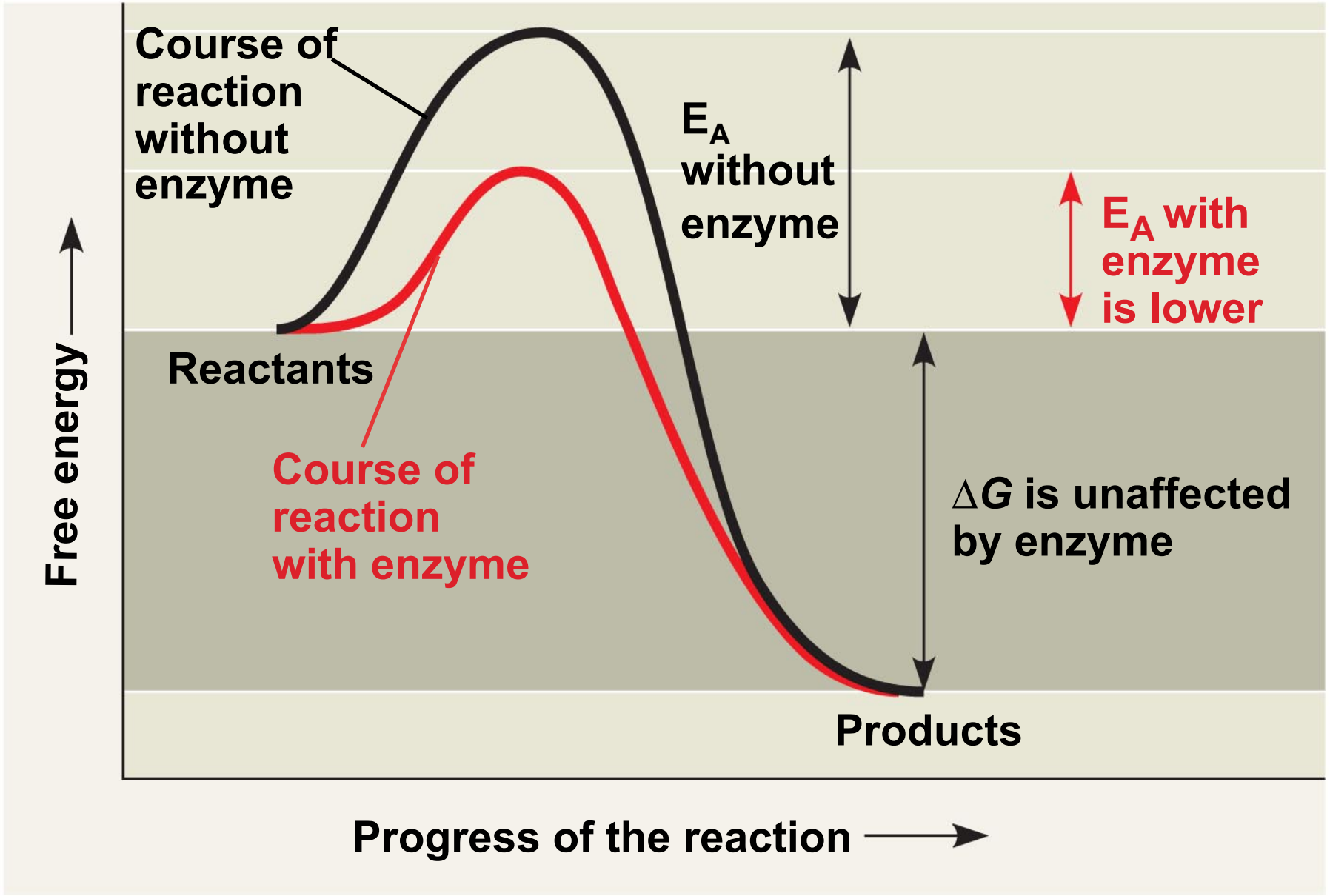


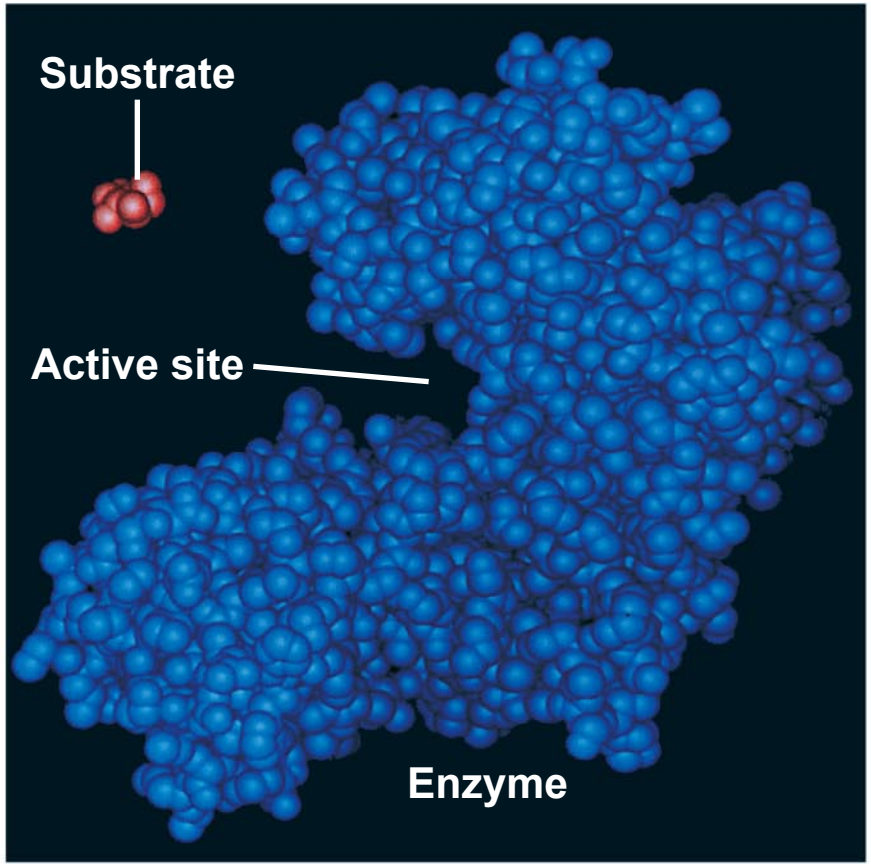
Sucrose ($C_{12}H_{22}O_{11}$)



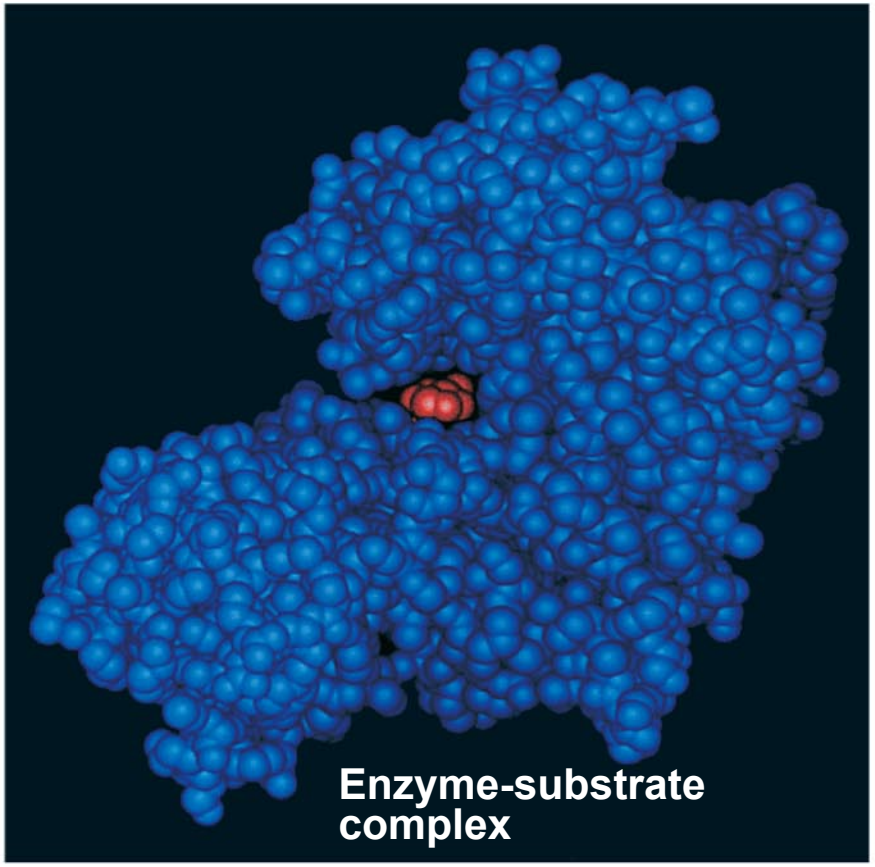
Glucose ($C_6H_{12}O_6$) **Fructose ($C_6H_{12}O_6$)**



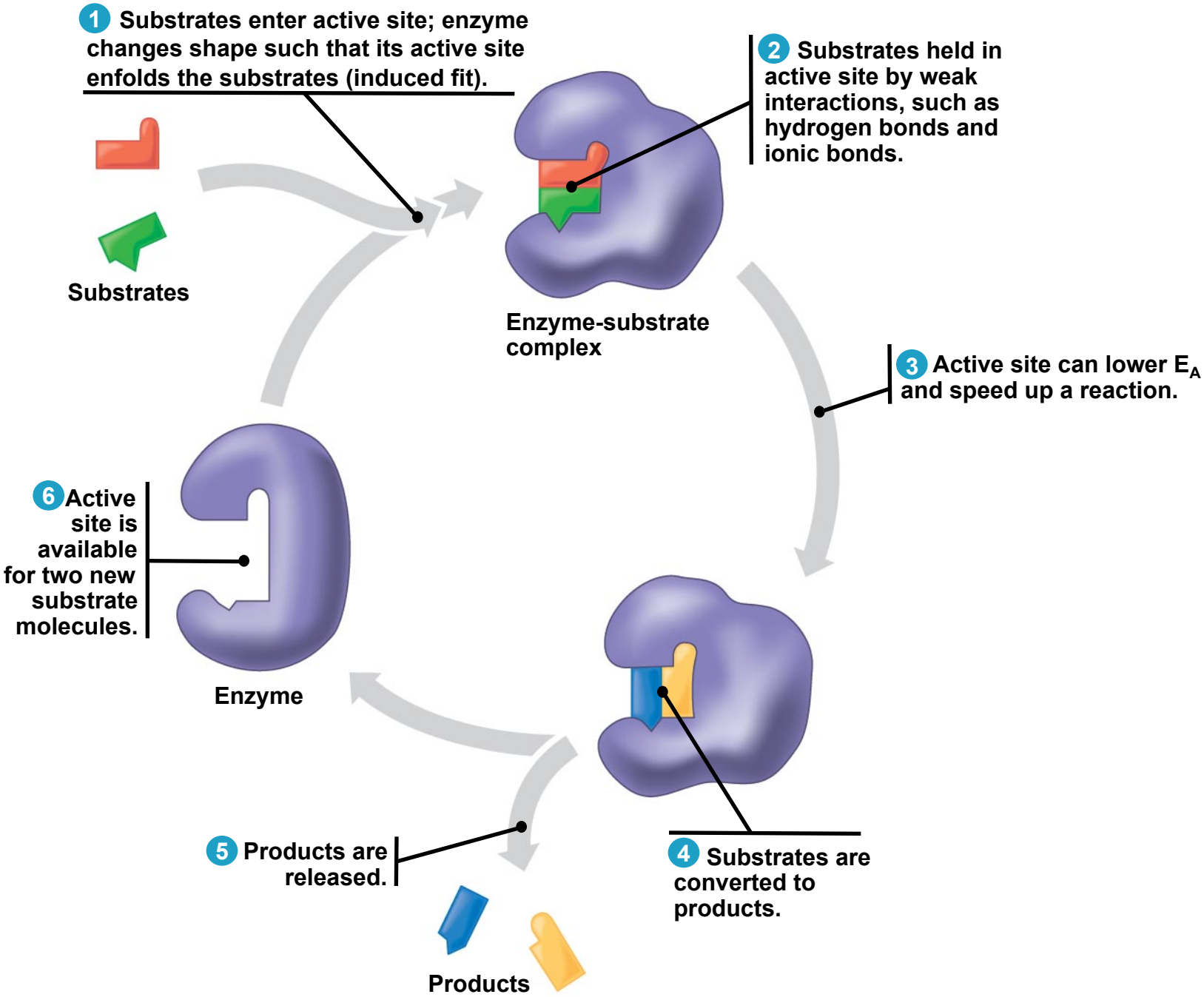


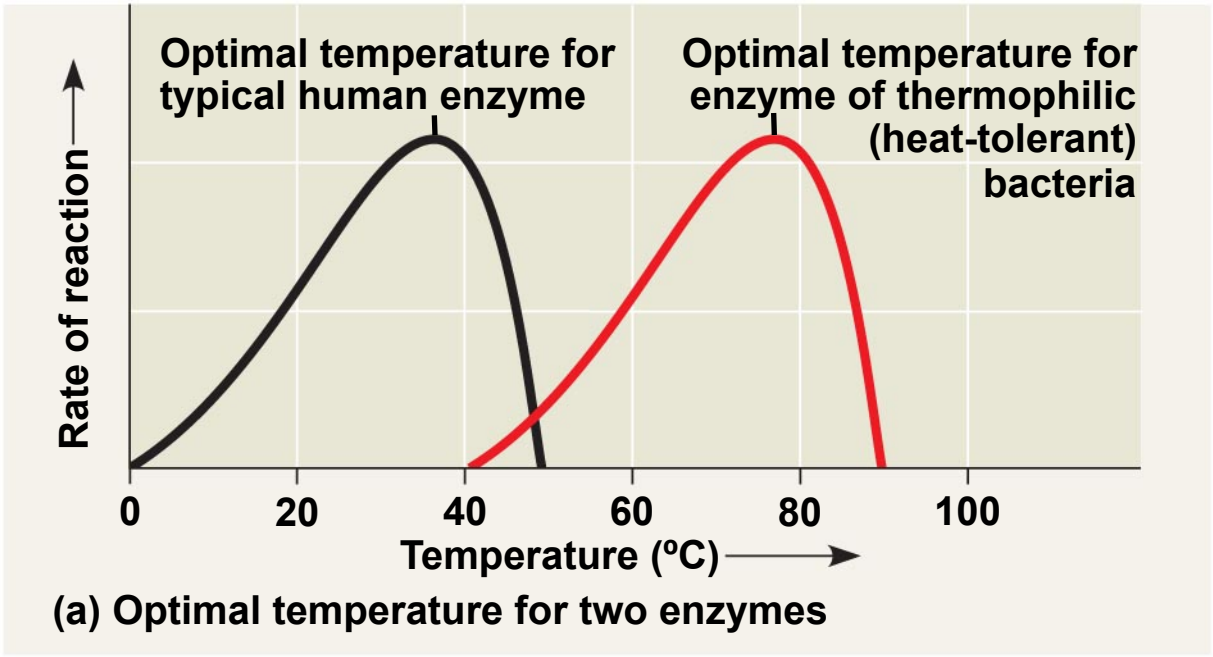


(a)

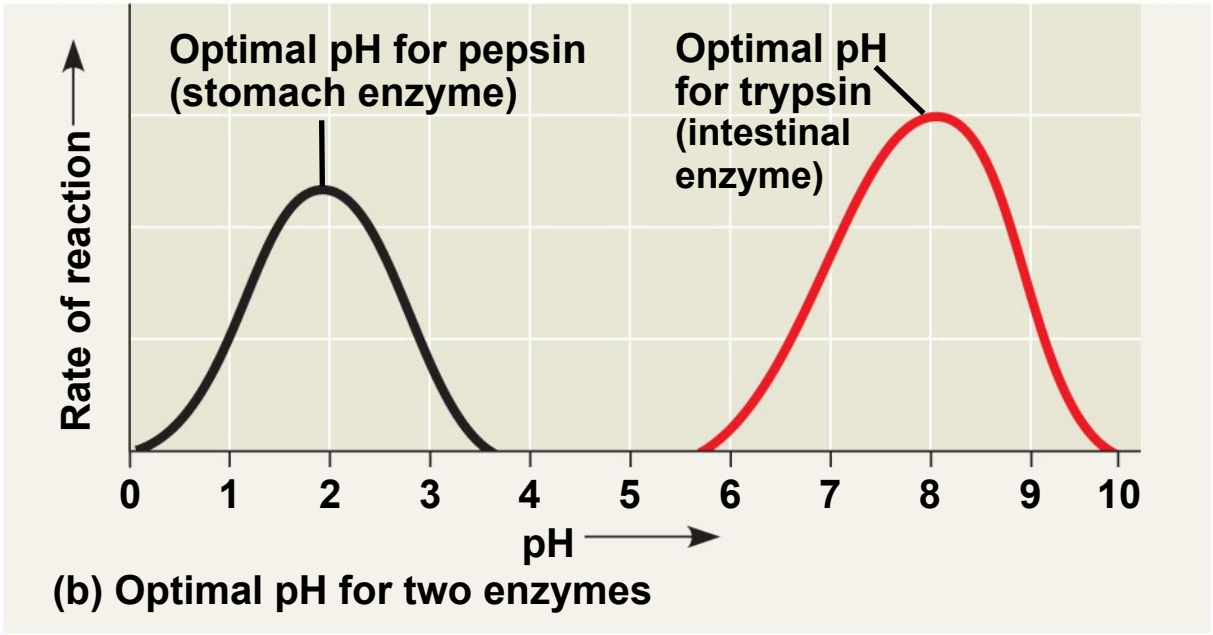


(b)

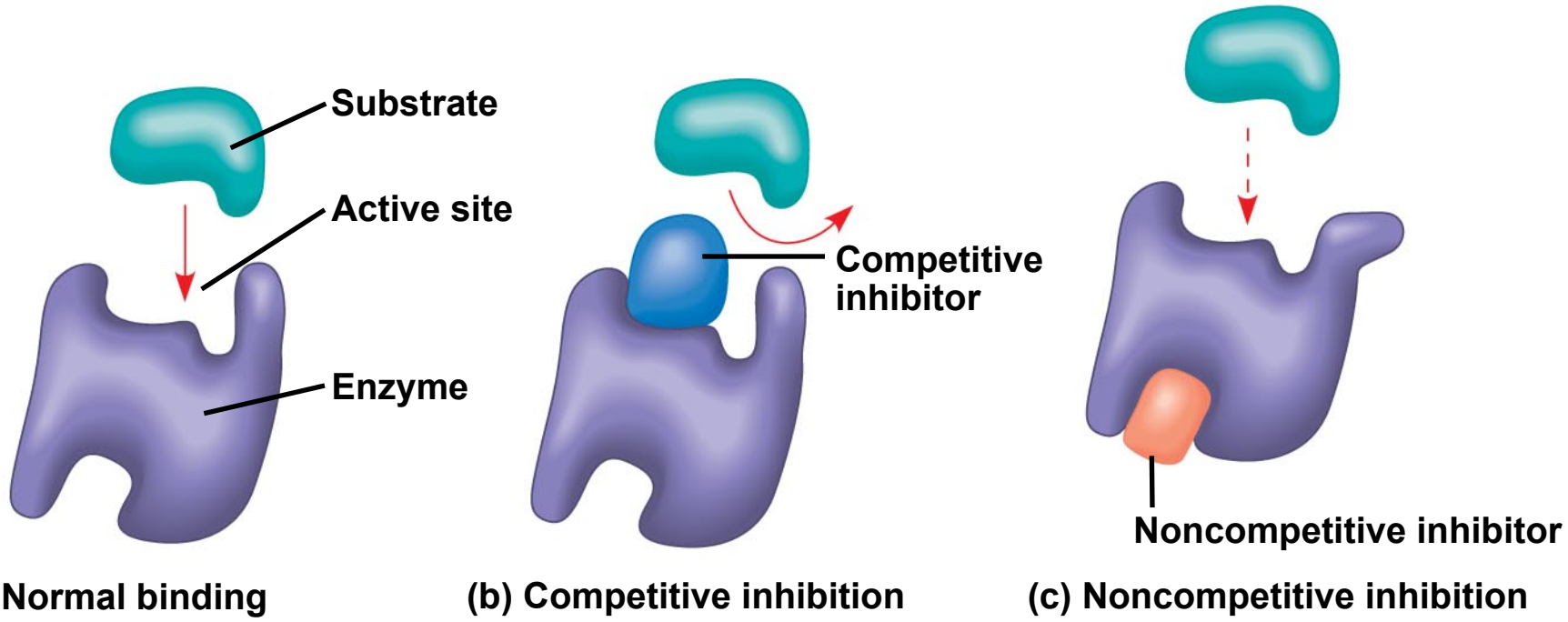


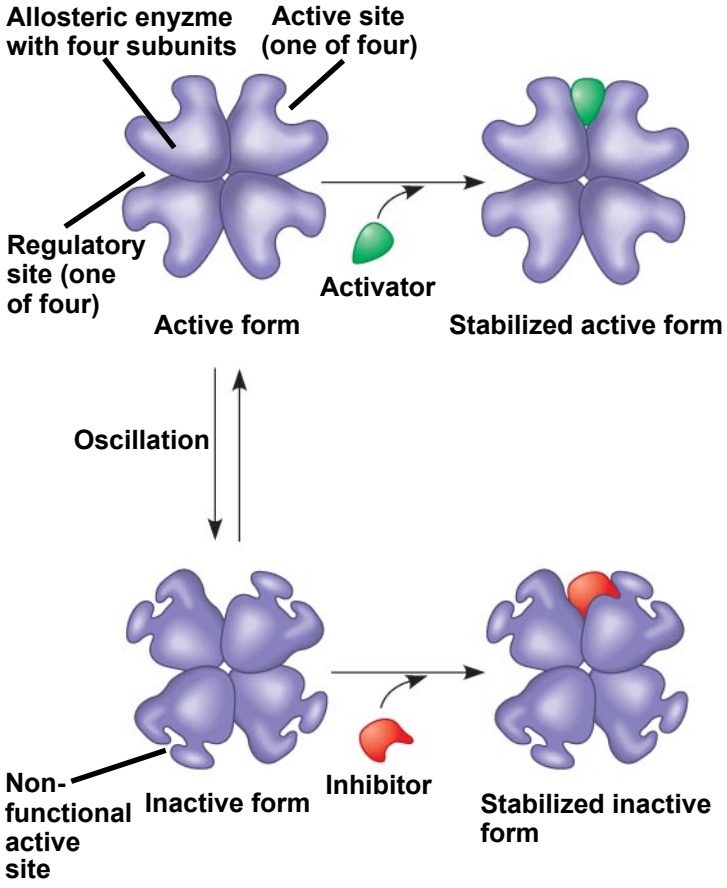


(a) Optimal temperature for two enzymes

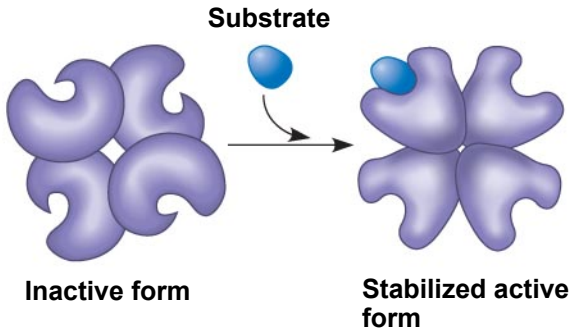


(b) Optimal pH for two enzymes





(a) Allosteric activators and inhibitors



(b) Cooperativity: another type of allosteric activation