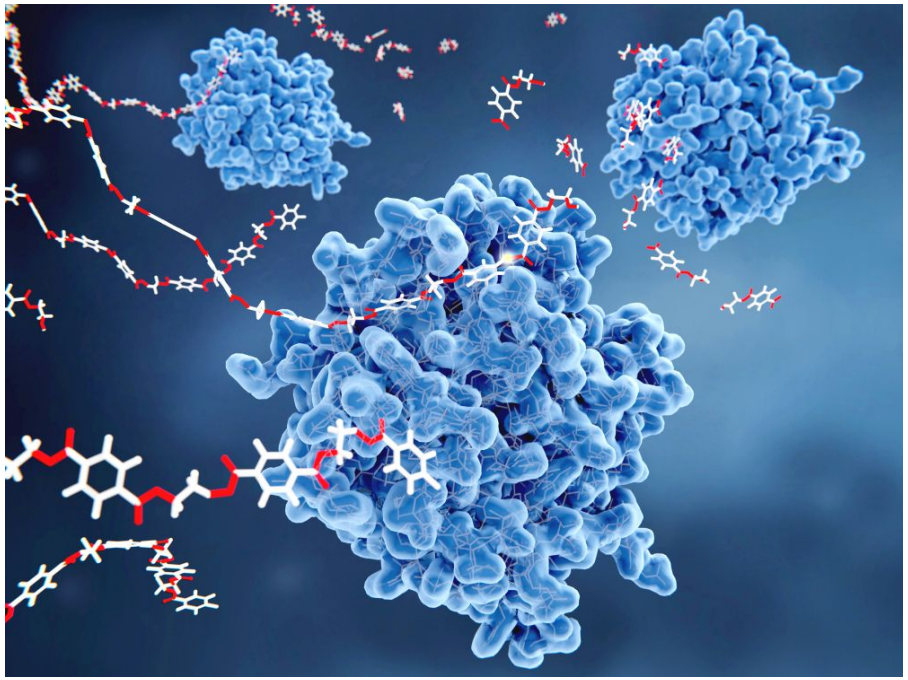
Lesson 5
Free Energy, Reaction Kinetics and Enzymes



Free energy difference

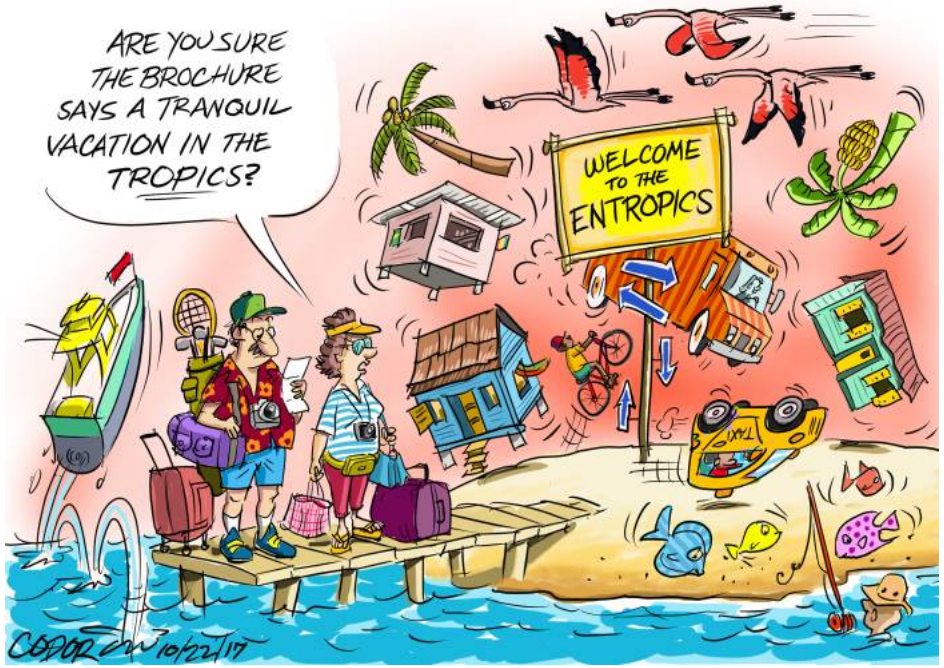
- Reactions are governed by **free energy** (*usable energy*) **G**

  Reagents ⇄ Products

- What really matters is the **free energy difference $\Delta G = \Sigma G_P - \Sigma G_R$**
- ΔG stems from a fundamental law of thermodynamics

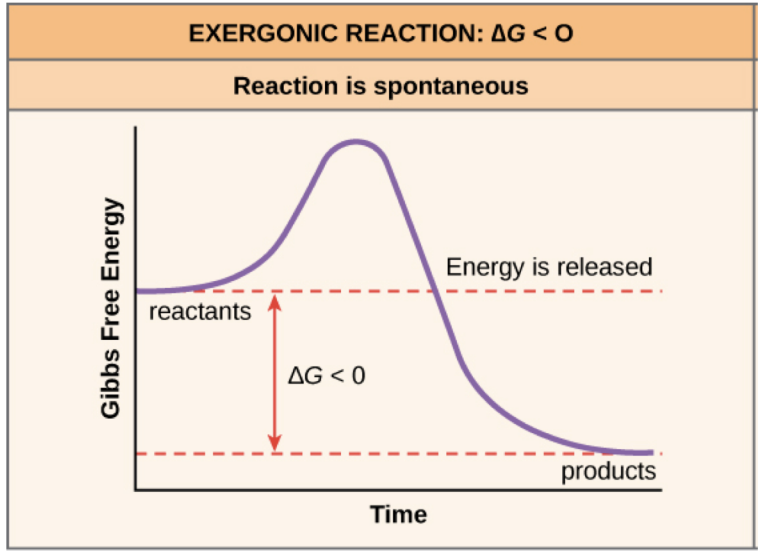
  $\Delta G = \Delta H - T\Delta S$

- **H** = **Enthalpy** = *total energy*
- **T** = **Temperature**
- **S** = **Entropy** = *useless energy*



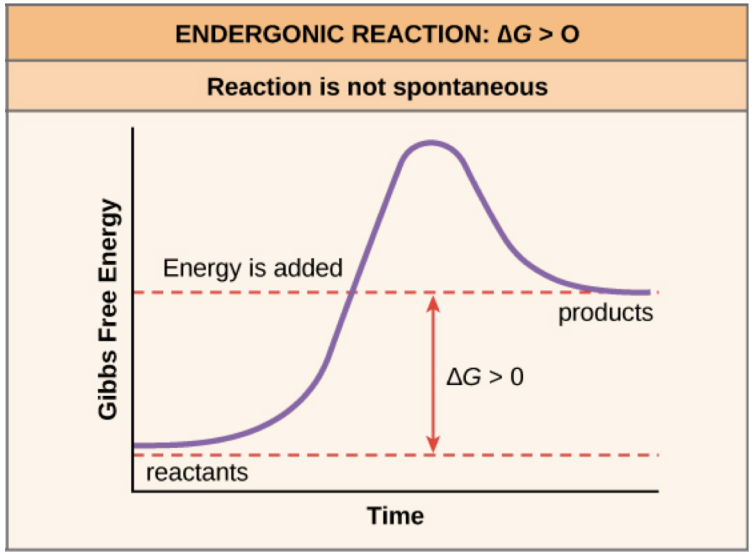
Free energy difference

- $\Delta G < 0$ ($G_P < G_R$) → Energy released, reaction proceeds (thermodynamically spontaneous, exergonic)



Free energy difference

- $\Delta G < 0$ ($G_P < G_R$) → Energy released, reaction proceeds (thermodynamically spontaneous, exergonic)
- $\Delta G > 0$ ($G_P > G_R$) → Reactions requires energy to proceed (thermodynamically non-spontaneous, endergonic)

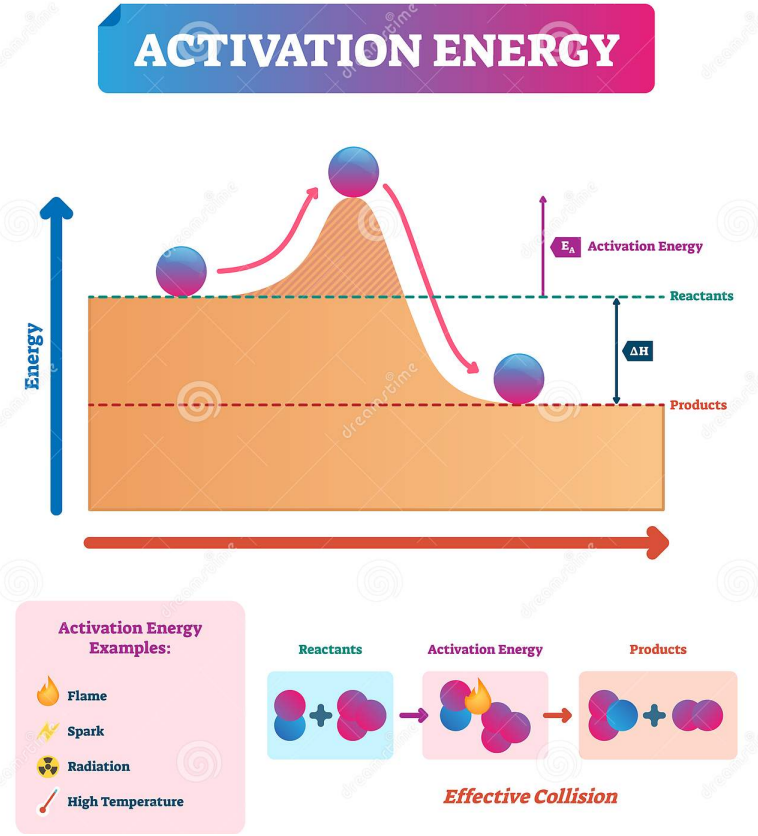


Free energy difference

- $\Delta G < 0$ ($G_P < G_R$) → Energy released, reaction proceeds (thermodynamically spontaneous, exergonic)
- $\Delta G > 0$ ($G_P > G_R$) → Reactions requires energy to proceed (thermodynamically non-spontaneous, endergonic)
- $\Delta G = 0$ ($G_P = G_R$) → Chemical equilibrium ($R \rightarrow P = P \rightarrow R$)

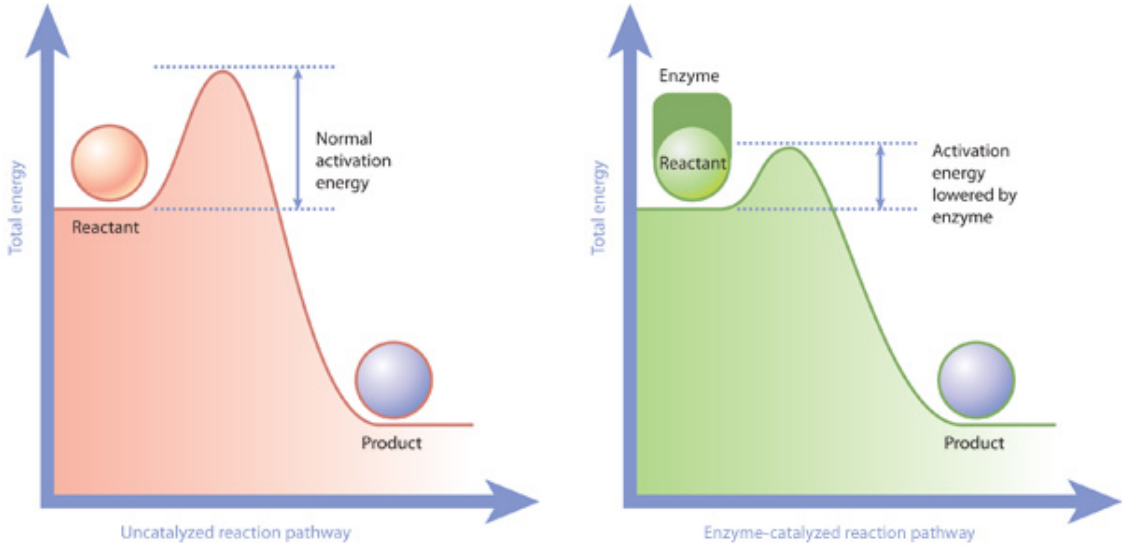
Free energy difference

- Even if a reaction is thermodynamically spontaneous ($\Delta G < 0$), it may not occur
  - It needs an “energetical push”
- **Activation energy E_a = energy barrier**



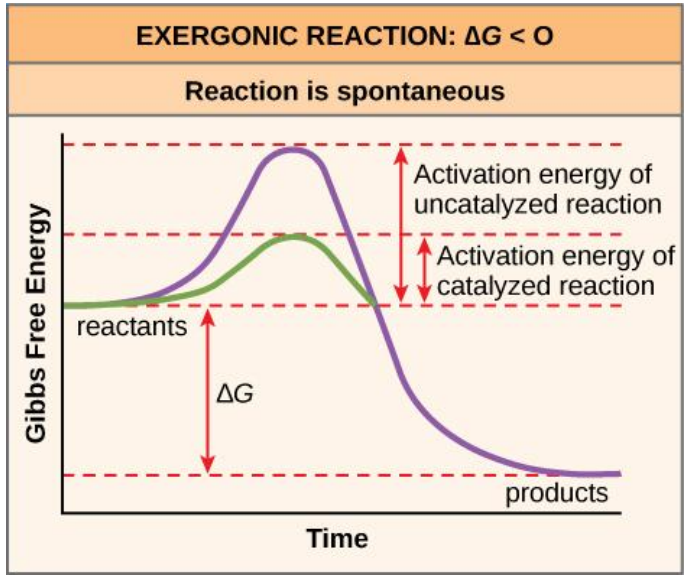
Enzymes

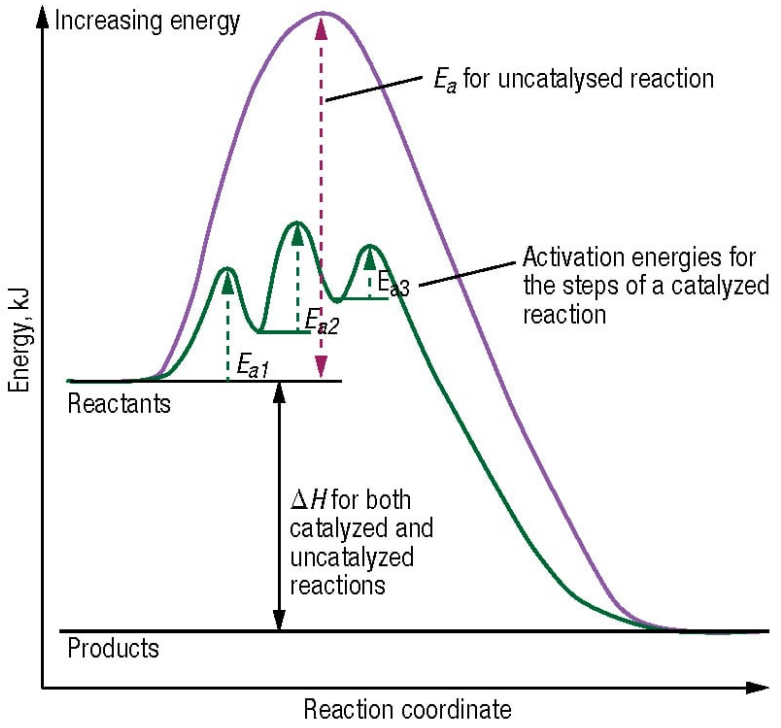
- Even if a reaction is thermodynamically spontaneous ($\Delta G < 0$), it may not occur
  - It needs an "energetical push"
- **Activation energy E_a = energy barrier**
- **Catalysts** = particular class of chemical substances that lower E_a and promote reactions
- **Enzymes** = biological catalysts (mostly proteins)



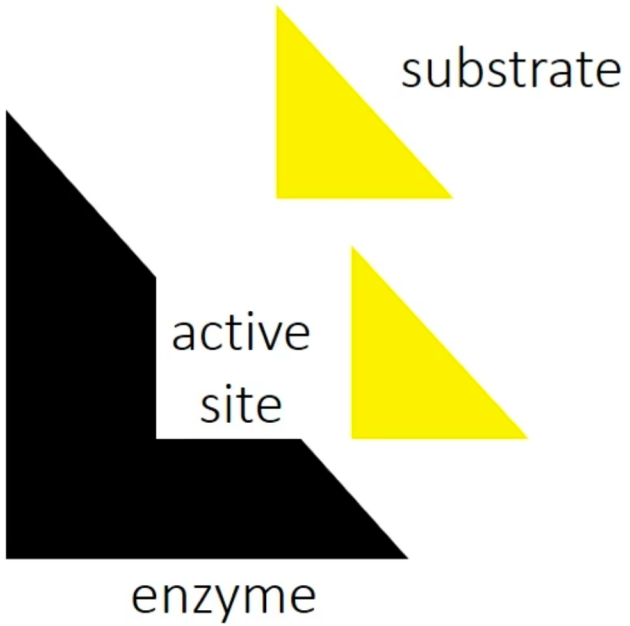
Enzymes

- There are approximately 1300 different enzymes found in the human cell
- Each enzyme catalyzes a specific chemical reaction
- **ENZYMES DO NOT CHANGE THE ΔG OF A REACTION BUT JUST SPEED UP THE REACTION RATE**



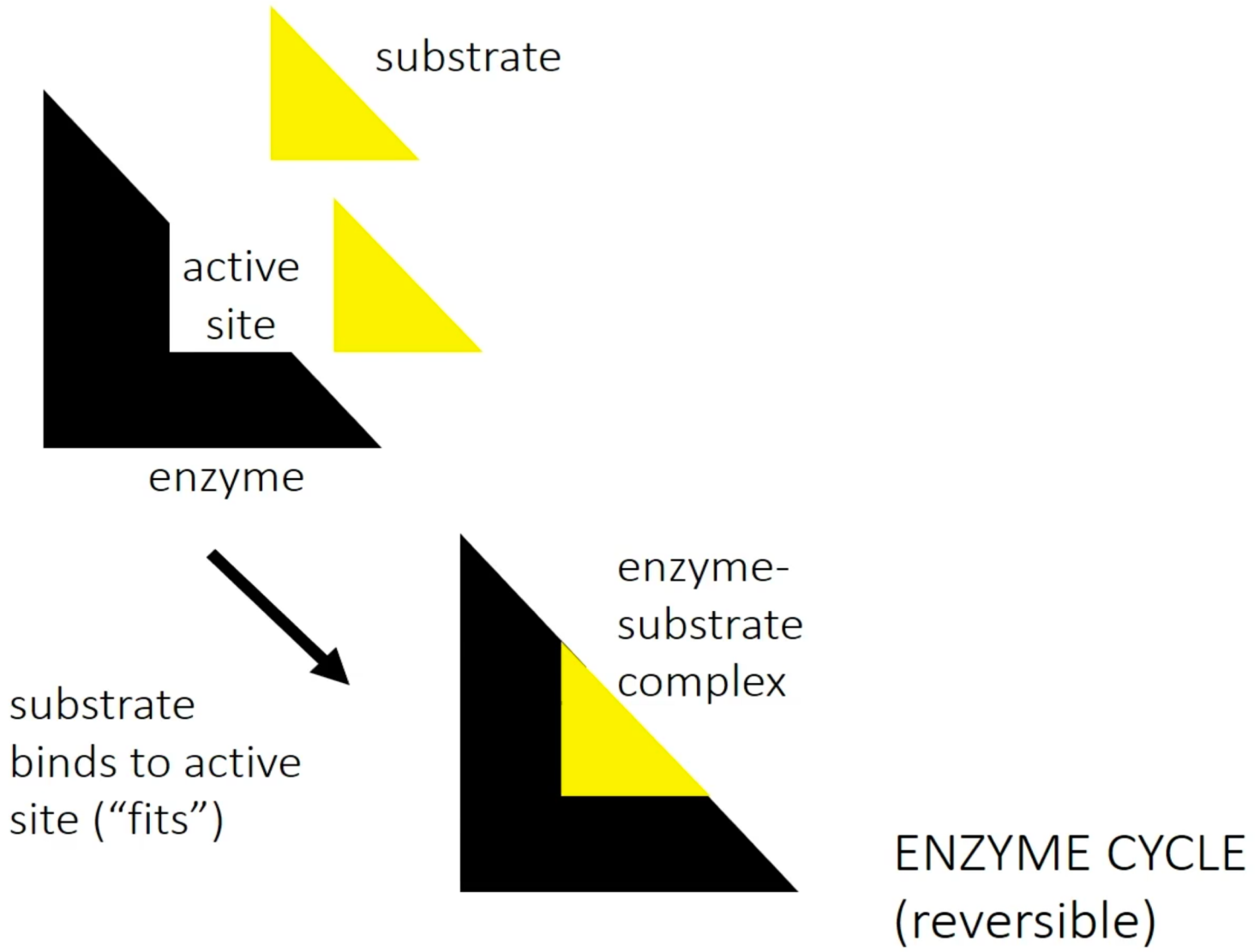


Enzymes

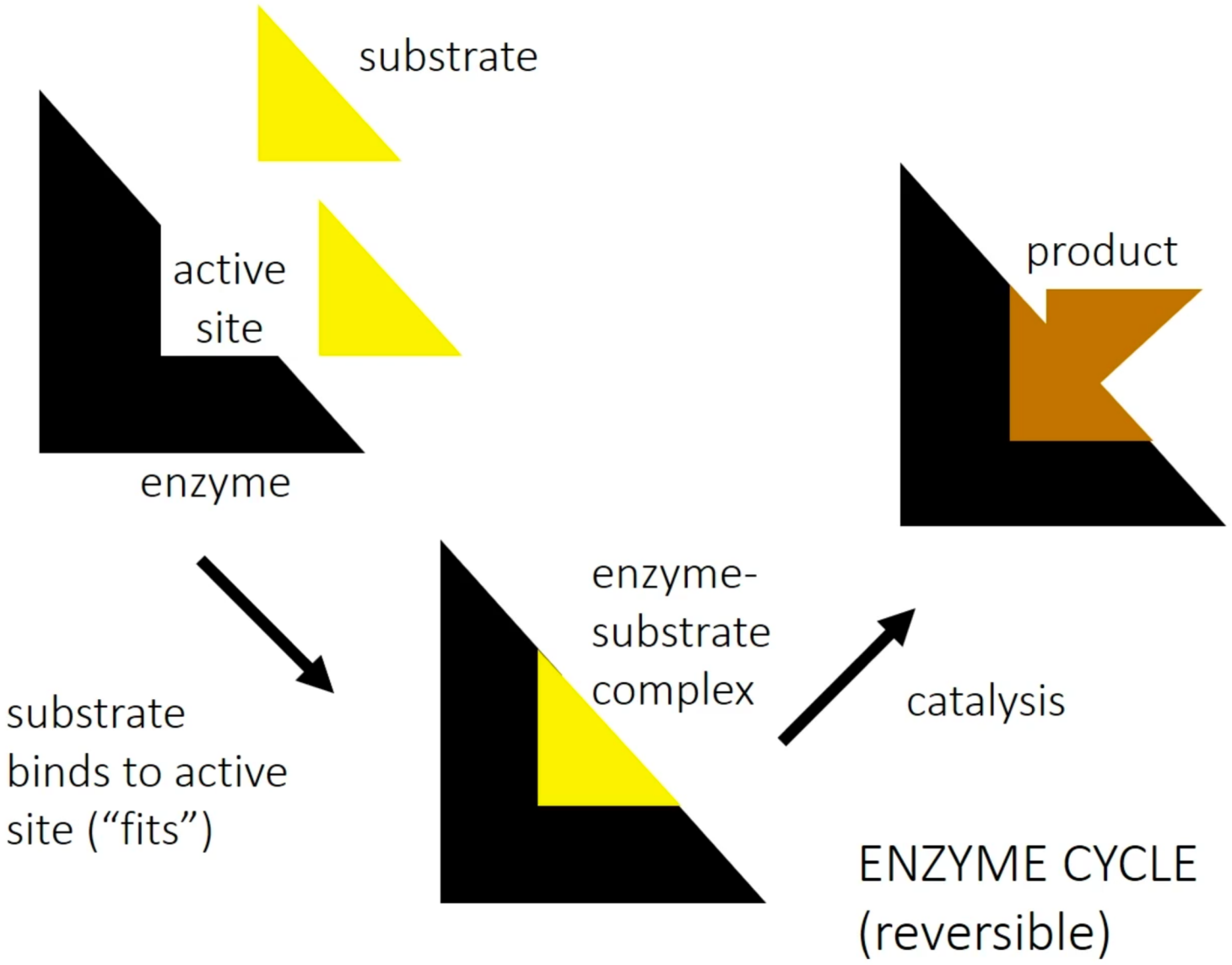


ENZYME CYCLE
(reversible)

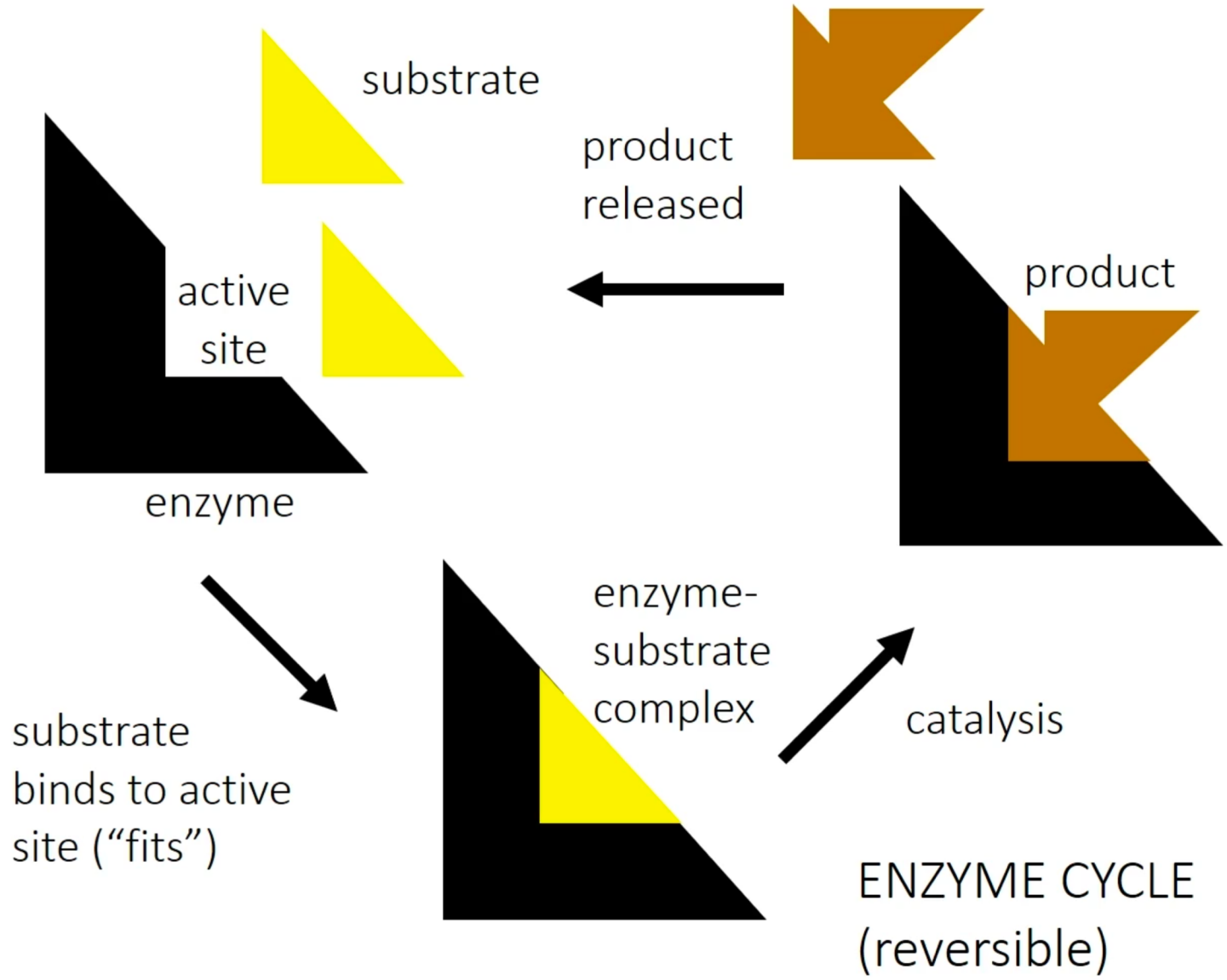
Enzymes


substrate
active
site
enzyme
enzyme-
substrate
complex
substrate
binds to active
site (“fits”)
ENZYME CYCLE
(reversible)

Enzymes


substrate
active
site
enzyme
product
enzyme-
substrate
complex
catalysis
substrate
binds to active
site (“fits”)
ENZYME CYCLE
(reversible)

Enzymes

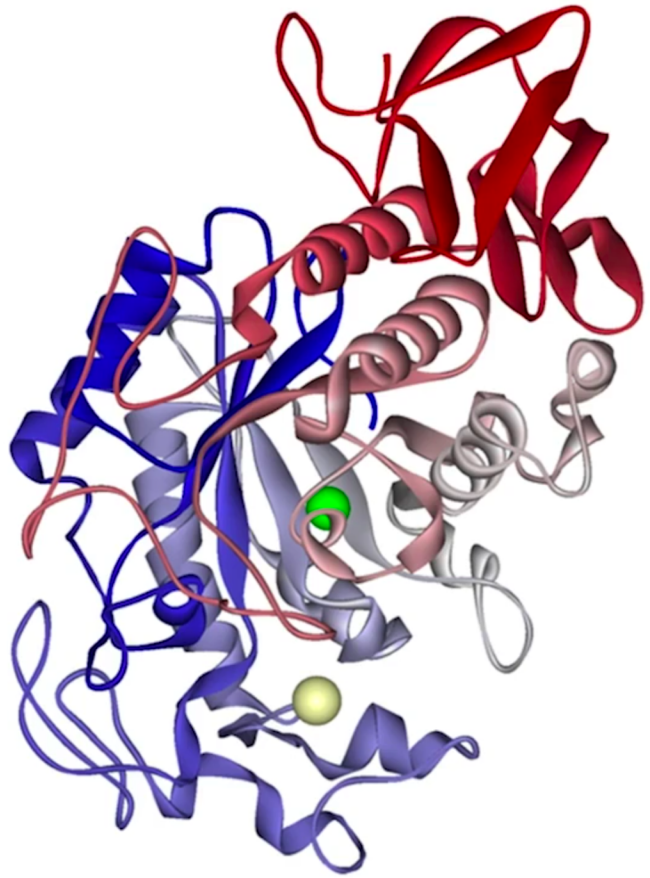

substrate
product
released
active
site
product
enzyme
enzyme-
substrate
complex
substrate
binds to active
site (“fits”)
catalysis
ENZYME CYCLE
(reversible)

Enzyme specificity

Cellulose and starch
are both glucose polymers

Cellulase
breaks β-1,4 bonds in cellulose
People do not have this enzyme
so we cannot digest grass!

Amylase
breaks α-1,4 bonds in starch
People have this enzyme!



ENZYME SPECIFICITY

Free energy, Reaction Kinetics and Enzymes

- Take assignment 5: Free energy reaction kinetics and enzymes