Enzymes and Biochemical Pathways

Ch. 6.3

Biochemical Pathways

- http://highered.mheducation.com/sites/0072943696/student_view0/chapter2/animation__a_biochemical_pathway.html

6.3 Metabolic Pathways and Enzymes

- Reactions usually occur in a sequence
  - Products of an earlier reaction become reactants of a later reaction
  - Such linked reactions form a **metabolic pathway**
    - Begins with a particular reactant, proceeds through several intermediates, and terminates with a particular end product

A→B →C →D →E →F→G

"A" is Initial Reactant

B, C, D, E, and F are Intermediates

"G" is End Product

6.3 Metabolic Pathways and Enzymes

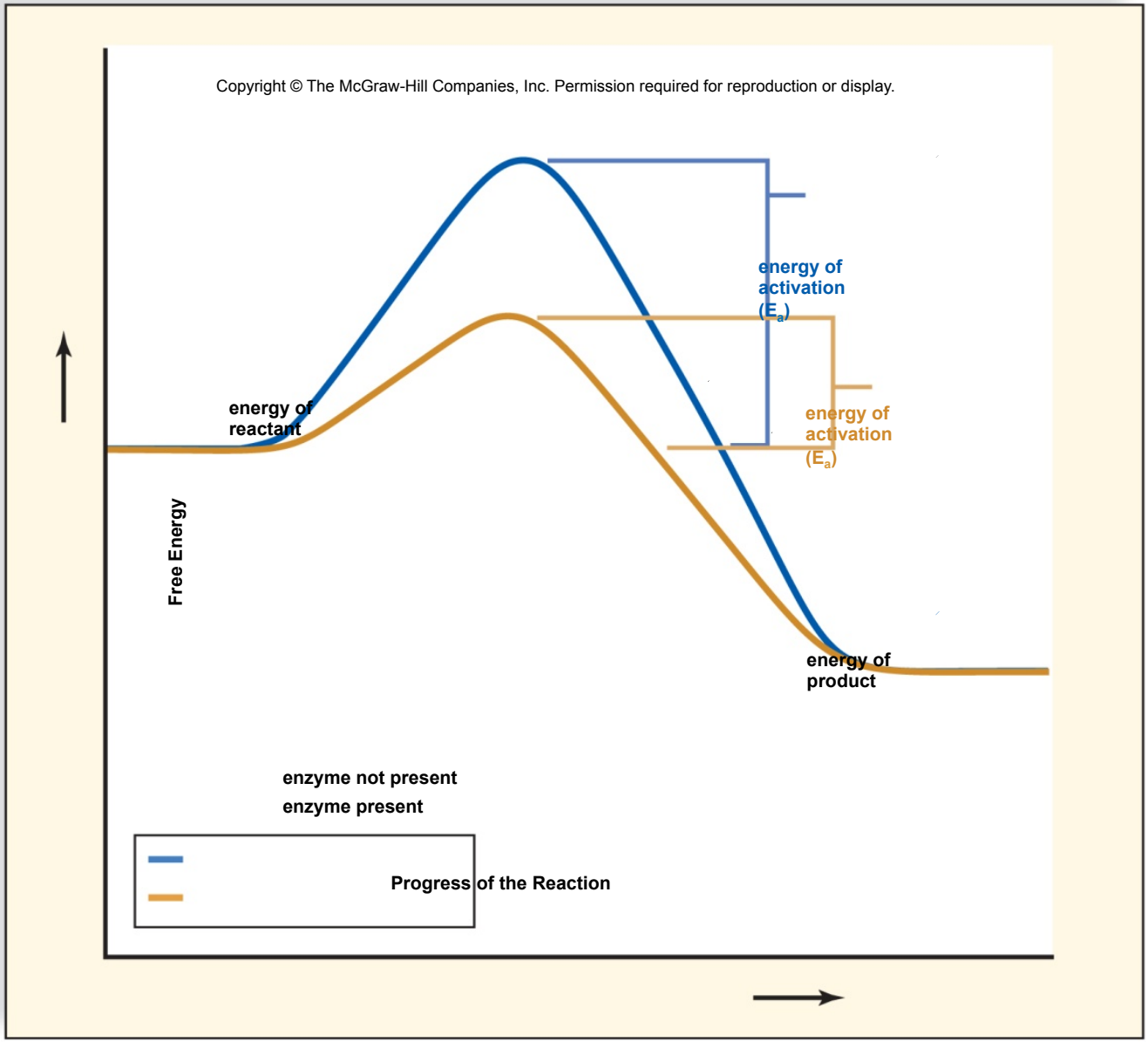
- **Enzyme**
  - Protein molecules that function as catalysts
  - The reactants of an enzymatically catalyzed reaction are called **substrates**
  - Each enzyme accelerates a specific reaction
  - Each reaction in a metabolic pathway requires a unique and specific enzyme
  - The end product will not be formed unless ALL enzymes in the pathway are present and functional

$$A \xrightarrow{E_1} B \xrightarrow{E_2} C \xrightarrow{E_3} D \xrightarrow{E_4} E \xrightarrow{E_5} F \xrightarrow{E_6} G$$

Energy of Activation

- Molecules frequently do not react with one another unless they are activated in some way
  - Energy must be added to at least one reactant to initiate the reaction
    - **Energy of activation**
- Enzyme Operation:
  - Enzymes operate by ***lowering*** the energy of activation
  - Accomplished by bringing substrates into contact with one another

Energy of Activation



How Enzymes Work

- http://highered.mheducation.com/sites/0072495855/student_view0/chapter2/animation__how_enzymes_work.html

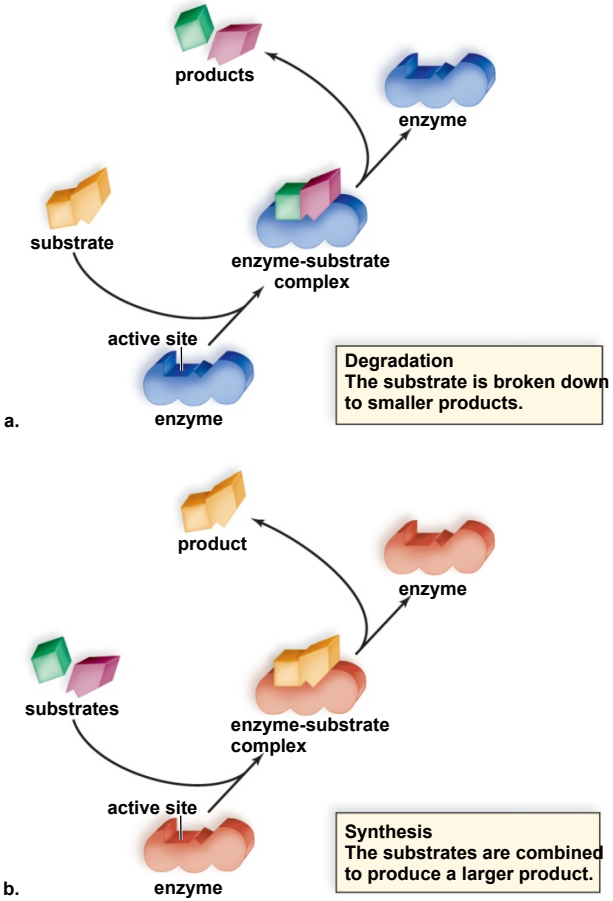
Enzyme-Substrate Complex

- The **active site** complexes with the substrates
  - Causes the active site to change shape
  - Shape change forces substrates together, initiating bond
  - **Induced fit model**
    - Enzyme is induced to undergo a slight alteration to achieve optimum fit for the substrates

Enzyme-Substrate Complex

- Degradation:
  - Enzyme complexes with a single substrate molecule
  - Substrate is broken apart into two product molecules
- Synthesis:
  - Enzyme complexes with two substrate molecules
  - Substrates are joined together and released as a single product molecule

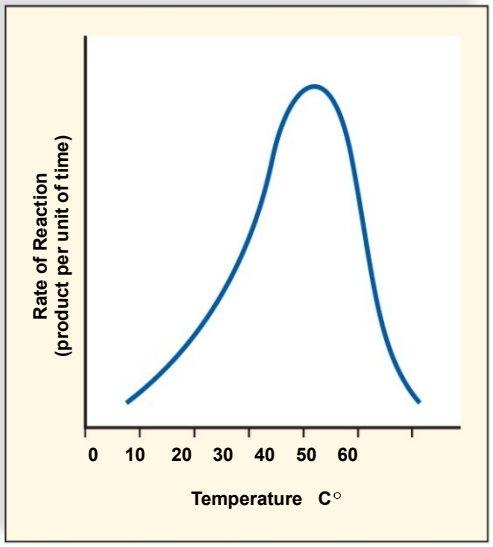
Enzymatic Actions



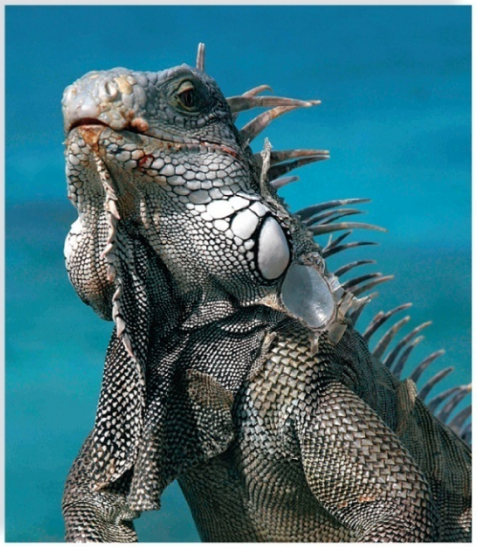
Factors Affecting Enzymatic Speed

- Substrate concentration
  - Enzyme activity ***increases*** with substrate concentration due to more frequent collisions between substrate molecules and the enzyme
- Temperature
  - Enzyme activity ***increases*** with temperature
  - Warmer temperatures cause more effective collisions between enzyme and substrate
  - However, hot temperatures can **denature** and destroy enzymes
- pH
  - Most enzymes are optimized for a particular pH

The Effect of Temperature on Rate of Reaction



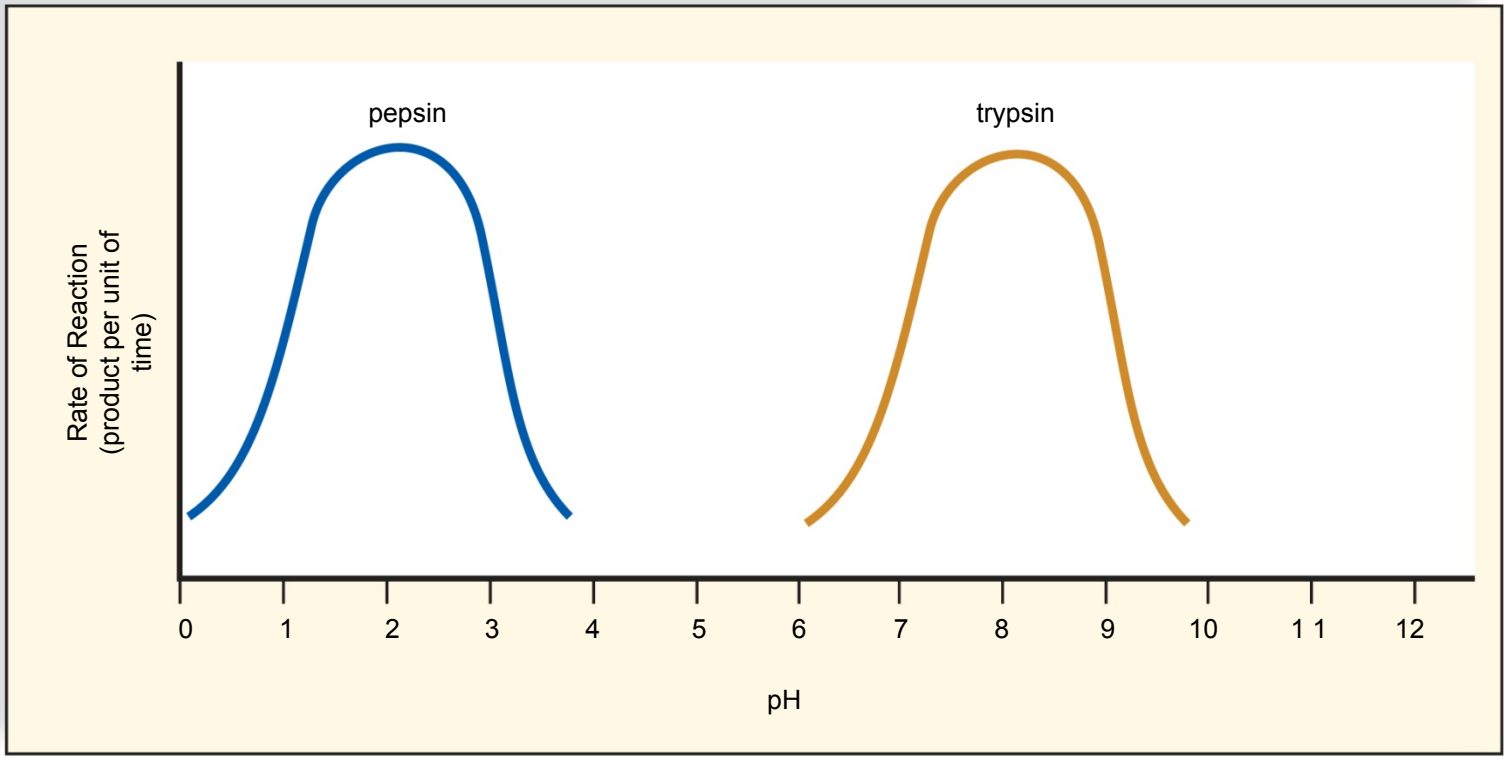
a.Rate of reaction as a function of temperature



b. Body temperature of ectothermic animals often limits rates of reactions.

c. Body temperature of endothermic animals promotes rates of reactions.

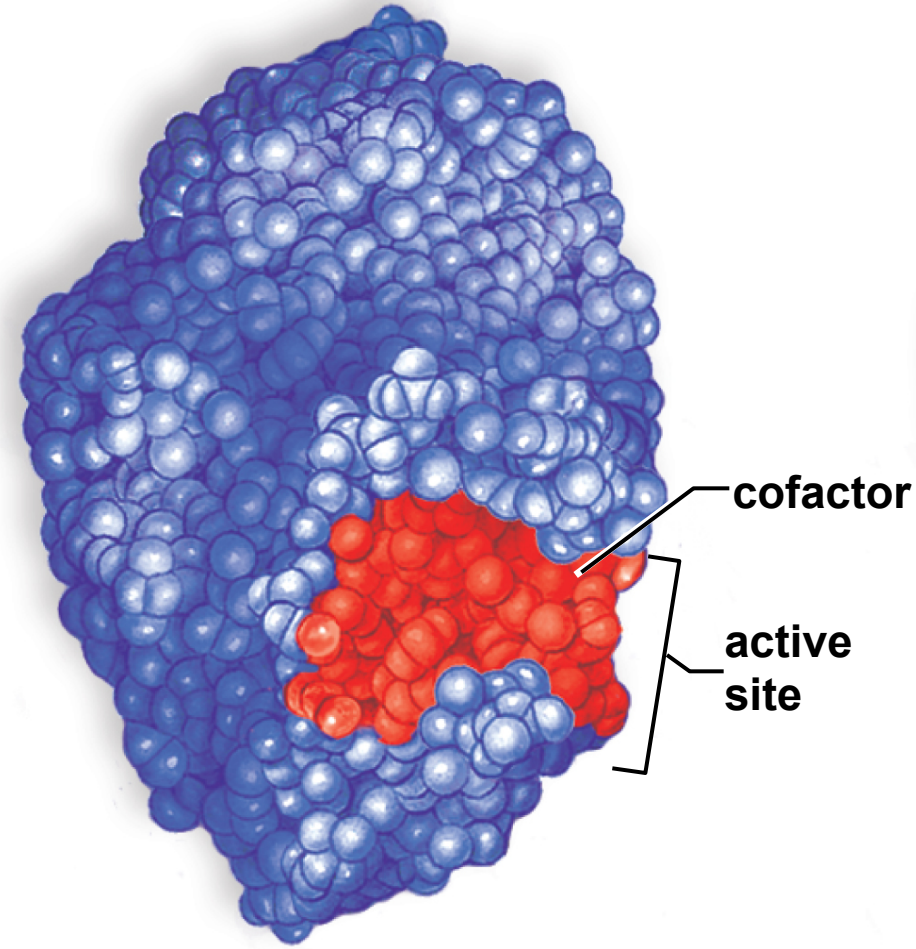
The Effect of pH on Rate of Reaction



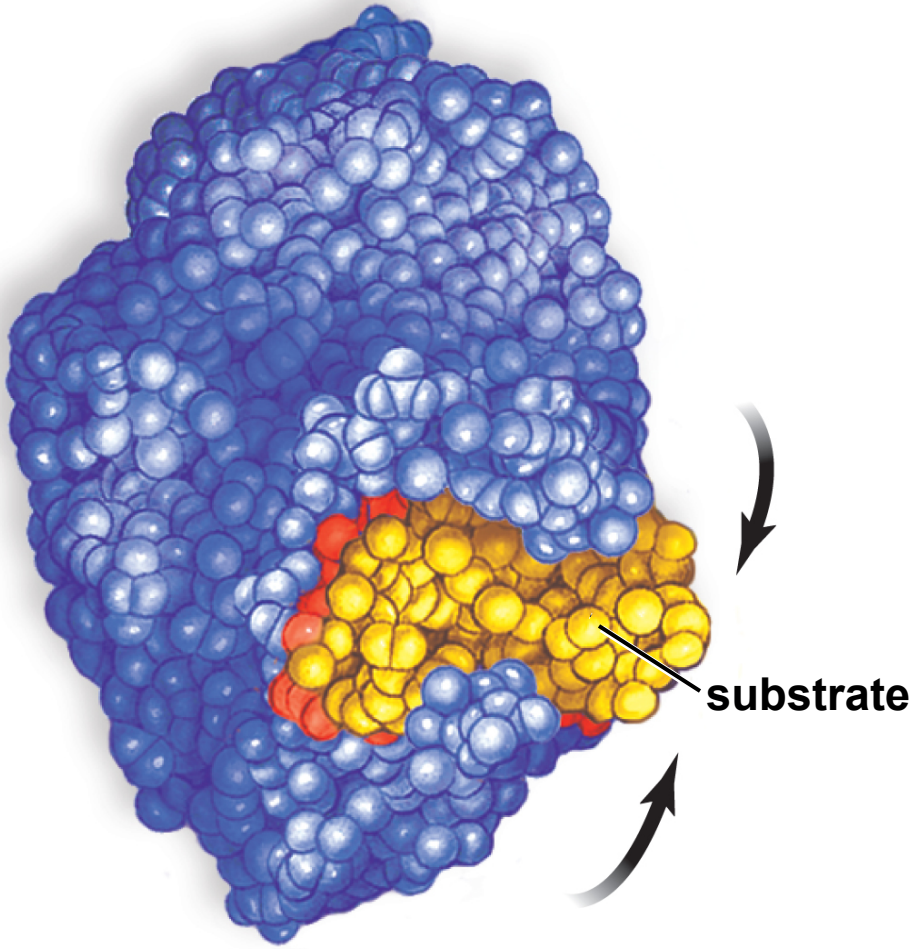
Factors Affecting Enzymatic Speed

- Cells can regulate the presence/absence of an enzyme
- Cells can regulate the concentration of an enzyme
- Cells can activate or deactivate some enzymes
  - Enzyme **Cofactors**
    - Molecules required to activate enzyme
    - **Coenzymes** are nonprotein organic molecules
    - **Vitamins** are small organic compounds required in the diet for the synthesis of coenzymes

Cofactors at Active Site



a.



b.

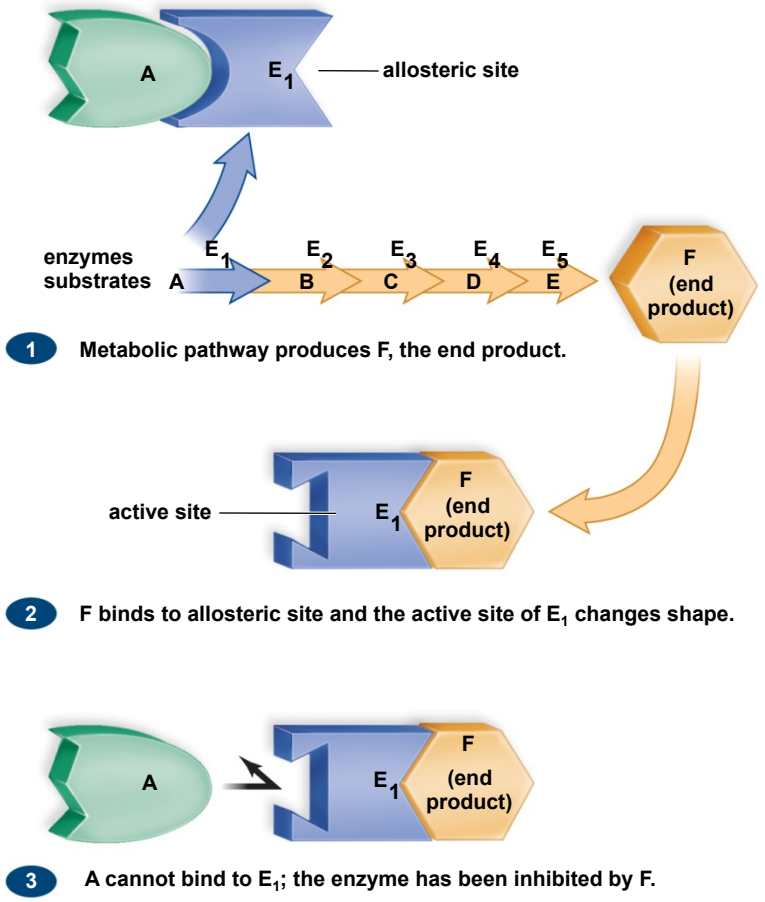
Coenzymes

- http://highered.mheducation.com/sites/0072943696/student_view0/chapter17/animation__b_vitamins.html

Enzyme Inhibition

- Reversible enzyme inhibition
  - A substance known as an inhibitor binds to an enzyme and decreases its activity
    - **Competitive inhibition** – the substrate and the inhibitor are both able to bind to active site
    - **Noncompetitive inhibition** – the inhibitor does not bind at the active site, but at an allosteric site

Noncompetitive Inhibition of an Enzyme



Feedback Inhibition

- http://highered.mheducation.com/sites/0072943696/student_view0/chapter2/animation__feedback_inhibition_of_biochemical_pathways.html

Enzyme Inhibition

- http://bcs.whfreeman.com/thelifewire/content/chp06/0602002.html