General Biology 1
BIO1101
Syllabus & Textbook: http://goo.gl/rvgdrH

Lecturer: Michael Gotesman, PhD
Email: mgotesman@citytech.cuny.edu

Letter Grade	Numerical Ranges
A	93-100
A-	90-92.9
B+	87-89.9
B	83-86.9
B-	80-82.9
C+	77-79.9
C	70-76.9
D	60-69.9
F	59.9 and below

OER

Lecture:https://openlab.citytech.cuny.edu/bio-oer/page/2/
Lab: https://openlab.citytech.cuny.edu/bio-oer/

Grade Breakdown:

Exams (4): 20% Each
Quizzes: 20% Average

Study Strategies

Name: _____ Date: _____

KWL Chart

Select a topic you want to research. In the first column, write what you already know about the topic. In the second column, write what you want to know about the topic. After you have completed your research, write what you learned in the third column.

What I **K**now What I **W**ant to Know What I **L**earned

What I **K**now	What I **W**ant to Know	What I **L**earned

Recap: Lecture 14

A. Energy (what is it?)

1) Potential versus Kinetic

2) Enthalpy (energy/heat) vs. Entropy (disorder)

B. Laws of Thermodynamics:

1) First Law – Law of conservation of energy

2) Second Law – the Entropy of the universe is INCREASING

C. Metabolism: the sum total of chemical reactions in an organism

1) Anabolism versus Catabolism

2) Energy Coupling – Energy released from Catabolic pathways is used to drive Anabolic pathways

D. Reactions

Chemical bonds store energy (Glucose -- $C_6H_{12}O_6$) 686 kcal/mol

Dehydration synthesis/condensation vs. Hydrolysis

Endergonic versus Exergonic (What is ΔG and why is it important)

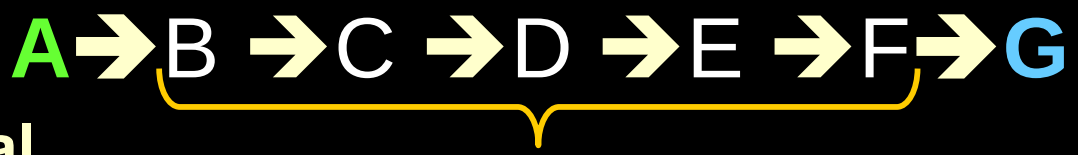
Continuation of Metabolism

The need for Catalysts!

- ΔG tells if a reaction is Spontaneous, but does NOT tell about the RATE (speed): [Bread on your table]
  - Some reaction may be spontaneous ($\Delta G<0$), but take a MILLION YEARS to reach equilibrium!
- A **Catalyst** increases the RATE of a reaction without changing ΔG for the reaction.
  - *i.e.* a catalyst merely "facilitates" a reaction
  - Catalysts are NOT consumed in the reaction
- **Enzymes** are biological catalysts (proteins)
- (What are proteins made out of?)

Metabolic Pathways

- 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" is Initial Reactant

Intermediates

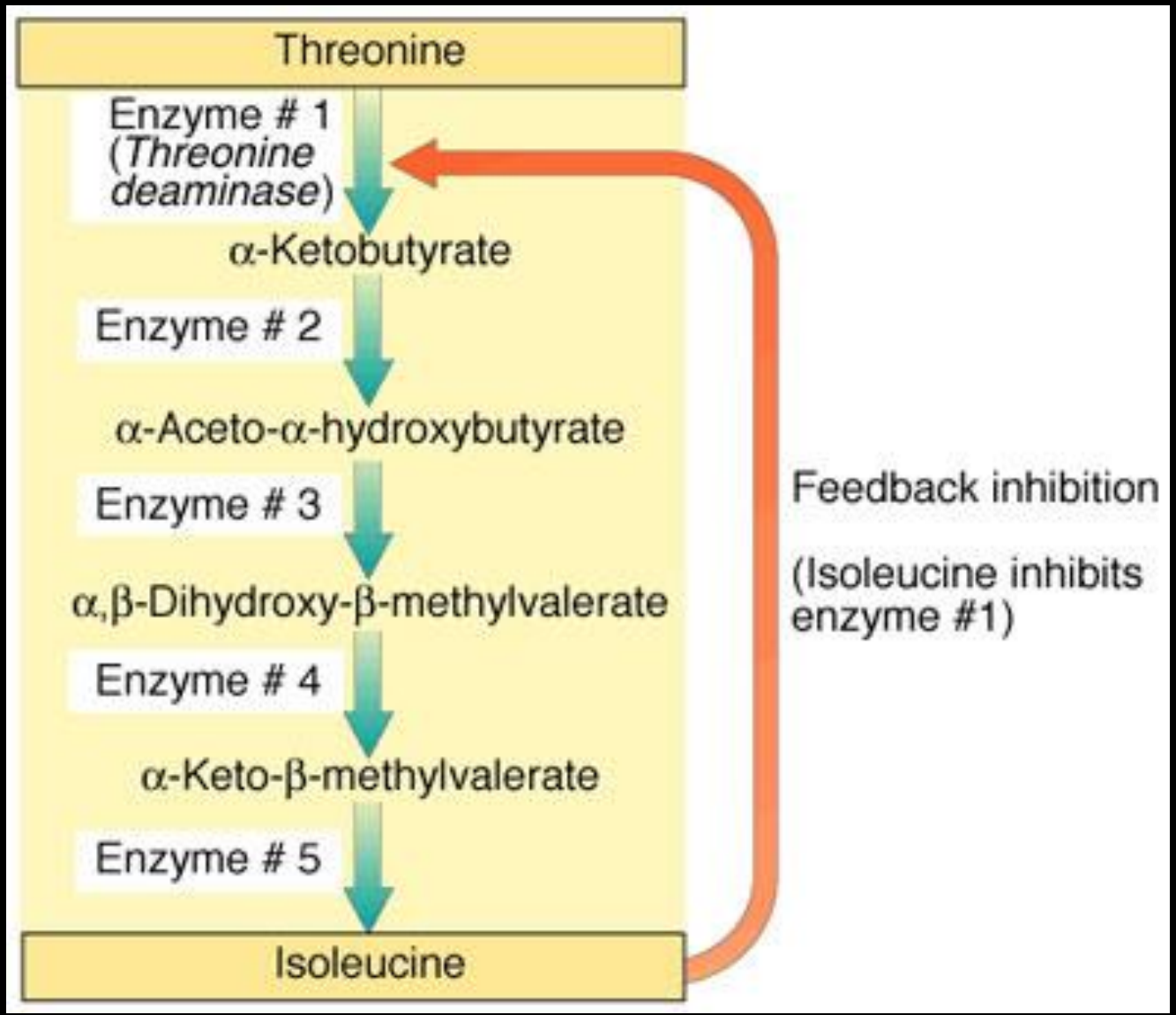
"G" is End Product

Enzymes

- Protein molecules that function as catalysts
- The reactants of an enzymatically accelerated reaction are called substrates
- Each enzyme accelerates a specific reaction
- Each reaction in a metabolic pathway requires a unique and specific enzyme
- End product will not appear unless ALL enzymes present and functional

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

Enzyme – Pathway (example)

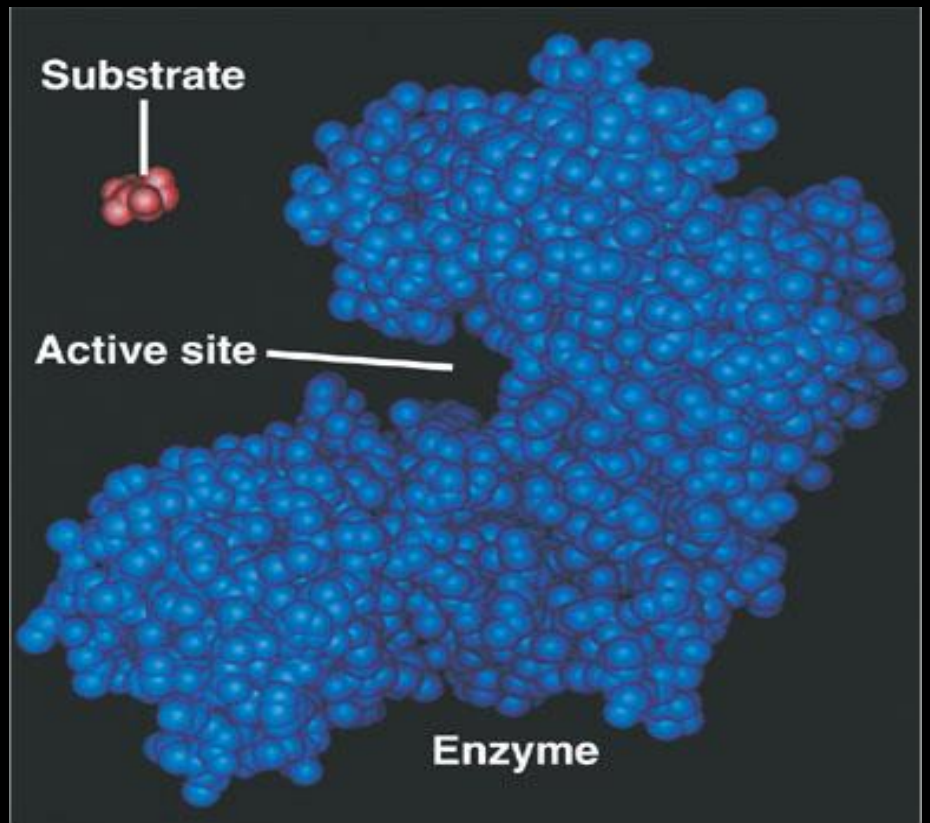


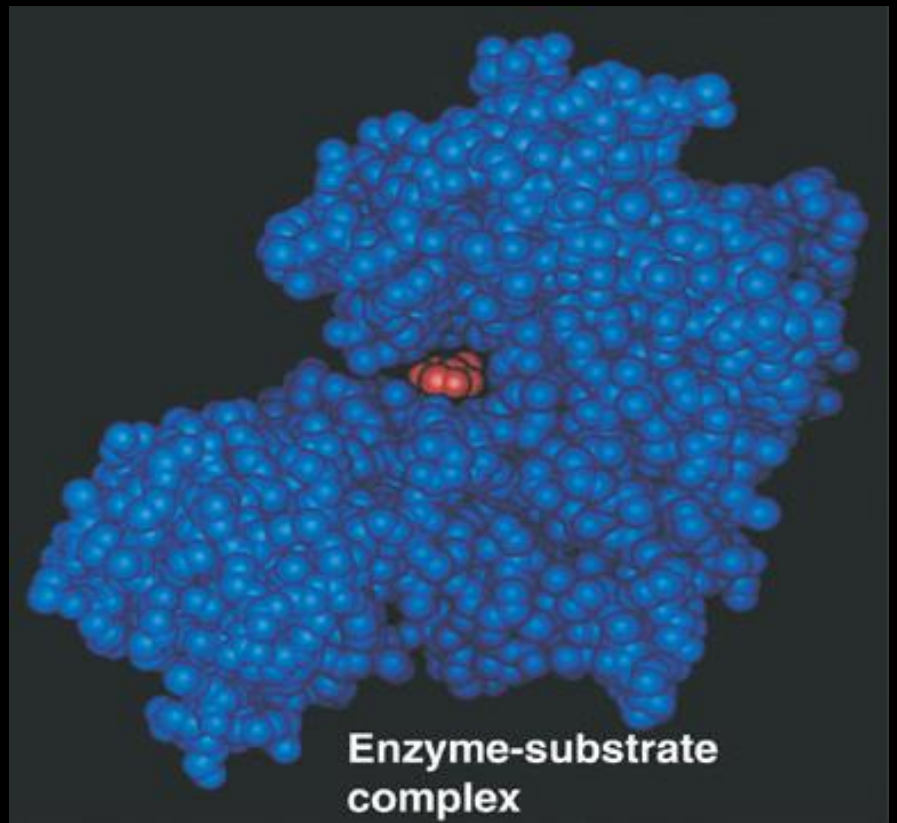
Enzymes: **Energy of Activation**

- Reactants often “reluctant” to participate in reaction
  - 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 the substrates into contact with one another

Enzyme-Substrate Complex

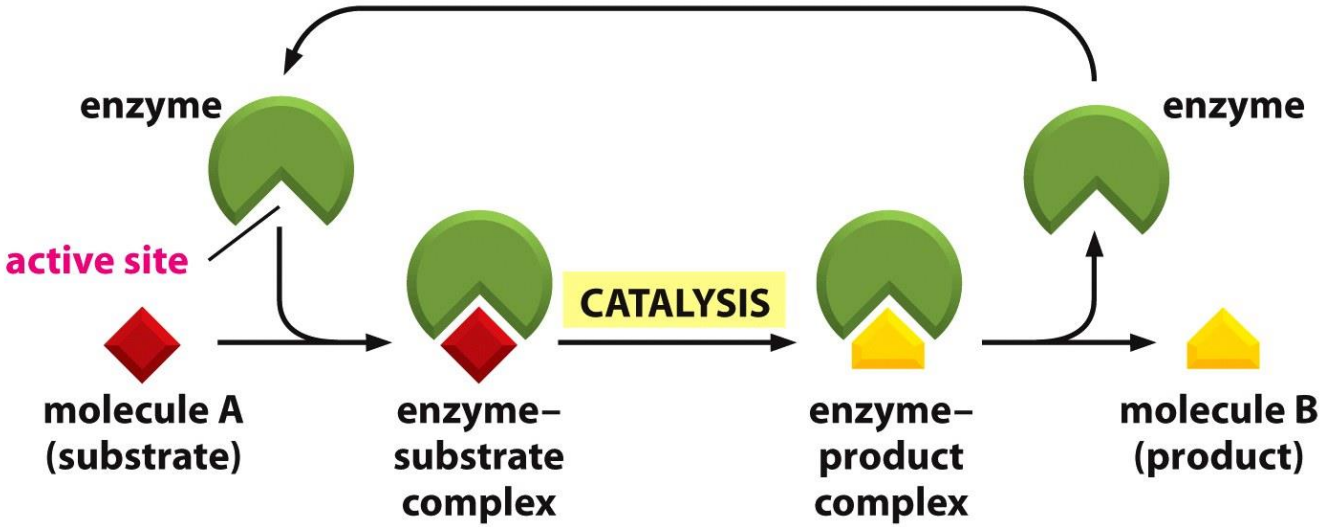
- The active site complexes with the substrates
- Causes active site to change shape
- Shape change forces substrates together, initiating bond





Enzymes

- specific for substrate (active site)
- direct each of the many different molecules along a specific path

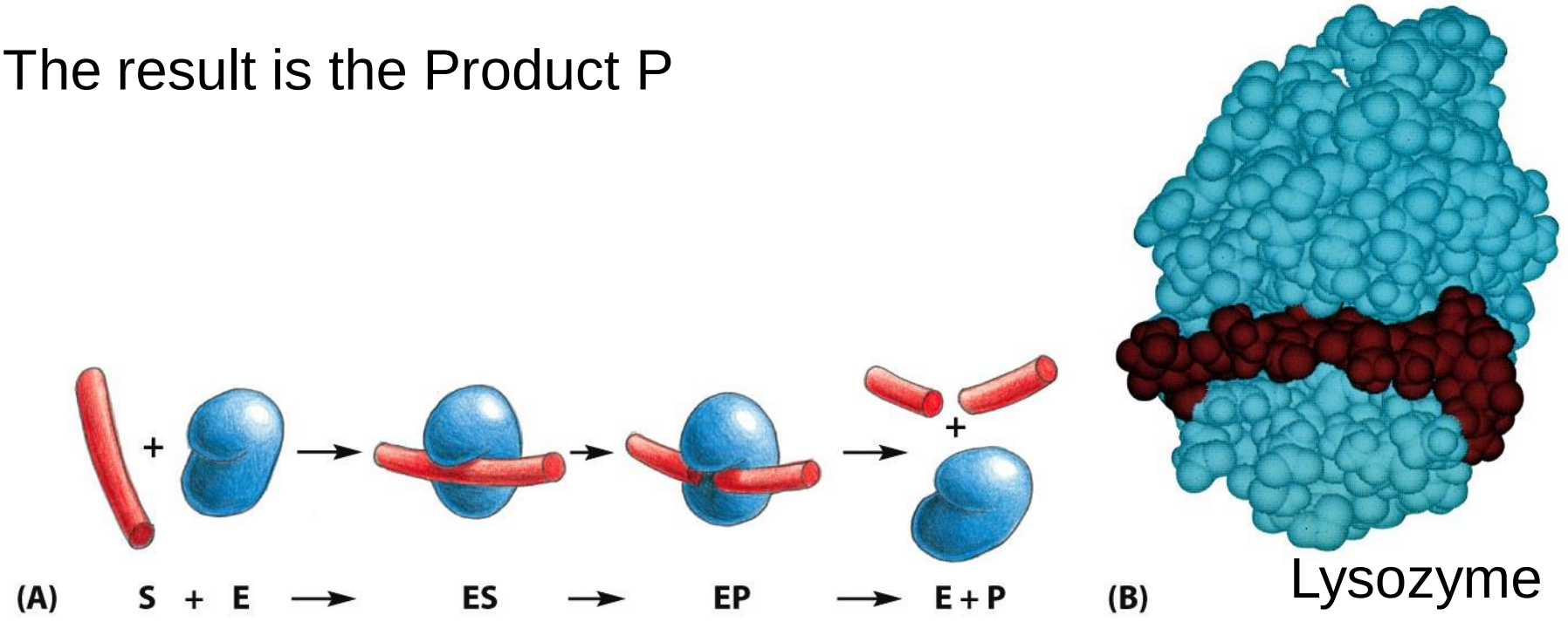


The **active site** is the location that a substrate comes in contact with the enzyme

Each enzyme has a specific Substrate S.

They can break a covalent bond or create a covalent bond

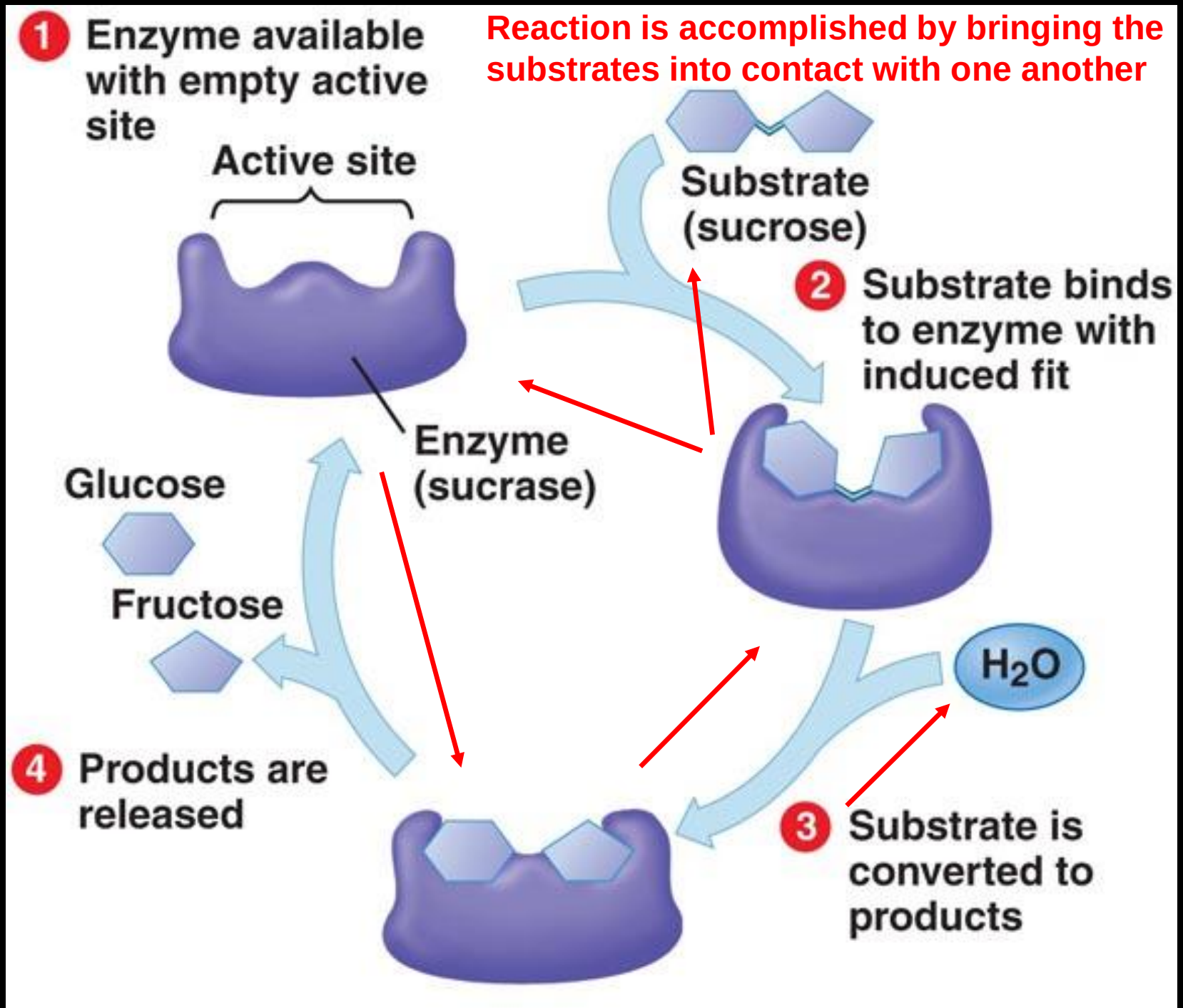
The result is the Product P



Enzyme stays intact

Lysozyme are enzyme that breaks down glycosidic linkages in bacterial cell wall

Figure 4-30 *Essential Cell Biology* (© Garland Science 2010)

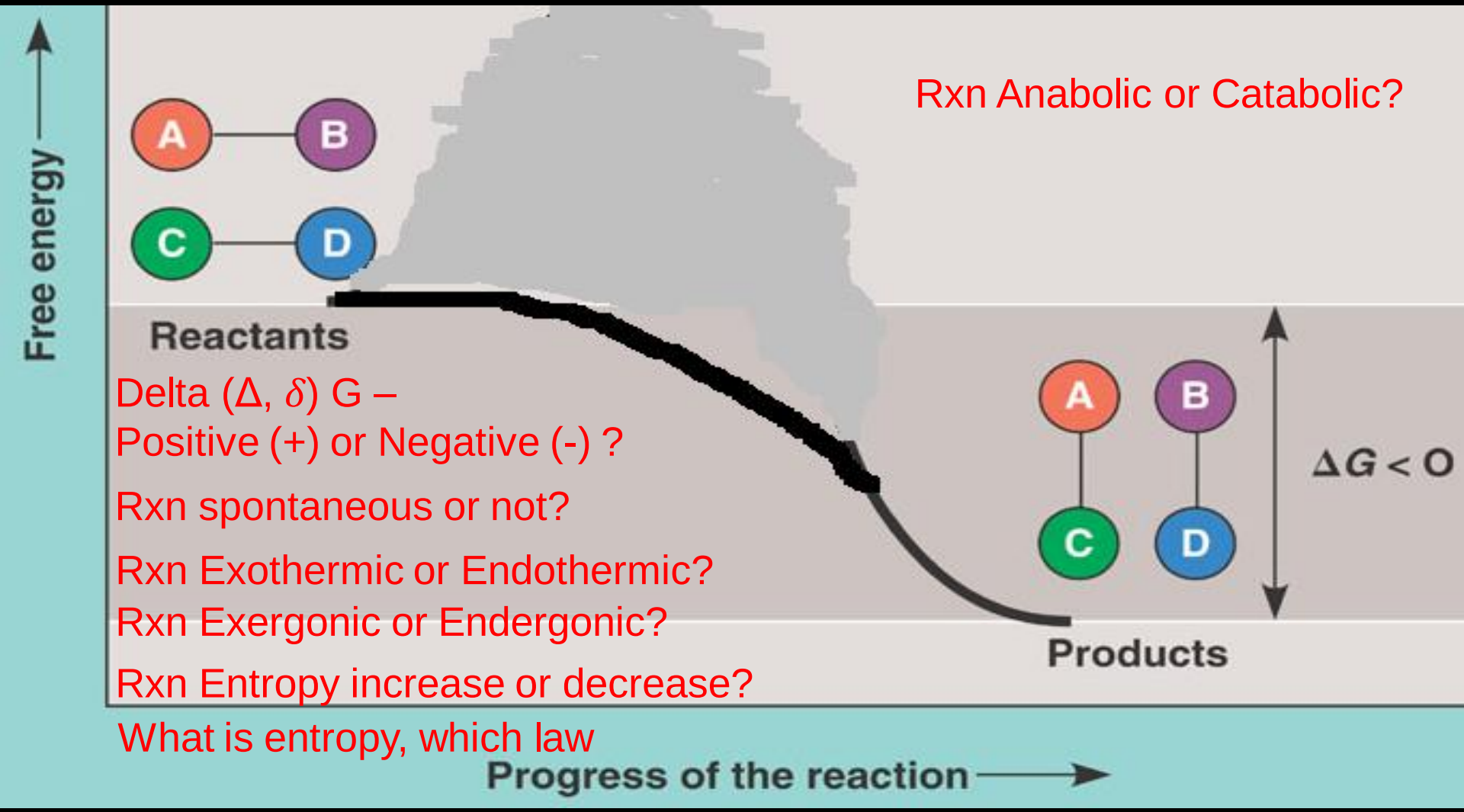

Reaction is accomplished by bringing the substrates into contact with one another
1 Enzyme available with empty active site
Active site
Enzyme (sucrase)
Substrate (sucrose)
2 Substrate binds to enzyme with induced fit
3 Substrate is converted to products
H_2O
4 Products are released
Glucose
Fructose

Activation Energy (E_a)

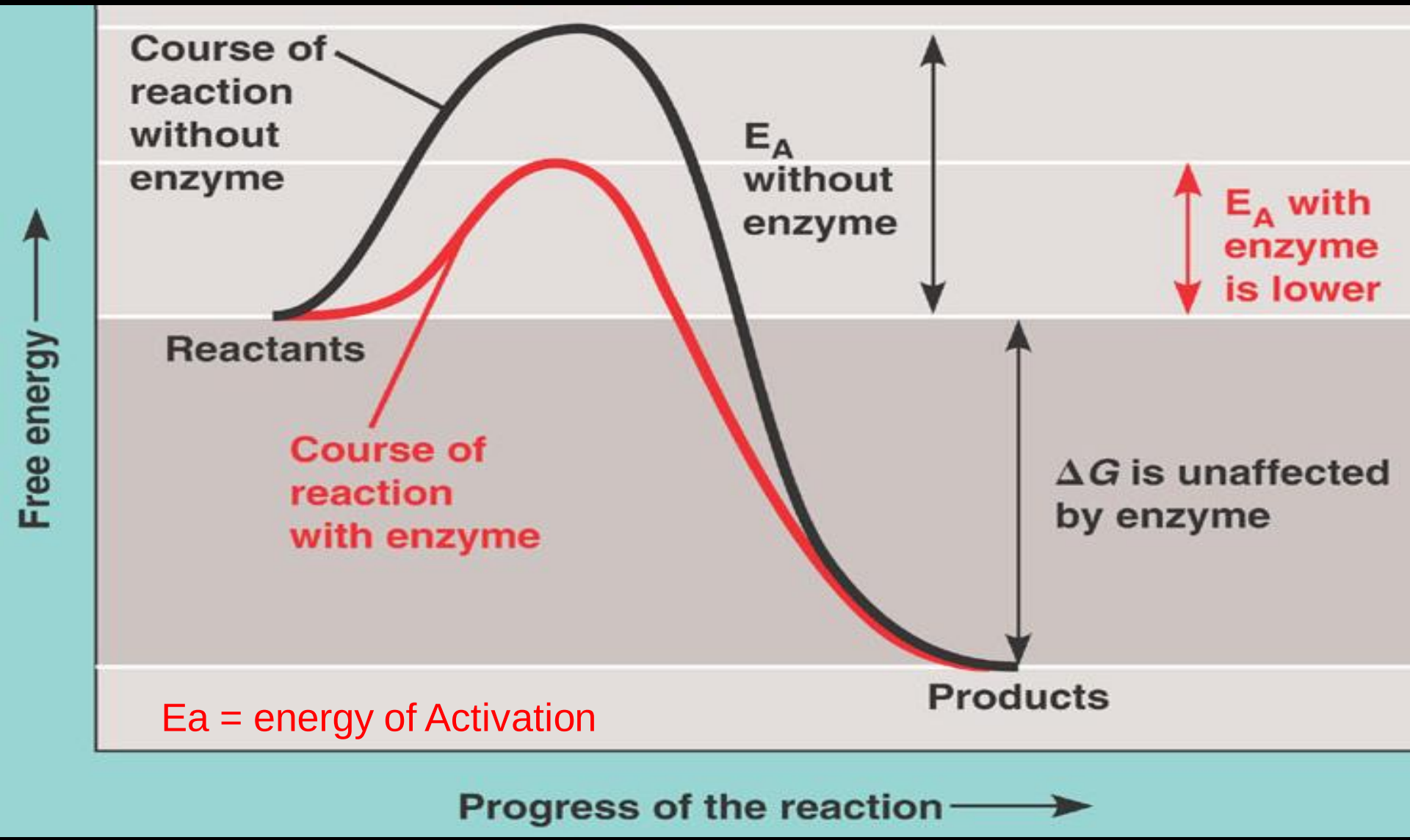
- Because chemical reactions involve stretching, breaking, and forming of chemical bonds, there is an **activation energy** (E_a)

- Enzyme increases the RATE of a reaction:
  - Lowers the E_a
  - Does NOT affect ΔG
  - Allows reactions to reach equilibrium much more quickly

Energy Profile of a reaction.



Energy Profile of a reaction.



Ea = energy of Activation

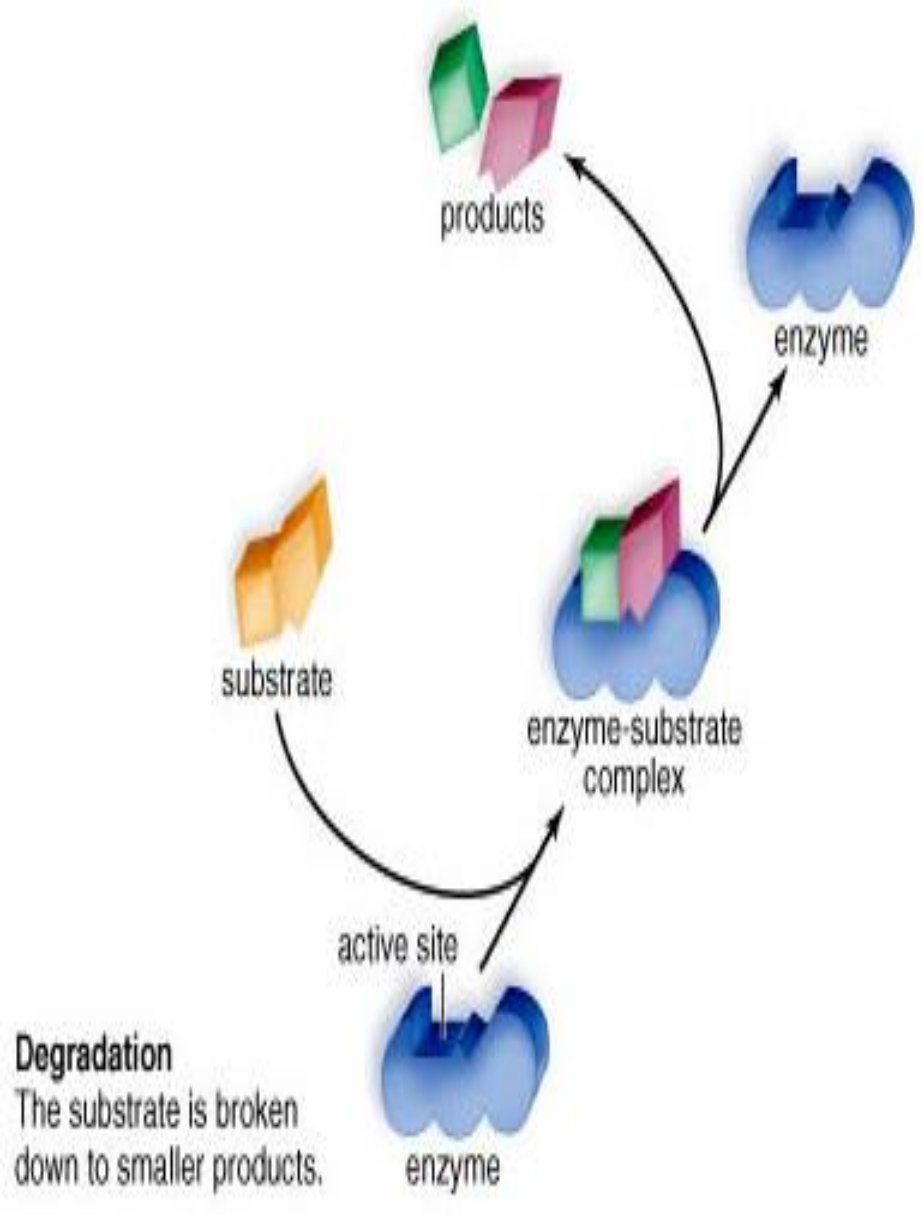
Definitions

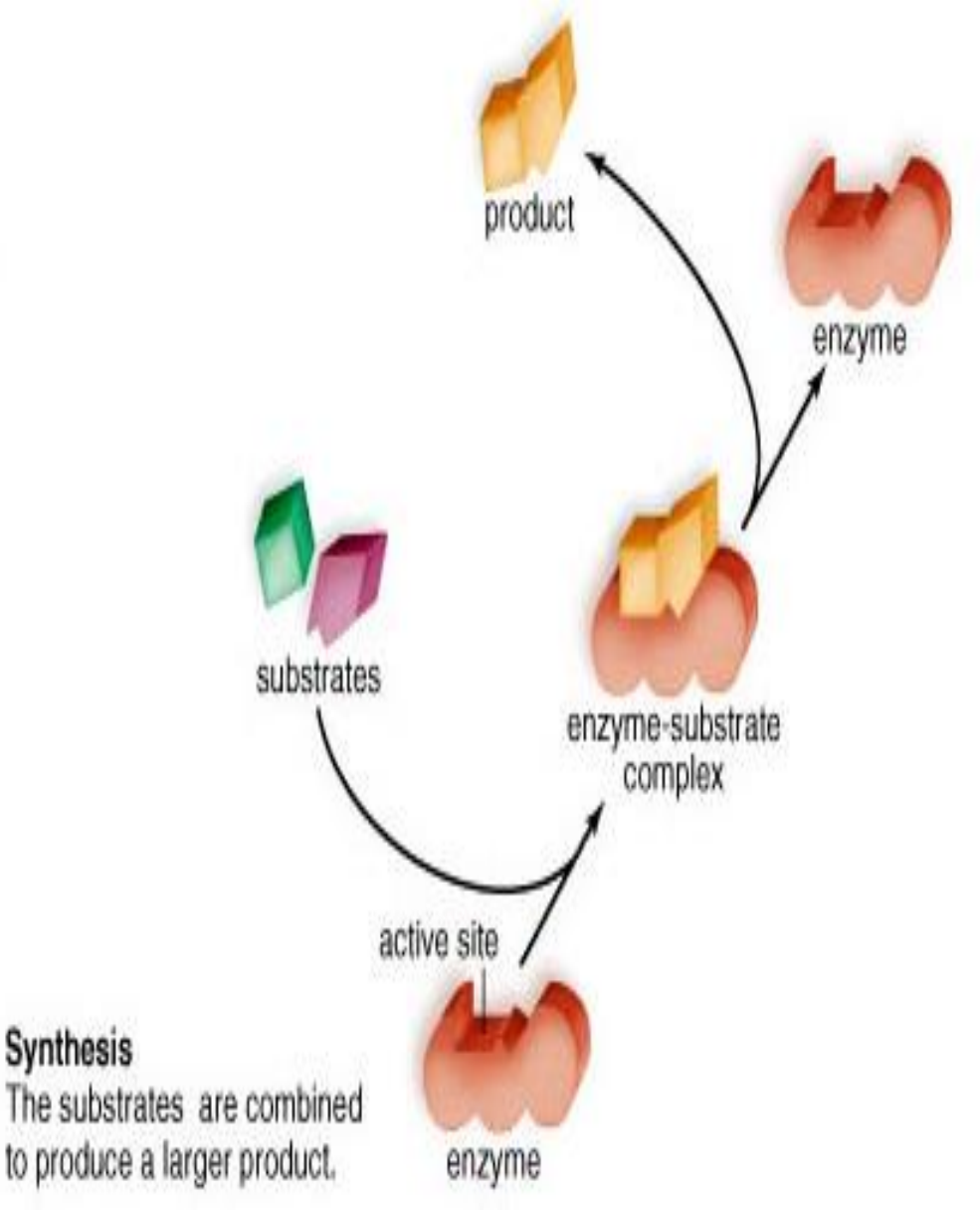
- **Catalysis** – the mechanism by which an enzyme facilitates a chemical reaction.
- **Substrate** – the reactant that is acted upon by an enzyme.
- **Active Site** – the precise region of an enzyme that binds to the substrate
  - The amino acids side chains interact with the substrate through hydrogen bonds, electrostatic attractions, van der Waals, etc…
- An enzyme can facilitate many thousands of reactions per second!

Degradation vs. Synthesis

- Degradation:
  - Enzyme complexes with a single substrate molecule
  - Substrate is broken apart into two product molecules
    (What type of reaction is this?)
- Synthesis:
  - Enzyme complexes with two substrate molecules
  - Substrates are joined together and released as single product molecule
    (What type of reaction is this?)

Degradation *vs* Synthesis

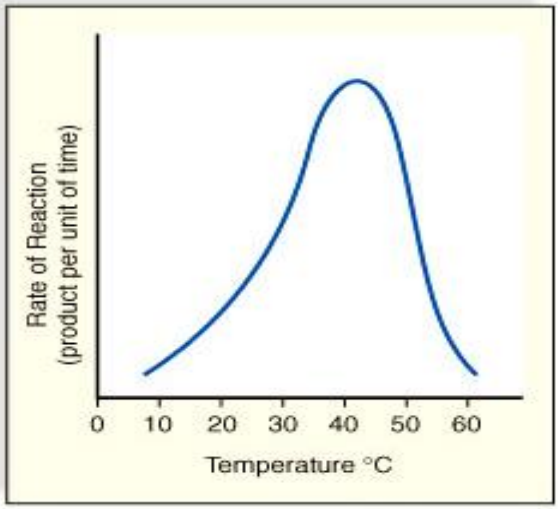




Factors Affecting Enzyme Activity

- Substrate concentration
  - Enzyme activity increases with substrate concentration
  - More 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 destroy enzyme
- pH
  - Most enzymes are optimized for a particular pH

Factors Affecting Enzyme Activity: Temperature

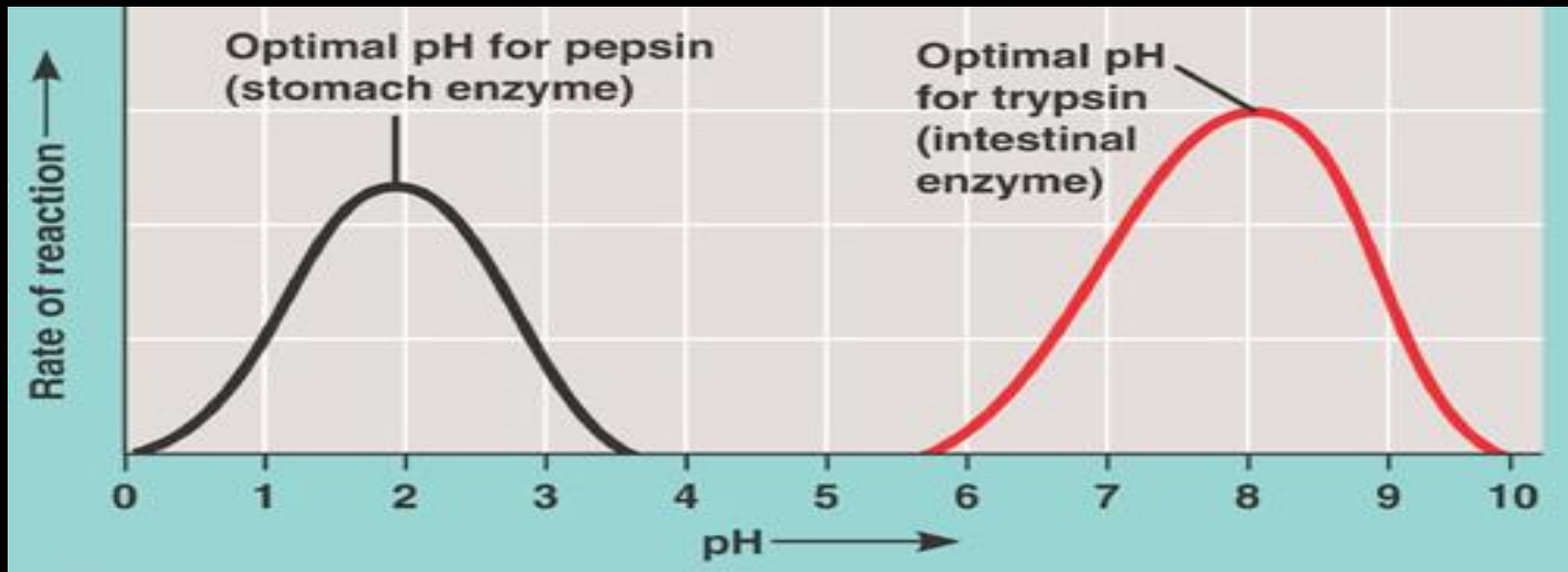


a. Rate of reaction as a function of temperature.

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

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

pH

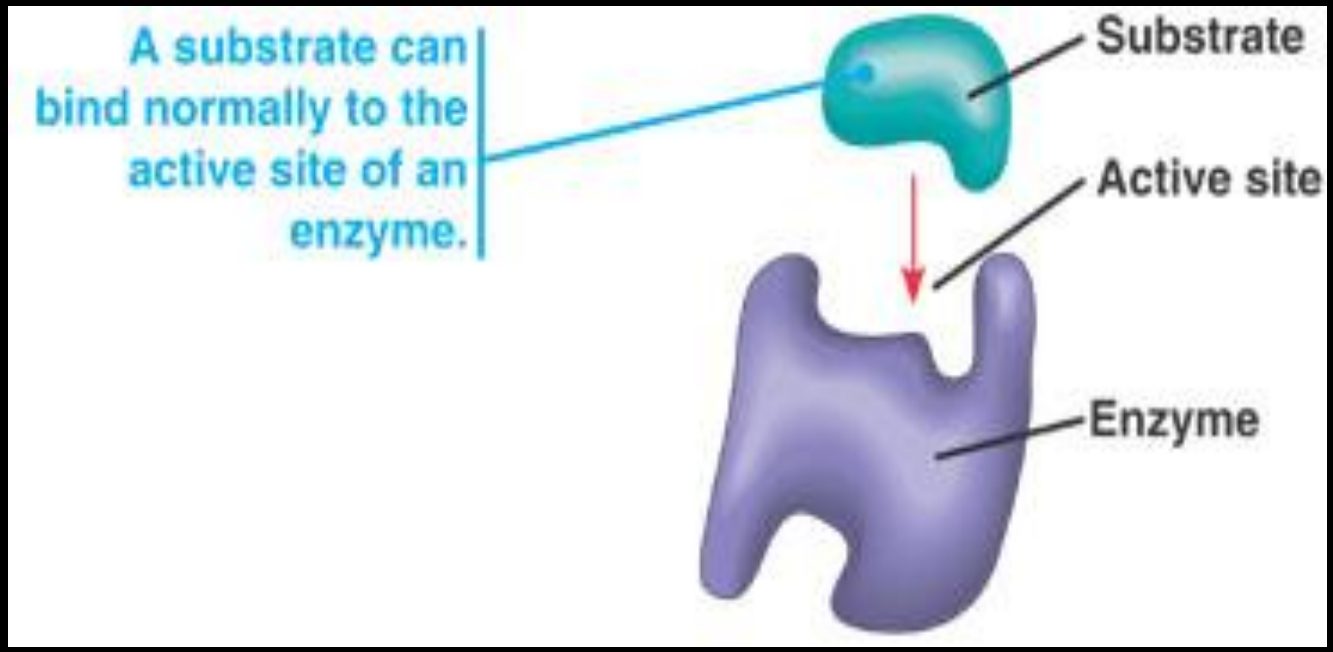


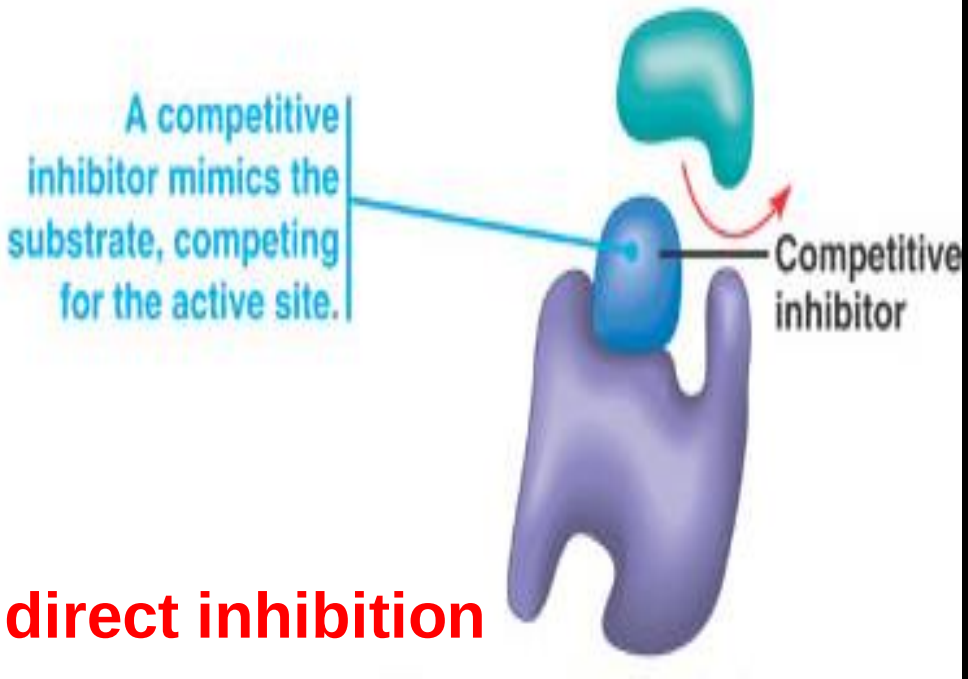
Factors Affecting Enzyme Activity

- Cells can affect presence/absence of enzyme
- Cells can affect concentration of enzyme
- Cells can activate or deactivate enzyme
  - Enzyme Cofactors
    - Molecules required to activate enzyme
      - Coenzymes are organic cofactors, like some vitamins
      - Phosphorylation – some require addition of a phosphate

Factors Affecting Enzyme Activity

- Reversible enzyme inhibition
  - When a substance known as an inhibitor binds to an enzyme and decreases its activity
    - Competitive inhibition – substrate and the inhibitor are both able to bind to active site
      - Directly interferes with enzyme-substrate interaction
    - Noncompetitive inhibition – the inhibitor binds not at the active site, but at the allosteric site (think “other site”)
      - Inhibit by inducing a change in the shape of the enzyme’s active site





direct inhibition

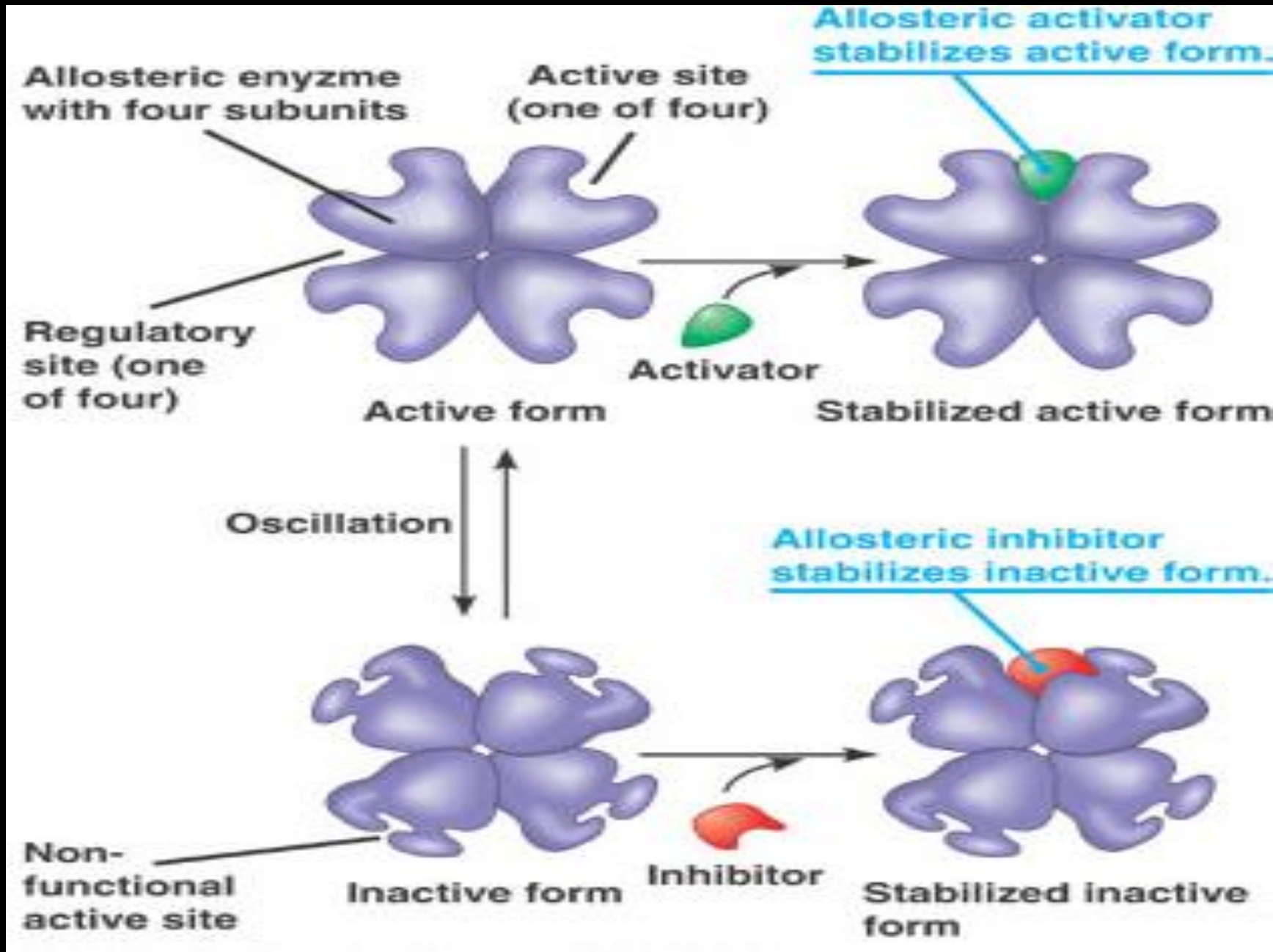
allosteric inhibition

Metabolic Control

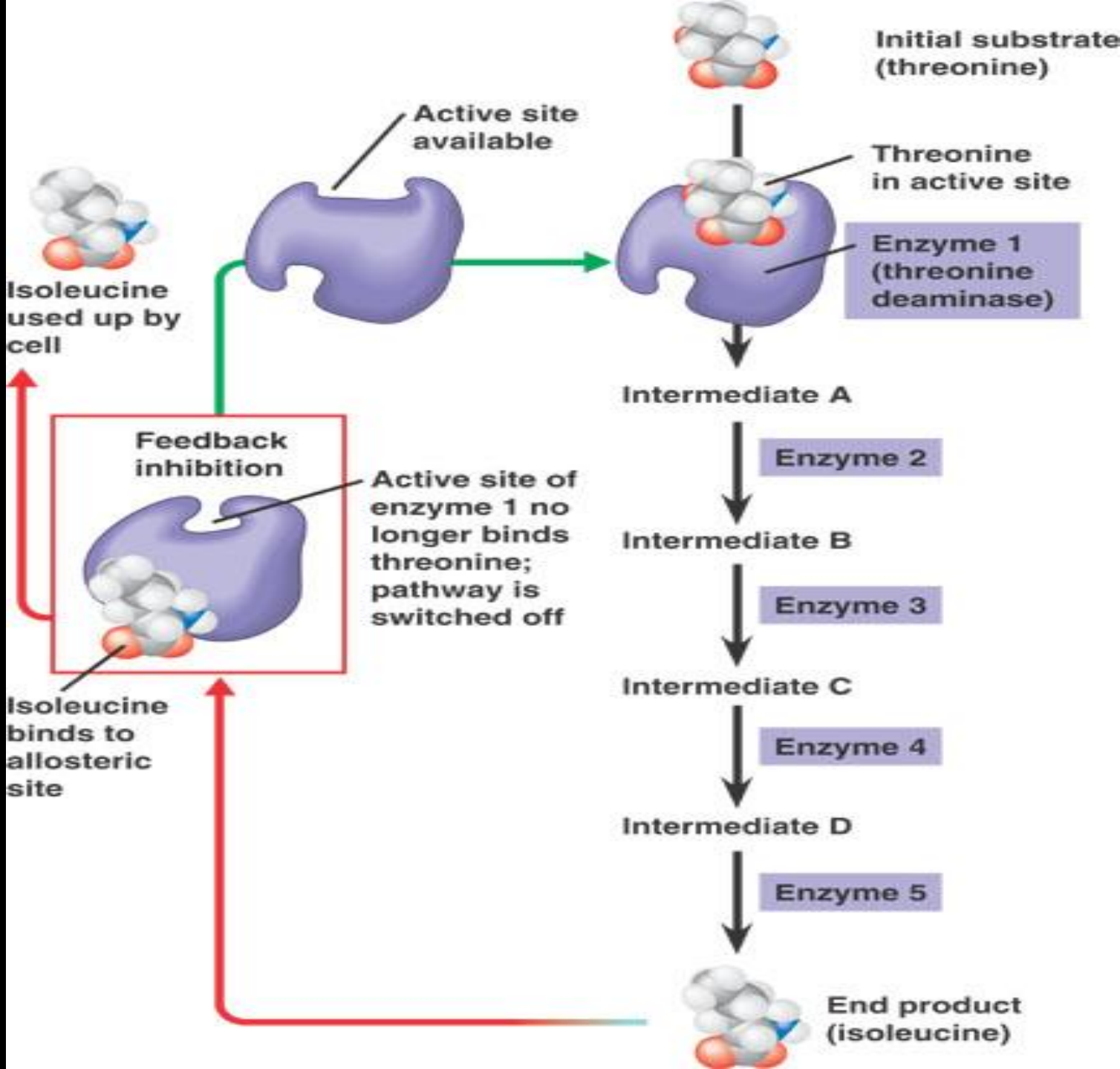
- Not all metabolic pathways are “turned on” all the time.
- Enzyme pathways are “regulated” (ON or OFF as needed)
  - Sometimes, enzyme are only MADE when needed
  - More often… they are controlled by **allosteric regulation**
    - Can be positive or negative
- **Feedback Inhibition** is the most common
  - This is when the final product of a pathway (in high concentration) inhibits the enzymes of that pathway

Allosteric regulation:

Lactate dehydrogenase is composed of four subunits (tetramer).



Feedback inhibition



Irreversible Inhibition

- Materials that irreversibly inhibit an enzyme are known as poisons
- Cyanides inhibit enzymes resulting in all ATP production
- Penicillin inhibits an enzyme unique to certain bacteria
- Heavy metals irreversibly bind with many enzymes
- Nerve gas irreversibly inhibits enzymes required by nervous system

Review

- What is entropy?
- What is a catabolic pathway?
- What is the first law of thermodynamics?
- If a rxn is FAVORABLE, what is the ΔG?
- If energy is required for a rxn to proceed, what do you know about the rxn?
- Is Photosynthesis a favorable reaction?
- Hydrolysis of ATP… favorable or unfavorable?
- What are the products of Respiration?
- What is a catalyst?
- How does an enzyme affect ΔG?
- What is activation energy?
- What is the difference b/w competitive and noncompetitive enzyme inhibitor?
- Is Respiration a favorable reaction?
- What is feedback Inhibition?