MCB 150
The Molecular and Cellular Basis of Life

Denaturation of Proteins; Enzymes and Enzyme Inhibition

Today’s Learning Catalytics Session ID is: 12970167

Announcements:

• Remember to (or start to) use your illinois.edu address

• PLEASE turn off wireless capabilities in any device you are not using for class activities

• Exam I is two weeks away (Thurs., Feb. 9), 7–9 PM
  - Last semester’s exam will be made available this week as a practice exam
Does the information for how a protein will fold lie in its primary structure?

- How could we determine this?

Removal or inactivation of stabilizing forces unfolds (denatures) the protein to 1° structure, but no peptide bonds are broken

- All 2° and 3° structure is lost
- Almost always leads to loss of function
- Acids/bases, heat, detergents

If denaturing agent is removed, some proteins will resume properly folded 3D structure

- “instructions” are in 1° structure
Many proteins are **enzymes**: biological catalysts; they facilitate biological reactions

- This is necessary because most cellular reactions proceed at a very slow rate

Two broad categories of cellular reactions based on change in energy level (E):

- Reactions that **require** an input of energy
- Reactions that **release** energy upon completion

Reactions that **require** energy are called **biosynthetic** or **anabolic**

- Linking together of smaller molecules into larger ones, such as condensation reactions of monomers to macromolecules

Reactions that **release** energy are called **catabolic**

- Break down larger molecules into smaller ones, such as the hydrolysis reactions of macromolecules to monomers
- Also referred to as **spontaneous** reactions
2 different meanings for the word *spontaneous*:

- Typical meaning: happens automatically
- Biology meaning: a reaction that *releases energy*, much of which is lost as heat
- If the meanings were equivalent, what would happen?

Catabolic (E-releasing) reactions require a certain amount of energy to get started

- **Energy of Activation**, or $E_a$
- Could come from heat, but why not?  
- Instead, comes from Enzymes

**Standard Activation Energy Diagram:**

- $[S] =$ energy level of substrate (reactants)
- $[P] =$ energy level of products
- $E_a =$ activation energy, which converts substrates into unstable transition states

**ΔG** = Free Energy of Reaction: difference in E between reactants & products
Standard Activation Energy Diagram:

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\[ΔG = \text{Free Energy of Reaction: difference in } E \text{ between reactants & products}\]

Enzymes do not cause reactions to occur that would not eventually occur anyway; only speed up existing reactions

- Many enzymes ↑ reaction rates by several million times
- Some enzymes ↑ reaction rates by several trillion times

Example of enzyme catalyzed reaction:

- \(2\text{H}_2\text{O}_2 ↔ 2\text{H}_2\text{O} + \text{O}_2\)
  - platinum (inorganic catalyst) decreases \(E_a\) by 1/3rd
  - catalase (enzyme) decreases \(E_a\) by almost 90%!
Enzymes bind substrates with extremely high specificity into their **active sites** (usually just a few amino acids)

- Enzymes will most likely cause some conformational change in the substrate molecule(s), but they themselves usually change shape upon binding substrate
  - Called **induced fit**

How does substrate binding to active site decrease $E_a$?

- Acting as a template for substrate orientation
- Stressing the substrate(s) and stabilizing the transition state
- Providing a favorable microenvironment
- Participating directly in the catalytic reaction

**Very Important Point:**

- If an enzyme accepts a group from a substrate, it must in turn donate that group to help form product
- **ENZYMES ARE (ultimately) UNCHANGED BY THE REACTIONS THEY CATALYZE**
Another Very Important Point:

- **ENZYMES DO NOT CHANGE THE EQUILIBRIUM OF REACTIONS**, they only make it easier (and therefore faster) to reach that equilibrium.

\[
\text{Enzymes decrease } E_a \text{ by the same amount in both directions}
\]

**Exergonic**

\[ A \rightarrow B \]

\[ E - \Delta G \]

**Endergonic**

\[ B \rightarrow A \]

\[ +\Delta G \]

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Next: Enzyme Inhibition; Begin Nucleic Acids & Lipids