ENZYMES

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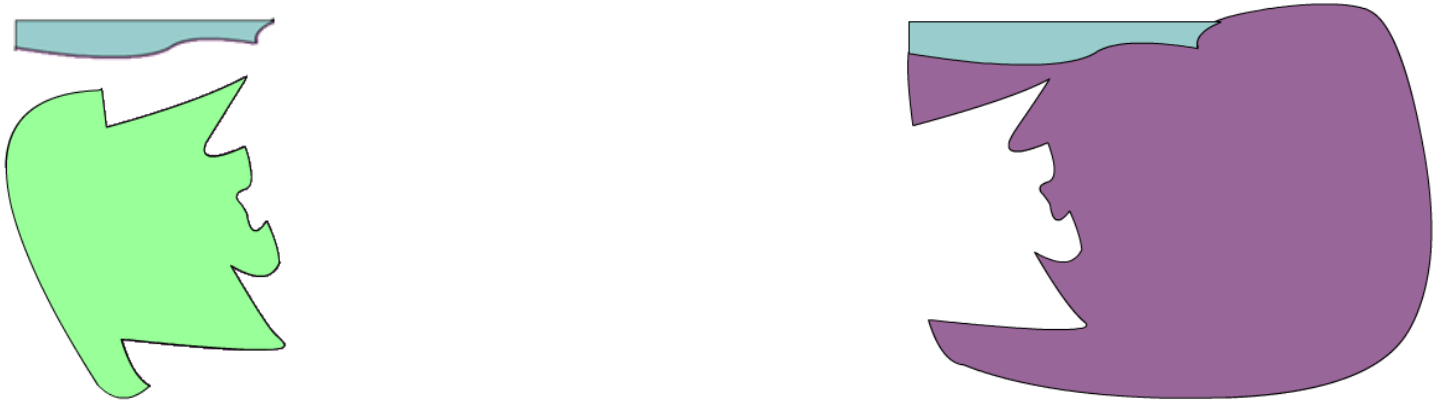
General properties of proteins

- **The function of nearly all proteins depends on their ability to bind other molecules (ligands)**
- **Two properties of a protein characterize its interaction with ligands:**
  - **Affinity: the strength of binding between a protein and other molecules**
  - **Specificity: the ability of a protein to bind one molecule in preference to other molecules**



The Biological Catalysts; Enzymes

- **What are enzymes? (specialized proteins, small amounts, acceleration, no change). Ribozymes are the exception**
- **Enzymes are the most efficient catalysts known**
  - **Usually in the range of 10^6 to 10^{14}**
  - **Non-enzymatic catalysts (10^2 to 10^4)**
  - **The actions of enzymes are fine-tuned by regulatory processes**
- **Examples: catalase (10^8) & carbonic anhydrase (10^7)**

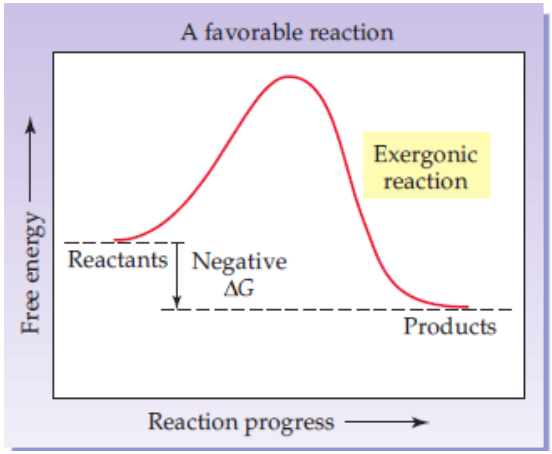
$$2\,H_2O_2 \xrightleftharpoons{\text{Catalase}} 2\,H_2O + O_2\,(g)$$

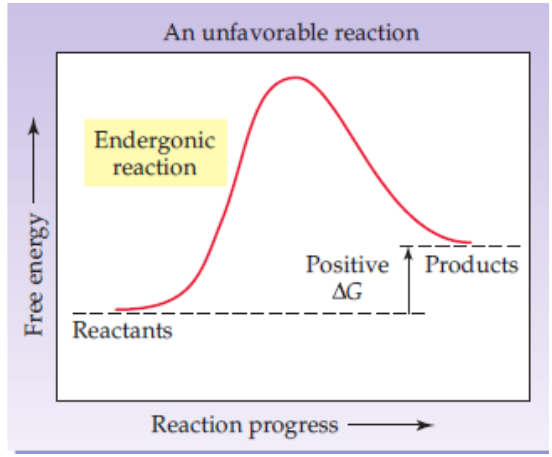
$$CO_2 + H_2O \xleftrightarrow{\text{Carbonic anhydrase}} H_2CO_3$$

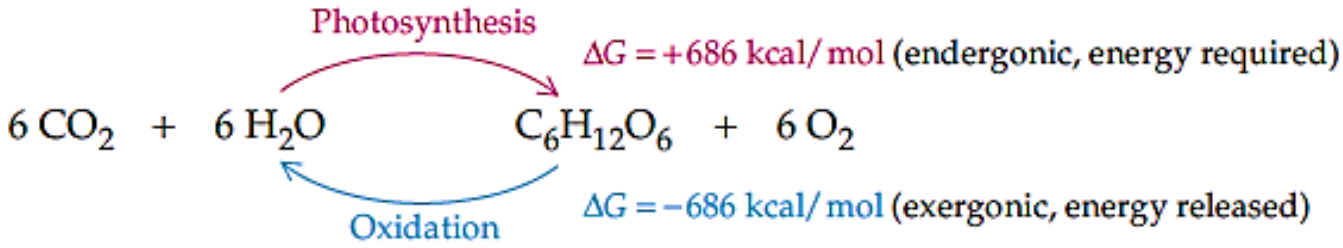
Reaction Conditions	Activation Free Energy		Relative Rate
	kJmol^{-1}	kcal mol^{-1}	
No catalyst	75.2	18.0	1
Platinum surface	48.9	11.7	2.77×10^4
Catalase	23.0	5.5	6.51×10^8

Energy & Biochemical Reactions

- **$\Delta G = \Delta H - T\Delta S$**
- **Spontaneous vs. non-spontaneous, favorable vs. non-favorable, exergonic vs. endergonic, exothermic vs. endothermic, switch of signs**
- **ΔG, ΔG°**
- **Biochemical pathways; storage (endergonic) & release (exergonic)**
- **Kinetics (rate) vs. Thermodynamics (favorability)**





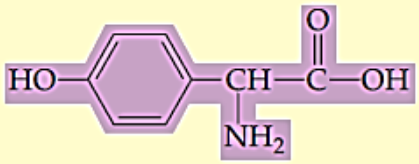


Are enzymes important?

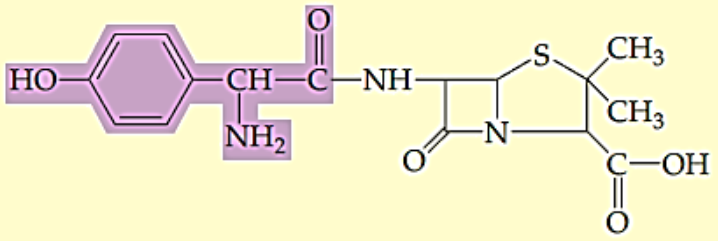
- **In the human body, almost every metabolic process involve the use of enzymes**

Sucrose (table sugar), yeast enzyme breaks sucrose into its two smaller sugar

crushed leaves are exposed to the oxygen in air, a polyphenoloxidase breaks up polyphenols into tannins which impart the darker color and characteristic flavors



p-Hydroxyphenylglycine



Amoxicillin

How to express an enzymatic reaction?

- **In enzymatic reactions, reactants are known as substrates**
- **We can simply express an enzymatic reaction using this formula**

$$E + S \leftrightarrows ES \leftrightarrows EP \leftrightarrows E + P$$

Or

$$E + S \leftrightarrows ES \leftrightarrows E + P$$

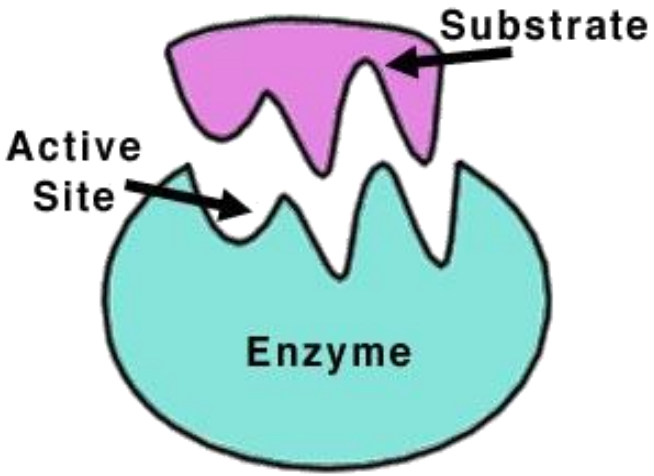
where E is the free enzyme; S is the free substrate, ES is the enzyme-substrate complex; P is the product of the reaction; and EP is the enzyme-product complex before the product is released

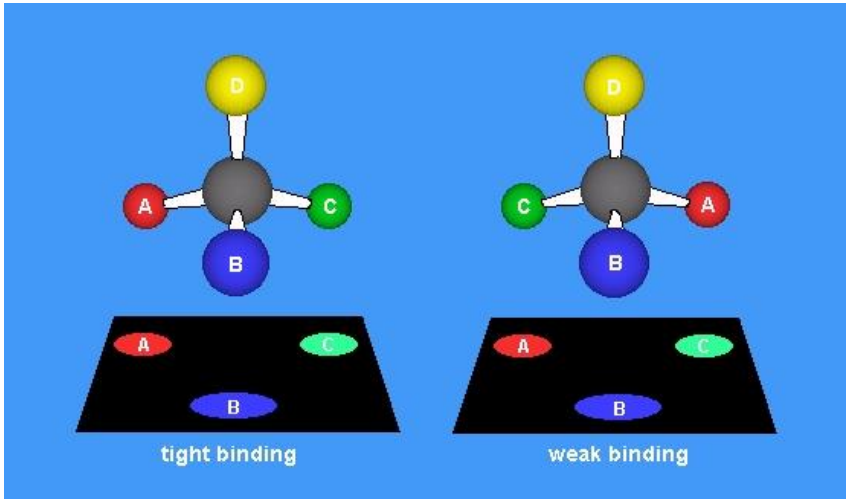
Active sites of enzymes

- **A specific three-dimensional shape which includes a region where the biochemical reaction takes place**
- **Contains a specialized amino acid sequence that facilitates the reaction**
- **Within the active site are two sub-sites, the binding site and the catalytic site, The binding & catalytic site may be the same**
- **Binding site: binds substrate through ionic, H-bonding or other electrostatic forces**
- **Catalytic site: contains the catalytic groups**

Features of active site

- **Active sites; structures that look like <u>canals, clefts or crevices</u>**
- **<u>Water is usually excluded</u> after binding unless it participates in the reaction**
- **Substrates are bound to enzymes by <u>multiple weak attractions</u> (electrostatic, hydrogen, van der Waals, & hydrophobic)**
- **Binding occurs at least at <u>three points (chirality)</u>**





Features of active site

- **Forms by groups from <u>different parts</u> of the amino acid sequence usually forming a domain made of <u>multiple secondary structures</u>**
- **Takes up a relatively <u>small part</u> of the total volume**
- **The <u>"extra"</u> amino acids help create the <u>three-dimensional active site</u> & in many enzymes, may create <u>regulatory sites</u>**