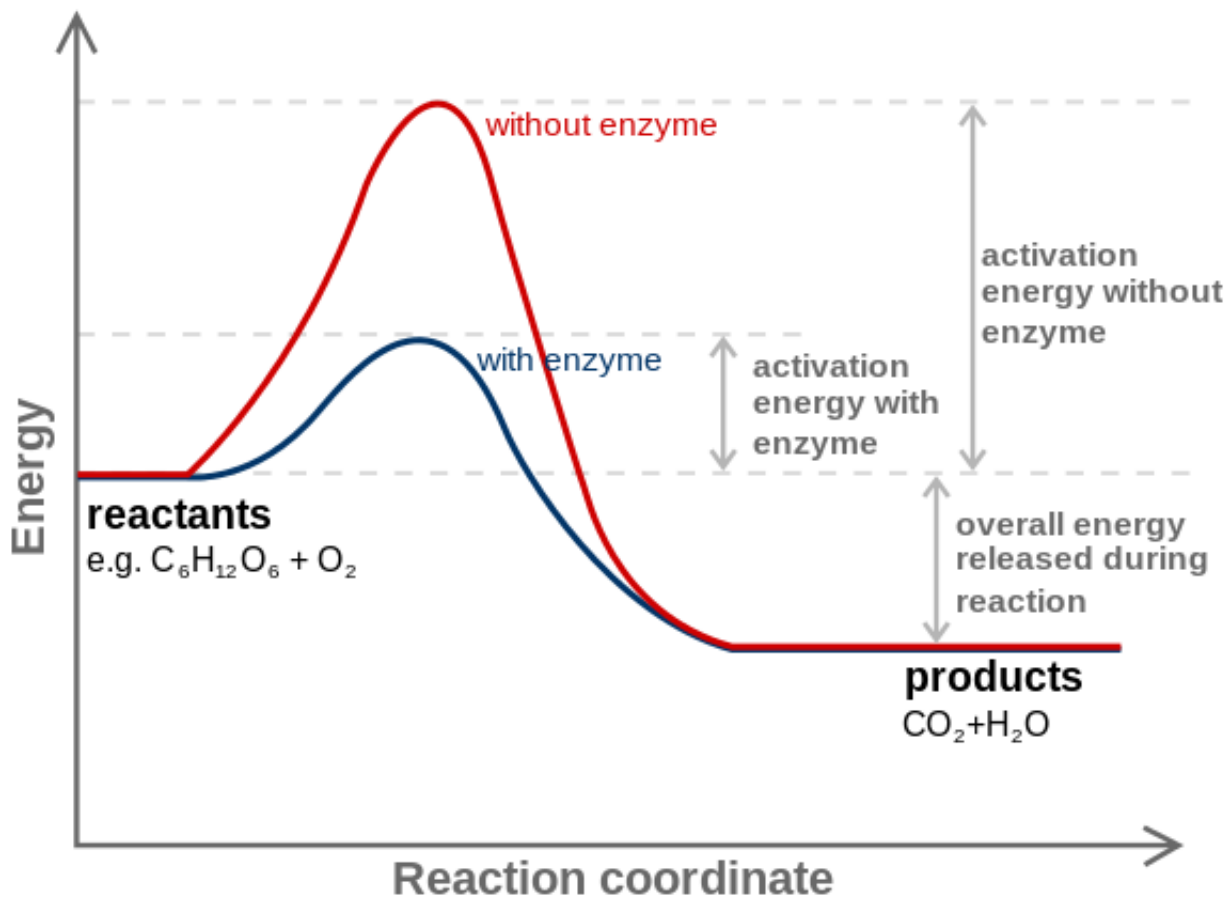


Enzymes

Energy and catalysts

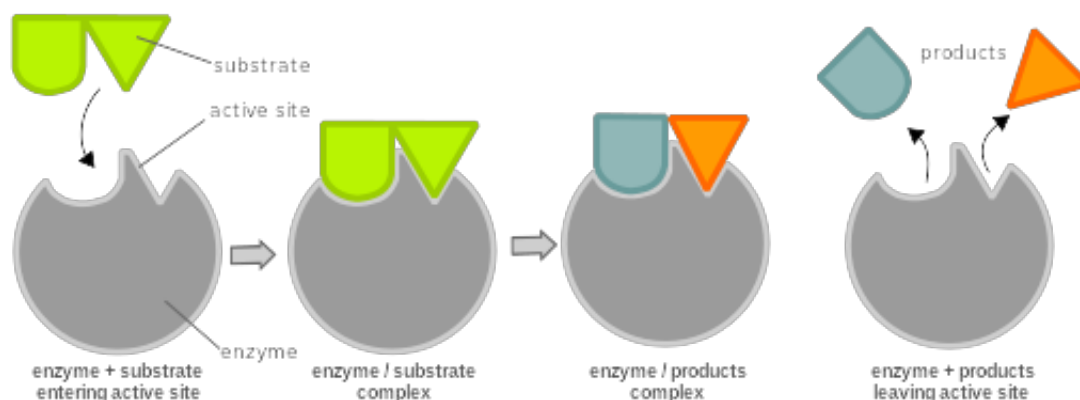
In Biological systems, **energy** is roughly defined as the capacity to do work. Molecules are held together by electrons. Breaking and building these bonds requires an input of energy. The energy needed to initiate such reactions is referred to as **activation energy** (E_A). Sometimes the necessary energy to initiate a reaction is so great, that it greatly limits the likelihood of the reaction ever occurring. **Catalysts** are chemicals that take part in facilitating reactions by reducing the energy of activation. If the activation energy is reduced, the likelihood of a reaction occurring is greatly enhanced. In cells, the catalysts are often made of proteins and called **enzymes**.



Reaction coordinate of an **exothermic** reaction with and without an enzyme. The enzyme reduced the E_A to facilitate the likelihood that the reaction occurs. This **catabolic** reaction breaks complex things down, thus increasing entropy and releasing energy into the system.

Enzymes

Reactants in enzymatic reactions are called **substrates**. They have an imperfect fit to a binding domain of the enzyme called the **active site**. Substrate binding to this active site induces a change in the shape of the protein that coordinates the substrate into a transition state that will reduce the amount of E_A required for the reaction to go to completion. The **induced fit** of the protein also aids in coordinating other cofactors or **coenzymes** that will aid in the reaction.

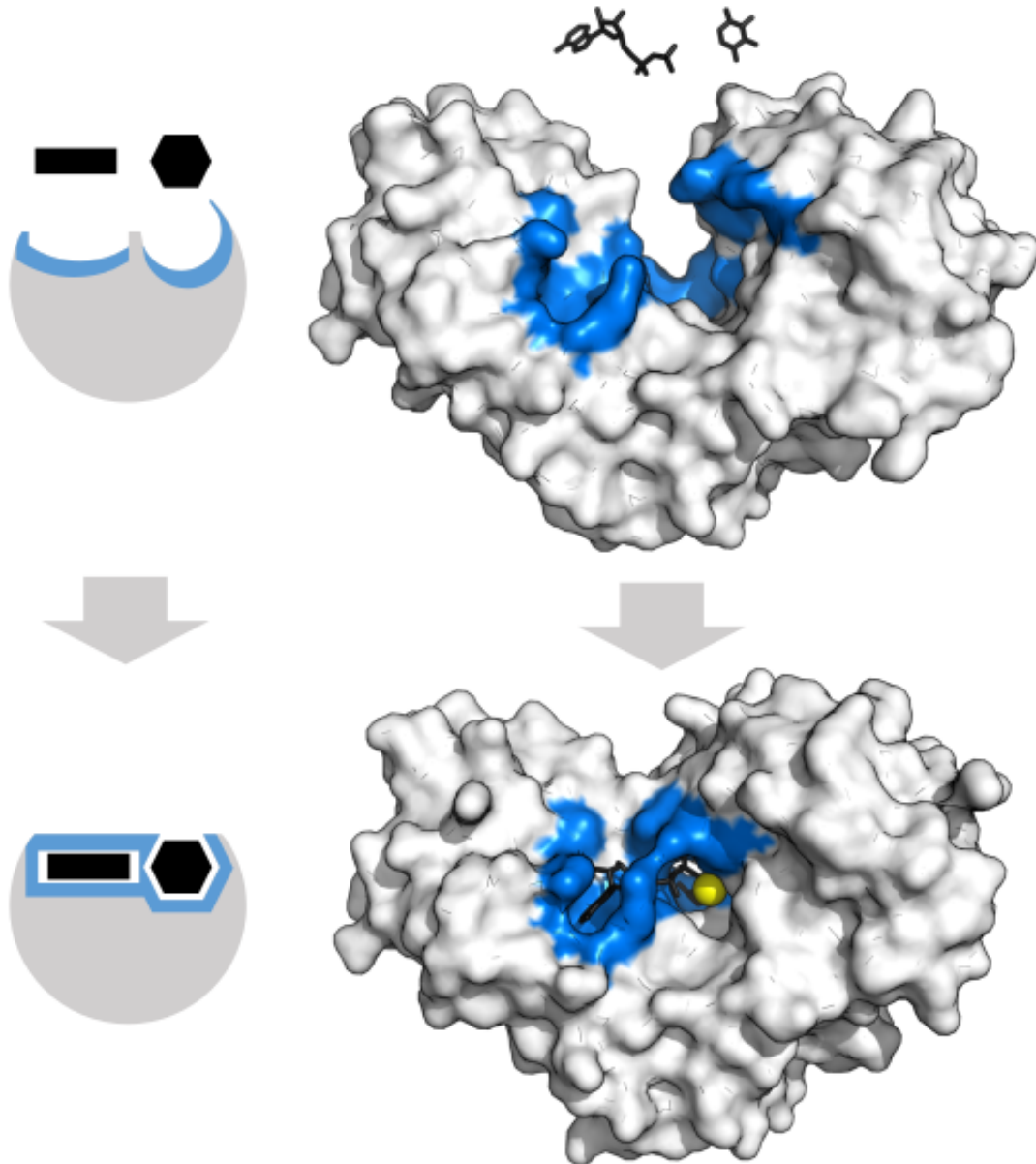


Induced fit model of enzymes and substrates. The active site of the protein is an imperfect match for the substrate. Intermolecular interactions between the enzyme and substrate induce a new fit that facilitates the formation of a **transition state** and results in the catalysis of the reaction.

The reaction follows the standard flow where the Enzyme (E) and the Substrate (S) interact to form an Enzyme-Substrate Complex (ES). The ES then dissociates into Enzyme and the resultant Product (P)



The induced fit of the enzyme-substrate complex coordinates the transition state to facilitate the reaction. This induced fit occurs through non-covalent means that result in a tugging on the molecules (an application of energy) while molecules are coaxed into the reactions.



Hexokinase enzyme interacts with an ATP and a hexose. These interactions alter slightly the structure of the enzyme (induced fit). This pulling on the enzyme and the substrates aids in catalyzing the reaction through coordinating the molecules, sometimes with the aid of cofactors and coenzymes. The yellow sphere represents the cofactor Mg²⁺. Coenzymes can be covalently linked to amino acid side chains of the enzyme and are also referred to as **prosthetic groups**. While prosthetic groups are organic in nature, they may also involve the coordination of metal ions, like the heme group which binds to iron. These prosthetic groups enhance the repertoire of the amino acids to provide additional functioning to the entire protein. Early coenzymes were described as being vital to normal functioning and were characterized as organic molecules with amine groups. Because of this coincidence, they were referred to as **vitamins** (for *vital amines*) though not all vitamins have amine groups. The trace metal ions that work with these groups are also required and represent the minerals on food items.

Tags: [quantitative reasoning](#), [visual communication](#), [integration of knowledge](#)