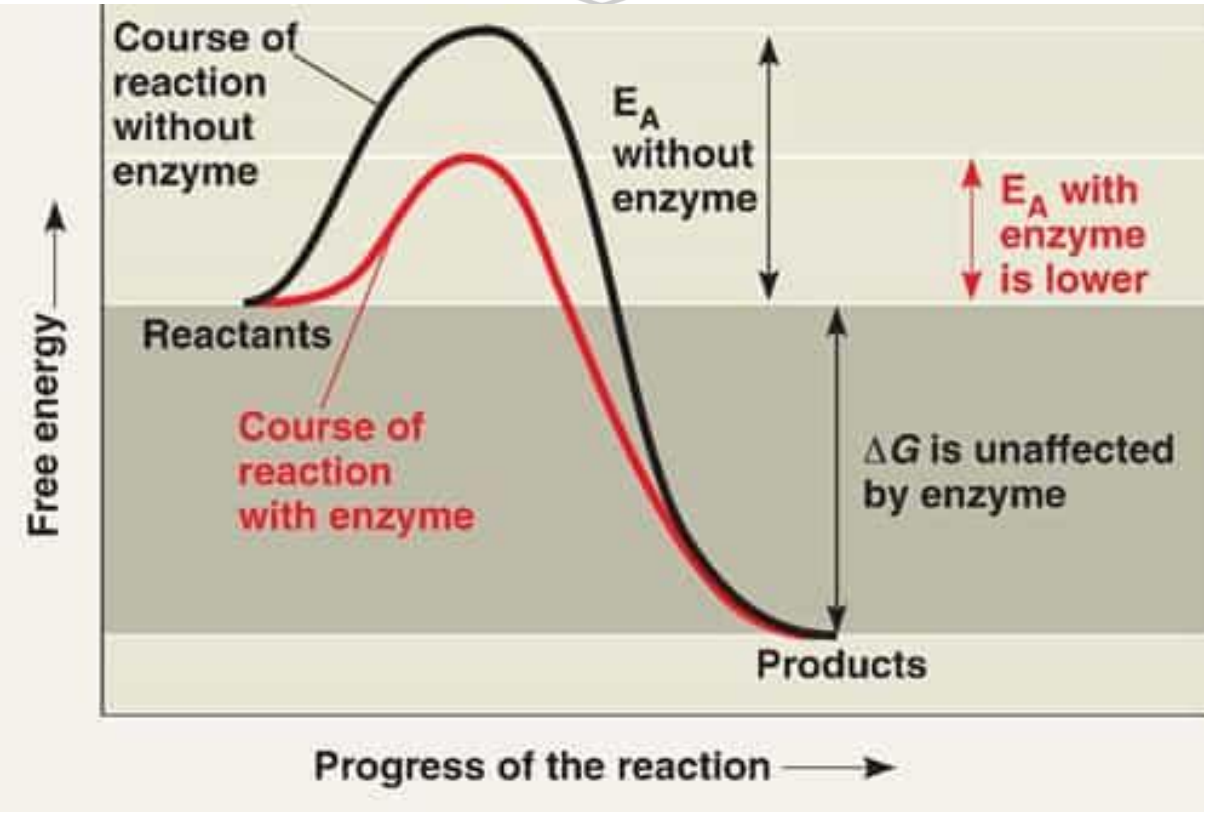
Enzymes

Enzymes are highly specialized proteins that act as catalysts (biocatalysts) within a biological system. These biocatalysts are highly specific for the reaction and other conditions, e.g., pH, temperature, etc., for maximum performance. Some enzymes require an additional factor known as cofactors for their biological activity.

MECHANISM OF ENZYME ACTION:

- Enzymes act on the substrate and form a complex after interactions with the enzyme. This binding action makes both enzyme and substrate stable.
- The interaction between substrate and enzyme may be ionic bonds and hydrogen bonds or Van der Waal forces. The enzyme's active sites have some special groups that bind the substrate though above bonds to form a transitional (intermediate) compound called enzyme-substrate complex (ES).
- The enzyme-substrate complex is unstable and readily dissociates into the product, and the enzyme molecule is also obtained back after the reaction. Therefore, the enzyme does not participate in the reaction and is obtained back after the reaction it has catalysed is completed.

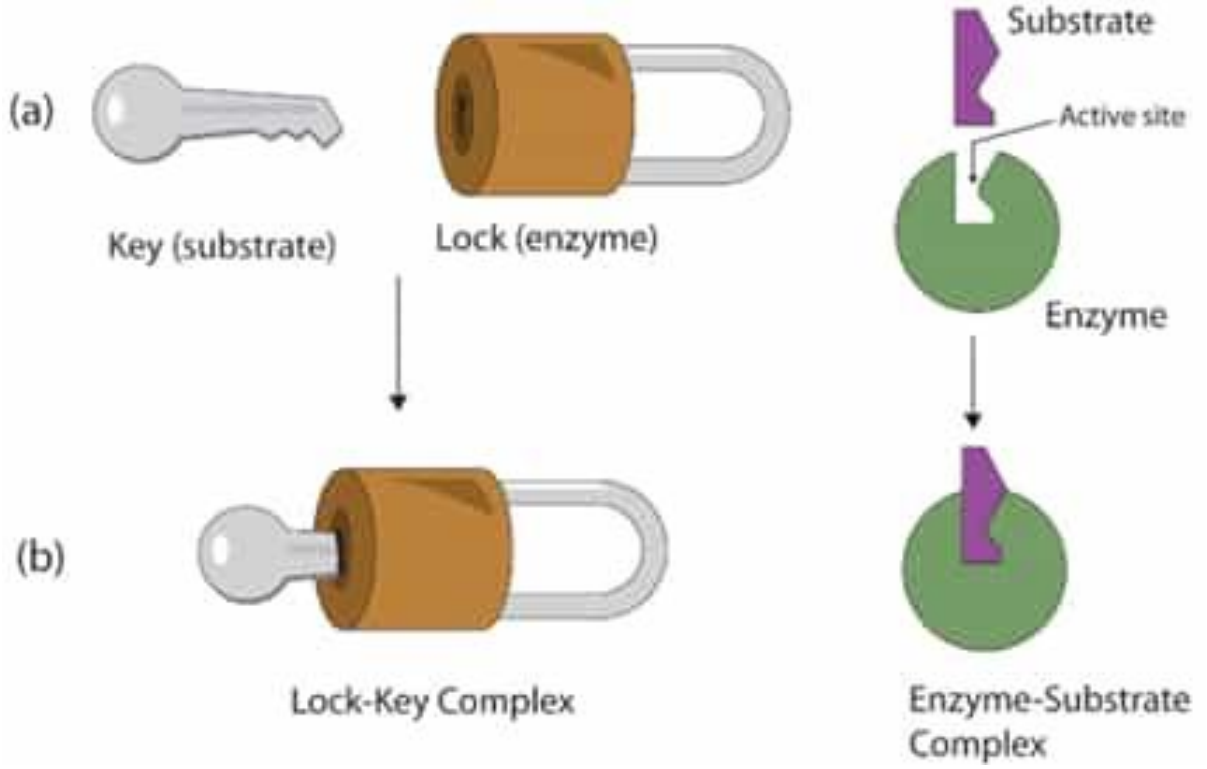


- The enzyme works by lowering the activation energy of the substrate molecule. The reaction requiring vigorous conditions outside the body is completed in normal conditions with the assistance of enzymes.
- The unstable ES complex dissociates to produce the product finally from the substrate, which can be represented by:

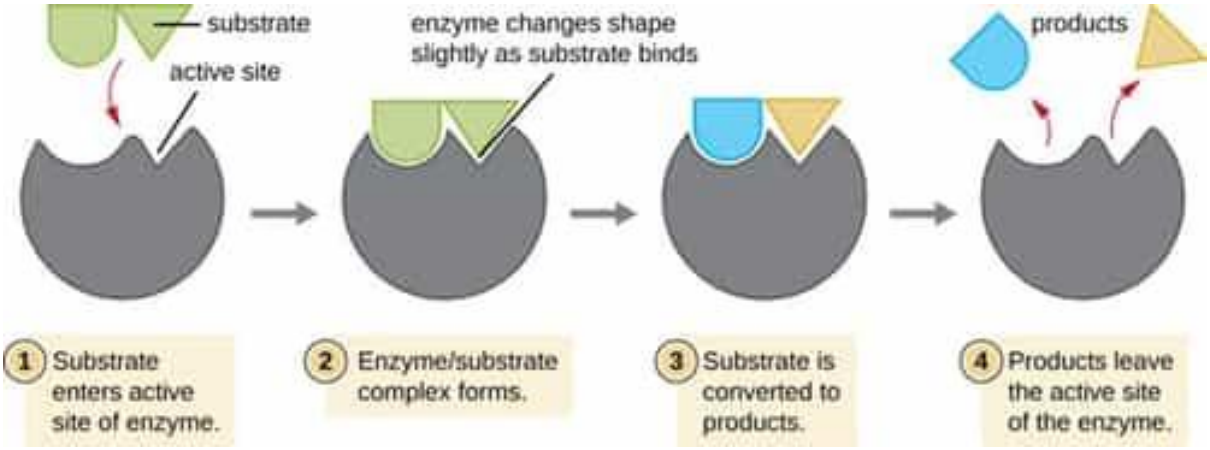
Enzyme + Substrate → enzyme-substrate complex → Enzyme + Product

The interaction between substrate and enzyme can be explained via two models, namely Lock and Key model and the induced fit model.

- **Lock and key model:** Emil Fischer explained the specific action of an enzyme with the substrate using a theory of the Lock and Key model. According to this model, the enzyme's site for binding with a substrate known as the active site and the substrate molecule geometrically resembles each other. The interaction between the complementary substrate and the enzyme binding site (active site) is similar to a key exactly fitting inside the lock. Hence, the name lock and key theory.



- **Induced fit model:** Koshland put it forward. According to him, the enzyme's substrate binding site (active site) is not rigid. Still, it can induce some geometrical changes upon substrate interaction, such that the substrate completely fits inside the active site.

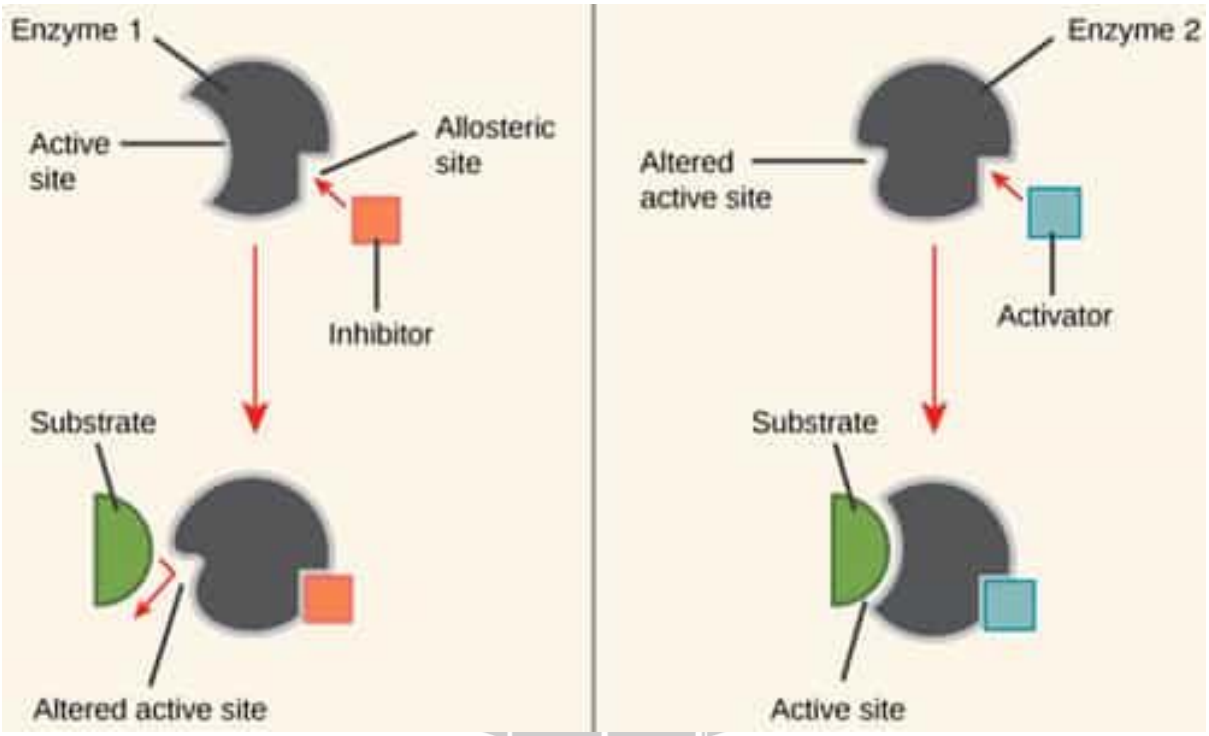


ENZYME REGULATION:

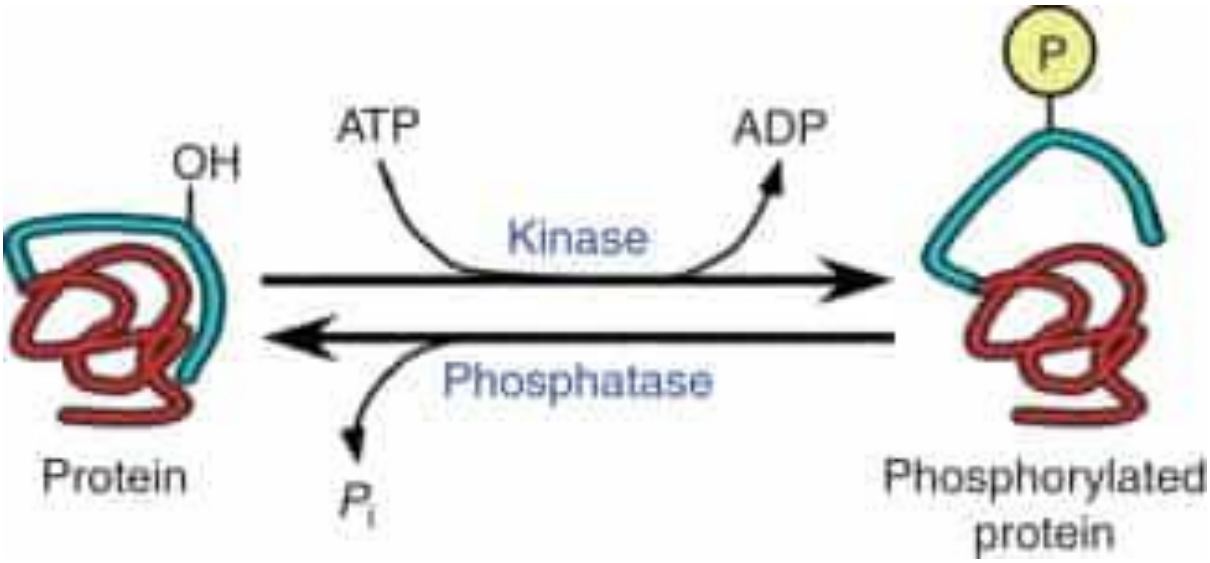
Enzyme catalysed reactions can be catalysed in two different ways, i.e., either by control of enzyme availability or by control of enzyme activity. Enzyme availability can be regulated in a cell by its rate of formation or production or by the rate of its degradation. In contrast, enzyme activity can be regulated either positively or negatively depending upon the type of structure interacting with the enzyme. The enzyme activity can be regulated by modulating the enzyme-substrate binding affinity. Enzymes whose catalytic activity can be modulated by binding a molecule other than substrate are known as **Regulatory enzymes.** The catalytic activities of such enzymes can be modulated through:

1. Allosteric regulation (Reversible non-covalent binding)
2. Reversible covalent binding
3. Feedback inhibition & feedback repression

- **Allosteric regulation:** In allosteric regulation, the enzyme catalytic capabilities are decreased or increased on interacting with a suitable regulator. If the regulator increases the catalytic capabilities of the enzyme, hence, would be called an **activator** or **positive modulator,** whereas if the regulator molecule decreases the catalytic capabilities of the enzyme, hence, would be called a **negative modulator** or **inhibitor**. These regulatory molecules bind to the enzyme on the site other than the active site known as the allosteric site. The binding of the regulator molecule with the allosteric site causes conformational changes in the active site, causing either increase or decrease in enzyme catalytic capabilities.



- **Reversible covalent binding:** Covalent modifications of enzymes includes **adenylation** (addition of AMP molecule), **phosphorylation** (addition of phosphate), **methylation** (addition of methyl group), etc. The most common type of them is the addition of a phosphate (phosphorylation). The addition of phosphate is accomplished by *protein kinases,* whereas the removal of phosphate is accomplished by *phosphatase.*



- **Feedback inhibition and feedback repression:** In **feedback inhibition**, the end products of a biosynthetic pathway inhibit the first activity that is unique to the pathway, thereby stopping the reaction and controlling the

production of the end product. E.g., Trp Operon. It is an example of negative regulation where the end product inhibits the pathway.

In the case of **feedback repression**, negative regulation occurs at the level of enzyme synthesis, mainly at the level of transcription. The end product of the pathway represses the synthesis of the enzyme, which is required in the initial steps of the pathway. Thereby controlling the pathway as negative regulation.