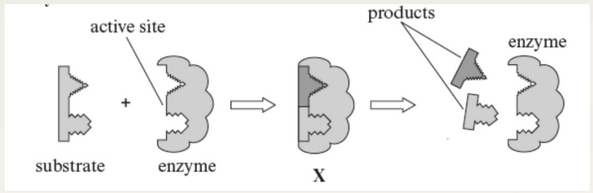
Enzymes and biological reactions

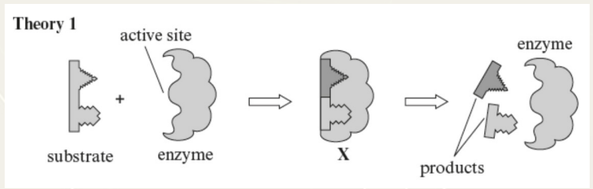
Enzymes

These are tertiary structure proteins and so they are a very specific 3D shape, which includes an active site which is held together by peptide, hydrogen, ionic and disulphide bonds.

Lock and Key Theory



In this theory of enzyme action, a **successful collision** has the **substrate** fit exactly into the **active site** of the enzyme forming an **enzyme/substrate complex**. The reaction occurs and the **products** are released. The enzyme remains unchanged at the end of the reaction.

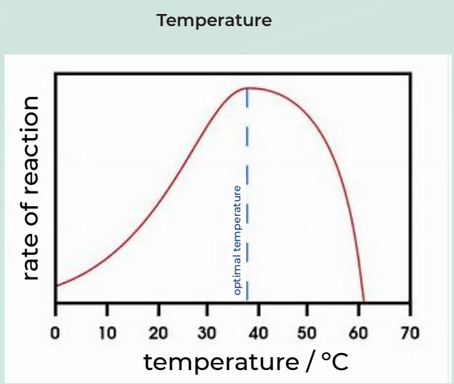


The **induced fit** theory is an alternative theory of enzyme action - **lysozyme** is proposed to function in this way. In this, the active site and substrate are **not fully complementary** in shape. Reactive groups in these areas align and the substrate forces its way into the active site. Both areas change structure slightly, the bonds in the substrate weakens and the reaction occurs at a lower **activation energy.**

Intracellular enzymes

These work **inside** cells and **extracellular enzymes** are secreted from cells for use **outside** of the cell.

Factors affecting enzymes

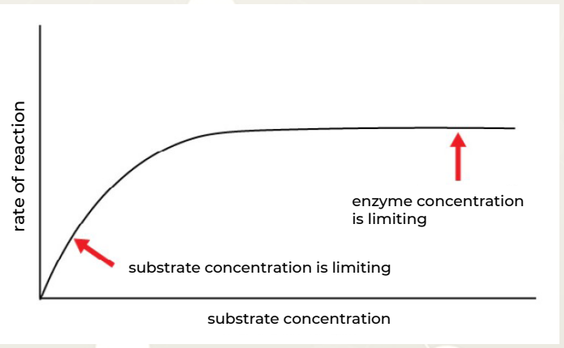


At **low temperatures** there **is low kinetic** energy and so **few successful** collisions where the substrate is able to enter the **active site** of the enzyme and form products.

As the **temperature increases**, the **kinetic energy increases** and so there are **more collisions and enzyme/substrate complexes** formed per unit time leading to increased product. This continues up to an **optimum temperature.**

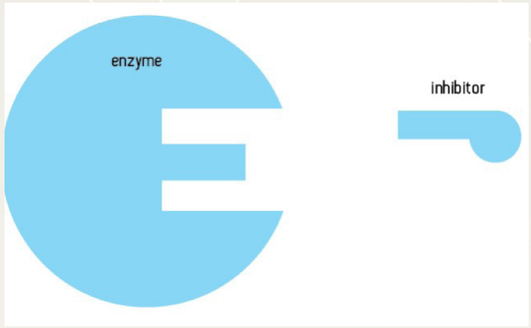
If the temperature continues to increase the kinetic energy increases to a point where **vibrations in the enzyme molecule weaken some bonds** holding the 3D tertiary structure of the **active site** together. The active site loses its shape, the substrate is no longer complementary to the active site, **no further enzyme/substrate complexes** can be made, and the enzyme is said the be **denatured**.

Substrate concentration

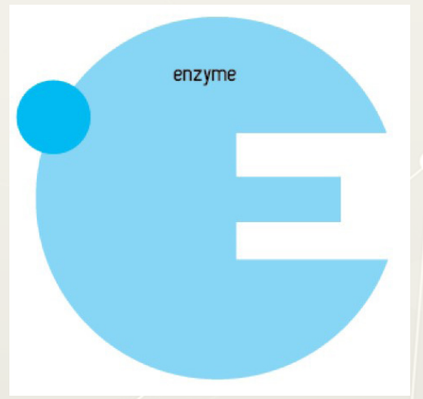


As enzyme reaction relies on **successful collisions** between enzymes. Any increase in the substrate concentration will increase collisions and the rate of reaction. Therefore, at low substrate concentrations it is this factor that is **limiting the rate of reaction** as increasing the substrate concentration increases the rate of reaction. At some point though, any further increase in substrate concentration has no effect on the rate of reaction. It is no longer the limiting factor. **The rate of reaction plateaus as all the enzymes have full active sites** at any one time. The enzyme concentration is the limiting factor now.

Inhibitors



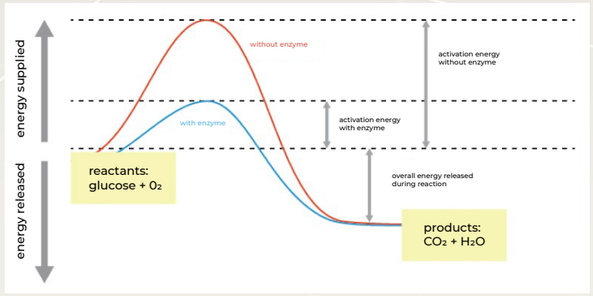
Competitive inhibitors are complementary in shape to the active site of the enzyme. They therefore prevent the formation of enzyme/substrate complexes by blocking the active site. They do not bind permanently.



Non-competitive inhibitors bind to the enzyme away from the active site at an 'allosteric' site. This alters the shape of the active site so no enzyme/substrate complexes can be formed. Some inhibitors bind reversibly, others irreversibly.

Enzymes and biological reactions

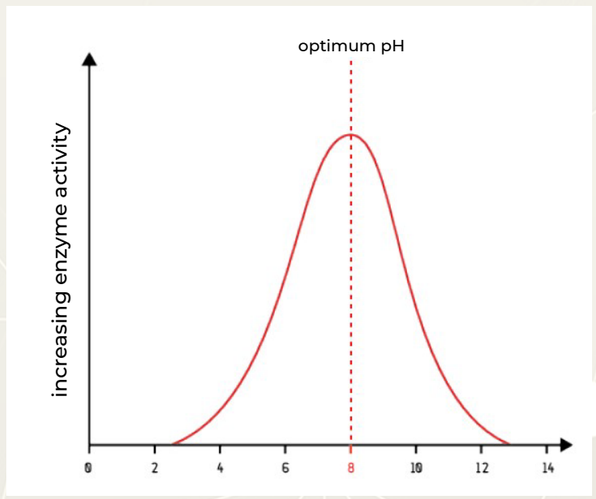
Activation energy



Enzymes are **catalysts**, this means they **lower the activation energy** of reactions, but they remain unchanged in the reaction.

pH

Most enzymes have an optimum pH. Small **changes from the optimum**, either above or below optimum pH, **make small reversible** changes in the enzyme molecule reducing its efficiency. **Large changes in pH** can **disrupt ionic and hydrogen bonds** in the enzyme causing permanent changes to the shape of the active site, **preventing the formation of enzyme/substrate complexes, denaturing the enzyme.**



Immobilised enzymes

Enzymes can be attached to an **inert matrix** such as **cellulose microfibrils** or **sodium alginate beads.**

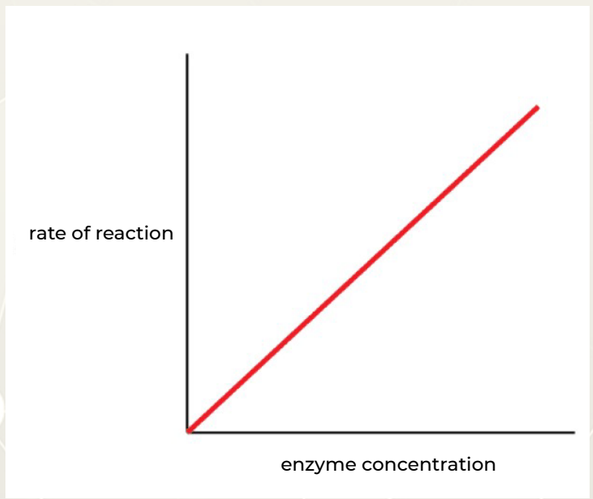
Advantages:

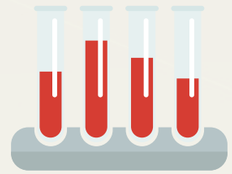
- **Increased stability** so will denature at higher temperature and can be used efficiently over a wider range of pH.
- **Products uncontaminated** with enzyme.
- Enzymes **easily added and removed** giving control over reactions or **recovered for re-use.**

Immobilised enzymes are used to create **lactose-free milk** and in **biosensors.**

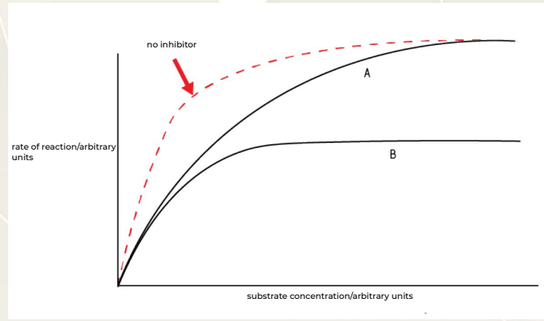
Enzyme concentration

Assuming an excess of substrate any increase in enzyme concentration increases the rate of reaction as more active sites are available for reactions.





Inhibitors



As competitive inhibitors compete with the substrate for the active site any increase in substrate concentration will decrease the effect of the inhibitor as the substrate will collide more often than the inhibitor with the active site of the enzyme. (Line A)

An increase in substrate concentration has no effect on a non-competitive inhibitor. (Line B)

Metabloism - Anabolic reactions (building up molecules) and catabolic reactions (breaking down molecules) are catalysed by enzymes.