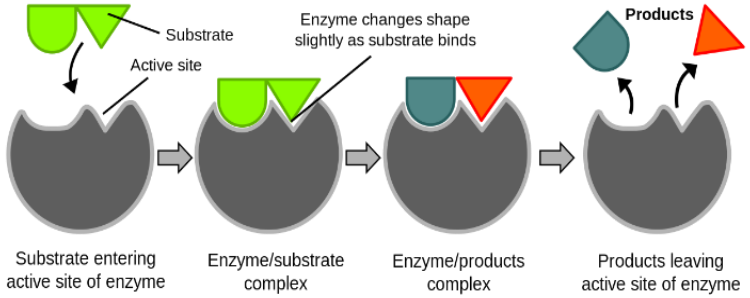
science

biology

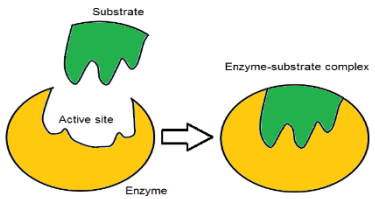
# A-Level Proteins (ENZYMES)

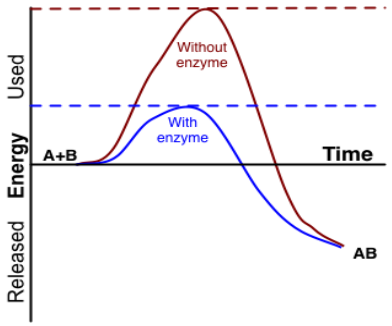
**Enzymes** are globular proteins which speed up biochemical reactions and so are called **biological catalysts.** They have a tertiary structure which determines their 3D shape and so the substrate they join to.

Part of the enzyme molecule forms the **active site**. This is a **specific** shape to allow the **substrate** molecule to enter. The active site and form an **enzyme-substrate complex**.




The shape of the active site may not be precisely complementary to the shape of the substrate.
As the substrate binds, the enzyme changes shape slightly to bind the substrate. This is called the **induced-fit model** and is a modified form of the **lock and key model** of enzyme action.



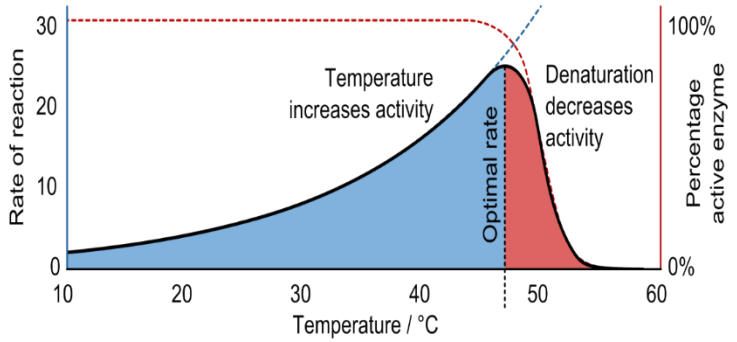

The minimum energy needed to start a chemical reaction is called the **activation energy**.
Enzymes lower the activation energy of the reactions that they catalyse. Enzymes increase the rate of reaction without being used up.

The rate of an enzyme catalysed reaction is dependent on the rate of successful collisions between the enzyme and the substrate which leads to the formation of an enzyme-substrate complex and then a product.

There are a number of factors that affect the speed at which enzymes convert reactants to products.

- pH
- concentration of enzyme
- temperature
- concentration of substrate
- concentration of inhibitors (competitive and non-competitive)

**Temperature –** the graph shows the effect of temperature on the rate of enzyme activity. Each enzyme has an **optimum temperature** at which it works fastest. In human systems, this is often around 37°C (core temperature).




An increase in temperature results in an increase in the numbers of successful collisions between the enzyme and substrate molecules as they gain **kinetic energy** (blue line). However, beyond the **optimum temperature**, the increased vibrational energy of the enzyme causes **ionic** and **hydrogen bonds** to break disrupting the tertiary structure. The substrate can no longer fit into the active site. Enzyme activity decreases (red line) and eventually stops. The enzyme is **denatured.** This change is **irreversible**.

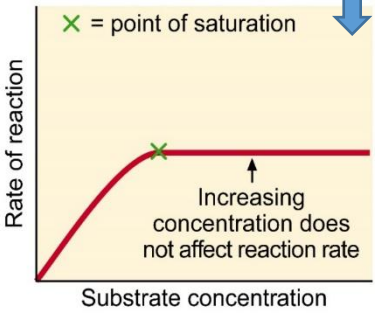
**pH -** the graph shows the effect of pH on the rate of enzyme activity. Each enzyme has an optimum pH at which it works fastest.

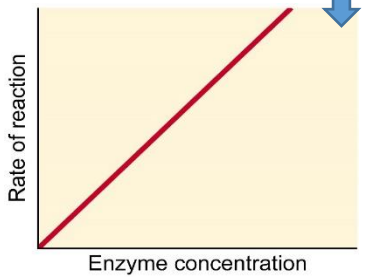
If the environment of an enzyme deviates either side of the optimum, This will cause disruption of both the **secondary** and **tertiary structure** of the enzyme and so affect the shape of the **active site**. Fewer enzyme-substrate complexes are formed and the rate of reaction decreases. Further changes in pH result in no activity at all and the enzyme is **denatured.**

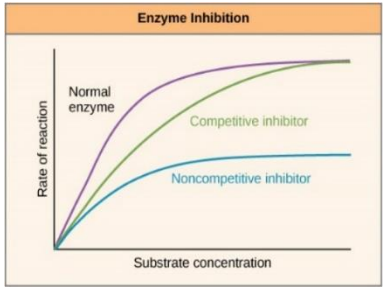
**Denaturation due to a change in pH is generally reversible.**

**Substrate concentration** – for a fixed amount of enzyme, increasing the substrate concentration results in an increase in the rate of reaction (the substrate is acting as a **limiting factor**). Once there is sufficient substrate to saturate the active sites, increasing substrate concentration results in no further increase in rate (substrate is no longer limiting).

**Enzyme concentration** – increasing the enzyme concentration of a biochemical reaction results in an increase in the rate of reaction. As more enzyme is added, more active sites are available to form **enzyme-substrate complexes** and so more product is formed per second. If the substrate is in excess and not limiting, the rate of reaction continues to rise.




**Competitive inhibitors -** so called because a molecule **similar in shape** to the substrate, **competes** for a space on the active site
**Non-competitive inhibitors -** substances that attach to the enzyme somewhere other than at the active site.

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