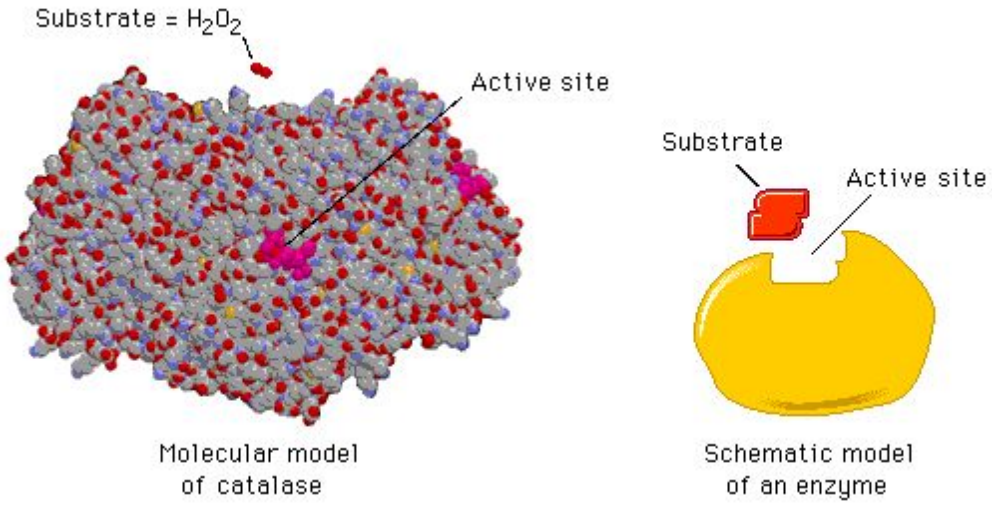
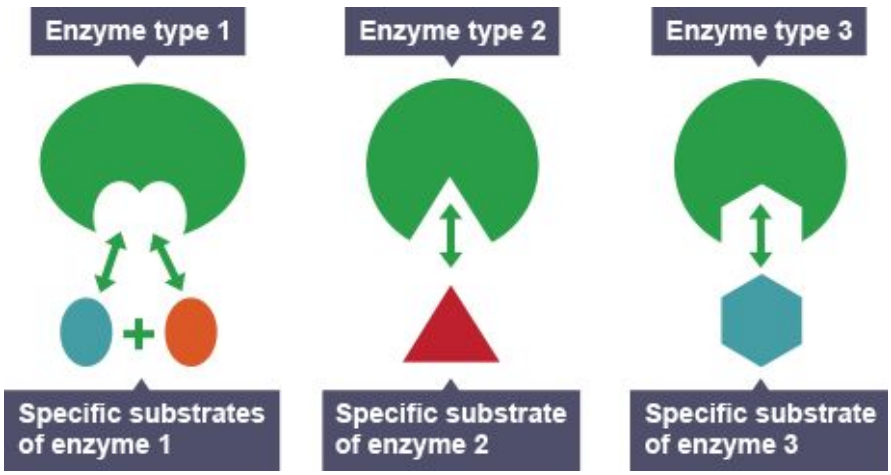
Enzymes are proteins, folded into their tertiary or quaternary structure



All enzymes have one (or more active sites)

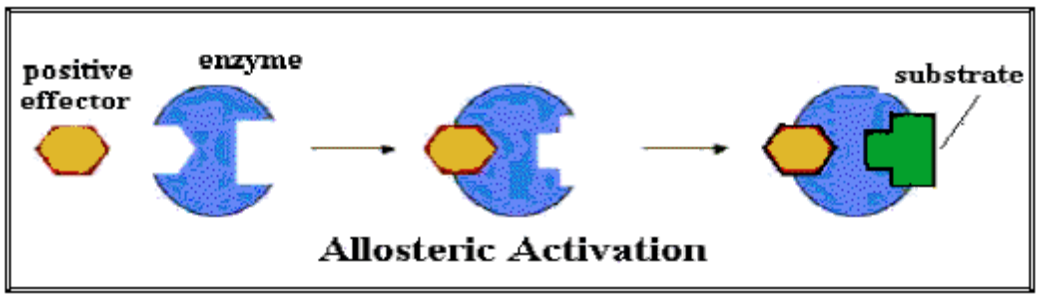
The substrate binds to the active site, forming an **enzyme-substrate complex**

Substrate is **complementary** to the enzyme's active site

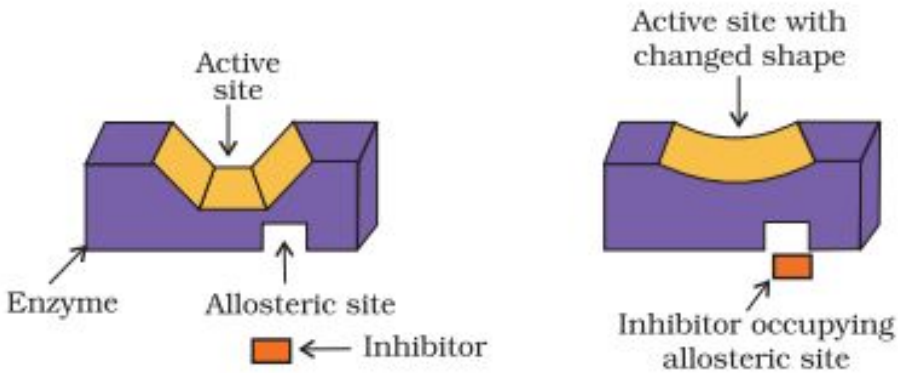


Enzymes can have allosteric sites

Allosteric site is different to active site



Activators can change shape of active site, allowing substrate to bind



Inhibitors change the shape of the active site, such that substrate can no longer bind

An enzyme is a biological catalyst

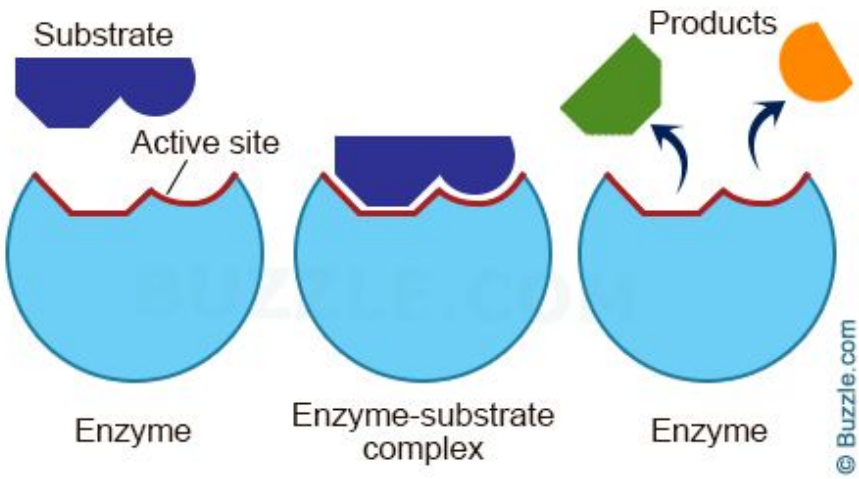
It can reduce the energy required to carry out a reaction

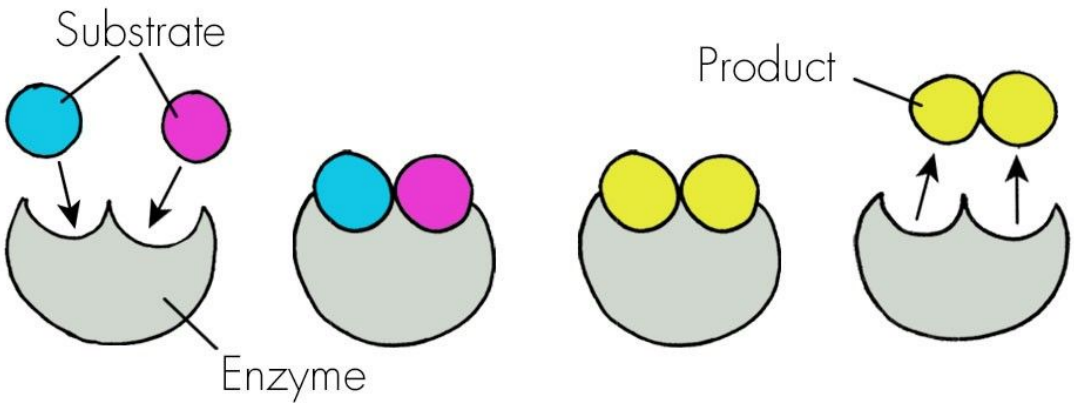
$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ H_2O + 6\ CO_2 + \text{ENERGY}$

glucose + oxygen → water + carbon dioxide + energy

In the laboratory = high temp

In the body = 37°C

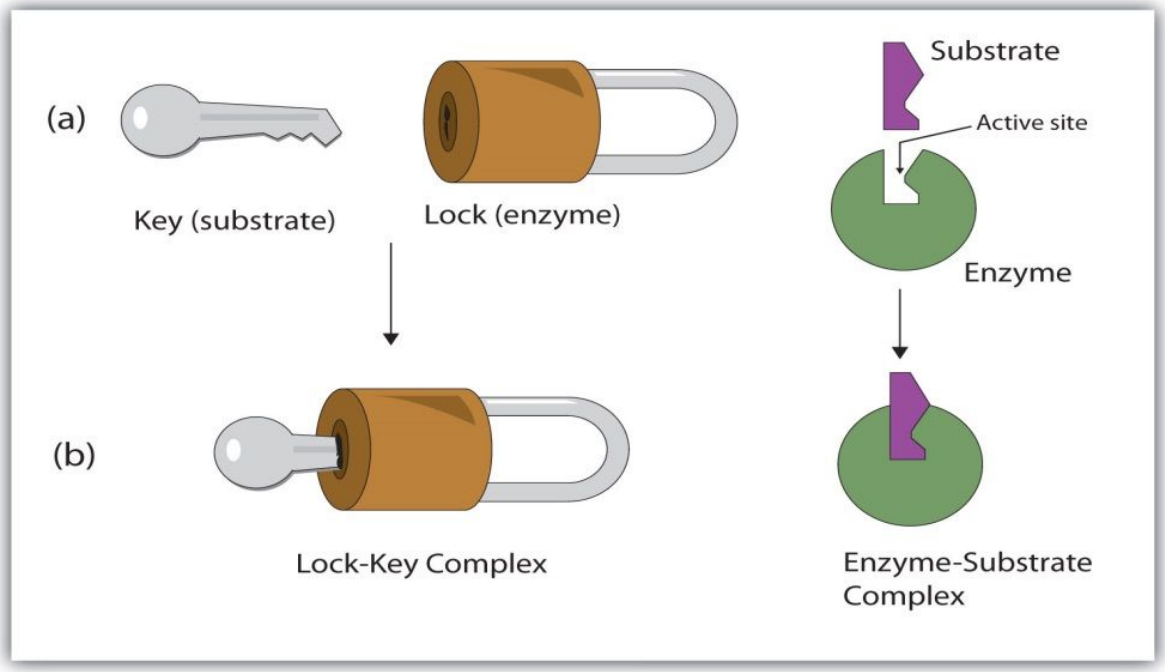




How does an enzyme work?

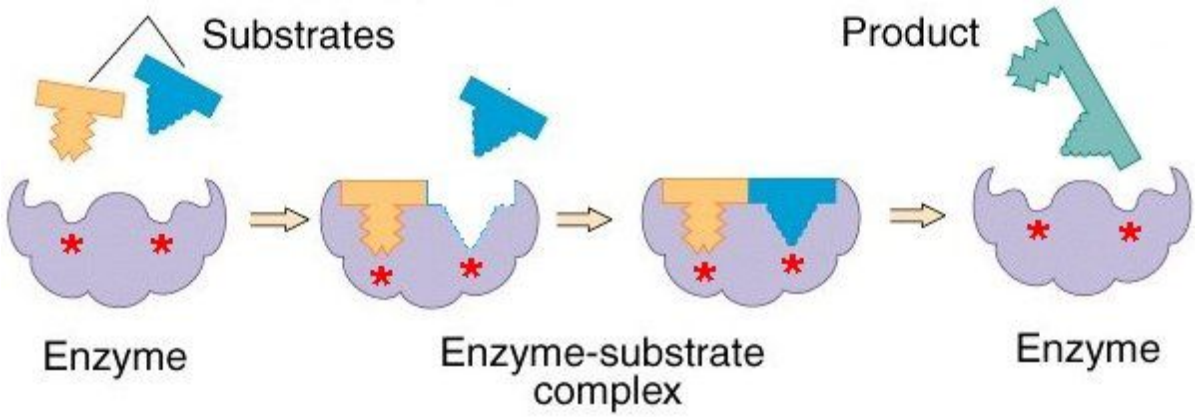
1) Lock and Key Theory

The substrate fits the active site of the enzyme like a lock fits a key. Neither the enzyme nor the substrate change their shape after binding.



2) Induced Fit Theory

When the substrate binds to the enzyme the active site changes shape and molds itself to the substrate, like a glove fitting on a hand. This theory assumes that the enzyme's active site is not rigid, instead, it can change (slightly) to accommodate the substrate.



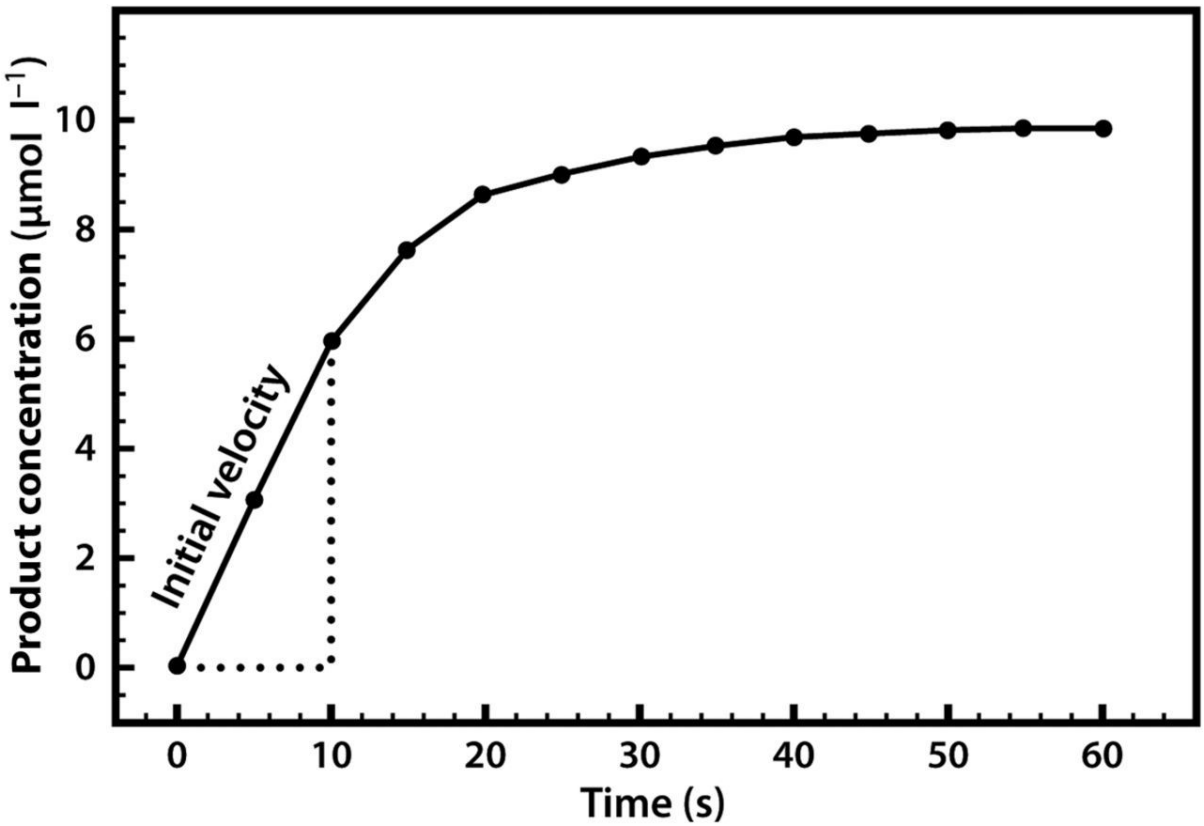
This model is better at explaining how an enzyme can reduce activation energy

When the enzyme molds itself around substrate, it can **produce strain within the bonds** of the substrate, making the bonds easier to break (lower temperatures). New bonds are then formed to make the product.

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ H_2O + 6\ CO_2 + \text{ENERGY}$

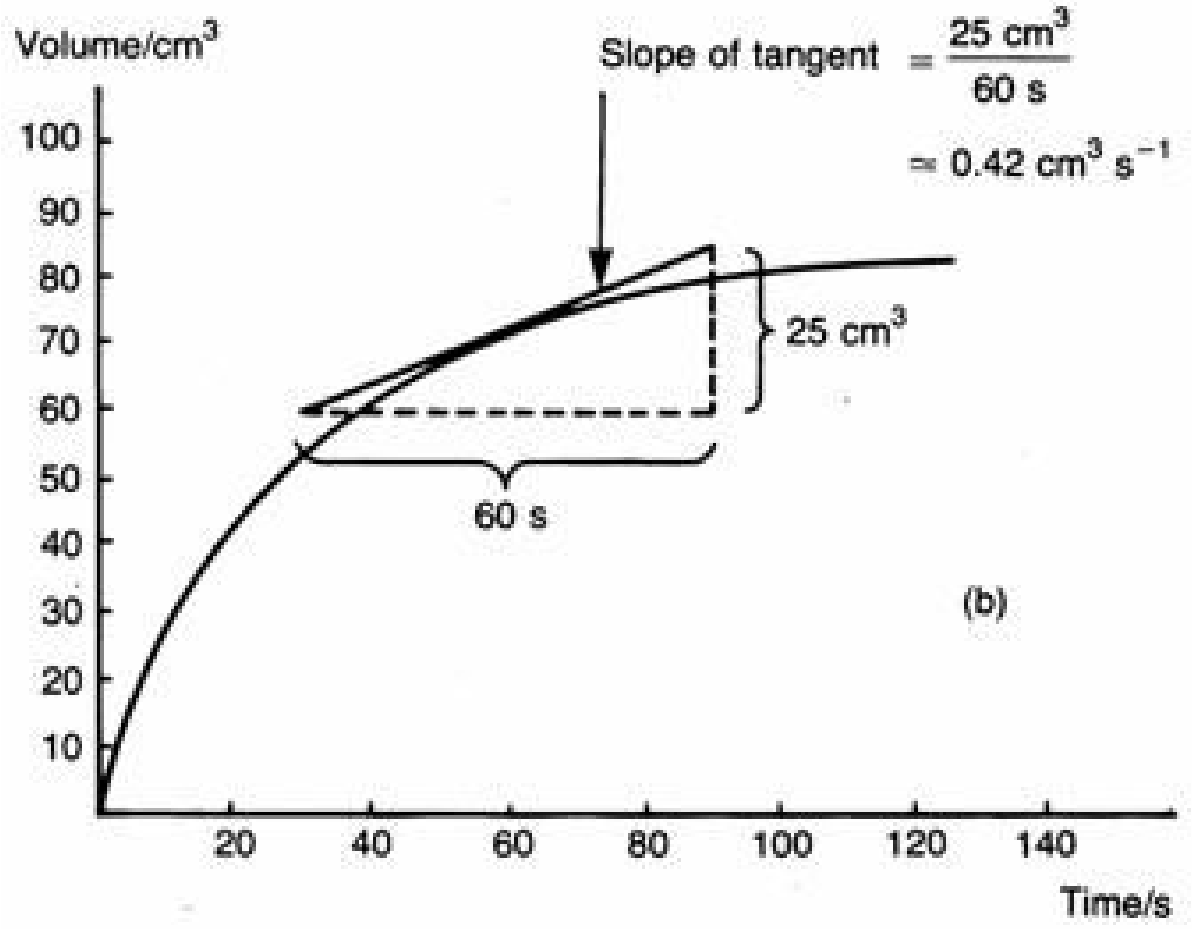
glucose + oxygen → water + carbon dioxide + energy

Measuring enzyme catalysed reactions



Slows down over time, as substrate concentration <u>becomes limiting</u>

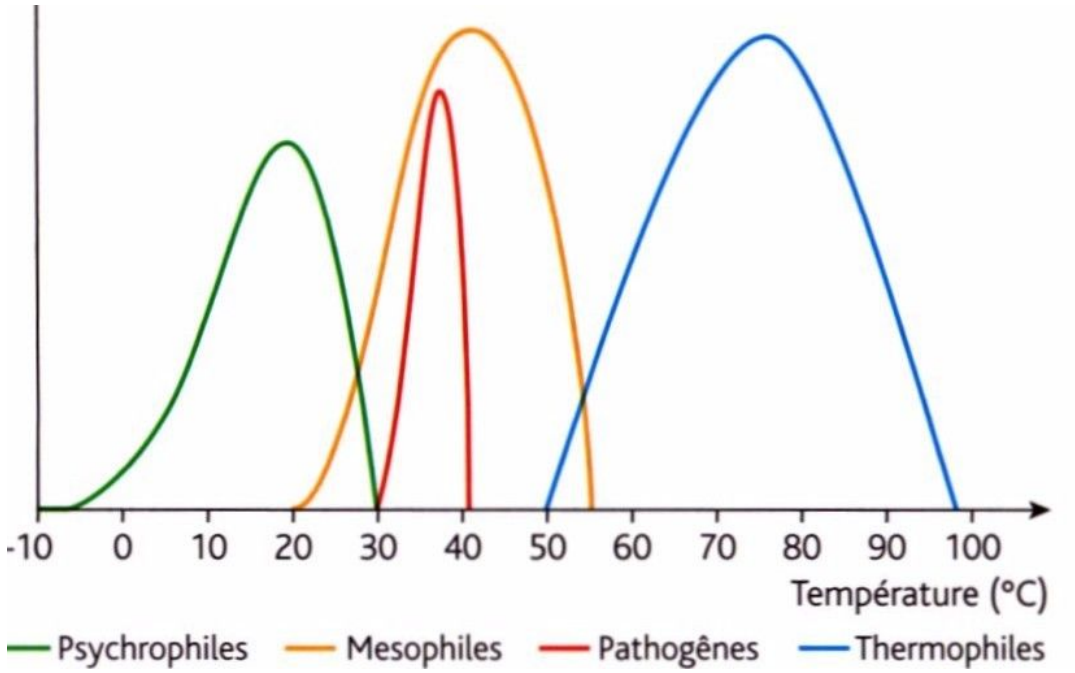
$$\text{Rate} = \frac{\textit{Concentration of product}}{\textit{Time}}$$



As you can see from the graph, the shape of the curve changes over time

Effect of temp on enzyme activity

Low temp affects kinetic energy
High temp affects hydrogen bonds



Temp of max rate = Optimum temp

Varies for different organisms
Human enzymes = 37C

Low temp

- Low kinetic energy
- Fewer effective collisons between E and S
- Fewer products

High temp

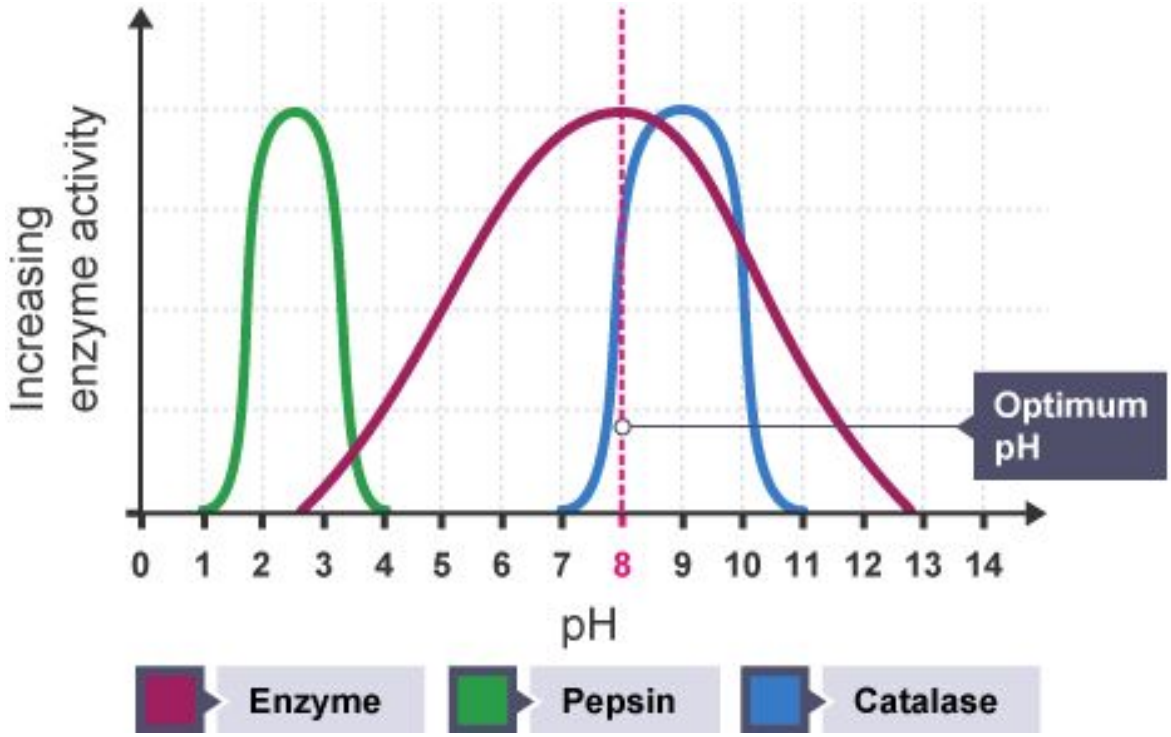
- H-bonds start to break
- Active site starts to lose tertiary structure
- Substrate cannot fit into active site
- Is reversible to a certain extent

Denatured

- Tertiary structure is permanently lost
- Not reversible
- No enzyme activity

Effect of pH on enzyme activity

pH affects ionic bonds



Low pH = excess H^+, $NH_2 \rightarrow NH_3^+$

High pH = excess OH^-, $COOH \rightarrow COO^-$

As charge on R-group changes, tertiary structure of active site changes

Same enzyme from different organisms can have different optimum pH

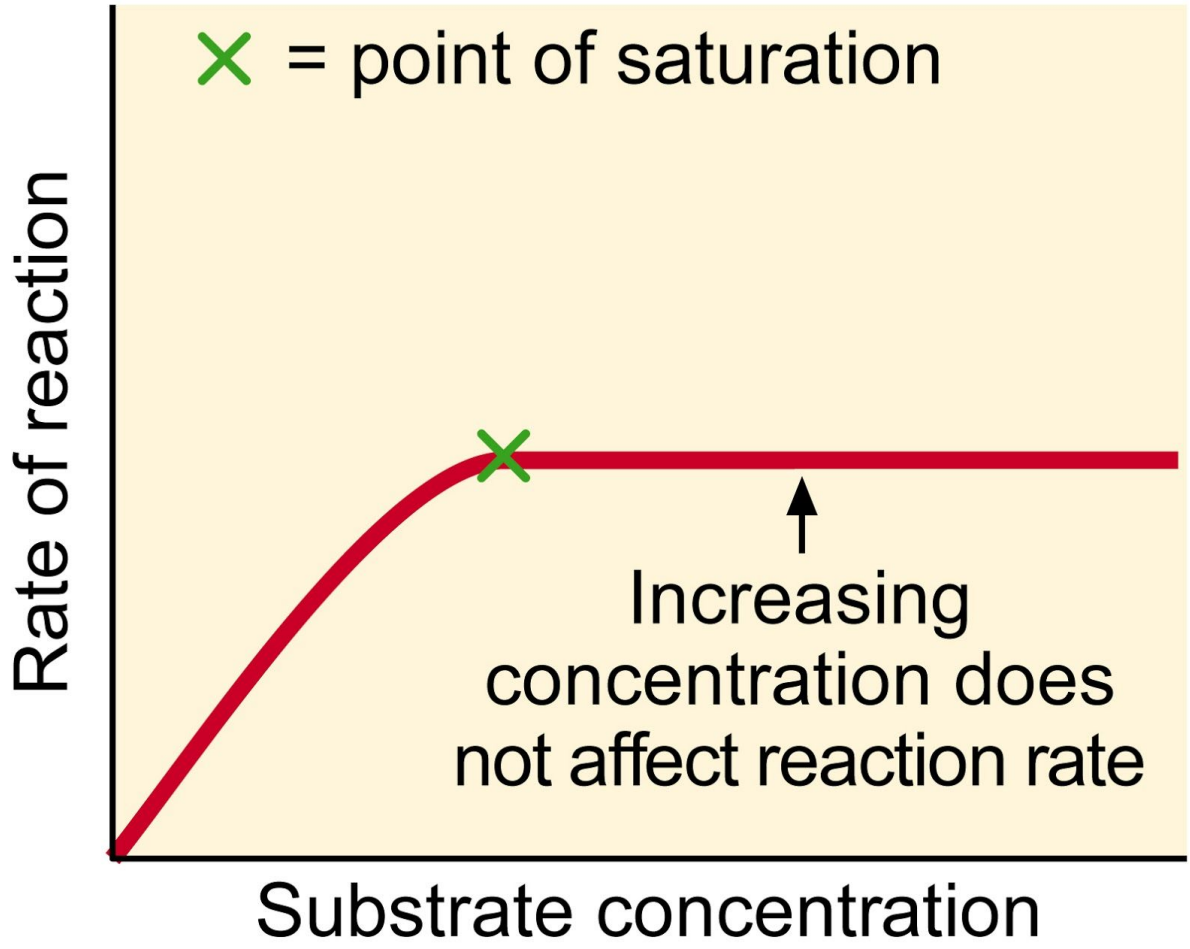
A **buffer** is a solution that prevents fluctuations in pH

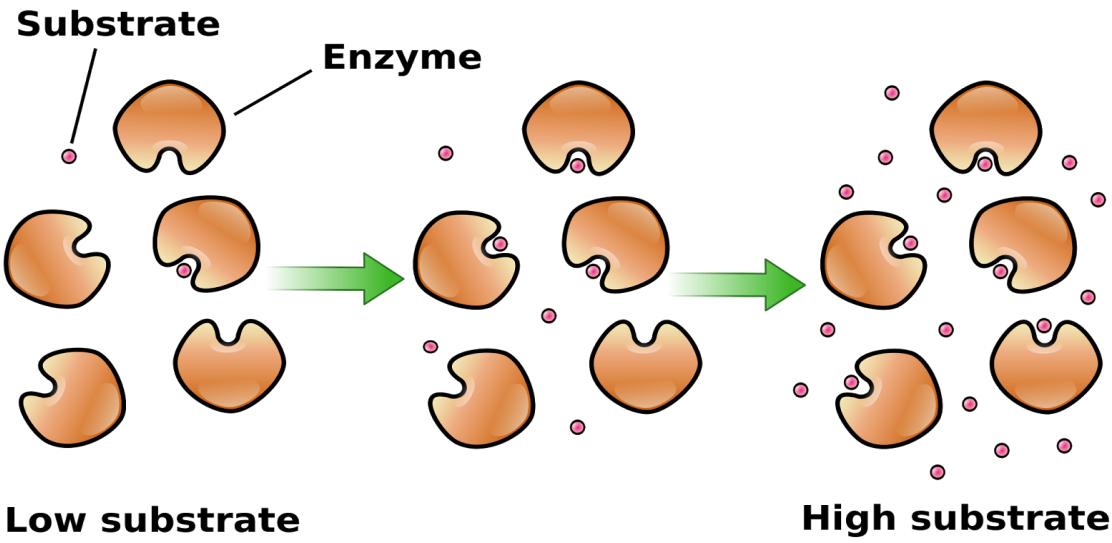
In the human body, some of the CO_2 released in respiration dissolves in blood, creating a buffer system

The pH of blood and tissues is tightly controlled and kept between 7.2-7.4

In the laboratory, buffers are often used to maintain the pH within a set range

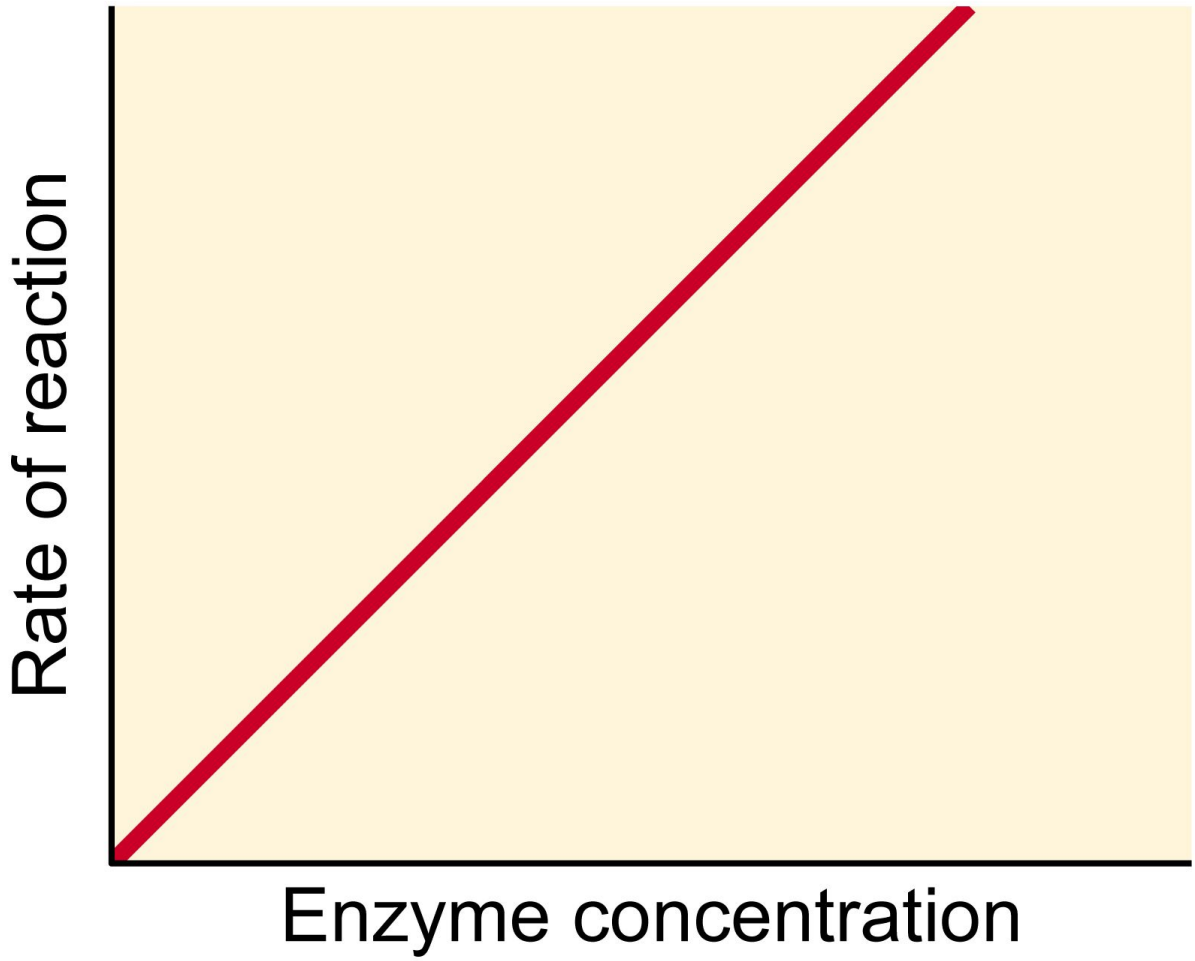
Effect of substrate on rate of reaction





- Initial rate is limited by substrate concentration
- When the graph levels out, the enzyme concentration becomes limiting
- All active sites filled, so no new enzyme-substrate complexes formed (saturation point)
- No further increase in rate, unless extra enzyme is added

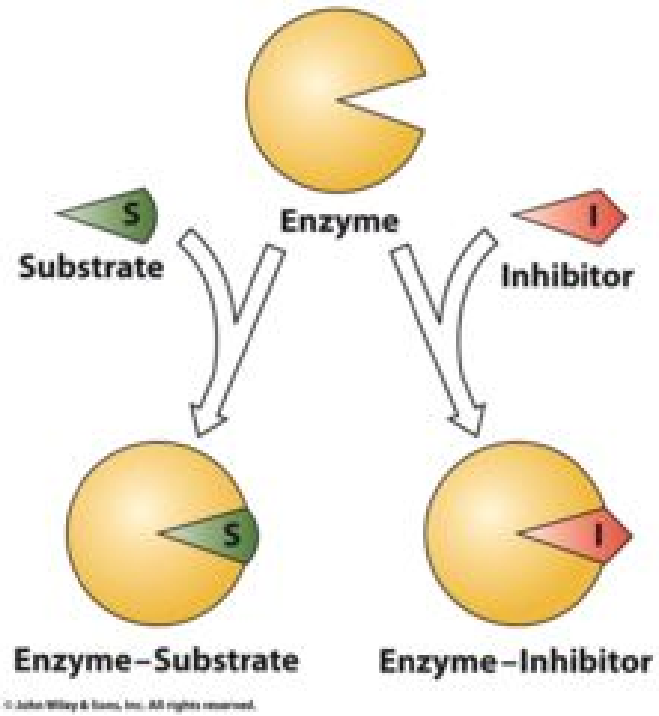
Effect of enzyme on rate of reaction



- As enzyme conc increases, rate of reaction increases, as long as substrate is in excess
- If substrate concentration is limiting, rate of reaction will level off (page 29)

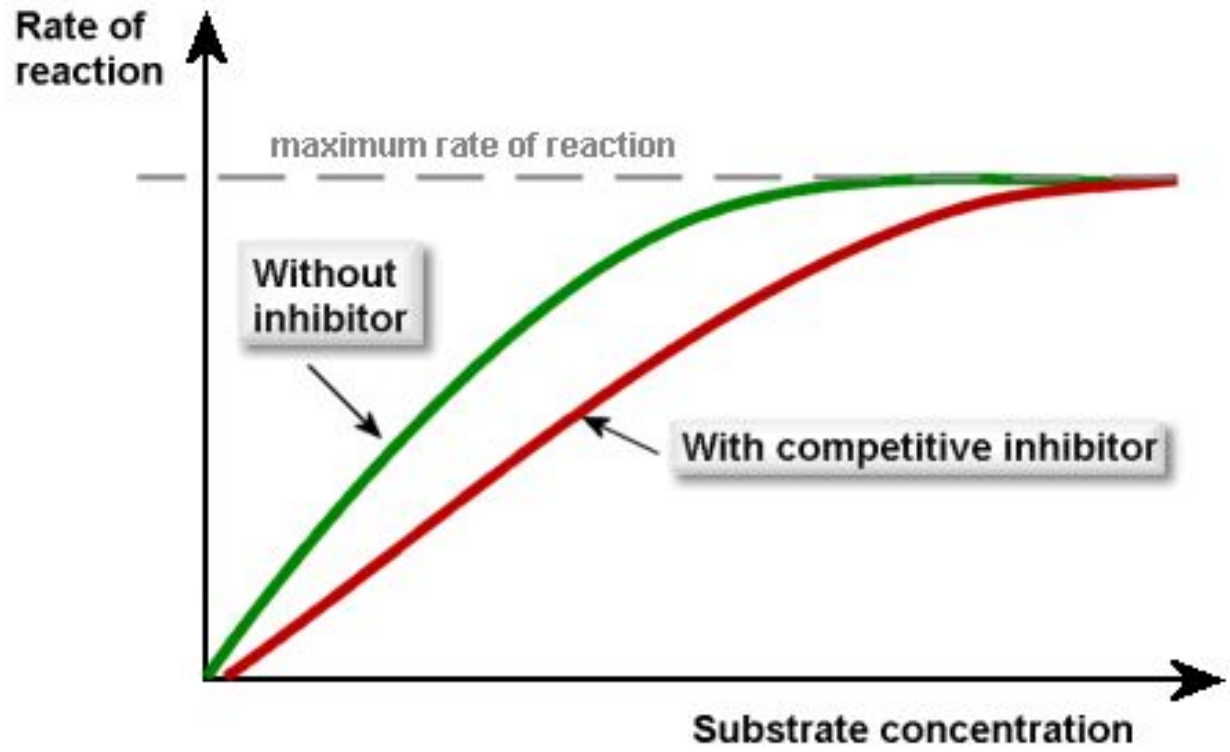
Competitive inhibition of Enzymes

Competes with the Substrate for the active site of the enzyme



- Has a similar tertiary structure to substrate
- Can bind to the enzyme's active site, preventing the substrate from binding

- Binding is not permanent - reduces rate of reaction, but not the amount of product formed



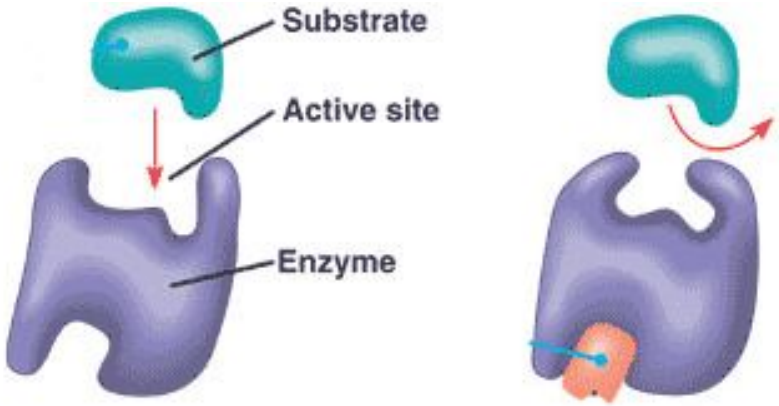
Same amount of product formed, just at a slower rate

Effects can be overcome by adding excess substrate

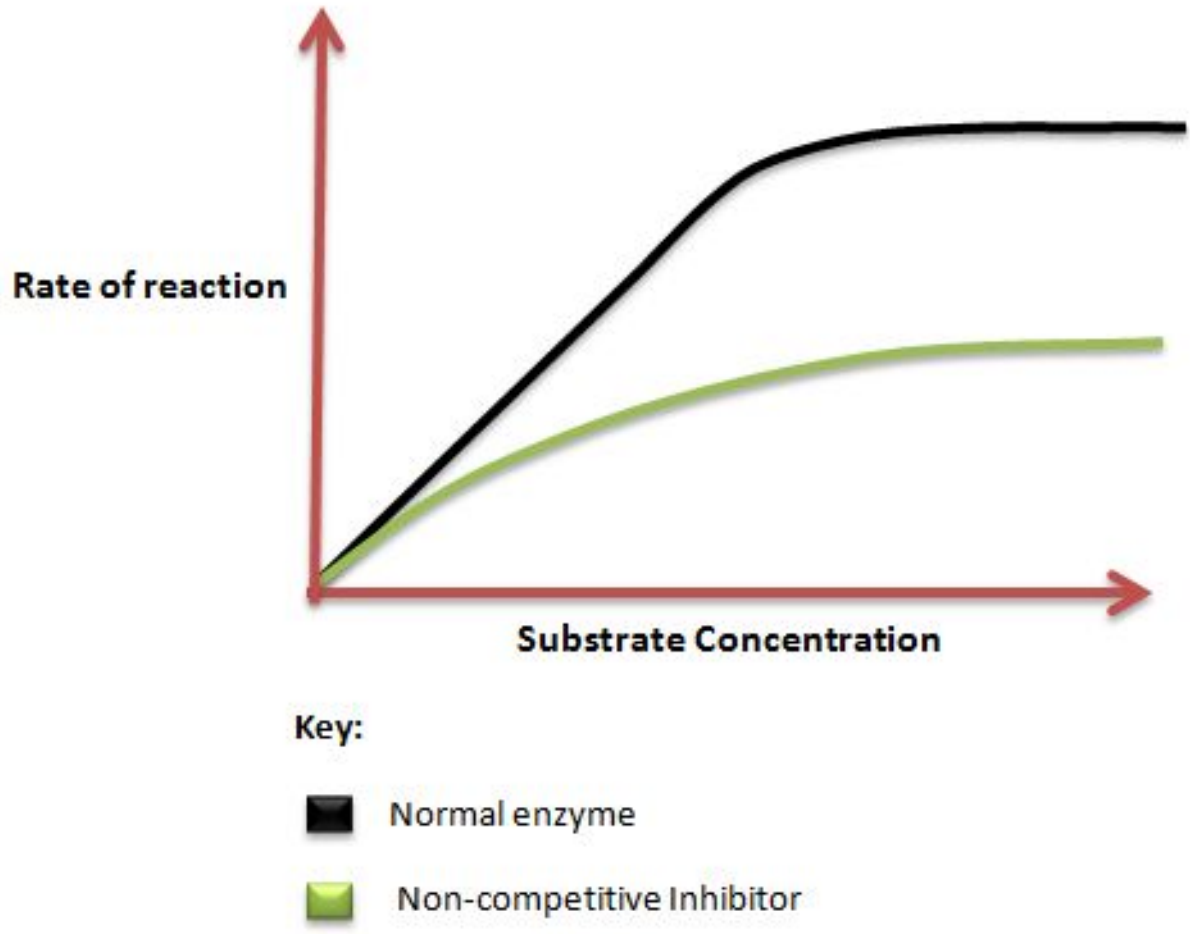
E.g. antibiotics can often act as competitive inhibitors for bacterial enzymes

Non-competitive inhibition of enzymes

Inhibitor binds to a site that is not the active site - like the allosteric site



- Has a <u>different</u> tertiary structure to substrate
- <u>Cannot</u> bind to the enzyme's active site
- Binds to allosteric site
- <u>Binding is often permanent</u> - reduces rate of reaction, and the amount of product formed



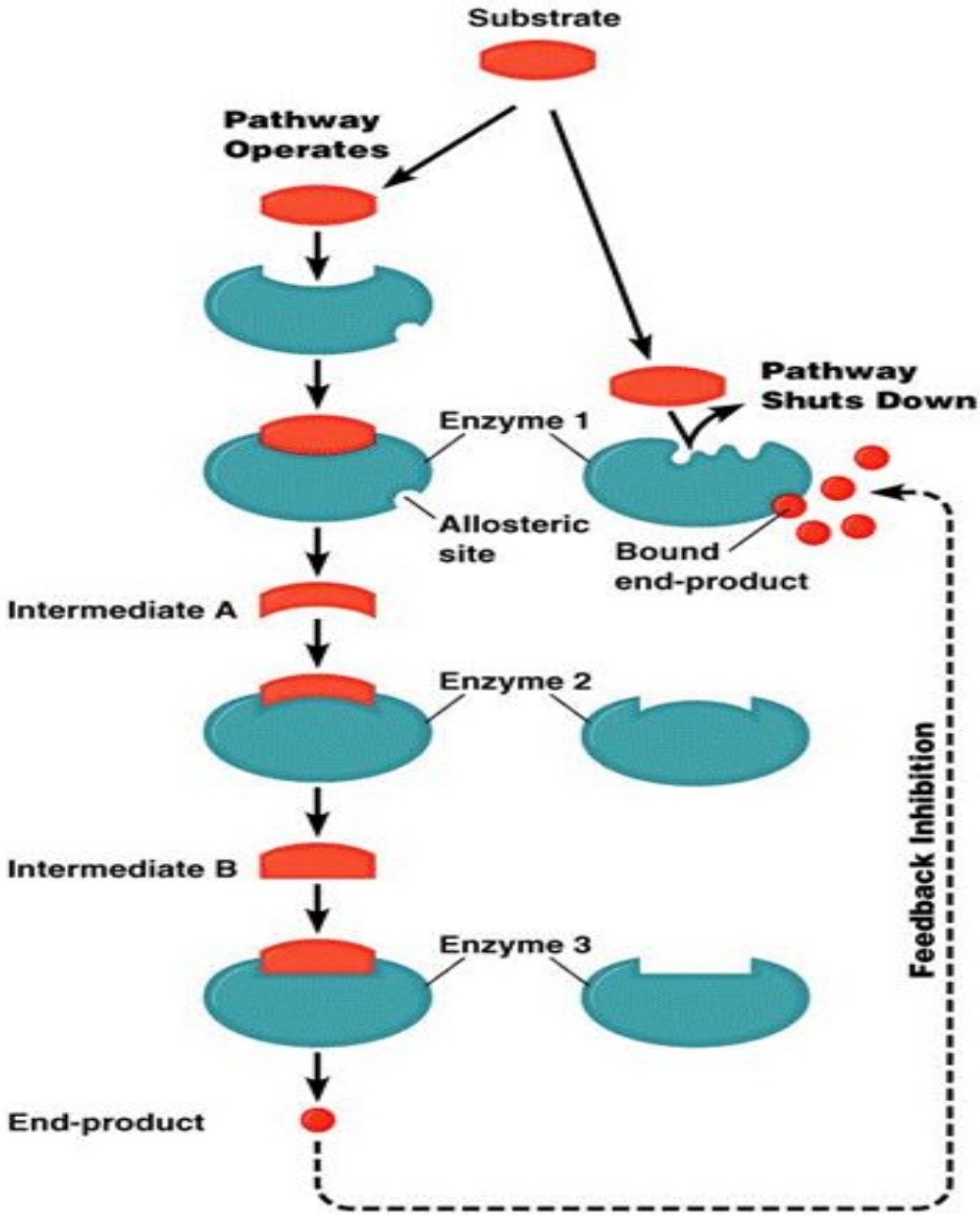
Lower amount of product formed

Rate is slower

Effects cannot be overcome by adding excess substrate

E.g. cyanide binds irreversibly to enzymes in the mitochondria, preventing ATP synthesis

End product inhibition of metabolic pathways



End product of the reaction inhibits the first enzyme in the metabolic pathway

Prevents waste of cellular resources