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Chapter 3: Enzymes

▼ 3.1. Mode of action of enzymes

▼ What are enzymes?

Enzymes are globular proteins that increase the rate of reaction by lowering the activation energy of the reaction they catalyze.

▼ Where does the enzyme’s reaction with the substrate takes place.

The active site is the area for that

▼ Enzyme specificity/ Lock and key theory

Each enzyme has a specific shape that must be complementary to the substrate, meaning that only one type of substrate fits to the active site of each enzyme.

The theory is proposed by Fischer in 1894:

1. Active site and subtrate have complementary shapes prior to binding.
2. The enzyme binds with substrate forming an enzyme-substrate complex.
3. Products are released from active site and enzyme can be reused.
4. Only one substrate can fit each active site.

▼ Induced fit

When the enzyme and substrate form a complex, the structure of the enzyme is altered so that the active site of the enzyme fits around the substrate.

The theory is proposed by Koshland in 1958:

1. Enzyme has active site.
2. Enzyme substrate is altered around substrate as it enters to become complementary forming an enzyme-substrate complex.
3. Bonds form between oppositely charged groups on substrate and R groups to induce a better-fit. This puts a strain on the substrate molecule so reactions occur more easily.

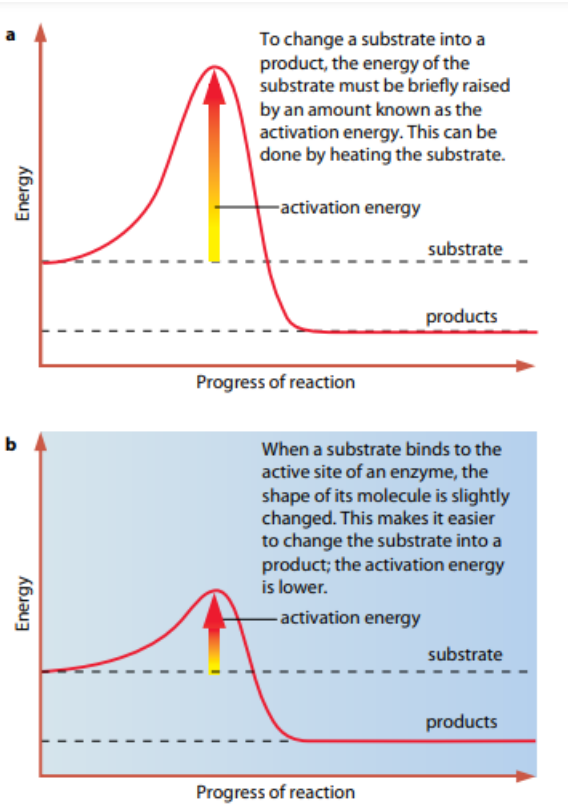


Figure 3.5 Activation energy **a** without enzyme; **b** with enzyme.

▼ 3.2. Factors that effect enzyme action

▼ Enzyme concentration

The rate of reaction increases as the enzyme concentration increases as there are more sites for substrates to bind to, however increasing the enzyme concentration beyond a certain point has no effect on the rate of reaction as there are more active sites than substrates so substrates concentration becomes the limiting factor.

▼ Substrate concentration

The rate of reaction increases as the substrate concentration increase as more enzyme-substrate complexes are formed. However beyond a certain point the rate of reaction becomes constant as the enzyme concentration becomes the limiting factor.

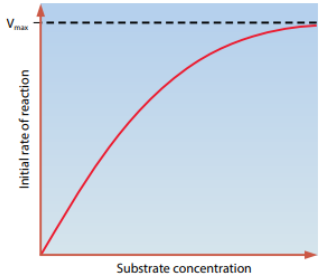


Figure 3.8 The effect of substrate concentration on the rate of an enzyme-catalysed reaction.

▼ Temperature

The rate of reaction increases up to the optimum temperature as Kinetic energy increases. Rate of reaction decreases beyond the optimum temperature because at very high temperature, bonds in the enzymes tertiary structure begin to break. This causes the shape of the enzyme to change so substrate can no longer bind to the active site. This is called **denaturation**.

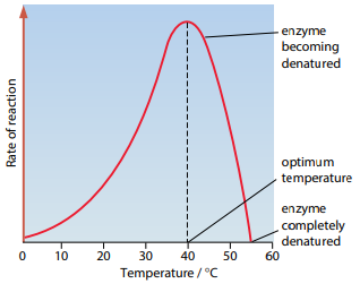


Figure 3.9 The effect of temperature on the rate of an enzyme-controlled reaction.

▼ pH

As the pH moves away from the enzyme's optimum, rate of reaction decrease. the pH is a measure of the concentration of H+ ions. Each enzyme has an optimum pH: the wrong pH alters the charges on the amino acids which make up the active site, breaking the bonds between enzyme's tertiary structure and leading to denaturation. Thus, when the enzyme is not in its optimum pH, the substrate can no longer become detached to the active site and the enzyme-substrate complex cannot form.

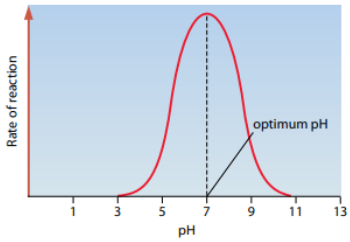
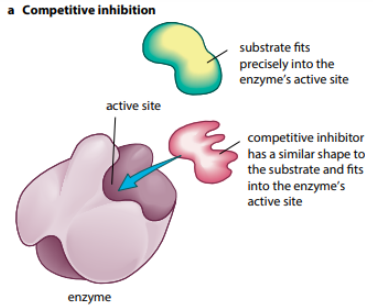


Figure 3.11 The effect of pH on the rate of an enzyme-controlled reaction.

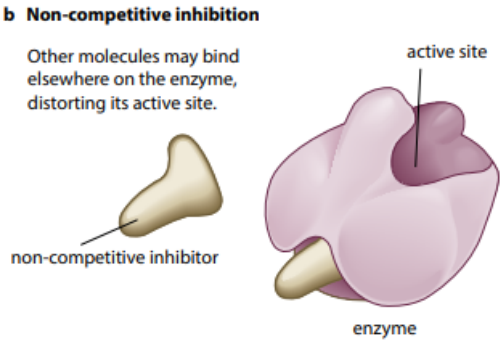
▼ Concentration of competitive reversible inhibitors

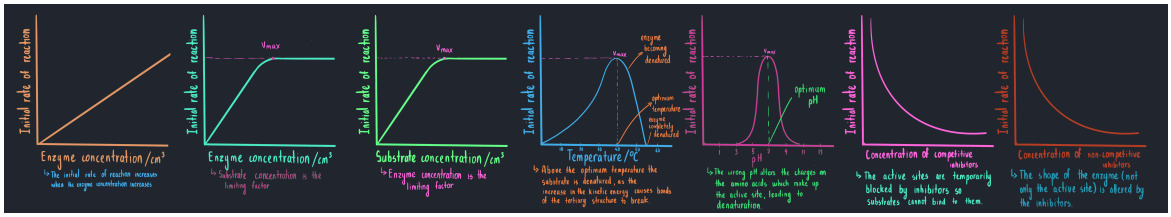
As concentration of competitive reversible inhibitors increases, rate of reaction decreases as the active sites are temporarily blocked by inhibitors so substrates cannot bind to them.



▼ Concentration of non-competitive reversible inhibitors

As concentration of non-competitive reversible inhibitors increases, rate of reaction decreases as the shape of the enzyme(not the active site) is altered by the inhibitors.





- Factors that effect enzyme action

▼ 3.3. Enzyme inhibitors

▼ What are inhibitors

Inhibitors are substances which stop the enzyme from binding to its substrate. They can therefore control the progress of a reaction.

▼ Types of inhibition

▼ Reversible inhibition

They can be competitive or non-competitive. Once they are removed from the enzyme, inhibition stops and it can work again.

▼ Competitive inhibition

This is when an inhibitor molecule binds to the active site of the enzyme and stops the substrate from forming enzyme-substrate complex; it can be reversed by increasing the substrate concentration as the inhibitor is diluted.

▼ Non-competitive inhibition

A non-competitive inhibitor doesn't bind to the active site, but binds to a different part of the enzyme which changes the shape of the enzyme; it decreases the reaction rate as the substance cannot bind to the enzyme.

▼ Feedback inhibition/ End-product inhibition

This occurs when the end product binds to the enzyme at the start of the reaction and this stops the pathway until the concentration of the end product decreases.

▼ 3.4. Comparing enzyme affinities

▼ What is the turn-over rate:

The turn-over rate is the number of substrate molecule converted into product by enzyme molecule in a unit time when the enzyme is fully saturated with substrate.

▼ What is the Michaelis-Menten equation

Michaelis-Menten equation can be used to calculate the maximum rate of reaction(Vmax) by relating the velocity of enzyme reactions(V) to concentration of a substrate(S). Vmax represents the maximum rate of reaction achieved by the system at maximum substrate concentration.

$$V_0 = \frac{V_{max}[S]}{K_m + [S]}$$

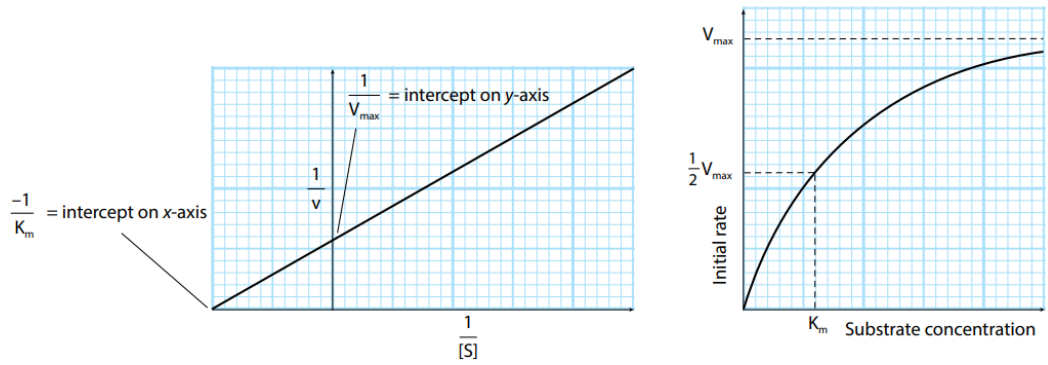


Figure 3.14 **a** A double-reciprocal plot of substrate concentration against initial rate: **b** A graph showing the effect of substrate concentration on initial rate, with V_{max}, ½ V_{max} and K_m values shown.

▼ 3.5. Immobilizing enzymes in alginate

▼ Why and what are the benefits of immobilizing enzymes

When enzymes are in solution, they can be used once as it is very difficult and time consuming to separate them from the product. Therefore, they are immobilized by attaching them to an insoluble inert material e.g. calcium alginate. which forms a gel capsule around them thus holding them in place during the reaction. This process enables enzymes to be reused as they can easily be separated from the products.

Immobilized enzymes are used in industry because it it enables the reaction to flow continuously. Moreover, the use of immobilized enzymes is much cheaper than using enzymes in solution as they can be reused.

If you have any questions reach out to**: 23C Chinguun.M, IG: @chinguun__0511, FB: Chinguun Tsetsgee.**
Or post questions on the discord server for help!