Enzymes

A. MODE OF ACTION OF ENZYMES

Enzymes are globular protein molecules which can be defined as **biological catalysts**. They increase the rate of reaction by lowering the activation energy of the reaction they catalyse.

Intracellular and Extracellular Enzymes

- Intracellular enzymes : enzymes that function **within cells**, e.g. : DNA polymerase.
- Extracellular enzymes : enzymes that are secreted by cells and catalyse **outside cells**, e.g. : protease, amylase, maltase, lipase, etc.

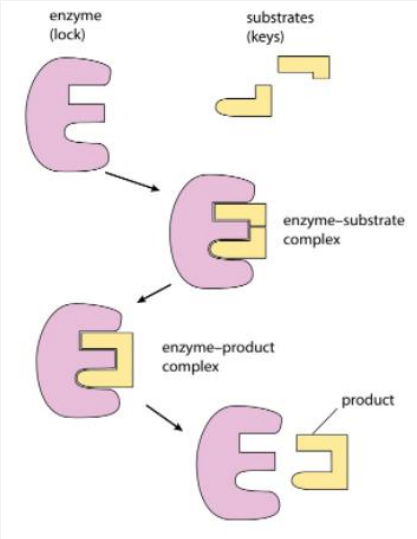
Lock and Key

The active site of an enzyme is a region, usually a **cleft** or depression, to which another molecule or molecules can bind. This molecule is the **substrate** of the enzyme. The shape of the active site allows the substrate to fit perfectly. The idea that the enzyme has a particular shape into which the substrate

fits exactly is known as the **lock and key hypothesis**.

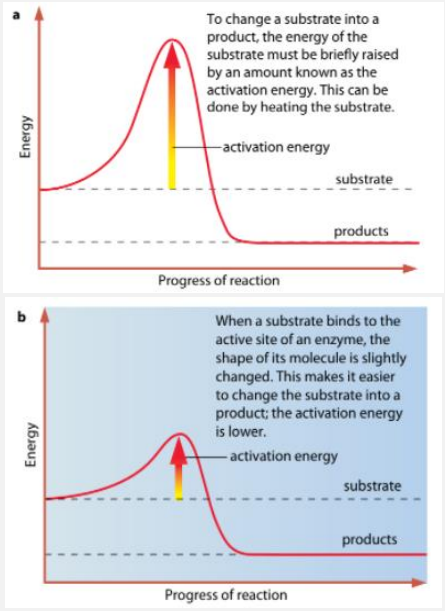
Induced Fit

It is basically the same as the lock and key hypothesis, but it is recognized that **enzymes are more flexible and able to change shape slightly to fit the substrate**. This makes the **catalysis** even **more efficient**.



Enzymes Reduce Activation Energy

Activation energy is the amount of energy needed for a reaction to happen and all metabolic reactions need extra activation energy to happen. Enzymes speed up the rate of a reaction by **lowering the activation energy** of a reaction.

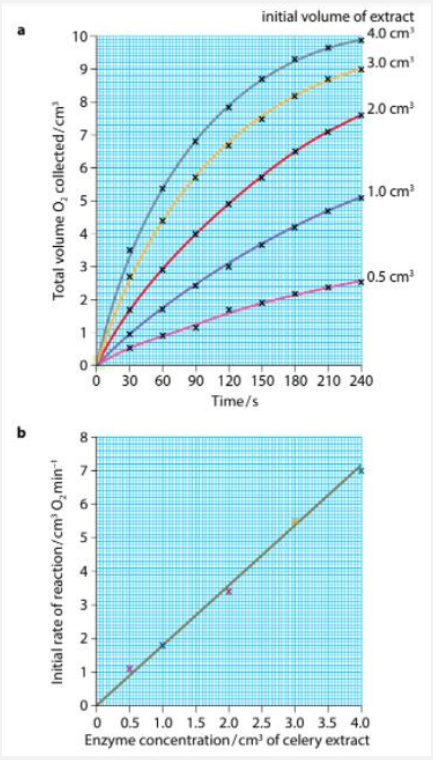


Activation energy a. without enzyme; b. with enzyme

B. FACTORS THAT AFFECT ENZYME ACTION

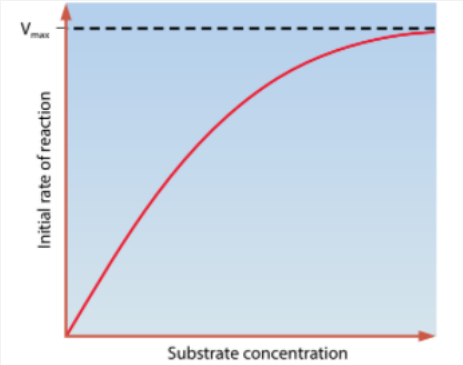
Enzyme Concentration

As the rate of reaction increases, **the enzyme concentration also increases**, and there are more available active 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. At this point**, the limiting factor is the substrate concentration**.



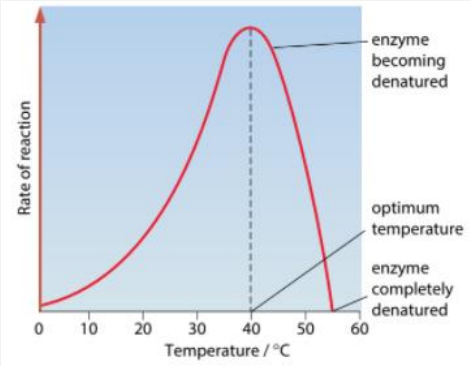
Substrate Concentration

As concentration of substrate increases, rate of reaction increases as more enzyme-substrate complexes are formed. However, beyond a certain point the rate of reaction no longer increases **as enzyme concentration becomes the limiting factor**.



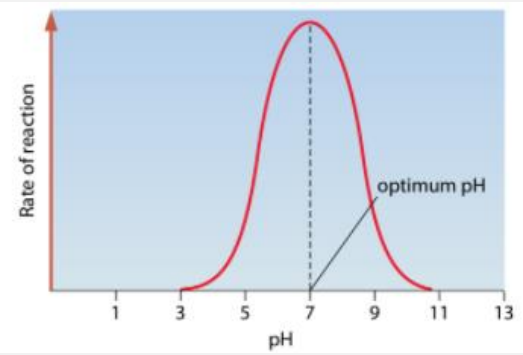
Temperature

Optimum temperature is the temperature at which an enzyme catalyses a reaction at the maximum rate. As the **temperature increases**, the **kinetic energy** and the enzyme activity increase as well until optimal temperature is reached. Rate of reaction decreases beyond the optimum temperature. At very high temperatures, bonds in the enzyme's tertiary structure break, changing the shape of the active site so reactions cannot occur. This is called **denaturation**.



pH

pH is a measure of the concentration of hydrogen ions in a solution. The lower the pH, the higher the hydrogen ion concentration. If the **concentration** of **ions increases** the environment becomes more **acidic**. **Change of pH can disturb the ionic bond** which is important to the tertiary structure of a protein.

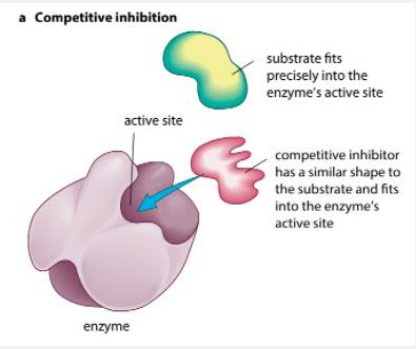


C. ENZYME INHIBITORS

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

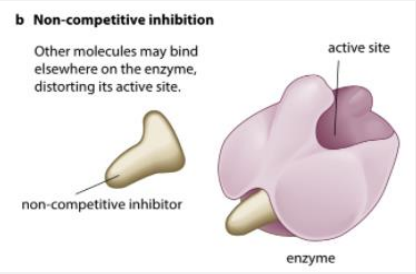
Competitive Inhibition

This is when an inhibitor molecule binds to the active site of the enzyme and stops the substrate from binding to it; it can be reversed by increasing the substrate concentration as the inhibitor is diluted. An example of competitive inhibition occurs in the treatment of a person who has drunk ethylene glycol.



Non-competitive inhibition

Inhibition- an 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 substrate cannot bind to the enzyme.



D. COMPARING ENZYME AFFINITIES

The 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.

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

Keterangan :
V = Initial velocity (moles/times)
[S] = substrate concentration (molar)
V = maximum velocity
K = substrate concentration at half V

E. IMMOBILISING ENZYMES

When enzymes are in solution, they can only be used once as it is very difficult and time consuming to separate them from the product. Therefore they are immobilised 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 be easily separated from the products. Immobilised enzymes are used in industry because it enables the reaction to flow continuously. Moreover, the use of immobilised enzymes is much cheaper than using enzymes in solution as they can be reused.

F. EXERCISE

1. The enzyme lysozyme secreted from tear glands forms deposits on contact lenses. Which ingredient would be effective in a contact lens cleaner for removing these deposits?
   A. Ethanol
   B. Lysosomes
   C. pH buffers
   D. Proteases

   Answer : D
   Mainly, contact lens cleansing solutions have been prepared using plant (papain) and animal (pancreatin, trypsin and chymotrypsin) **proteases**.

2. Which of these statements are correct for all enzymes
   a) They are globular proteins
   b) They are formed in the smooth endoplasmic reticulum.
   c) They are only found attached to the plasma membranes in the cell.
   d) They can be inhibited by competitive inhibitors.

   A. 1&2
   B. 1&3
   C. 3&4
   D. 1&4

   Answer : D
   Enzymes are **globular protein** molecules which can be defined as biological catalysts. They increase the rate of reaction by lowering the activation energy of the reaction they catalyse.
   Competitive inhibitors = Bind at the active of an enzyme – competing with the substrate.

3. Why do large increases in temperature or pH alter enzyme activity?
   1) They change the 3D shape of the enzyme
   2) They disrupt hydrogen and ionic bonds in the structure
   3) They increase hydrophobic interactions in the enzyme

   A. 1&2
   B. 1&3
   C. 3&4
   D. 1&4

   Answer : A
   PH , temperature, salinity and the presence of heavy metals as these are the factors that contribute to the **change of the 3D shape of the enzyme**. Changing the pH **disrupts the hydrogen bonds**, and this changes the shape of the protein.