Enzyme Specificity

Enzymes show different degrees of specificity:

1. Relative, low or bond specificity

In this type the enzyme acts on substrates that are similar in structure and contain the same type of bonds e.g.

a. Amylase, which acts on α 1-4 glycosidic, bonds in starch, dextrin and glycogen.
b. Lipase that hydrolyzes ester bonds in different triglycerides

2. Moderate, structural or group specificity

In this type of specificity, the enzyme is specific not only to the type of bond but also to the structure surrounding it.

For example:

a. **Pepsin** is an endopeptidase that hydrolyzes central peptide bonds in which the amino group belongs to aromatic amino acids e.g. phenyl alanine, tyrosine and tryptophan.
b. **Trypsin** is an endopeptidase that hydrolyzes central peptide bonds in which the amino group belongs to basic amino acids e.g. arginine, lysine and histidine.
c. **Chymotrypsin** is an endopeptidase that hydrolyzes central peptide bonds in which the carboxyl group belongs to aromatic amino acids.
d. **Aminopeptidase** is an exopeptidase that hydrolyzes peripheral peptide bond at the amino terminal (end) of polypeptide chain.
e. **Carboxypeptidase** is an exopeptidase that hydrolyzes peripheral peptide bond at the carboxyl terminal of polypeptide chain.

3. Absolute, high or substrate specificity

In this type of specificity, the enzyme acts only on one substrate e.g.

a) Uricase, which acts only on uric acid.
b) Arginase, which acts only on arginine.
c) Carbonic anhydrase, which acts only on carbonic acid.
d) Lactase, which acts on lactose.
e) Sucrase, which acts on sucrose.
f) Maltase, which acts on maltose.

4. Optical or stereo-specificity

In this type of specificity, the enzyme is specific not only to the substrate but also to its optical configuration e.g.

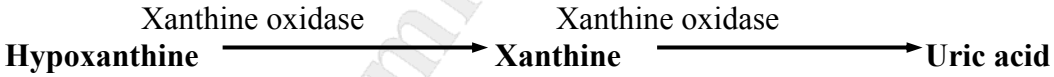
- **a.** L amino acid oxidase acts only on L amino acids.
- **b.** D amino acid oxidase acts only on D amino acids.
- **c.** α- glycosidase acts only on α- glycosidic bonds, which are present in starch, dextrin and glycogen.
- **d.** β- glycosidase acts only on β- glycosidic bonds that are present in cellulose.

N.B. We can digest glycogen and starch due to presence of α-glycosidase, but we can not digest cellulose due to the absence of β-glycosidase

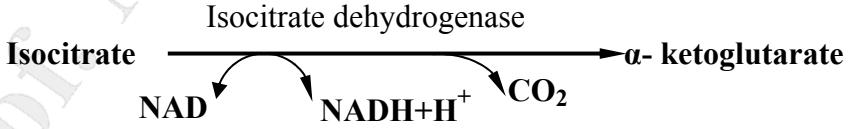
5. Dual specificity

There are two types of dual specificity:

A- The enzyme may act on two substrates by one reaction type. e.g. xanthine oxidase enzyme acts on xanthine and hypoxanthine (two substrates) by oxidation (one reaction type).



B- The enzyme may act on one substrate by two different reaction types e.g. isocitrate dehydrogenase enzyme acts on isocitrate (one substrate) by oxidation followed by decarboxylation (two different reaction types).



Factors Affecting the Rate of Enzyme Action

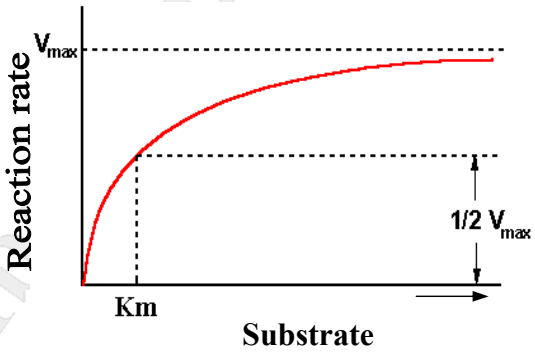
1. Effect of enzyme concentration

The rate of enzyme action is directly proportional to the concentration of enzyme provided that the condition of the reaction remains constant and sufficient substrate is supplied.

2. Effect of substrate concentration

The rate of reaction increases as the substrate concentration increases until a certain point (Vmax) at which the reaction attains maximal velocity.

Any increase in substrate concentration after this point does not cause further increase in the rate of the reaction because at Vmax enzyme molecules are completely saturated with substrate molecules.



The substrate concentration that causes the reaction to proceed at its half maximal velocity (1/2 Vmax) is called Michaelis constant (Km).

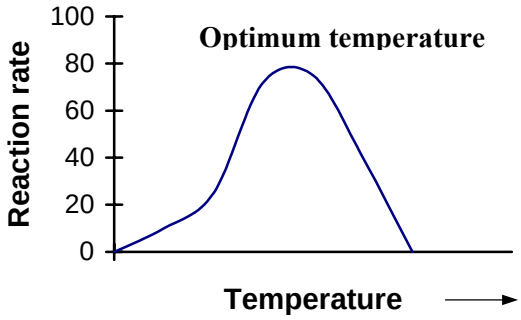
Enzymes that have low Km have high affinity to the substrate and act at maximal velocity at low substrate concentration e.g. hexokinase enzyme that acts on glucose in the fasting state (low glucose concentration).

Enzymes with high Km have low affinity to substrate and need high concentration of substrates e.g. glucokinase which needs high concentration of glucose so it acts maximally in the fed state.

3. Effect of temperature

At very low temperature, enzymes are inactive.

Enzyme activity increases gradually with the rise in temperature until a temperature at which the enzyme attains its maximal activity, this temperature is called optimum temperature, which lies between 37 – 40 °C in humans.



Optimum temperature is the temperature at which the enzyme attains its maximal activity.

The rise in temperature from low temperature to optimum temperature causes an increase in the rate of reaction due to:

a. The rise in temperature increases the initial energy of substrate leading to a decrease in the activation energy and lower the energy barrier of the reaction.

b. Also, the rise in temperature increases collision of the molecules i.e. more molecules become in the bond forming or bond breaking distance.

The rise in temperature above the optimum temperature leads to a decrease in the rate of enzyme activity.

At higher temperature (60 – 65 °C in humans) irreversible loss of enzyme activity occurs due to denaturation of the enzymes, which are protein in nature.

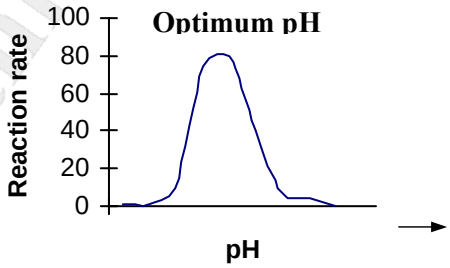
4. Effect of pH

Each enzyme has an optimum pH at which it attains its maximal activity e.g.

a. Optimum pH of pepsin is 1.5 – 2 (acidic).

b. Optimum pH of pancreatic lipase is 7.5 – 8 (alkaline).

c. Optimum pH of salivary amylase is 6.8 (slightly acidic).



Any change of pH below or above the optimum pH decreases the rate of enzyme action due to:

a. Changes in pH lead to changes in the ionization state of the substrate or the enzyme or both.

b. Also, extreme changes in pH lead to denaturation of the enzyme that is protein in nature.

5. Effect of time

At the beginning, the rate of reaction increases but by time the rate of reaction decreases due to:

a. Depletion of substrate.

b. Accumulation of end products.

c. Change in pH of the reaction, which becomes different from the optimum pH of the enzyme.

6. Concentration of coenzymes

In the conjugated protein enzymes that need coenzymes, the increase in the coenzyme concentration causes an increase in the rate of enzyme action.

7. Concentration of metal ion activators

The increase in metal ion activators increases the rate of enzyme action. Many enzymes are activated by metal ions e.g.

a. Chloride ions activate salivary amylase.

b. Calcium ions activate thrombokinase enzyme.

8. Presence of inhibitors

Inhibitors decrease or even abolish enzyme activity.

Enzyme inhibitors may be:

a. Competitive inhibitors

b. Noncompetitive inhibitors