Chap 3 (Enzymes) F.Sc 1st Year Biology

Chapter 3: Enzymes

Life would not be possible without metabolic activities of the cell. This in turn is depends upon the Catalytic molecules called the enzymes. With-out enzymes, the dynamic, steady state of the cell would cease to exist. Life to a complex mesh work involving a perfect co-ordination of a vast majority of chemical reactions. Some of these reactions result in synthesizing large molecules, others in cleaving large molecules and still others either utilize energy or liberate energy. All these reactions would occur very slowly at low temperature and atmospheric pressures, the conditions under which living cells carry on their life proteases. But in the living system these reactions proceed at extremely high rates. This is due to the presence of some specialised substances or Biocatalysts which are synthesized inside the living cells. These biocatalysts are called

enzymes (Gr: En = in; zyme = yeast). The term 'enzyme' was coined by Friedrich Wilhelm Kuhne (1878). Enzymes may be defined as organic substances capable of catalysing specific chemical reactions in the living system. Just a few years ago, it was considered that all enzymes were proteins. During the 1980s, however, Thomas Cech and Sidney Altman discovered that certain molecules of ribonucleic acid also function as enzymes. These molecules are called ribozymes; which catalyze reactions involved in processing genetic information to be used by a cell. But generally enzymes are proteinaceous in nature.

Energy of Activation

The questions arise here, how enzymes are able to accomplish such effective catalysis and why thermodynamically favourable reactions do not proceed on their own at relatively rapid rates in the absence of enzyme? Chemical transformation requires that certain covalent bonds be broken within the reactants. To do so the reactants must contain sufficient kinetic energy (energy of motion) to overcome a barrier called Energy of activation or Activation energy. The important role played by the enzymes during reactions is that they lower the activation energy of the reaction. The enzyme reacts with the energy rich and energy poor molecules to form an intermediate complex. This complex again breaks into product and enzyme. If activation energy of this complex is low, many molecules can participate in reaction. In this way activation energy is lowered by the enzyme but in this action equilibrium (ratio of concentration of reactant and product) is never altered, it remains the same.

Characteristics of Enzyme

Enzymes are biocatalysts produced in the protoplasm. They are synthesized in the cell. The basic properties of enzymes are:

- Most of the enzymes are proteinaceous in nature. They are macromolecules of globular proteins with higher molecular weight. They may entirely consist of protein e.g. amylase or pepsin or may contain, along with protein, a non-protein part. E.g. holoenzyme.
- They react with both acidic and alkaline substances due to the presence of protein as their major part.
- Enzymes generally act within the living cell where they have been produced but sometimes they diffuse out of the cell and perform catalytic function out side the cell or in other cells. An enzyme which acts within the same cell is called intracellular enzymes or endoenzyme and the enzyme which acts outside the cell is called exoenzyme.
- They are specific in their nature and their action.
- Their molecules are much greater in size than the substrate.
- They have particular sites to react with the substrates called active site.
- They are biocatalyst, which speed up the rate of reaction. They are required in very small quantities which are capable of bringing about a change in large amounts of substrates.
- Enzyme activities can be accelerated by certain ions or salts called activators e.g. Mn, Ni, Mg, Cl, etc. ix) Enzymes activities can be inhibited by certain factors called inhibitors e.g. substrate concentration, enzyme concentration, pH.
- They are heat sensitive i.e. they are thermolabile and pH sensitive i.e. they work on specific pH.
- They remain chemically unchanged during and after the chemical reactions.

(Short Questions Answers)

Why Competitive inhibitors are unable to make product.

Because they are not able to activate the catalytic sites.

Differentiate between activator and prosthetic group.

Some enzymes use metal-ions as co-factors like Mg2+, Fe2+, Cu2+ & Zn2+ etc. The detachable co-factor is known as an activator if it is an inorganic ion. If on-protein part is covalently bonded to enzyme, it is known as a prosthetic group e.g., FAD, FMN, haem.

Write basic difference between lock and key model, and induced fit model of enzyme action.

According to Lock and key model, there is no modification or flexibility in the active site of enzyme before, during or after the enzyme action. However, in induced fit model, a slight change occurs in the structure of enzyme during the action.

Why enzymes are denatured at high temperature.

Enzymes, are proteins which cannot maintain their structure at high temperature so they are denatured.

Differentiate between apoenzyme and prosthetic group.

An enzyme with its coenzyme, or prosthetic group, removed is designated as apoenzyme. If the non-protein part is covalently bonded to .enzyme, it is known as a prosthetic group e.g., FAD, FMN, haem.

How does low and high temperature affect enzyme activities? or Write the effect of temperature on enzyme action.

All enzymes can work at their maximum rate at a specific temperature called as optimum temperature. At low temperature the rate of reaction will be slow and with increase in temperature the rate of enzyme activity will increase up to a limit. High temperatures may denature or break down globular structure of the enzyme.

Differentiate between apoenzyme and holoenzyme.

An enzyme with its coenzyme, or prosthetic group, removed is designated as apoenzyme while an activated enzyme consisting of polypeptide chain and a cofactor is known as holoenzyme.

Write down any four characteristics of enzymes.

- The enzymes are globular proteins.
- They increase the rate of reaction without any damage to them.
- An enzyme can speed up the chemical reaction even in small amount.
- They are highly specific in their action. Usually a single enzyme catalyzes only a single substrate or a group of related substrates.

What is difference between pepsin and pepsinogen?

Pepsin is an enzyme that breaks down proteins into smaller peptides. Pepsinogen is an inactivated form of pepsin which is released by the chief cells in the stomach wall, and upon mixing with the hydrochloric acid of the gastric juice, pepsinogen activates to become pepsin.

Describe. lock and key model of enzyme action or What do you know about lock and key model?

A Lock and Key model was proposed by Emil Fischer (1890). It visualizes substrate and enzyme interaction. A specific enzyme can transform only one substrate into products(s) just like a special key which can open only a specific lock. The active site is a rigid structure in this model. There is no modification or flexibility in the active site before, during or after the enzyme action. Active site is used only as a template.

At high substrate concentration, rate of reaction does not increase. Give reason.

This is because all the active sites of the enzyme are occupied by high substrate concentration and further increase in the substrate does not increase the reaction rate.

Give effect of pH on enzyme action. or What is the effect of changed pH on the working of enzymes?

A slight change in pH can change the ionization of the amino acids at the active site. A change in PH may also affect the ionization of the substrates. Under these changed conditions enzyme activity is either retarded or blocked completely. Extreme changes in pH cause the bonds in the enzyme to break, resulting in the enzyme denaturation.

How substrate concentration affects rate of enzyme action?

If substrate concentration is low, the reaction rate is directly proportional to the substrate available. If the amount of substrate is increased at constant enzyme concentration, a point is reached when a further increase in the substrate does not increase the rate of the reaction anymore. This is because all the active sites of the enzyme are occupied by high substrate concentration and further increase in the substrate does not increase the reaction rate.

Define feedback inhibition of enzyme with diagram.

A cellular control mechanism in which an enzyme that catalyzes the production of a particular, substance in the cell is inhibited when that substance has accumulated to a certain level, thereby balancing the amount provided with the amount needed.

Feedback inhibition Initial substrate intermediate substances Enzyme Enzyme Enzyme Enzyme Final product Precursor activation.

Differentiate between activator and coenzyme.

The detachable co-factor is known as an activator if it is an in janic ion e.g. Mg2+, Fe2+, Cu2+ & Zn2+ etc. If non-protein part is loosely attached to the protein part or enzyme it is known as coenzyme.