5.1 Metabolism

Metabolism

- Metabolism refers to dall chemical reactions that occur in a living organism.
- The processes in metabolism involve the conversion of food into energy in the form of ATP, and the formation of carbohydrate, protein, lipid and nucleic acid.

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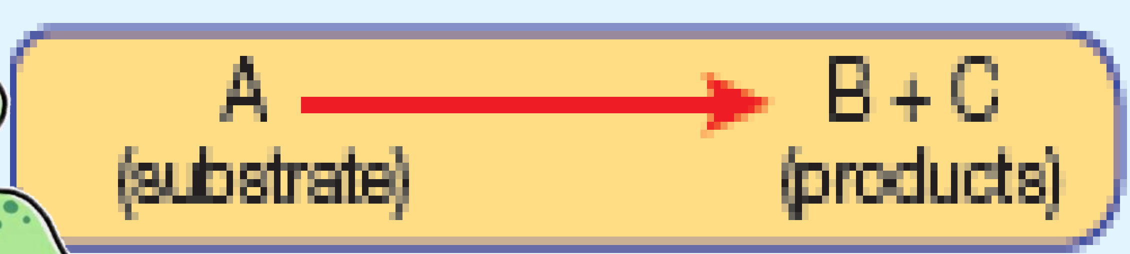
Types of metabolism in a cell

- There are two types of metabolism, which are catabolism and anabolism.
- Catabolism is the process of breaking down complex substances into simple substances. This reaction releases energy
- For example, the breakdown of glucose during cellular respiration to generate energy.

Catabolism



Anabolism

$$\underset{\text{(substrate)}}{A + B} \longrightarrow \underset{\text{(product)}}{C}$$

- Anabolism is the process of synthesising complex molecules from simple molecules.
- This reaction uses or absorbs energy..
- For example, the formation of glucose during photosynthesis.

5.2 ENZYME

- In a cell, biochemical reactions occur at a high rate to protect the living processes.
- In a cell, biochemical reactions occur at a high rate to protect the living processes.
- An enzyme is an organic catalyst that is mostly made up of proteins and is produced by living cell organisms
- However, not all enzymes are synthesised from proteins
- The substances needed for an enzyme reaction are called substrates.
- Substrates will bind with enzymes at a specific site known as the active site and form an enzyme-substrate complex

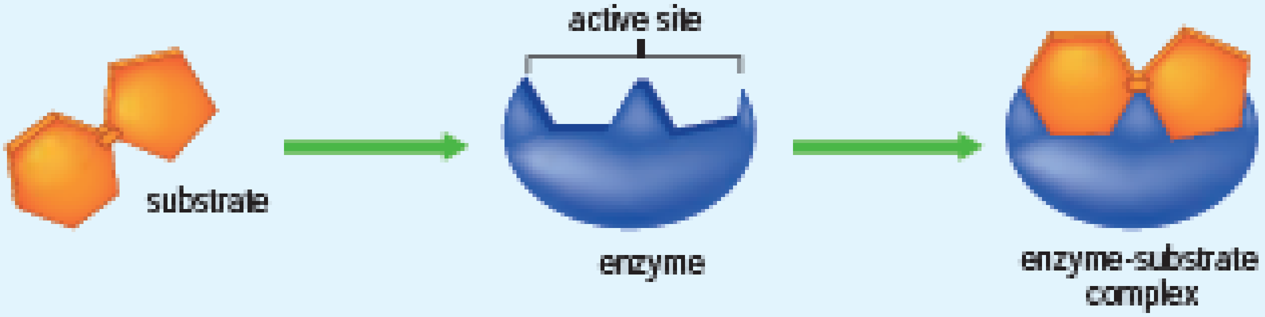


FIGURE 5.1 Formation of an enzyme-substrate complex

ENZYME NOMENCLATURE

- In the 1960s, The International Union of Biochemistry and Molecular Biology (IUBMB) introduced the enzyme nomenclature based on the substrate or reaction it catalyses
- The name of the enzyme is derived by adding '-ase' to the name of the substrate it catalyses.
- An example of the '-ase' added to substrate is the lactase enzyme, which catalyses the hydrolysis of lactose. An example of the '-ase' added to substrate is the lactase enzyme, which catalyses the hydrolysis of lactose
- examples are: trypsin, pepsin, and renin..

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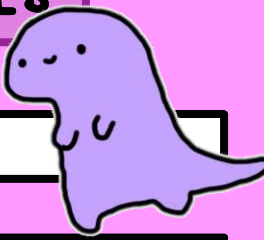
Lactose + water $\xrightarrow{\text{Lactase}}$ Glucose + galactose

GENERAL CHARACTERISTICS OF ENZYMES



- Enzymes act rapidly.
- Enzymes are only required in small quantities and ar reusable
- The structure of enzymes remain unchanged and are not destroyed after a reaction.
- The reaction of enzymes are specific. Only substrate that fit the form completely with an enzyme in an active site can combine
- Most of the reactions catalysed by enzymes are reversible
- Enzyme activity can be slowed down or stopped by enzyme inhibitors. An example of an inhibitor is heavy metal such as lead or mercury.
- Some enzymes need cofactors to work more efficiently. An example of a cofactor is vitamin B, and magnesium ion
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INTRACELLULAR AND EXTRACELLULAR ENZYMES

- Enzymes that are synthesised in a cell for its own use are called intracellular enzymes.
- For example, the hexokinase enzyme that is used in the glycolysis process during cellular respiration
- On the other hand, enzymes that are secreted outside the cell are known as extracellular enzymes.
- For example, the trypsin enzyme is produced by the pancreatic cells and secreted into the duodenum to break down polypeptides..

1 Ribosome is the site of protein synthesis.

2 Proteins synthesised by ribosome enter the lumen of the rough endoplasmic reticulum and are transported through it

3 Once it reaches the end of the rough endoplasmic reticulum, the membrane buds off to form transport vesicles.

4 The transport vesicle that contains proteins moves towards the Golgi apparatus and then fuses with it.

5 In the Golgi apparatus, the proteins are modified into enzymes and secreted in secretory vesicles that are formed from the tip of the Golgi apparatus.

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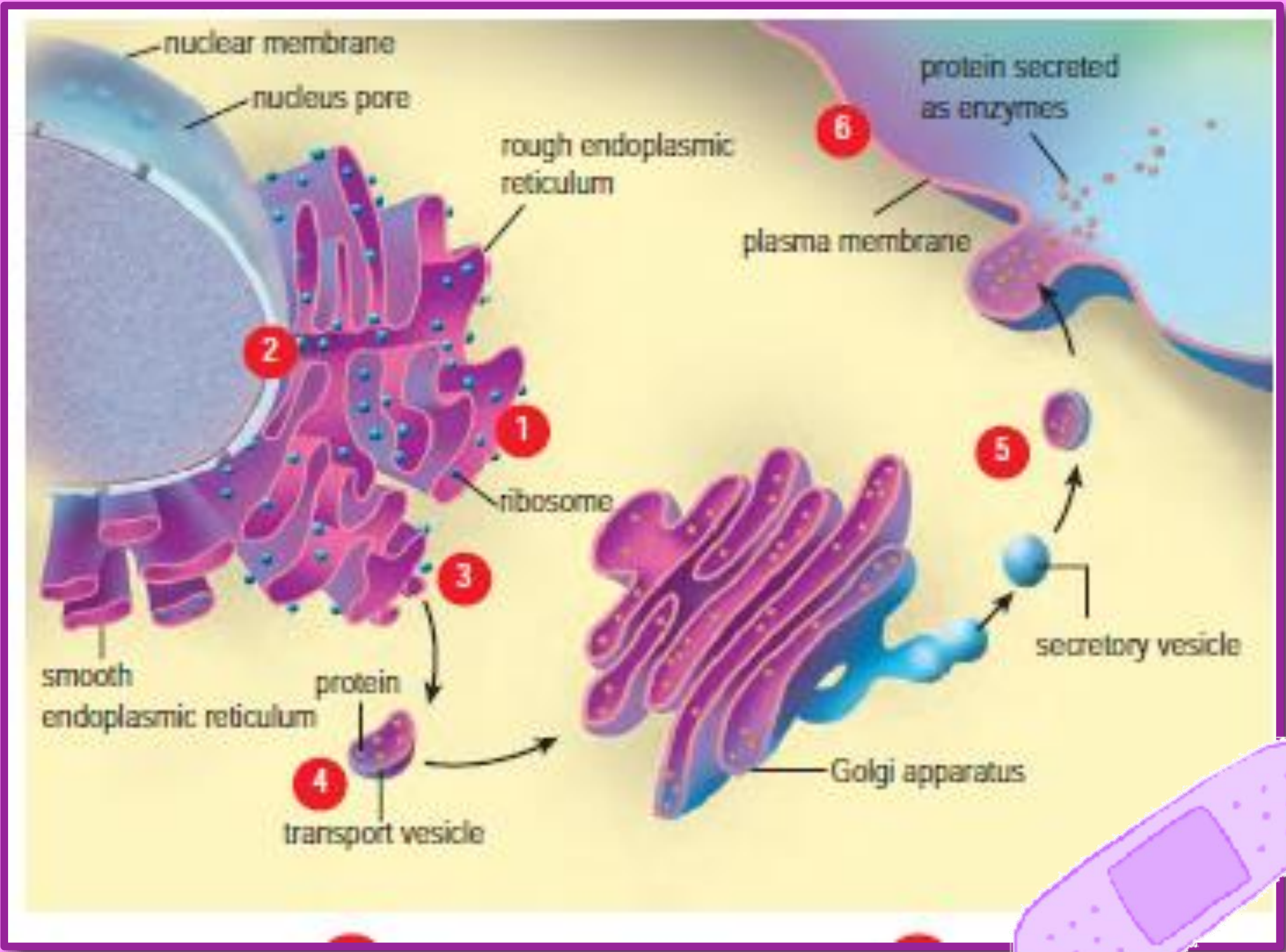

MECHANISM OF ENZYME ACTION

The 'Lock and Key' hypothesis

- Most enzymes are complex proteins made up of polypeptide chains that are folded into three-dimensional structures.
- This three-dimensional structure has an active site with a specific configuration that complements a specific substrate molecule.
- The binding of a molecule substrate on an active site of enzymes is specific like a 'lock and key' combination.

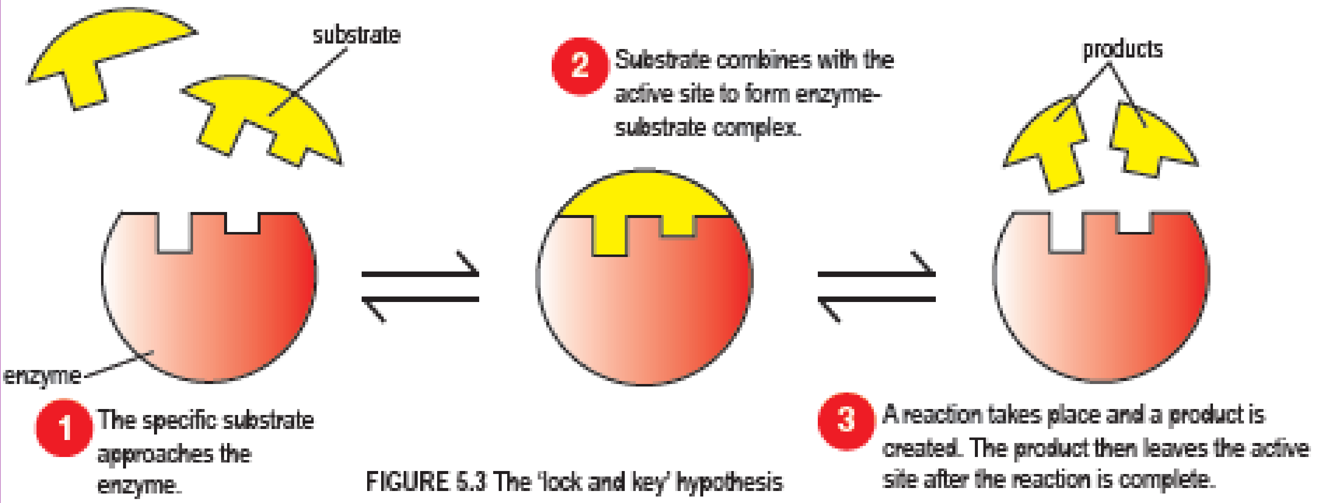

FIGURE 5.3 The 'lock and key' hypothesis

- Most reactions inside the cell require high activation energy
- Activation energy is the energy needed to break the bond in the substrate molecule before reaction can occur.
- Enzymes function by lowering the activation Energy
- By doing so, the rate of biochemical reactions in the cell is accelerated.

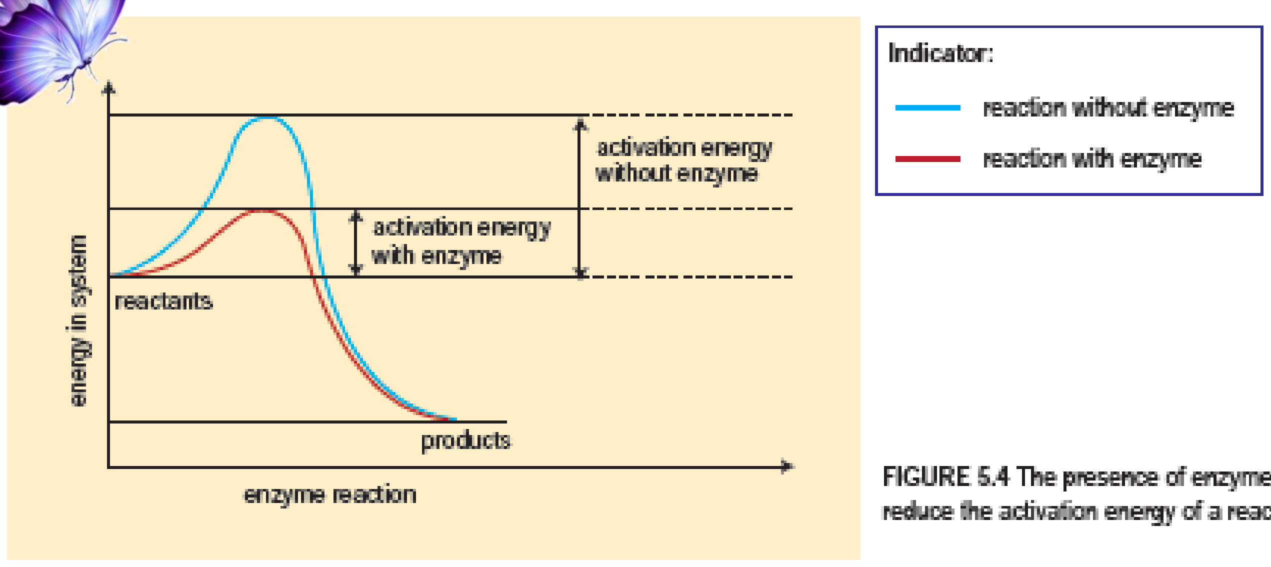

FIGURE 5.4 The presence of enzymes will reduce the activation energy of a reaction

THE MECHANISM OF ENZYME ACTION AND FACTOR CHANGES

- There are many factors that affect the mechanism of enzyme action. The chemical bond in enzymes can be easily transformed as a result of chemical changes and physical conditions
- Among these factors are temperature, pH, enzyme concentration and substrate concentration.

Effects of temperature

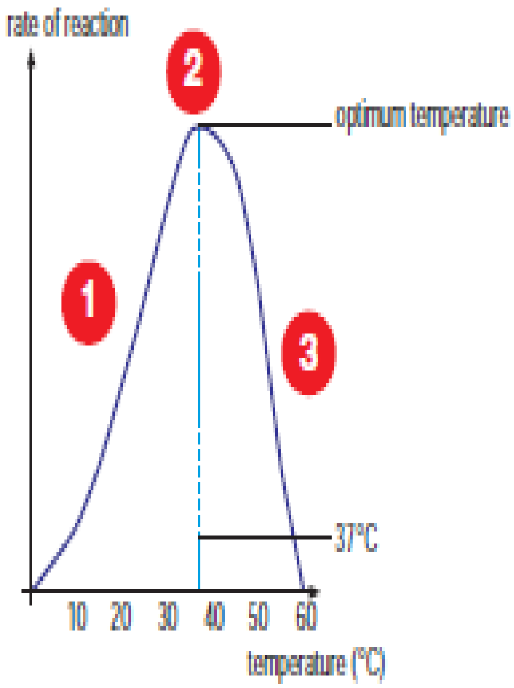

FIGURE 5.5 The effects of temperature on the reaction rate of an enzyme

1

- At a low temperature, the rate of reaction catalysed by enzymes is low.
- When the temperature rises, the kinetic energy of the substrate molecules and enzymes also increases. This increases the frequency of effective collision between the substrate molecules and enzyme molecules.
- The rate of reaction between enzymes and substrate molecules increases.
- With every rise in temperature of 10°C, the rate of reaction controlled by the enzymes will double until it reaches the optimal temperature

2

At optimal temperature, the enzyme reaction is at it maximum. The optimal temperature for enzym reactions in the human body is around 37°C.

3

- After reaching the optimal temperature, any further increase in temperature will reduce the enzyme activity rapidly until it stops at 60°C.
- At this temperature, the enzymes become denatured as the chemical bonds in the enzyme molecules break at extreme temperatures.
- The enzymes are unable to retain the three-dimensional form. The active site of enzymes changes. The substrate does not complement the active site of enzymes.

Effects of PH

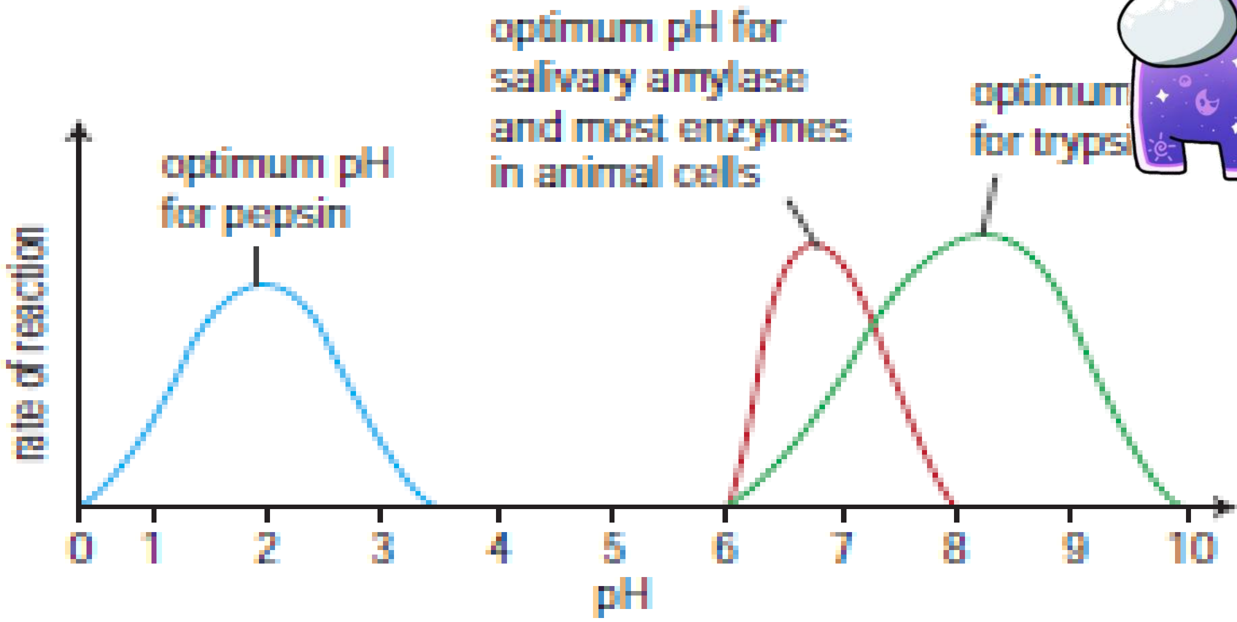

FIGURE 5.6 The effect of pH on the enzyme activities of pepsin, salivary amylase and trypsin

- The enzyme activity is influenced by the pH of the surrounding solution. Generally, all enzymes react most effectively at their optimal pH.
- Most enzymes are most active in the range of between pH 6 and 8. For example, the salivary amylase works at pH 6.8.
- However, there are some exceptions . For example, the pepsin enzymes in the stomach act at the optimal pH range of between 1.5 and 2.5. The trypsin enzyme in the duodenum, on the other hand, only works well in an alkaline medium, at a pH of around 8.5
- The change in pH value changes the charge (ion H+) of the active site of enzymes and the substrate surface. As a result, the enzymesubstrate complex cannot be formed.
- When the pH of the environment returns to the optimum level, the charge on the active site will be restored. The enzyme will return to function as normal.
- The extreme change in the pH value will break the structural chemistry bond and change the active site of enzymes. Denatured enzyme

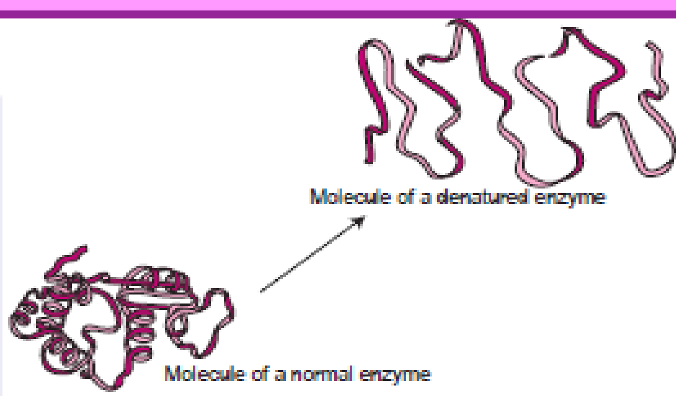

FIGURE 5.7 Molecule of a denatured enzyme

The effect of substrate concentration

If the concentration of enzymes is fixed while the concentration of substrate is increased, the reaction rate controlled by enzymes will also increase, leading to an increase in products created

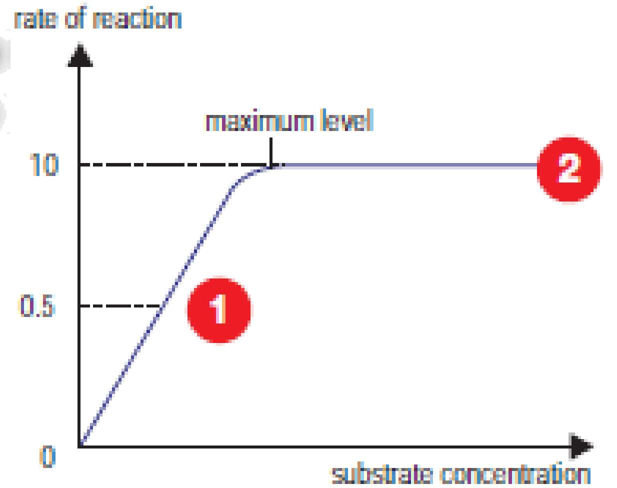

FIGURE 5.8 The effect of substrate concentration on the rate of enzyme reaction

1

- When substrate concentration increases, the opportunity for an effective collision between the substrate and enzyme molecules also increases.
- The reaction rate continues to increase until it reaches the maximum level. The rate of reaction is constant.

2

- At the maximum level, the concentration of enzymes becomes a limiting factor. The reaction rate can only increase when the concentration in enzymes increases.
- After reaching the maximum level, all active sites of enzymes are saturated with substrate and are involved in the catalytic reaction

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The effect of enzyme concentration

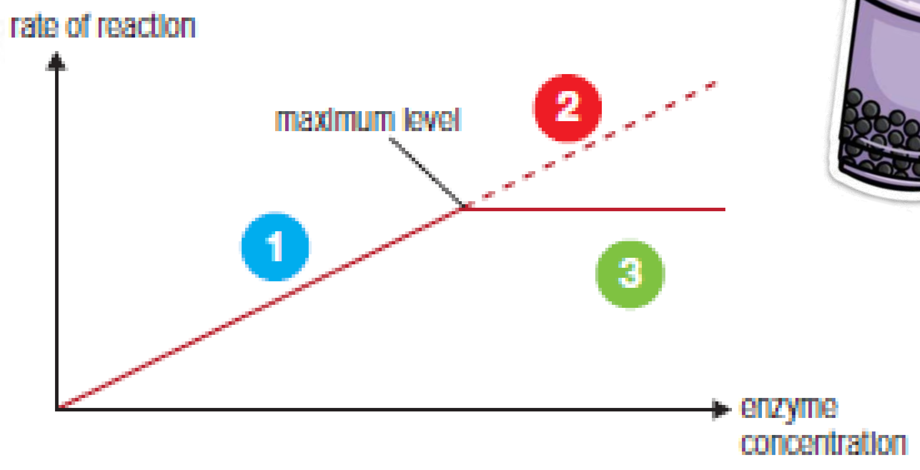

FIGURE 5.9 Effects of enzyme concentration on the enzyme reaction rate

When the concentration of enzyme increases, the rate of enzyme reaction will increase because of the presence of more active sites that are ready for catalytic action

1

2

If the concentration of an enzyme in one reaction is doubled, the amount of substrate converted to products per unit of time is also doubled with the condition that there is an excess supply of substrate

At the maximum rate, the concentration of the substrate becomes the limiting factor. The rate of reaction can only be increased by adding more substrate

3

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5.3 APPLICATION OF ENZYMES IN DAILY LIFE

APPLICATION OF ENZYMES IN DAILY LIFE

- Enzymes have long been widely used in the commercial sector and for everyday use.
- The enzymes used are extracted from natural resources such as bacteria or are produced synthetically.
- Immobilized enzymes are enzymes that combine with inert and insoluble substances to increase the resistance of enzymes towards change in factors such as pH and temperature.
- With this method, the enzyme molecules will remain in the same position throughout the catalytic reaction and then be separated easily from its product
- This technology is known as immobilized enzyme technology.
- This technology is used in various industrial applications

- Digestive enzymes are used in the medical sector
- Lactose Enzymes are used in lactose-free Milk
- Pectinase and cellulase enzymes are used in juice production
- Amylase, lipase, protease and cellulase enzymes in bio detergent
- Trypsin enzyme extracts fur from animal hide to make leather products
- Protease enzyme separates the fish skin

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