

Name: _____ () Class: _____ Date: _____

JURONG WEST SECONDARY SCHOOL
SCIENCE DEPARTMENT
SECONDARY THREE BIOLOGY

4. Enzymes

Learning Outcomes:

- e) explain the mode of action of enzymes in terms of an **active site**, **enzyme-substrate complex** and enzyme specificity using the 'lock and key' hypothesis
- f) investigate and explain the effects of **temperature** and **pH** on the rate of enzyme catalysed reactions

What are Enzymes?

Definition:

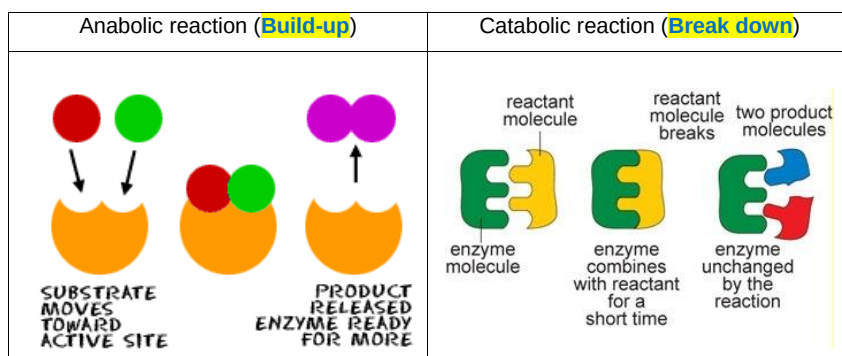
Enzymes are **proteins** that function as a **biological catalyst***.
They can **alter or speed up** chemical reactions.
They remain **chemically unchanged** at the end of the reaction.

What are catalysts*?

Catalysts are substances which **alter** (**speed up**) the **rate of chemical reaction** without itself being **chemically changed** at the end of the reaction.

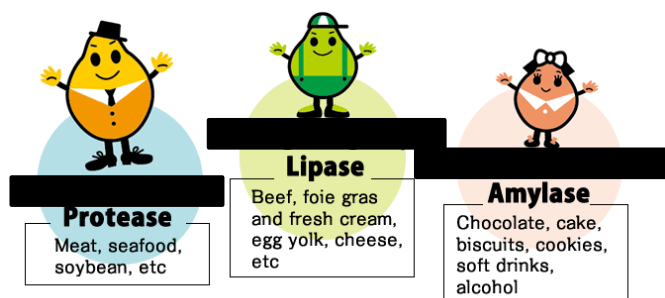
What reactions do Enzymes catalyse?

- Enzymes either **build up** (**anabolic** reactions) or **break down** (**catabolic** reactions) complex substances
- Enzymes can catalyse BOTH anabolic and catabolic reactions.



How are enzymes named and classified?

- Enzymes are named according to a scientific system.
- The name of each enzyme:
 - Shows the substance on which the enzyme acts; and
 - Ends in '**ase**'.
- For example, **Lipase** is an enzyme that acts on **lipids**



Enzymes are protein molecules

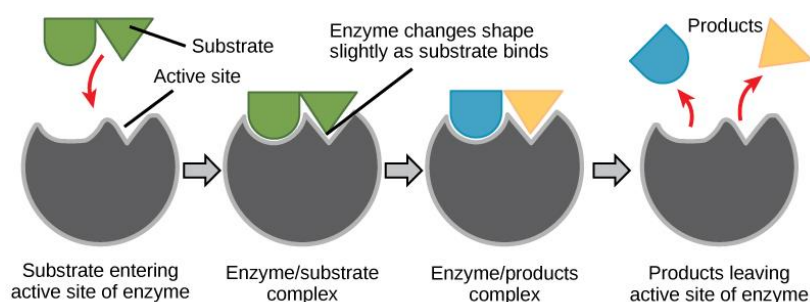
- They are made up of **amino acids** bonded with **peptide bonds to form polypeptides**.
- A protein molecule is made up of one or more such polypeptide chain folded into a 3-dimensional shape.

Amino acids	Polypeptides	Proteins
The basic units of proteins. There are 20 different kinds of amino acids.	Amino acids joined together by peptide bonds form a long chain known as a polypeptide.	Proteins are formed when two or more polypeptide chains fold together to form a complex, three-dimensional molecule .

Characteristics of enzymes

1. Enzymes **alter** or **speed up** chemical reaction
2. Enzymes are required in **minute (small)** amounts
 - Enzymes remained **unchanged** in the reactions they catalyse
 - Can be used repeatedly
 - Small amounts of enzyme can catalyse a large number of chemical reactions
3. Enzymes are **specific** in their actions
 - Each type of enzyme can only catalyse a **unique** chemical reaction.
 - E.g. **protease** can only break down **proteins** into polypeptides.
E.g. **Lipases** can act only on **lipids** and not proteins or carbohydrates
 - This **enzyme specificity** means that each chemical reaction is catalysed by a unique enzyme determined by its **unique 3-dimensional structure**

e) explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity using the 'lock and key' hypothesis



'Lock and Key' Hypothesis

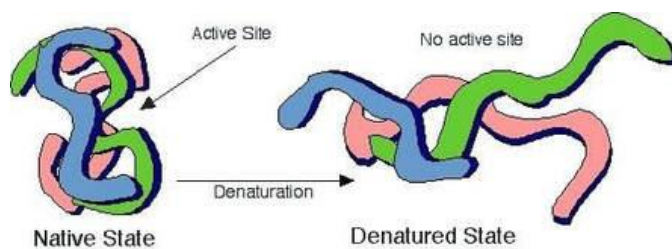
- 1) The enzyme is the "lock"
- 2) The substrate is the "key"
- 3) The **enzyme-substrate complex** forms when the **substrate** can fit into the **active site** of the **enzyme**. The substrate is said to be **complementary** to the active site.
- 4) When the substrate binds to the active site, a **chemical reaction** occurs. The substrate is converted into **products**.
- 5) Products leave the enzyme. Enzyme remains **chemically unchanged**, and is free to **take** part in the next reaction.

Explain using the 'lock-and-key' hypothesis the activity of pepsin.

Pepsin is an enzyme found in the stomach. In the presence of proteins, it converts proteins into polypeptides. Explain using the 'lock-and-key' hypothesis the activity of **pepsin** in the stomach.

What is Denaturation?

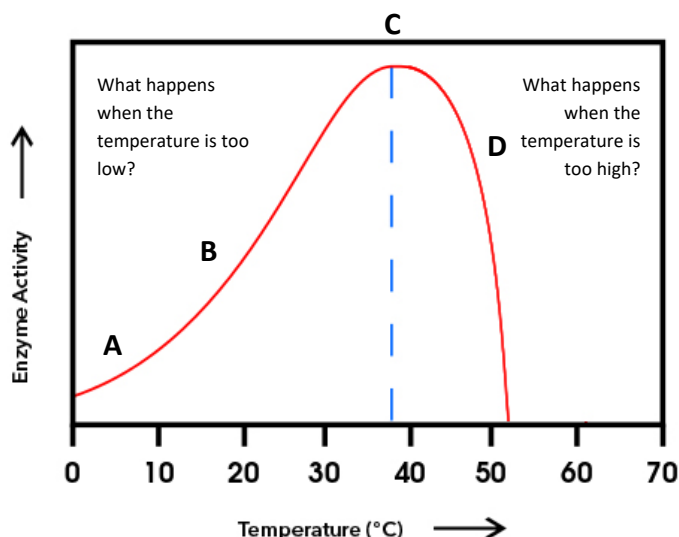
Denaturation is the **irreversible change** in the 3D structure of an enzyme or any soluble protein, caused by **heat or chemical** such as acids or alkalis.



- After denaturation, the **active site of an enzyme is destroyed**.
- Substrate molecules would be **unable to bind to the active site** as the substrate is no longer complementary to the active site.
- **No enzyme-substrate complexes** are formed, and no products are formed.

f) investigate and explain the effects of temperature and pH on the rate of enzyme catalysed reactions

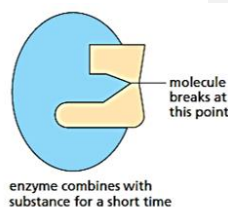
1. Enzymes are affected by temperature



Commented [PLX1]: <https://www.youtube.com/watch?v=loDEjeRZ0xE>

Commented [PLX2]: <https://biomanbio.com/HTML5GamesandLabs/LifeChemgames/enzymatichtml5page.html>

- At A: Enzymes are **inactive** at low temperature.
- At B:
 - As temperature increases, the amount of **kinetic energy** increases.
 - Enzyme and substrate molecules have a **higher rate of effective collision**.
 - That means, the chances of substrate fitting into the active site of the enzyme to form **enzyme substrate complex** increases.
 - More enzyme-substrate complexes** are formed.
 - More products are formed**. Therefore rate of reaction increases.
 - For every 10°C rise in temperature, the **rate of enzyme reaction is doubled**, until the **optimum temperature** is reached.
- At C: **Optimum temperature** is the temperature where the **enzyme activity is the fastest**.
- At D:
 - Beyond the optimum temperature, the rate of enzyme activity **rapidly decreases**.
 - Enzymes become **denatured**. Active site loses its shape
 - Substrate molecule could **no longer fit** into the active site of the enzyme.
 - Rate of reaction **decreases**.

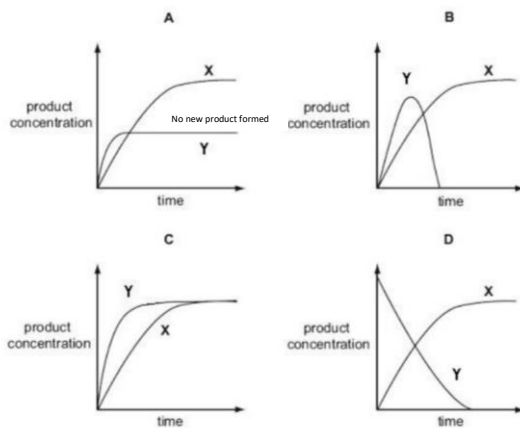


Pitstop 3: Explain the rate of activity of the enzyme with increasing temperature.

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Two enzyme experiments were carried out. The first experiment X was carried out at a constant temperature of 37°C. During the second experiment Y, the temperature was increased from 37°C to 80°C. The optimum temperature is 40°C.

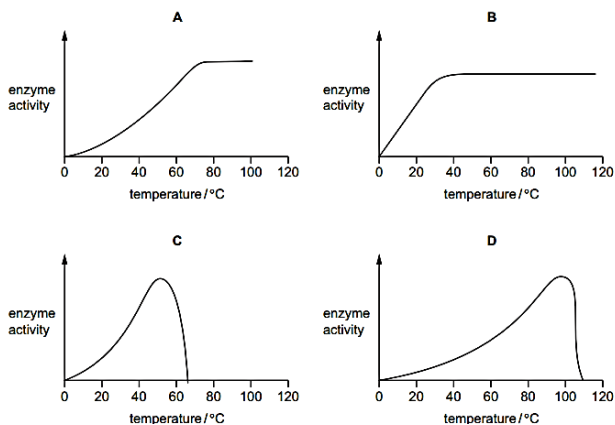
Which of the following graphs shows the results?



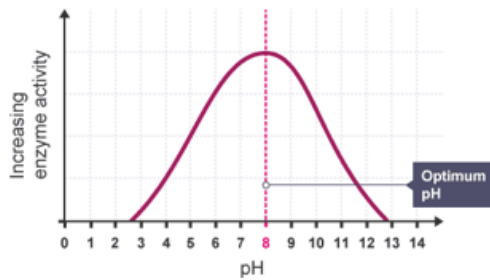
Pitstop 4:

- 4 A bacterium lives in hot springs at temperatures of 75°C to 85°C.

Which graph represents the activity of enzymes found in these bacteria?

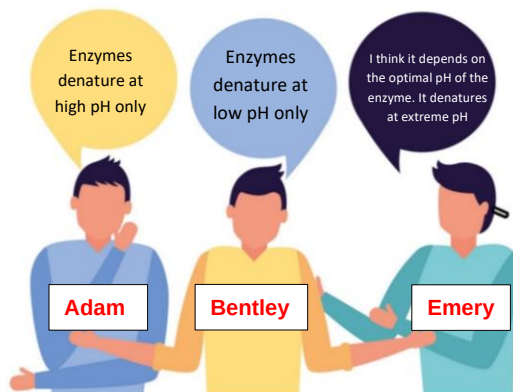


2. Enzymes are affected by pH



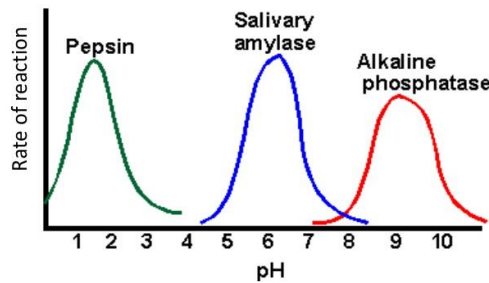
- Every enzyme has a particular pH range over which it works best. If this pH changes, the shape of the active site of the enzyme is changed, thus the substrate will not be able to fit into the active site, and the enzyme is said to be **denatured**.
- **Extreme changes in acidity or alkalinity** of the solutions **denature enzymes**.
[explanation for pH that is NOT at optimum pH]
 - o the rate of enzyme activity rapidly decreases.
 - o Enzymes become denatured. Active site loses its shape
 - o Substrate molecule could no longer fit into the active site of the enzyme.
 - o Rate of reaction decreases.
- Some enzymes work best in **acidic** medium while others function best in **alkaline** medium. Example, **pepsin** (protease found in **stomach**) has its **optimum** pH at 2.2 while **trypsin** (protease found in the **small intestine**) has its optimum pH of around **8**.

Who is correct? Why?



Emery is right. Enzymes only

Denature at extreme pH.



Using named example, describe the relationship between pH and rate of enzyme activity.

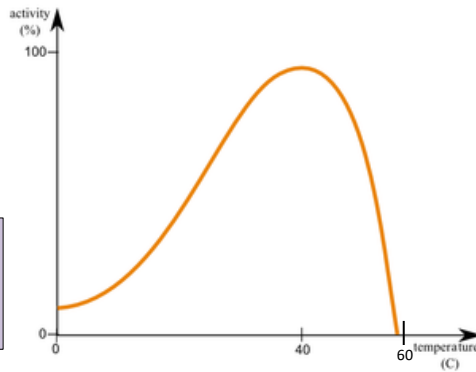
Pepsin works best at pH 2 OR the optimum pH of pepsin is 2.

At this pH, the rate of enzyme activity is the highest.

At pH below 2 or above 2, the rate of enzyme activity will decrease, because

Pepsin will denature at extreme pH, active site is lost. Protein cannot fit into the active site of pepsin, no products are formed.

The graph below shows the rate of an enzymatic activity against temperature of enzyme R.



Helpful
Tips

Read the command word of the question! If they ask for "Describe" then you don't have to explain ☺

- 1 **Describe** the shape of the graph as shown in the graph for enzyme R.
Enzymes are inactive at low temperatures. As temperature increases from 0°C, enzyme activity increases;

40 °C is the optimum temperature as the enzyme activity is the highest;

Beyond 40 °C, the rate of enzyme activity decreases drastically;

[3]

- 2 State another factor that will affect this reaction.
pH

[1]

- 3 The % activity for this enzyme at 60°C is 0.
Using the 'lock and key' hypothesis, **explain** this fact.
Enzyme is the lock, substrate is the key;

When the substrate binds to the active site, a chemical reaction occurs, enzyme-substrate complex is formed;

At 60 °C, the enzyme is denatured, the active site is lost and the substrate cannot fit into the active site and the enzyme activity is zero;

[4]