



**ABDUR REHMAN
BIOLOGY**

Biological molecules

4.1 Biological molecules

List the chemical elements that make up:

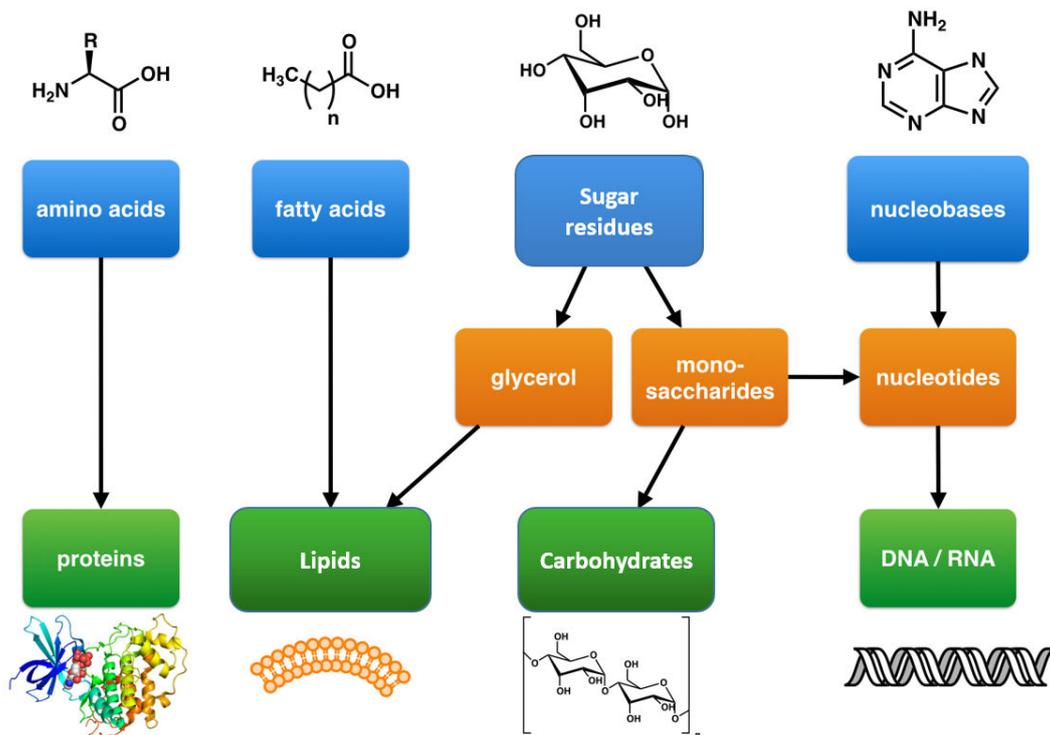
(a) carbohydrates

(b) lipids (fats and oils)

(c) proteins

(d) DNA

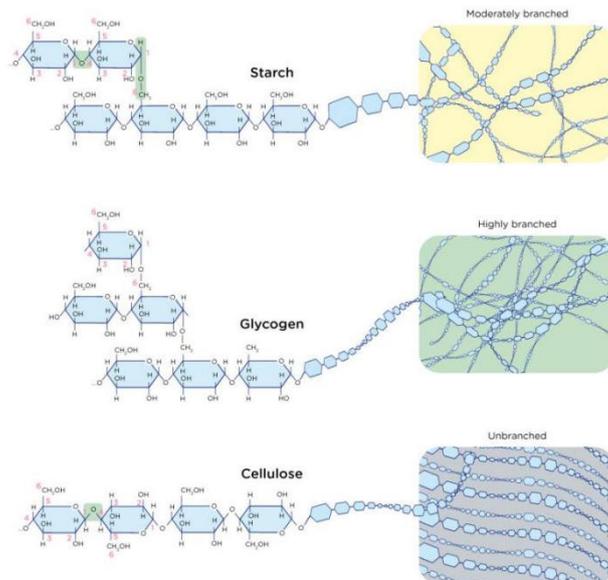
Sr. No.	Nutrients\Chemicals	Elements
1.	Carbohydrates	Carbon (C), Hydrogen (H), Oxygen (O)
2.	Proteins	Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), sometimes Sulphur (S) or Phosphorus (P)
3.	Lipids	Carbon (C), Hydrogen (H), Oxygen(O) but lower oxygen content as compared to carbohydrates.
4.	DNA	Carbon (C), Hydrogen (H), Oxygen(O) Sulphur (S) or Phosphorus (P)



State that large molecules are made from smaller molecules, limited to: starch, cellulose and glycogen from glucose; proteins from amino acids; lipids from fatty acids and glycerol; DNA from nucleotides.

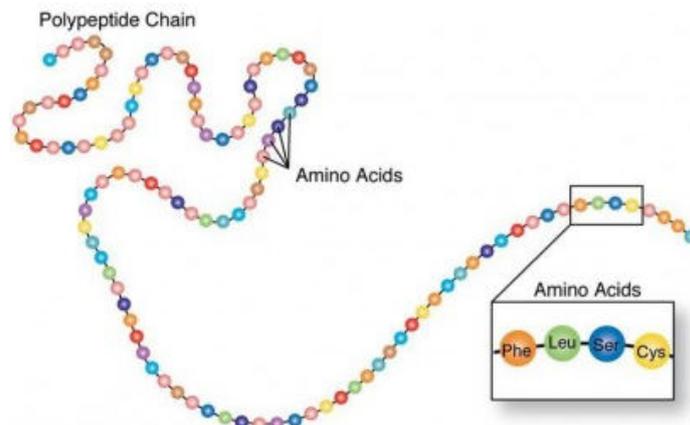
Carbohydrates

- Large molecules are made from smaller molecules through the process of polymerization.
- These smaller repeating sub units are called as monomers.
- Monomers join together through covalent bonds and result in the formation of large complex polymers.
- Glycogen is a large molecule (polysaccharide) made up of glucose molecules (monosaccharide). It is a food storage substance in many animal cells.
- The starch molecule (also a polysaccharide) is made up of hundreds of glucose molecules joined to make long chains. Starch is an important storage substance in plant cells.
- Cellulose (Polysaccharide) is made of even longer chain of glucose molecules. The molecules in the chain are grouped together to make microscopic fibers which are laid down in layers to make the cell wall in plant cells.
- Cellulose, Starch and Glycogen are insoluble in water.



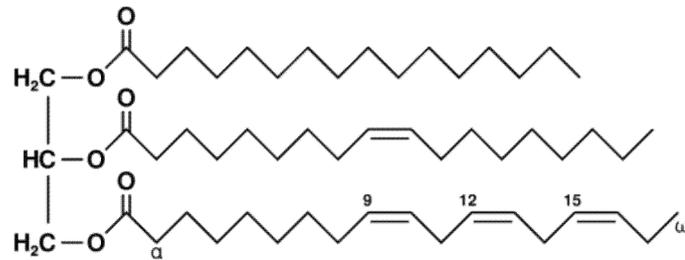
Proteins

- Proteins are formed from the polymerization of amino acids, which are linked together by peptide bonds. There are about 20 different types of amino acids in an animal protein. A small protein molecule can be made up from a chain consisting of a hundred or more amino acids.
- Each type of protein has its amino acids arranged in a special sequence.



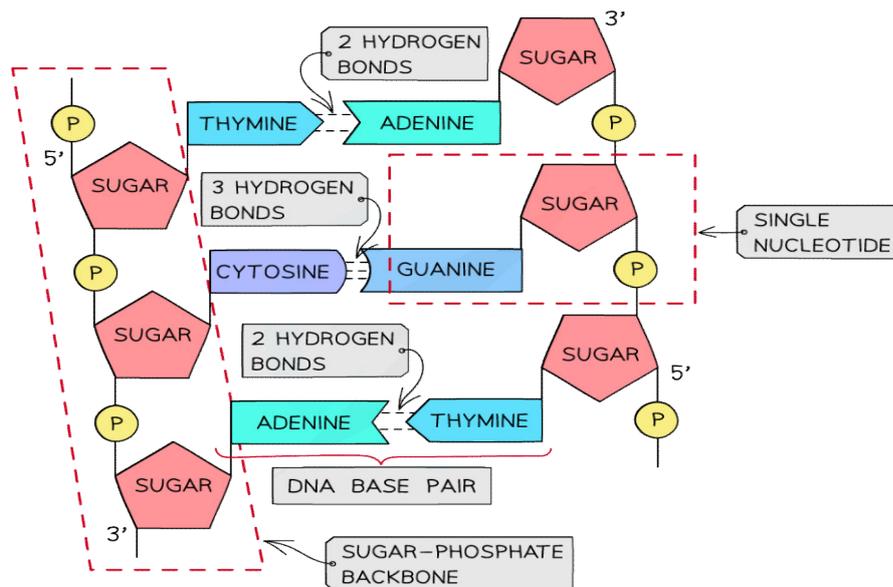
Lipids

- Lipids, such as fats and oils, are formed by the combination of fatty acids and glycerol molecules.
- A molecule of lipid is made up of 3 molecules of an organic acid called a fatty acid joined with one molecule of glycerol forming an ester bond. Droplets of lipids form a source of energy when stored in the cytoplasm.



DNA

- A DNA molecule consists of a 5-carbon sugar molecule joined to a phosphate group and an organic nitrogen base.
- These three join together to form a nucleotide.
- Accumulation of a large number of these nucleotides forms a DNA molecule.



Describe and be able to do chemical tests for:

(a) starch (iodine solution)

(b) glucose and maltose (Benedict's solution)

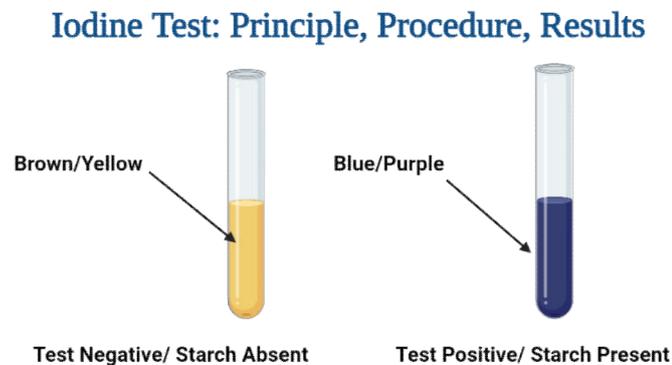
(c) protein (biuret test) (d) lipids (ethanol emulsion test)

Test for Starch (Iodine Solution)

- Shake a small amount of starch powder in a test tube with some warm water this will make a starch suspension.
- Add 3 or 4 drops of iodine solution in it.

Result

A blue color should be produced.

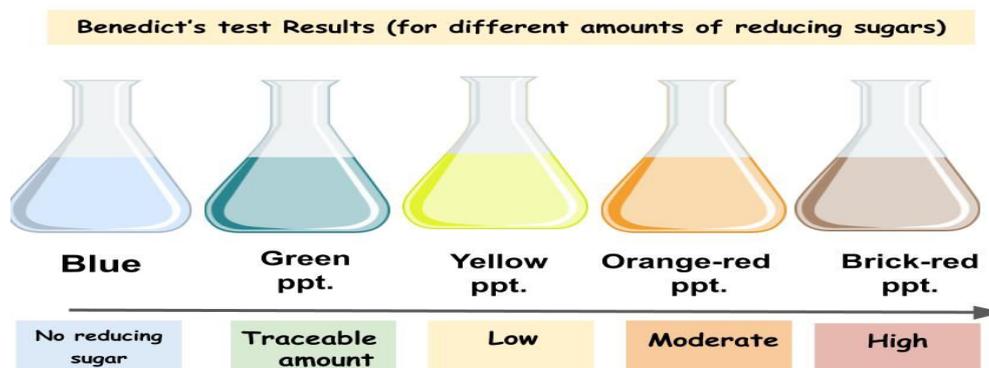


Test for reducing sugar (e.g. glucose, maltose)

- Heat 2cm³ of glucose solution with an equal volume of Benedict solution in a test tube.
- Place the test tube in a beaker of boiling water to heated or warm it in a water bath.

Result

The solution will change from clear Blue to cloudy green then yellow and finally to Red precipitate of copper oxide because glucose is a reducing sugar.



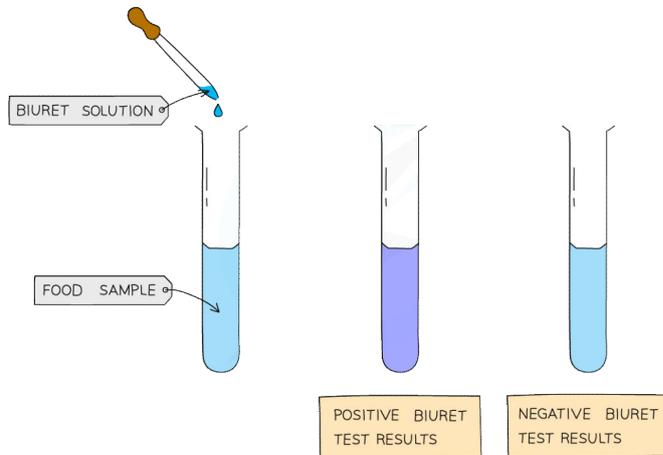
Test for protein (biuret test)

- Place 2cm³ of 1% albumin solution in a test tube.

- Add 2cm³ of dilute sodium hydroxide followed by 2cm³ of 1% copper sulphate solution.

Result.

A purple color indicates protein.



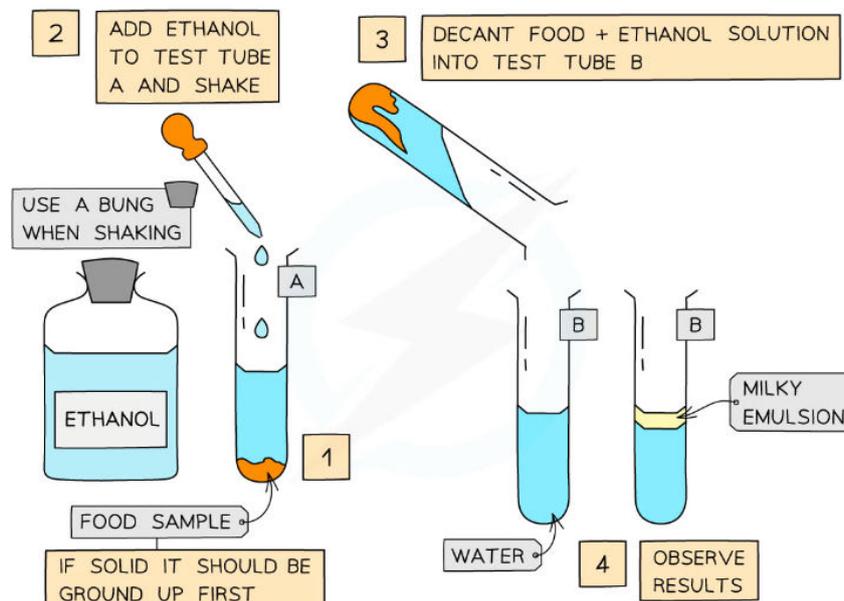
Test for lipid.

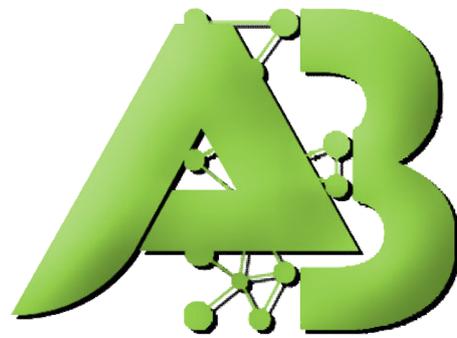
Shake 2 drops of cooking oil with about 5 cm³ ethanol in a dry test tube and till the lipid dissolves.

Pore this solution into a test tube containing a few cm³ of water.

Result.

Milky white emulsion will form.





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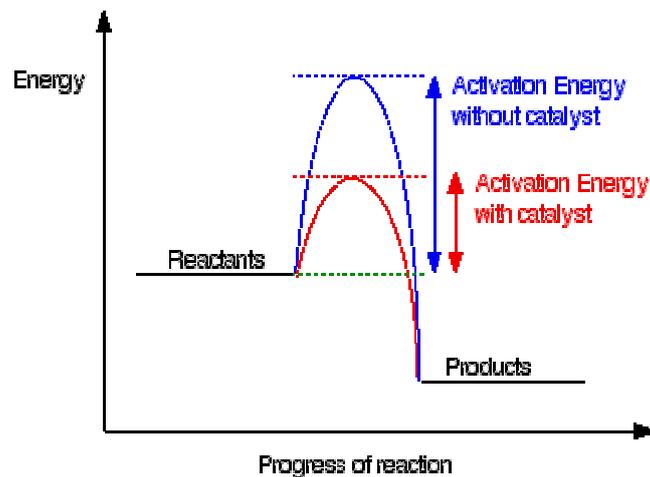
Enzymes

5.1 Enzyme action.

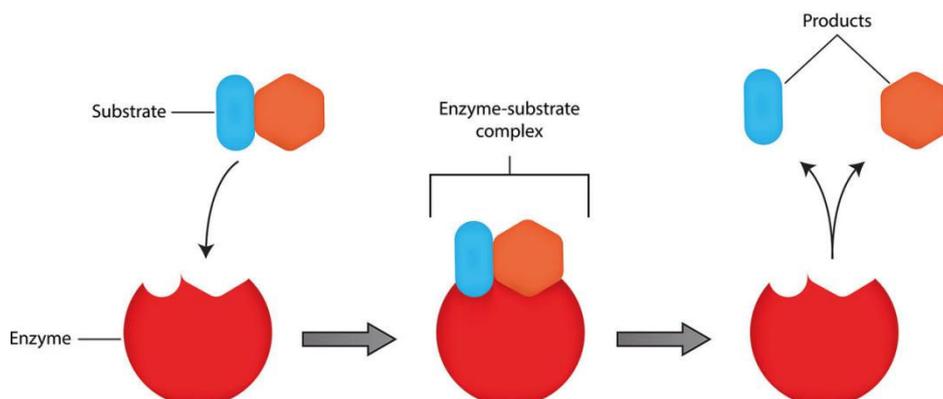
Describe a catalyst as a substance that increases the rate of a chemical reaction and is not changed by the reaction.

Describe enzymes as proteins that function as biological catalysts and are involved in all metabolic reactions.

Enzymes are proteins that function as biological catalysts and are involved in all metabolic reactions. A catalyst is a substance which increases the rate of a chemical reaction but it is not used up and remains chemically unchanged at the end. It functions by providing an alternative reaction pathway that has a lower activation energy compared to the uncatalyzed reaction. This lowered energy barrier enables the reactant molecules to more easily overcome the necessary energy threshold for the reaction to occur. Catalysts do not get consumed or permanently depleted during the reaction process, allowing them to be used repeatedly, making them highly efficient and cost-effective.

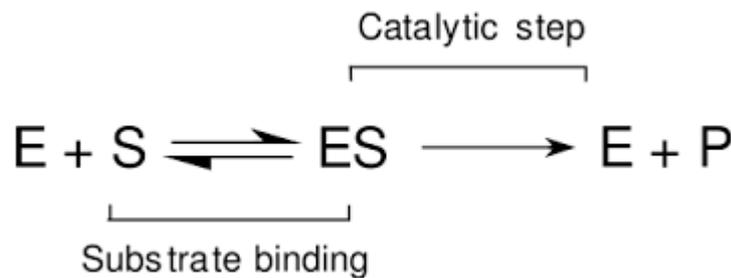


- Enzymes are proteins that acts as a biological catalyst facilitating and accelerating all chemical reactions within the living organism.
- Enzymes can be used repeatedly because they are not used up during the reaction.
- Only small amounts are needed to speed the reaction up.
- They play a fundamental role in all metabolic processes, including digestion, energy production, DNA replication, and synthesis of molecules necessary for cellular functions.



Explain enzyme action with reference to the substrate, active site, enzyme-substrate complex, and product.

An enzyme controlled reaction involves a substrate, an enzyme and a product. The substrate and product may be two or more different molecules.



Substrate

The molecule at the start of the reaction on which enzyme works.

Active Site

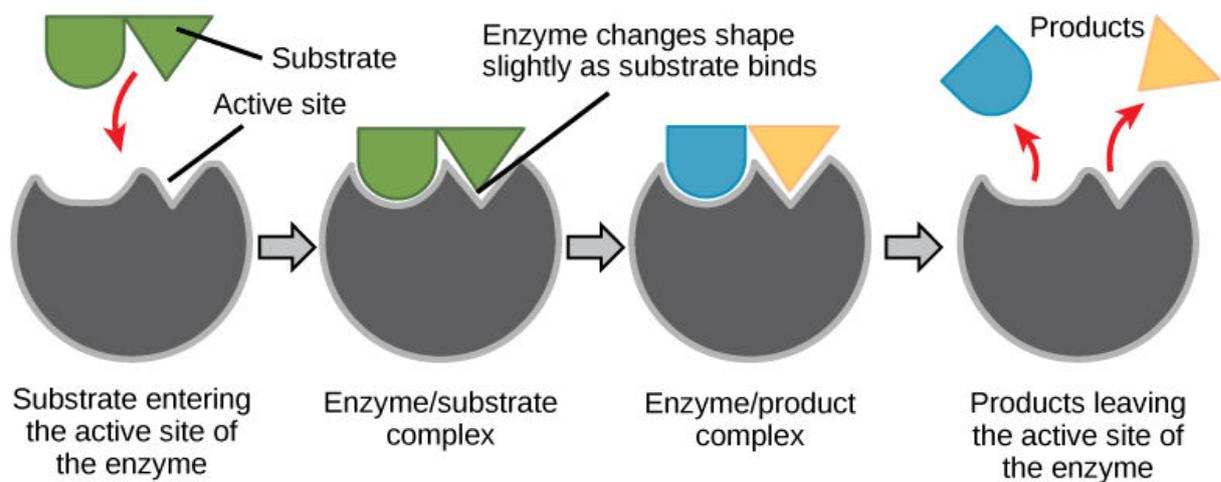
The 3-dimensional area or region where enzyme binds through various types of chemical bonds and initiates the reaction.

Enzyme-substrate complex

When an enzyme binds its substrate, it forms an enzyme-substrate complex. The enzyme-substrate complex is a temporary association that brings the substrate molecules into close proximity and enables the catalytic activity of the enzyme to act upon the substrate.

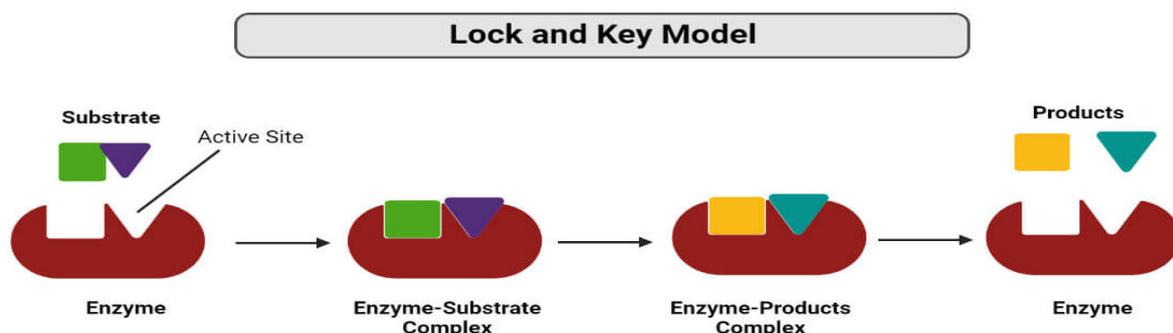
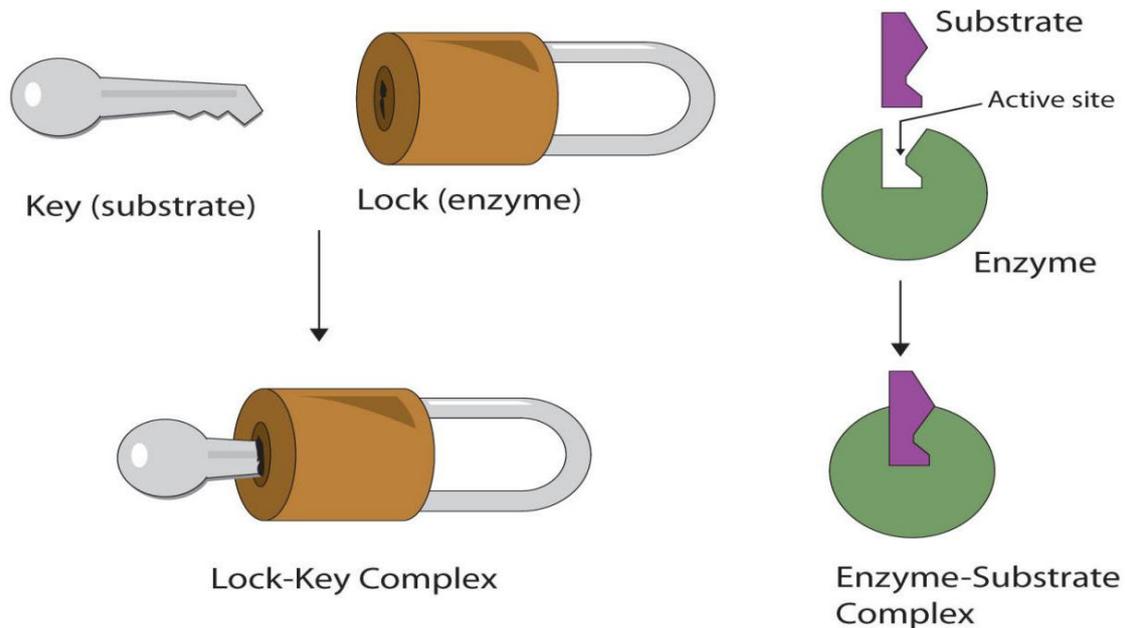
Product

The molecule that is produced by the chemical reaction catalyzed by the enzyme. Once the substrate is bound to enzyme, it converts it into product.



Explain the specificity of enzymes in terms of the complementary shape and fit of the active site with the substrate ('lock and key' hypothesis).

- Specification of an enzyme means that an enzyme will only work on one specific substrate and will not act on a different one. This is explained by the lock and key model hypothesis, which describes the relationship between the active site of an enzyme and its substrate.
- According to this hypothesis, the active site of an enzyme is a rigid structure which has a specific three-dimensional shape that is complementary to the shape of its substrate, much like a lock and key.
- According to this scenario enzyme is the lock and substrate is the key.
- The specificity of the active site is crucial for enzyme function because it ensures that only the appropriate substrate can bind and undergo catalysis.
- Enzymes have evolved to recognize and bind to specific substrates with high affinity while excluding other molecules that are structurally different.
- This specificity is essential for the efficiency and accuracy of enzymatic reactions within biological systems.



5.2 Effects of temperature and pH

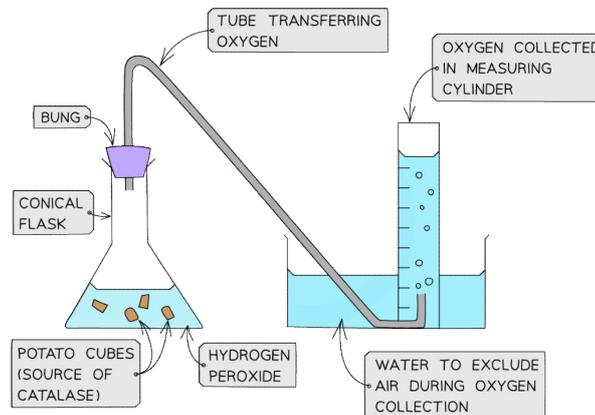
Understand that the progress of enzyme-catalysed reactions can be followed by measuring the concentrations of reactants and products.

The progress of enzyme catalysed reactions can be investigated by the following.

- Measuring the rate of formation of a product using catalase.
- Measuring the rate of parents of a substrate using amylase.

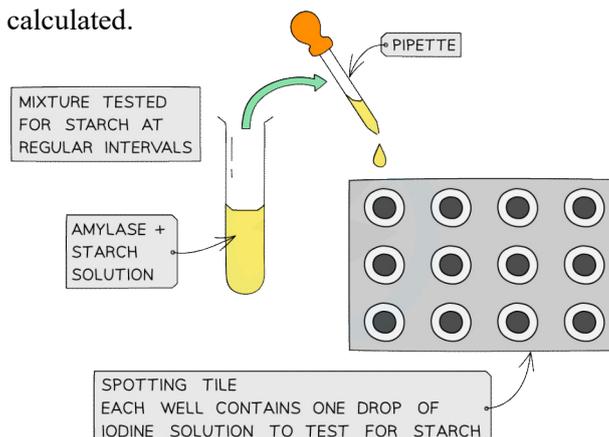
Catalase activity

- In this investigation the rate of product formation is used to measure the rate of enzyme controlled reaction.
- Hydrogen peroxide is common but toxic by-product of metabolism.
- It is broken down by an enzyme catalyst into water and oxygen.
- Hydrogen peroxide and catalase are combined and the volume of oxygen generated as a product is measured in a specific time.
- The rate of reaction can then be calculated.



Amylase activity

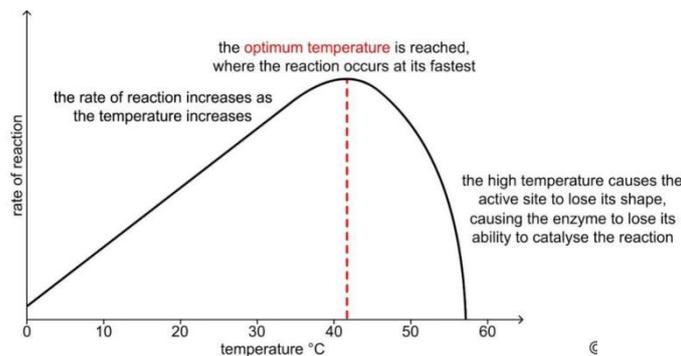
- In this investigation the rate of substrate disappearance is used to compare rates of reaction under different conditions.
- Amylase is a digestive enzyme that hydrolysis starch into maltose and glucose.
- Amylase and starch are combined and this reaction mixture is then tested for starch at regular time intervals.
- This can be done by taking samples from the reaction mixture at each time interval and adding each sample to some iodine in potassium iodide solution.
- In this way the time taken for starch to be broken down can be measured and the reaction time can be calculated.



Investigate and describe the effects of temperature and pH on enzyme activity. Explain the effect of changes in temperature and pH on enzyme activity in terms of kinetic energy, shape and fit, denaturation and the frequency of effective collisions.

Effects of Temperature

- Temperature directly affects the kinetic energy of molecules which in turn increases the enzyme collision with the substrate. Increased collision enhances the likelihood of effective collisions which facilitates the enzyme substrate complex formation up to a certain point.
- A rise of 10°C will double the rate of an enzyme-controlled reaction up to an **optimum temperature** of about 37°C. Above this optimum temperature the molecules gain excessive kinetic energy due to which the reaction will slow down.
- The protein molecules start to lose their shape at high temperature. The shape of active site changes and enzymes become **denatured**.
- Denaturation is a permanent change in the shape of the enzyme molecule.
- As a result although, there are more collisions due to high temperature and high kinetic energy of the molecules but the number of effective collision reduces.
- Substrate molecules cannot fit together with the with the enzyme hence stopping the reaction.
- The turning of egg white from a clear running liquid to a white solid due to heating is an example of this process.

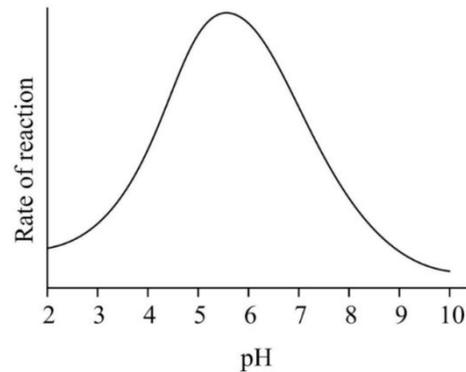


Experiment

- Use a plastic syringe to measure 5cm³ of 5% amylase solution and place 1cm³ in each of three test tubes labeled A,B, and C.
- Rinse the syringe thoroughly and use it to place 5cm³ of a 1% starch solution in each of the test tubes labeled 1,2 and 3.
- Using a dropping pipette, add six drops of dilute iodine solution to each of the tubes 1-3.
- Prepare three water baths by half filling beakers or jars. 1st beaker is filled with Ice and water. Keep adding eyes during the experiment to keep the temperature at about 10°C.
- Add water from the cold tap at about 20 °C in the 2nd beaker.
- Add warm water at about 35°C in the 3rd beaker. Please tubes one and A in the cold water bath, tubes 2 and B in the water bath at 20°C and tubes 3 and C in the warm water.
- Leave the beakers for 5 minutes to reach the temperature of the water they are each in.
- After 5 minutes, take the temperature of each water bath, then pour the amylase from tube A into the starch solution in tube 1. Then put one back in the water bath.
- Repeat this with tubes 2 and B, and 3 and C
- As the amylase breaks down the starch, it will cause the blue color to disappear.
- Observe how long it takes in each case.

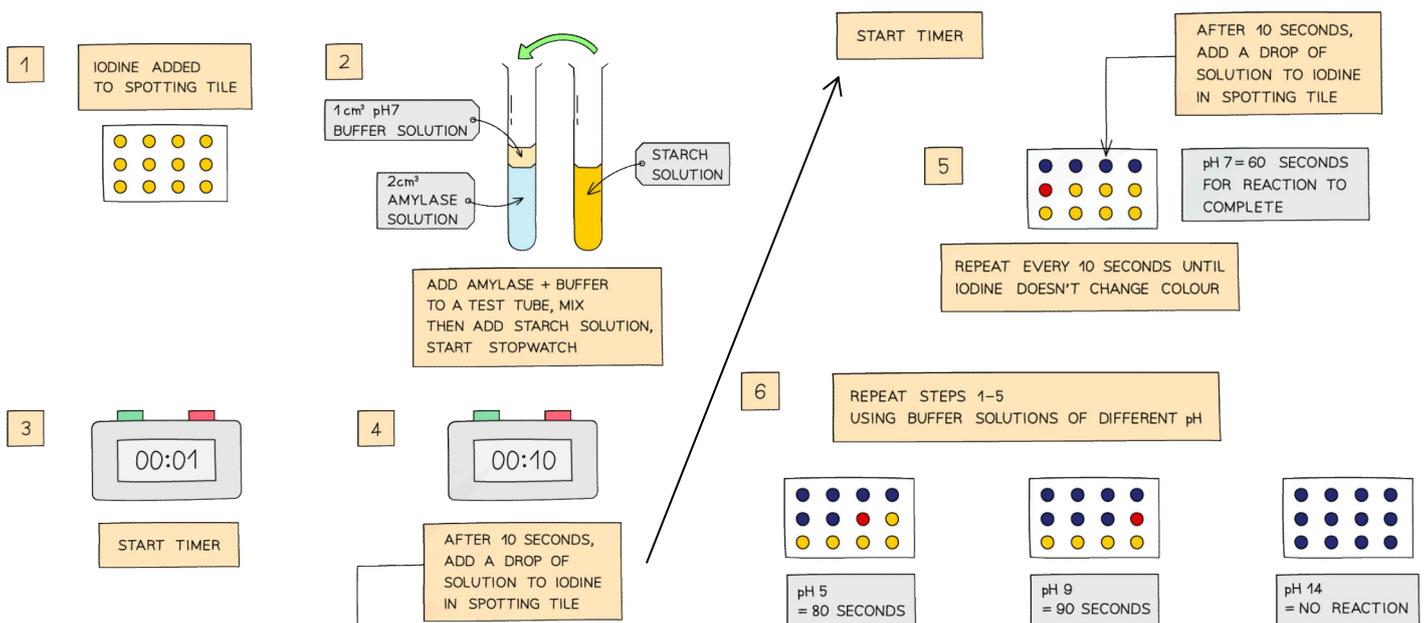
Effects of pH

- Most enzymes work best at a particular level of acidity or alkalinity.
- The pH at which a particular enzyme work at its best is called as optimum pH.
- Deviating from the optimal pH can alter the enzyme's tertiary structure, affecting its active site and substrate binding ability.
- The protein digesting enzyme in stomach has an optimal pH of 2.
- The lipid digesting enzymes are slightly alkaline: optimum pH for pancreatic Lipase is 8.
- Extreme pH levels can also lead to enzyme denaturation, similar to the effect of high temperatures. Although change in pH affects the activity of enzymes these are usually reversible provided tertiary structure remains intact.



Experiment

- Add a drop of iodine to each of the wells of a spotting tile. Use a syringe to place 2 cm³ of amylase into a test tube. Add 1 cm³ of buffer solution (at pH 2) to the test tube using a syringe.
- Use another test tube to add 2 cm³ of starch solution to the amylase and buffer solution, start the stopwatch whilst mixing, using a pipette. Every 10 seconds, transfer a droplet of the solution to a new well of iodine solution. (which should turn blue-black)
- Repeat this transfer process every 10 seconds until the iodine solution stops turning blue-black. (this means the amylase has broken down all the starch) Record the time taken for the reaction to be completed. Repeat the investigation with buffers at different pH values. (ranging from pH 3.0 to pH 7.0)





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