3. Enzymes

3.1 Mode of Action of Enzymes

Paper 2

Question Paper

1 Lysozyme is an antibacterial enzyme that was discovered in 1921 by Alexander Fleming, the scientist who discovered penicillin.

Lysozyme catalyses the hydrolysis of glycosidic bonds present in peptidoglycan molecules to form smaller products, NAG (N-acetylglucosamine) and NAM (N-acetylmuramic acid).

(a) Before the induced fit hypothesis was proposed in 1958, scientists believed that the lock and key hypothesis explained how lysozyme catalyses the hydrolysis of peptidoglycan to its products.

Draw labelled **and** annotated diagrams in the space provided to show how the **lock and key hypothesis** was used to explain the mechanism of action of lysozyme on peptidoglycan.

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2 In the mesophyll tissue of leaves, products of photosynthesis can be used to synthesise organic compounds, such as the polysaccharide cellulose and some amino acids.

A source of nitrogen for amino acid synthesis can be provided by nitrate ions that have been taken up in the roots and transported to the leaves.

(b) Studies of nitrate uptake and nitrate metabolism help to provide information to scientists who are investigating ways to increase the yield of crop plants.

The first step of nitrate metabolism in leaf cells is the reduction of nitrate to nitrite, catalysed by the enzyme nitrate reductase. The activity of the enzyme can be studied by detecting the presence of nitrite formed.

(ii) One method used to detect the presence of nitrite formed from the reduction of nitrate in leaf tissue involves:

- using an inhibitor to prevent nitrite from taking part in further reactions in the leaf tissue
- immersing the leaf tissue in a solution containing a colourless test reagent.

The nitrite from the leaf tissue enters the surrounding solution, changing the colour of the solution to magenta (red-purple).

Suggest why using a colorimeter can improve this method to detect the presence of nitrite.

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3 Fig. 2.1 is a photomicrograph of a longitudinal section (LS) through a root tip. Two different regions are visible:

- the root apical meristem
- the root cap.

Cells in the root cap synthesise a gel-like, sticky secretion known as mucilage, which is important in reducing friction between soil and the growing root. It is composed mainly of polysaccharides and also contains some amino acids and enzymes.

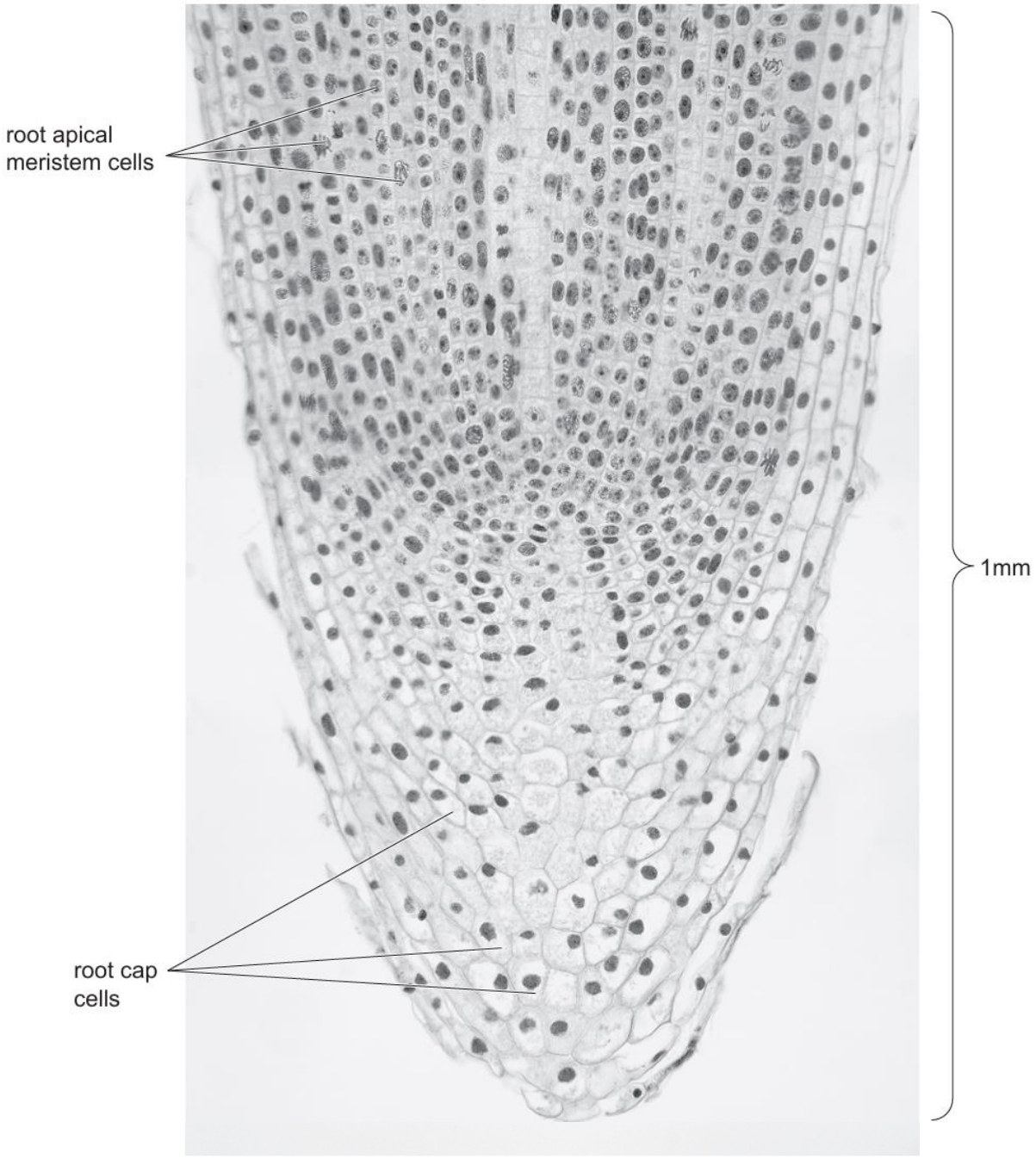


Fig. 2.1

(c) Enzymes present in mucilage catalyse the breakdown of organic compounds in the soil. This increases the presence of mineral ions in the soil.

State the term used to describe enzymes that act **outside** the cells that synthesise them.

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4 Keratin is the structural protein in feathers of birds. Keratin polypeptides are composed of a high proportion of cysteine amino acids, which have sulfur-containing R groups.

Keratin polypeptides form filaments. The two main types of keratin in feathers are α-keratin, which consists of many α-helices, and β-keratin, consisting of many β-pleated sheets.

(b) Protease enzymes hydrolyse proteins. Many proteases are able to hydrolyse more than one type of protein.

Suggest why it is possible for a protease to act on different types of protein.

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5 The enzyme carbonic anhydrase has been found in a wide range of organisms and acts as a catalyst in many tissues.

Studies have shown that there are differences in the protein structure of the enzyme and differences in the number and organisation of introns and exons of the gene coding for the enzyme.

All carbonic anhydrase enzymes catalyse the same reversible reaction, shown in Fig. 4.1.

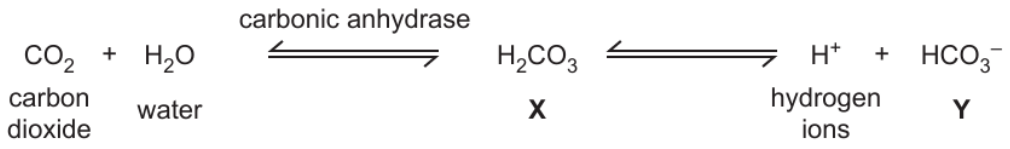


Fig. 4.1

(b) Carbonic anhydrase enzymes can have different primary structures.

Suggest how all carbonic anhydrase enzymes can catalyse the same reaction, even though they have different primary structures.

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6 A tyrosine kinase receptor (TKR) is a protein complex found in the cell surface membrane of mammalian cells.

TKR has two components involved in the process of cell signalling:

- a receptor for the signalling molecule (ligand)
- an enzyme that catalyses the transfer of a phosphate group from ATP to an intracellular protein.

Fig. 3.1 is a diagram to show how TKR is involved in cell signalling.

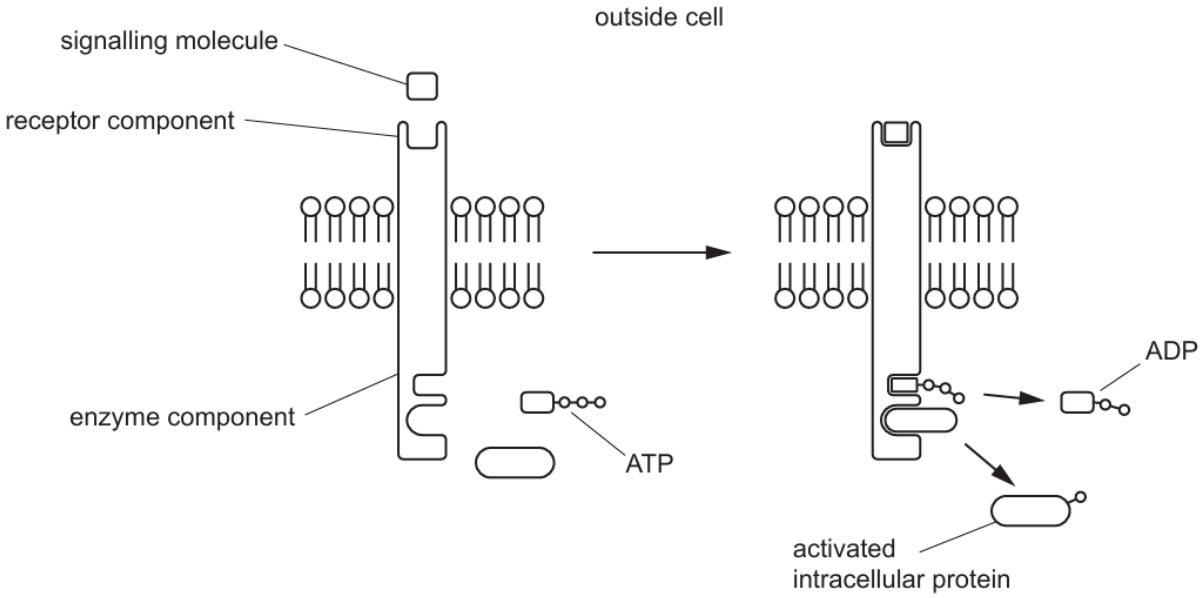


Fig. 3.1

(a) Most enzymes are specific to one reaction.

With reference to Fig. 3.1, explain how the structure of an enzyme provides its specificity.

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7 **(c)** Different strains of the influenza virus have formed as a result of mutations. Each strain of the virus contains the enzyme neuraminidase. Neuraminidase helps the virus to leave host cells after the virus has replicated. In each strain of the influenza virus, the primary structure of the active site of the neuraminidase enzyme remains unchanged.

Suggest why the primary structure of the active site of neuraminidase remains unchanged in each strain of the influenza virus.

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8 **(a)** The induced-fit hypothesis and the lock-and-key hypothesis are used to describe the mode of action of enzymes.

Explain the induced-fit hypothesis.

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9 In most plants, sucrose is the main sugar that is transported from sources to sinks.

(b) Fig. 5.1 shows part of one pathway that is used in plant cells to synthesise sucrose. The enzyme sucrose synthase catalyses the transfer of glucose from UDPG (uridine diphosphate glucose) to fructose.

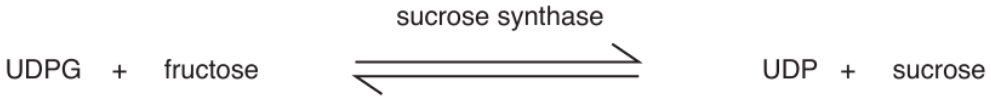


Fig. 5.1

The structure of UDPG is shown in Fig. 5.2.

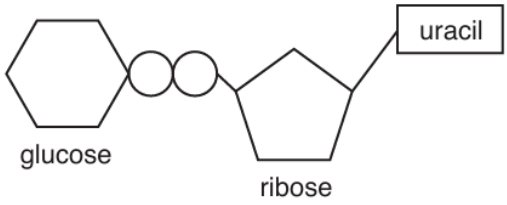


Fig. 5.2

(iii) Sucrose synthase acts by using an induced fit mechanism rather than a lock and key mechanism.

With reference to sucrose synthase and the **synthesis** of sucrose, outline the difference between the induced fit mechanism and lock and key mechanism of enzyme action.

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10 **(b)** Lipases are enzymes that digest triglycerides in the lumen of the human intestine. These enzymes are released by exocytosis from intestinal epithelial cells.

(i) Underline **all** the terms from the list that are used to describe these lipases.

macromolecule **extracellular enzyme** **fibrous protein** **polysaccharide**

[1]

11 Sucrose phosphorylase is an enzyme found in some species of bacteria. One function of this enzyme is for the production of compounds that help to protect the cell from harmful osmotic changes in the external environment.

Fig. 5.1 shows the reversible reaction that takes place within the bacterial cell.

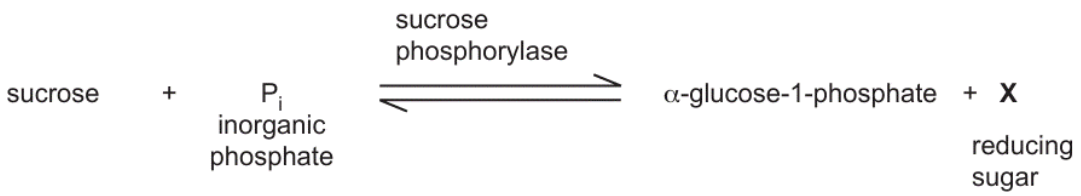


Fig. 5.1

(b) In the absence of sucrose phosphorylase as a catalyst, the reaction shown in Fig. 5.1 would take too long to occur to allow the bacterial cell to function efficiently.

Explain why the reaction shown in Fig. 5.1 proceeds at a much faster rate in the presence of the enzyme.

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12 Myasthenia gravis is a condition that results in muscle weakness by affecting the immune response.

(b) Myasthenia gravis is an autoimmune disease which disrupts a cell signalling pathway involving muscle cells.

Enzyme **Y** is found in the cell surface membrane of muscle cells. Enzyme **Y** acts to break down the cell signalling molecules which trigger muscle contraction when they are no longer needed.

(ii) Using the induced fit hypothesis of enzyme action, explain how enzyme **Y** breaks down the cell signalling molecules.

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13 Telomerase is an enzyme that is important in maintaining the telomeres that are located at the ends of chromosomes.

(c) Studies suggest that telomerase is a flexible molecule when binding its substrate. The active site changes its shape slightly to allow the formation of the enzyme-substrate complex.

Name the theory that describes this mode of enzyme action.

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14 Neutrase® is an enzyme that is used to hydrolyse proteins in solution. When the enzyme is mixed with a 2% protein solution the reaction mixture changes from white to colourless.

A student carried out an experiment to find the effect of copper sulfate and potassium sulfate on the activity of Neutrase®.

The student made four reaction mixtures in test-tubes **A** to **D**. Test-tubes **A** to **C** contained equal volumes of protein solution and 0.1 cm^3 of solutions of copper sulfate or potassium sulfate. Test-tube **D** contained the same volume of protein solution and 0.1 cm^3 of water.

0.5 cm^3 of a 1% Neutrase® solution was added to test-tube **A** and immediately placed into a colorimeter. The colorimeter was used to measure the intensity of light that is absorbed by the solution (absorbance) over 100 seconds. The procedure was repeated with the other reaction mixtures, **B**, **C** and **D**.

The results are shown in Fig. 3.1.

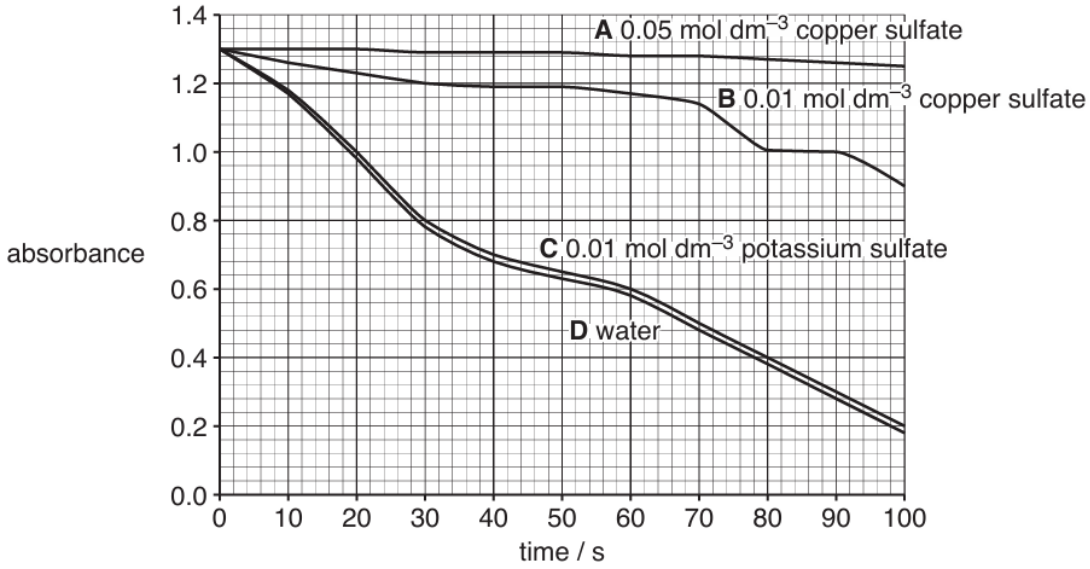


Fig. 3.1

(a) (i) Suggest **and** explain why measuring the absorbance of the reaction mixture over 100 s is a suitable method for determining the activity of Neutrase®.

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15 Catalase is an enzyme that catalyses the breakdown of hydrogen peroxide, which is a waste product of cell metabolism.

The reaction catalysed by catalase is shown in Fig. 6.1.

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

Fig. 6.1

(a) A student carried out two experiments to investigate the progress of the reaction shown in Fig. 6.1. Potato tissue was used as the source of the enzyme.

Six pieces of potato were cut, each measuring 20 mm × 10 mm × 10 mm.

In the first experiment, hydrogen peroxide solution was added to three of the pieces of potato tissue and the progress of the reaction was measured.

Fig. 6.2 shows how the first experiment was set up.

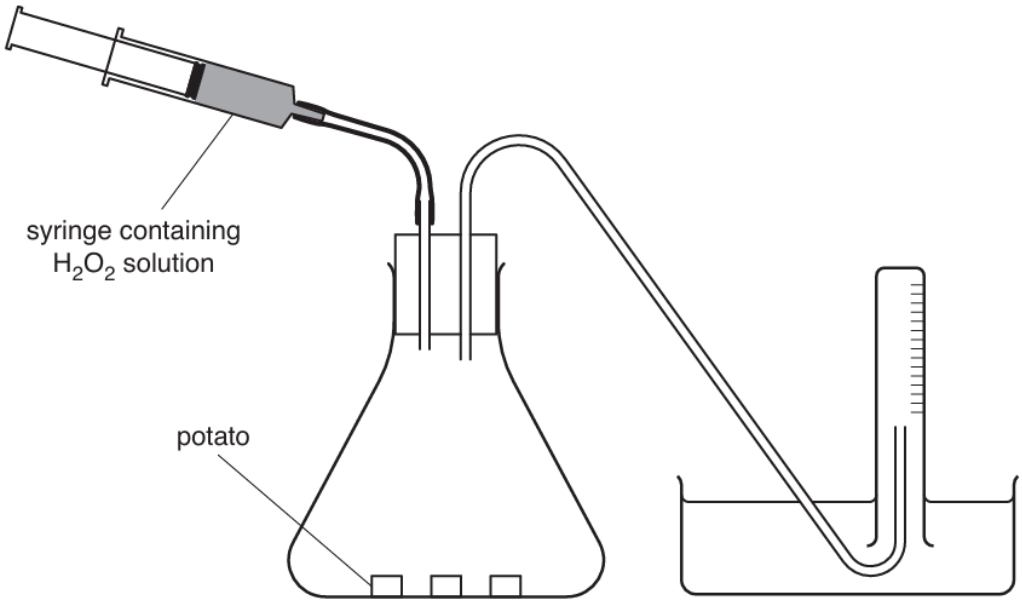


Fig. 6.2

(i) Suggest how the progress of the reaction could be measured.

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