



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2025

Centre Number

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Candidate Number

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Biology

StemUp Model Solution

Assessment Unit AS 1

assessing

Molecules and Cells



[SBY11]

SBY11

FRIDAY 9 MAY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete questions in black ink and use a dark HB pencil for drawings and graphs.

Do not write with a gel pen.

Answer **all eight** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.

Section A carries 60 marks. Section B carries 15 marks.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question. You may use a scientific calculator.

You are reminded of the need for good English and clear presentation in your answers.

Use accurate scientific terminology in all answers.

You should spend approximately **20 minutes** on Section B.

You are expected to answer Section B in continuous prose.

Quality of written communication will be assessed in Section B.

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Section A

1 Identify the most appropriate biological term or phrase for each of the following:

- The bond between two monosaccharides

Glycosidic bond

- The location, within a cell nucleus, of the DNA that codes for ribosomal RNA

Nucleolus

- The small loop of DNA found in prokaryotic cells

Plasmid

- The type of virus which contains the enzyme reverse transcriptase

Retrovirus (e.g. HIV)

- The molecule located in an animal cell membrane which influences membrane stability

Cholesterol

[5]

[Turn over



2 Enzymes act as biological catalysts.

(a) Describe the induced-fit model of enzyme action.

The substrate binds to the active site of the enzyme, which is not exactly complementary at first.

The active site then changes shape slightly to fit closely around the substrate, forming an enzyme-substrate complex and putting strain on the bonds in the substrate.

[2]

(b) Describe and explain the effect of temperature on enzyme activity.

As temperature increases, enzyme activity increases up to the optimum temperature, and above the optimum activity decreases rapidly.

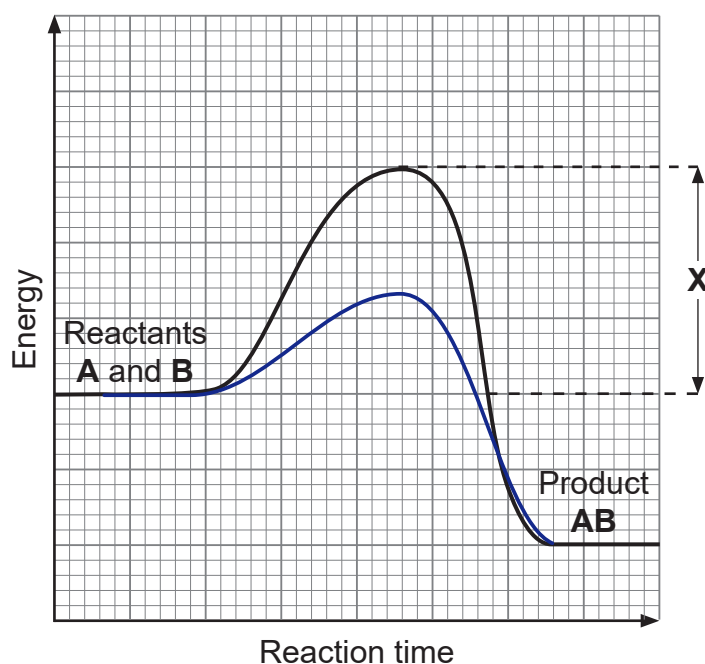
This is because as temperature rises the enzyme and substrate molecules gain kinetic energy, so they move faster and there are more successful collisions, so more enzyme-substrate complexes form per second.

Beyond the optimum, the increased vibration breaks the hydrogen bonds holding the tertiary structure and the active site in shape, so the enzyme is denatured: the active site is no longer complementary to the substrate and fewer enzyme-substrate complexes form.

[3]



(c) The graph below shows the energy profile between two reactants, **A** and **B**.



(i) Identify the term represented by **X** on the graph.

Activation energy

[1]

(ii) On the graph above, draw the alternative energy profile if an appropriate enzyme had been used to catalyse the reaction between **A** and **B**.

[1]



3 Replication of DNA is described as 'semi-conservative'.

(a) (i) Explain what this term means.

Each new DNA molecule contains one strand that is conserved from the original (parent) DNA molecule, and one strand that is newly synthesised from free nucleotides, using the parent strand as a template.

[2]

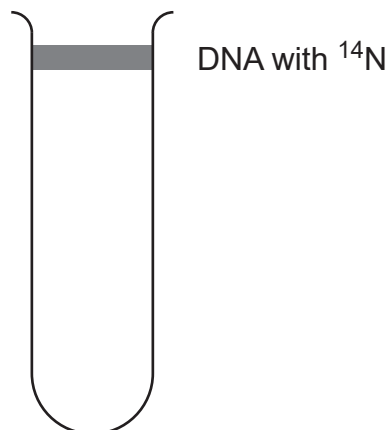
(ii) Name the bonds which form between base pairs in DNA.

Hydrogen bonds

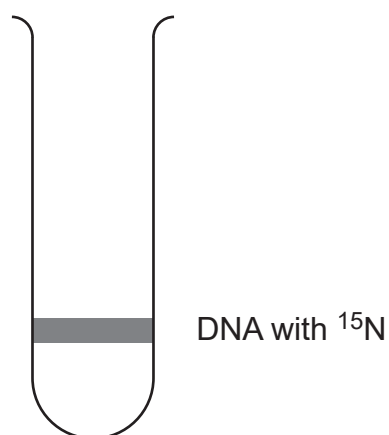
[1]



- (b) Meselson and Stahl investigated DNA replication. They first grew *E.coli* bacteria in a medium containing ^{14}N (a 'light' nitrogen isotope). When the DNA was extracted, centrifuged and examined under UV light, the DNA was seen as a band in the centrifuge tube, as shown below.

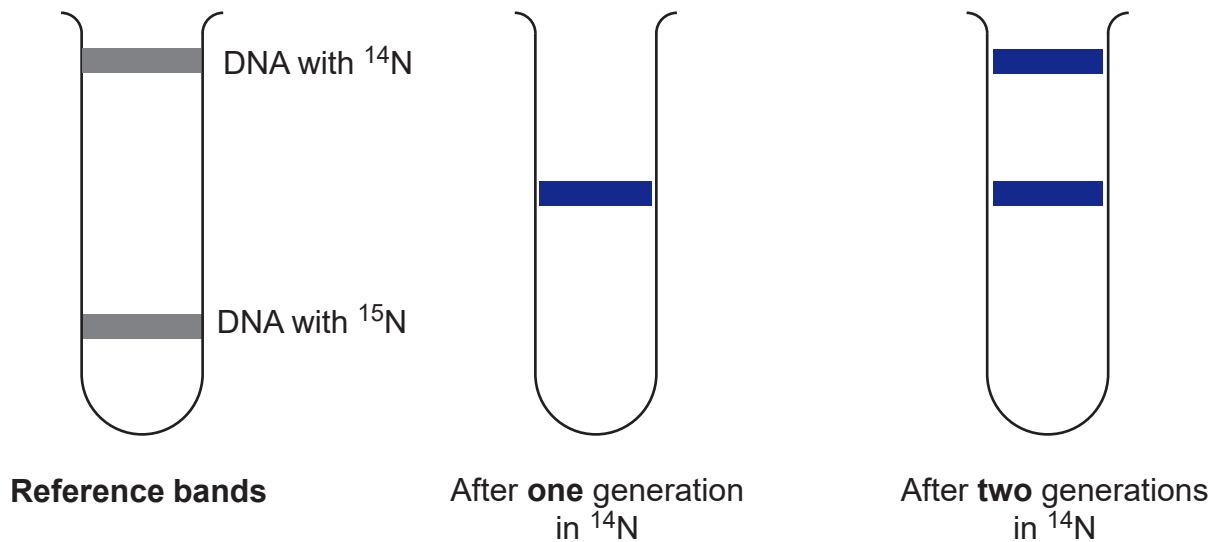


The bacteria were then transferred to a medium containing ^{15}N (a 'heavy' nitrogen isotope), and allowed to reproduce for many generations. The band was seen to be much lower in the tube as shown below.



The bacteria were then transferred back to a medium containing ^{14}N and allowed to reproduce. Samples of DNA were extracted and centrifuged after one generation. This process was repeated for further generations.

- (i) **Complete the diagrams below** by drawing appropriate bands to show the position of the extracted DNA. The first tube shows the position of bands when grown on ^{14}N and ^{15}N as described previously.



[2]

- (ii) Explain the result obtained following **two** generations in ^{14}N .

After two generations in ^{14}N there are two bands of equal intensity.

One (light) band contains DNA with only ^{14}N , as both strands are made of ^{14}N nucleotides.

The other (intermediate) band contains hybrid DNA with one ^{15}N strand and one ^{14}N strand, because each original ^{15}N strand is conserved and acts as a template.

[2]



(iii) Meselson and Stahl continued this experiment for several generations.

Suggest the appearance of the bands in the tube after several generations.

There would still be just two bands: the light (^{14}N only) band would
become much thicker/more intense with each generation,
while the intermediate (hybrid) band would stay the same thickness,
so it becomes relatively much fainter than the light band.

[2]

(c) Identify the stage of the cell cycle during which DNA replication occurs.

S (synthesis) phase of interphase

[1]

[Turn over]



- 4 Mitosis and meiosis are both processes of nuclear division. However, meiosis is a two-stage process.

(a) State one **similarity** and one **difference** between the following phases:

Prophase in mitosis and prophase I in meiosis.

Similarity In both, chromosomes condense and the nuclear membrane breaks down.

Difference In prophase I homologous chromosomes pair up to form bivalents and crossing over occurs at chiasmata (not in mitosis).

Metaphase in mitosis and metaphase I in meiosis.

Similarity In both, chromosomes line up on the equator and spindle fibres attach to centromeres.

Difference In metaphase I homologous pairs (bivalents) line up on the equator, but in mitosis single chromosomes line up.

[4]

- (b) Mitosis is the division of the nucleus and cytokinesis is the division of the cell into two daughter cells. Cytokinesis differs in plant and animal cells.

Describe concisely the main events which take place during cytokinesis in plant and animal cells.

Plant cells A cell plate forms along the centre (equator) of the cell, from vesicles, and develops into the new cell walls.

Animal cells A cleavage furrow forms as the cell membrane invaginates (pinches in) at the equator until the cell divides in two.

[2]



- (c) Asbestos is a substance which has been used to strengthen and fireproof materials. It has been found to be harmful to human health and is no longer used as a building material.

Asbestos can interfere with the production of spindle fibres, reducing the number of fibres formed.

Asbestos has also been shown to block chromosomes from moving in the cell.

- (i) Using the information provided, explain why prophase is likely to be affected by the presence of asbestos.

Fewer spindle fibres are produced, so the spindle does not form properly during prophase.

[1]

- (ii) Metaphase is also affected by asbestos.

Using the information provided, describe and explain how asbestos interferes with metaphase.

Fewer or no chromosomes will align on the equator of the cell during metaphase, because there are fewer spindle fibres to attach to the centromeres and chromosome movement is blocked by asbestos.

[2]

[Turn over]



(d) Drugs described as mitotic poisons can be used as cancer treatments.

Name a mitotic poison used for this purpose and describe how it works.

Name Vincristine

It inhibits microtubule formation, so spindle fibres cannot form and
chromosomes cannot be separated, which stops mitosis in the cancer cells.

[2]





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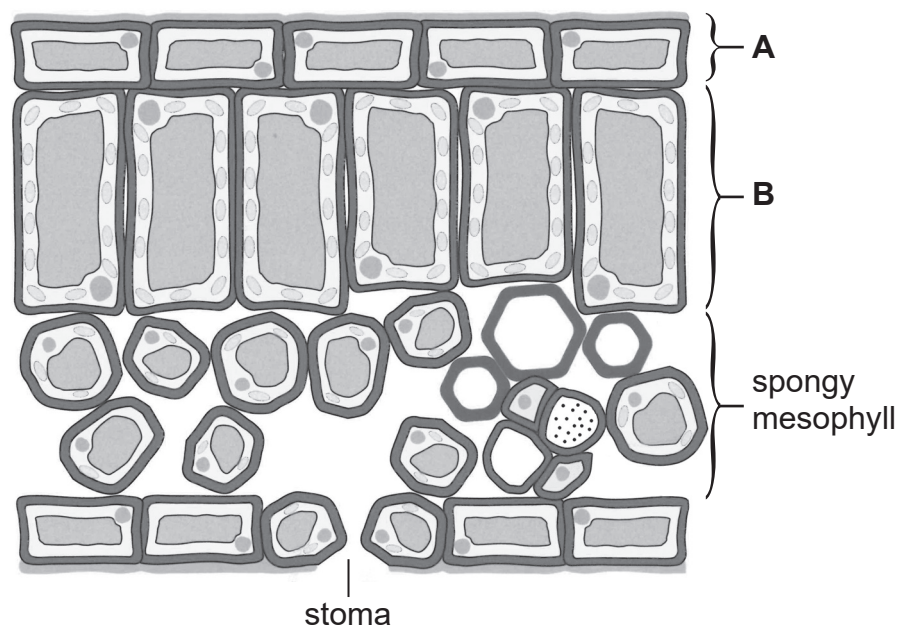
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[Turn over



- 5 The diagram below represents a transverse section through a mesophytic leaf.



Source: © Biology for CCEA AS Level by Dr J Napier, Colourpoint Books, 2016

- (a) Identify **one** difference between tissue layers **A** and **B** and explain the reason for this difference.

Layer B (palisade mesophyll) has many chloroplasts, but layer A (upper epidermis) has none and is thin and transparent.

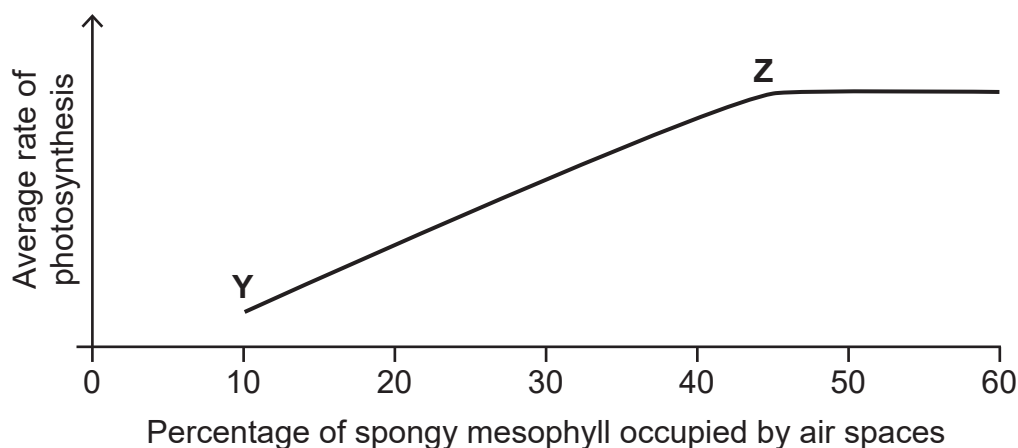
This allows maximum light transmission through A, and maximum light absorption for photosynthesis in B.

[2]



The spongy mesophyll tissue layer contains air spaces between cells to allow for the diffusion of gases through the leaf. Different species of plant vary in the percentage of spongy mesophyll occupied by air spaces. Investigations have been conducted to determine how this impacts the rate of photosynthesis.

The graph below shows the average rate of photosynthesis in plants with different percentages of spongy mesophyll occupied by air spaces.



- (b) Describe the trend shown between Y and Z and suggest an explanation.

The greater the percentage of spongy mesophyll occupied by air spaces, the greater the average rate of photosynthesis (a positive, roughly linear increase).

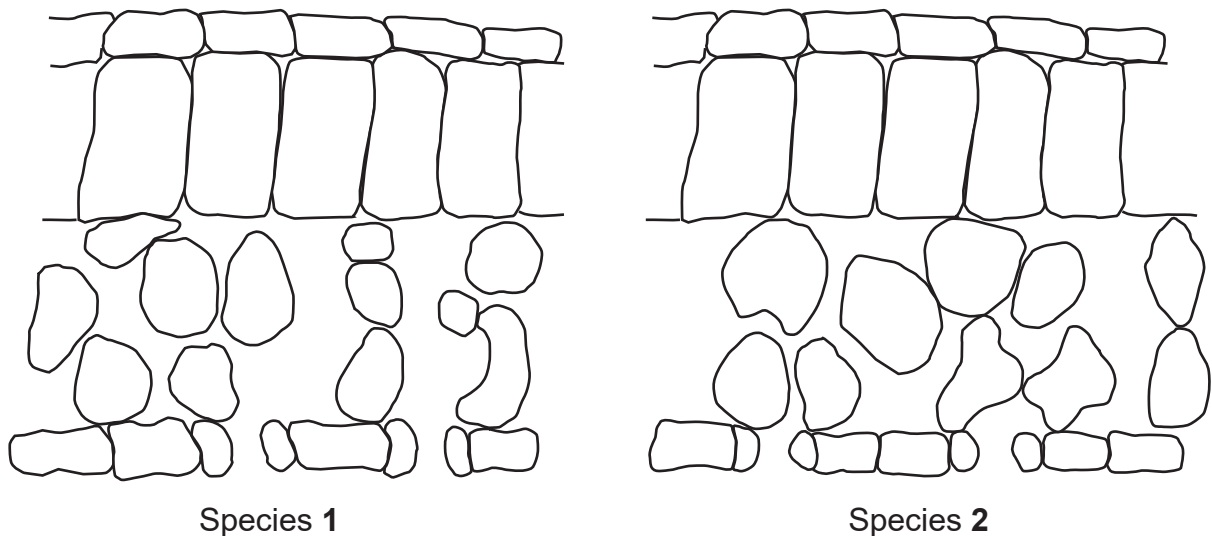
More air spaces allow more/faster diffusion of carbon dioxide through the leaf to the palisade layer, so less carbon dioxide limits photosynthesis.

[2]

[Turn over]



The drawings below represent leaf sections of two plant species, **1** and **2**. They both have similar percentages of their spongy mesophyll occupied by air spaces. However, species **1** photosynthesises at a faster rate.



Source: Principal Examiner

- (c) Using the drawings, suggest and explain **one** possible reason for the faster rate of photosynthesis in species **1**.

In species 1 the air spaces in the spongy mesophyll are aligned with the stomata (forming continuous channels).

So more carbon dioxide can diffuse in from the stomata to the photosynthesising cells, and faster.

[2]



- (d) In another investigation, stomatal distribution and density (average number of stomata per mm^2) were recorded in Magnolia and Acacia leaves.

The results are shown in the table below.

Plant species	Average number of stomata / mm^{-2}	
	Upper surface	Lower surface
Magnolia	115	400
Acacia	20	210

- (i) Summarise the data shown in the table and suggest a reason for the density of stomata on the upper surface of Acacia.

Magnolia has more stomata in total than Acacia (515 compared with 230 per mm^2).

Both species have fewer stomata on the upper surface than on the lower surface.

Acacia has very few upper stomata to conserve water/reduce transpiration, as the upper surface is exposed to the sun and is warmer.

[3]

- (ii) Calculate the percentage of the Acacia's stomata which are on its lower surface.

Show your working out.

Total stomata on Acacia = $20 + 210 = 230$ per mm^2

$(210 \div 230) \times 100 = 0.913 \times 100 = 91.3\%$

91.3 % [2]

[Turn over]



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6 (a) Osmosis involves the movement of water between a cell and its external environment. Solute potential and pressure potential are two factors involved in osmosis.

- (i) Explain why solute potential is always a **negative** value and pressure potential is always a **positive** value in turgid plant cells.

Solute potential is always negative because cell contents always contain some solutes, and pure water with no solutes has the highest potential, of zero.

Pressure potential is positive because it is the pressure exerted by the cytoplasm/cell membrane pushing outwards against the cell wall.

[2]

- (ii) State the equation used to calculate the water potential of a cell (Ψ_{cell}).

$$\Psi_{\text{cell}} = \Psi_s + \Psi_p$$

[1]

- (iii) A plant cell has a Ψ_{cell} of -900 kPa. The pressure potential (Ψ_p) of the cell is 250 kPa.

Calculate the solute potential (Ψ_s) of this cell.

$$\Psi_s = \Psi_{\text{cell}} - \Psi_p$$

$$\Psi_s = -900 - 250 = -1150 \text{ kPa}$$

-1150 kPa [1]

[Turn over]



- (b) Rock Samphire, shown in the photograph below, is a plant which is often found growing in coastal areas. The water in these areas has a salt concentration of 3–5%.



Source: Dr James Napier

The plants store salt in the vacuoles of their cells. The vacuoles can have salt concentrations of 30–45%.

- (i) Suggest how this adaptation enables Rock Samphire to survive in coastal areas.

The vacuoles have a more negative water potential than the surrounding (sea/soil) water, because of their high salt concentration, so the cells can still take in water by osmosis, down a water potential gradient, and do not lose water to the salty environment.

[2]



- (ii) In the past, Rock Samphire growing in coastal areas was harvested for human consumption. It was transported in saltwater to restaurants.

Describe and explain what would happen if the Rock Samphire was transported in tap water rather than saltwater.

Tap water has a much less negative (higher) water potential than the cell contents/vacuole.

So water would enter the cells by osmosis, down the water potential gradient.

The cells would become turgid (and could even burst), and the Rock Samphire would taste less salty.

[3]



7 Eukaryotic cells contain membrane-bound organelles.

Table 1 below shows the relative volumes of some cell organelles found inside a liver cell, presented as percentage of total cell volume, and the approximate number of each within a liver cell.

Table 1

Organelle	Percentage of total cell volume	Approximate number per cell
Mitochondria	22	1700
Endoplasmic reticulum	11	3
Nucleus	7	1
Golgi apparatus	3	1
Lysosomes	1	300

(a) Using the information in **Table 1**, suggest **two** cell processes which occur at relatively high rates in liver cells.

1. *Aerobic respiration (many mitochondria, 22% of the cell volume).*

2. *Intracellular digestion (about 300 lysosomes per cell).*

[2]



- (b) **Table 2** below shows the percentage of some membrane types within a liver cell.

Table 2

Membrane type	Percentage of total membranes within a liver cell
Mitochondria	39
Rough endoplasmic reticulum	35
Smooth endoplasmic reticulum	16
Nucleus (inner)	0.2
Golgi apparatus	7
Lysosomes	0.4

- (i) Using the information provided in **Table 1** and your knowledge, suggest explanations for the high percentage shown for mitochondria in **Table 2**.

There are a large number of mitochondria (about 1700 per cell, 22% of the cell volume).

Each mitochondrion has a double membrane with a highly folded inner membrane (cristae), giving a large membrane surface area.

[2]

- (ii) Using the information provided and your knowledge, suggest explanations for the low percentage shown for lysosomes in **Table 2**.

Lysosomes are surrounded by a single membrane only (not a double or folded membrane).

They are very small organelles (only 1% of cell volume), so each has a small surface area of membrane.

[2]

[Turn over



Plant cells are eukaryotic cells surrounded by a cell wall.

(c) Cell walls of adjacent plant cells are linked by the middle lamella.

Name the substance which forms the middle lamella.

Calcium pectate

[1]



Section B

In this question you will be assessed on the quality of your written communication skills including the use of specialist scientific terms.

- 8 (a) Give an account of the structure of proteins, including conjugated proteins. You should include details of the type of bond involved in each level of structure. [9]
- (b) Proteins can be classified as globular or fibrous. Distinguish between the two, with reference to structure and function. [6]

- (a) Give an account of the structure of proteins, including conjugated proteins. You should include details of the type of bond involved in each level of structure.

The primary structure of a protein is the sequence of amino acids in the polypeptide chain. Amino acids are joined by peptide bonds, formed in condensation reactions between the amino group of one amino acid and the carboxyl group of the next. The type of protein formed depends on the order of the amino acids, because the R-groups determine which bonds form in the higher levels of structure.

The secondary structure is formed when the polypeptide chain is coiled or folded and held by hydrogen bonds between the C=O of one amino acid and the N-H of another. This produces either an α -helix, where the chain twists into a helical (spiral) shape, or a β -pleated sheet, where sections of the chain lie (anti)parallel to each other.

The tertiary structure is the further folding of the secondary structure into a specific 3D shape. It is held by bonds between R-groups: hydrogen

[Turn over]



bonds, ionic bonds between charged R-groups, disulfide bridges between cysteine residues (strong covalent bonds) and hydrophobic interactions, where non-polar R-groups cluster in the centre of the molecule away from water.

The quaternary structure occurs only when two or more polypeptide chains are joined together, held by the same types of bonds as the tertiary structure, for example haemoglobin, which has four polypeptide chains.

Conjugated proteins are proteins that contain a prosthetic group, which is a non-protein group permanently attached to the protein. For example, haemoglobin contains the iron-containing haem group, and glycoproteins contain a carbohydrate group.



[illegible]

[Turn over

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- (b) Proteins can be classified as globular or fibrous.
Distinguish between the two, with reference to structure and function.

Globular proteins have a specific, compact, roughly spherical 3D shape, as the polypeptide chain is folded tightly with hydrophobic R-groups inside and hydrophilic R-groups outside, so they are usually soluble. They have metabolic roles, and their specific 3D shape is vital to their function, for example as enzymes (e.g. amylase, where the active site must be complementary to the substrate), antibodies, carrier proteins, membrane receptors and haemoglobin.

Fibrous proteins have structural and support roles and provide tensile strength. They form long strands, sheets or rope-like structures and are insoluble. They usually have a quaternary structure, consisting of several polypeptide chains wound around each other and held together by many hydrogen bonds (and cross-links). For example, collagen is a fibrous protein made of three polypeptide chains wound into a triple helix, found in tendons and skin.

So globular proteins are compact and functional (metabolic), whereas fibrous proteins are long and strong (structural).





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Examiner Number

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