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Write your **student number** in the boxes above.

Letter

Biology $\frac{3}{4}$

Question and Answer Book

VCE Examination (Term 1 Mock) - April 2025

- Reading time is **15 minutes**.
- Writing time is **2 hours 30 minutes**.

Materials Supplied

- Question and Answer Book of 42 pages.
- Multiple-Choice Answer Sheet.

Instructions

- Follow the instructions on your Multiple-Choice Answer Sheet.
- At the end of the examination, place your Multiple-Choice Answer Sheet inside the front cover of this book.

Students are **not** permitted to bring mobile phones and/or any unauthorised electronic devices into the examination room.

Contents

Pages

Section A (40 questions, 40 marks)	2–18
Section B (8 questions, 80 marks)	19–42

Student's Full Name: _____

Student's Email: _____

Tutor's Name: _____

Marks (Tutor Only): _____

Section A

Instructions

- Answer **all** questions in pencil on the Multiple-Choice Answer Sheet.
 - Choose the response that is **correct** or that **best answers** the question.
 - A correct answer scores 1; an incorrect answer scores 0.
 - Marks will **not** be deducted for incorrect answers.
 - No marks will be given if more than one answer is completed for any question.
 - Unless otherwise indicated, the diagrams in this book are not drawn to scale.
-

Question 1

A researcher is studying the enzyme **hexokinase**, which catalyses the phosphorylation of glucose to form glucose-6-phosphate in the first step of glycolysis. The researcher observes that specific amino acids in the enzyme's active site play a key role in binding glucose and catalysing the reaction. Modifying certain amino acids in the active site significantly reduces the enzyme's efficiency.

Which of the following best explains the role of the variable side chain (R-group) in determining the properties and function of these amino acids?

- A. The R-group forms peptide bonds, which stabilise the enzyme's structure.
- B. The R-group dictates the chemical reactivity and interactions of the amino acid, impacting enzyme activity.
- C. The R-group determines the structure of the amino acid backbone, which is critical for enzyme folding.
- D. The R-group does not affect the biochemical interactions or function of the amino acid in the enzyme.

Question 2

How does the degeneracy of the genetic code contribute to minimising the impact of mutations?

- A. It prevents mutations from occurring.
- B. It allows multiple codons to code for the same amino acid, reducing the likelihood of a harmful mutation.
- C. It ensures that all mutations lead to the same amino acid change, allowing consistency in gene expression.
- D. It restricts the types of mutations that can occur, ensuring they fall within given bounds to prevent unexpected harm to proteins.

Question 3

Which of the following incorrectly identifies a step during transcription?

- A. The stop codon is reached, and the polypeptide chain then detaches.
- B. RNA polymerase binds to the promoter region.
- C. The DNA double helix begins to unwind.
- D. The terminator sequence is reached and mRNA detaches.

Question 4

Which one of the following correctly identifies both the structure and a possible role of an RNA molecule in a eukaryotic cell?

	Conclusion	Possible role
A.	Is single-stranded and contains uracil	Serves as a template for protein synthesis during translation
B.	Consists of nucleotides with ribose and phosphate groups	Carries genetic information from the DNA to the ribosome for protein synthesis
C.	Contains a double helix and pairs adenine with thymine	Acts as a structural component of ribosomes
D.	Contains ribose sugar and is double-stranded	Stores genetic information in the nucleus

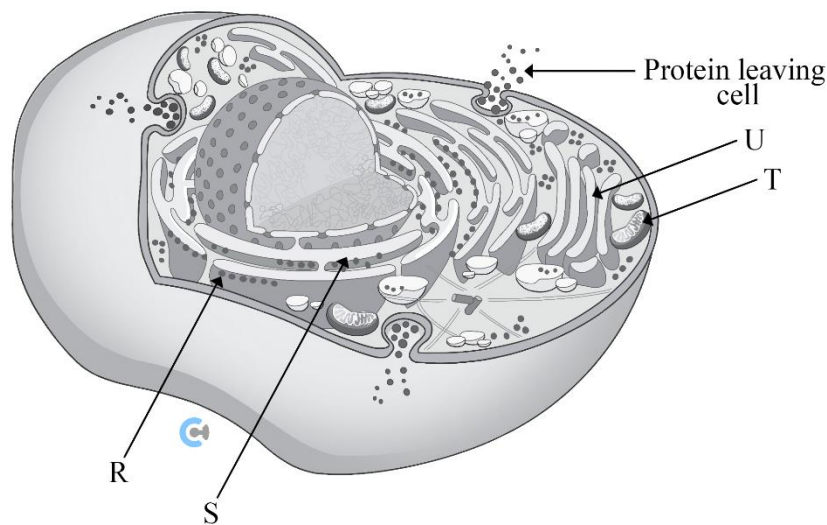
Question 5

You are designing an experiment to test the effect of pH on enzyme activity. Which of the following steps would best improve the reliability and validity of your results?

- A. Repeating the experiment multiple times and averaging the results.
- B. Including both a positive control and a negative control.
- C. Calibrating the pH meter before each measurement.
- D. Using a larger variety of pH levels in your tests.

Question 6

The diagram below represents a mammalian cell undergoing the process of exocytosis.



Source: adapted from Soleil Nordic/Shutterstock.com

In the process of exocytosis, the role of:

- A. Organelle *R* is to synthesise the proteins.
- B. Organelle *S* is to modify, sort, and package proteins for secretion.
- C. Organelle *T* is to transport proteins to their destination within or outside the cell.
- D. Organelle *U* is to generate ATP required for cellular activities.

The following information applies to the two questions that follow.

Question 7

A sequence of single-stranded nucleic acid containing both exons and introns would most likely be:

- A. Mature mRNA
- B. Pre-mRNA
- C. cDNA
- D. DNA

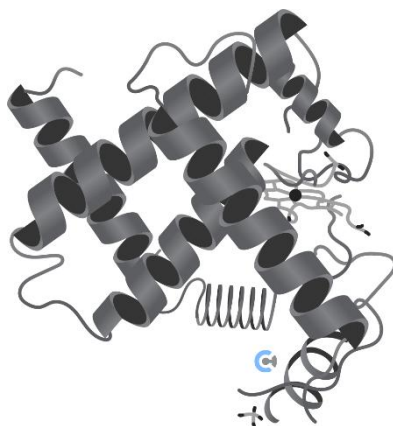
Question 8

This would most likely be found in the:

- A. Rough Endoplasmic Reticulum
- B. Golgi Apparatus
- C. Nucleus
- D. Ribosome

Question 9

Myoglobin is a protein with a three-dimensional shape and only one polypeptide. What is the highest level of protein structure in myoglobin?

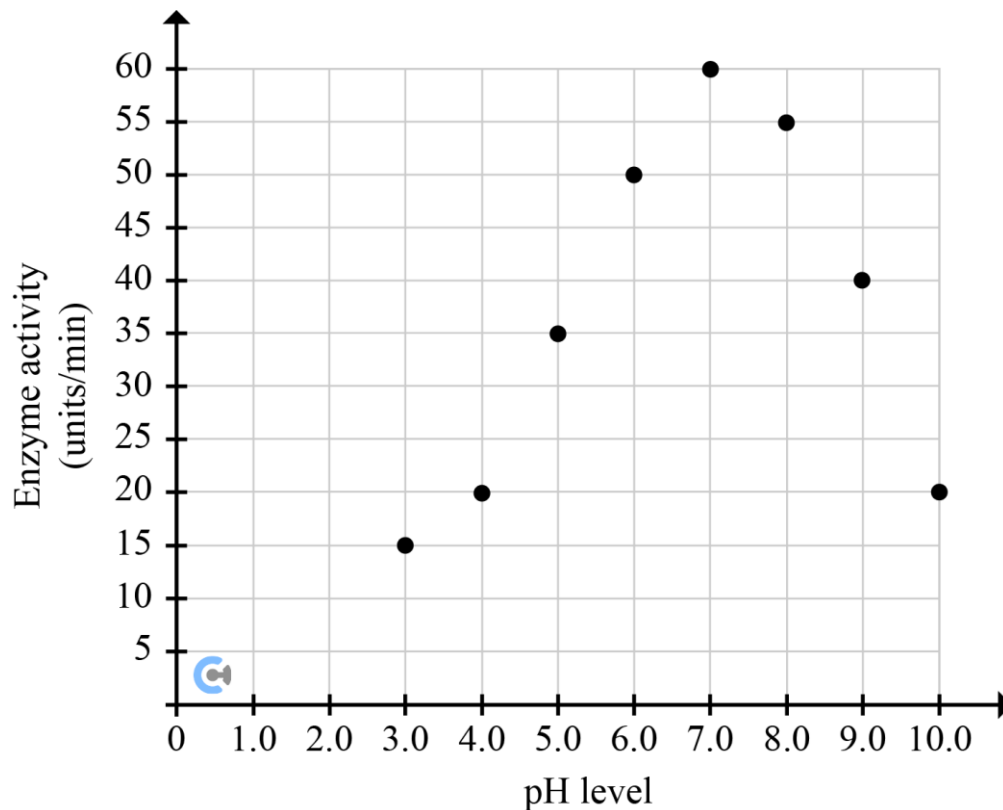


- A. Primary
- B. Secondary
- C. Tertiary
- D. Quaternary

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Question 10

A team of researchers conducted an experiment to measure the activity of an enzyme under different pH levels. The enzyme activity was measured in units of product formed per minute. The data collected is summarised in the table below:



Based on the data, which pH level is closest to the enzyme's optimal pH, and what does this imply about the enzyme's activity in a biological context, such as the human digestive system?

- A. pH 3.0; The enzyme is most active in highly acidic environments similar to the stomach.
- B. pH 6.0; The enzyme's activity peaks at a slightly acidic environment, indicating it might be functional in the small intestine.
- C. pH 7.0; The enzyme has the highest activity in neutral pH, suggesting it is most active in environments like the blood.
- D. pH 8.0; The enzyme works best in slightly basic conditions, indicating it might function well in environments such as the pancreas.

Question 11

A biochemical analysis of the bat muscle cells showed a high level of lactic acid. Which one of the following is a valid conclusion for a high level of lactic acid in the bat muscle cells?

	Conclusion	Reason for conclusion
A.	Oxygen is being efficiently used by the cells.	Lactic acid is produced only when oxygen is available.
B.	The cells are undergoing aerobic respiration.	Aerobic respiration produces lactic acid as a byproduct.
C.	There is no oxygen in the cells.	Anaerobic respiration occurs in the absence of sufficient oxygen, leading to lactic acid production.
D.	NADH is being recycled.	NADH is used in anaerobic respiration to convert pyruvate into lactic acid, allowing glycolysis to continue.

Question 12

A pharmaceutical company is conducting a clinical trial for a new medication aimed at treating a rare genetic disorder. The trial includes a diverse group of participants from various age groups and health backgrounds. The company has implemented extensive safety measures to minimise potential risks and has ensured that the potential benefits of the medication are well-communicated to the participants.

Which ethical principle is the company prioritising by focusing on minimising risks and maximising benefits?

- A. Integrity
- B. Justice
- C. Respect
- D. Beneficence

Question 13

Some species of bacteria can be added to biomass to produce bioethanol, a renewable energy source. The production of bioethanol involves the breakdown of starch:

- A. By glycolysis followed by alcoholic fermentation.
- B. Via aerobic respiration followed by carbon dioxide production.
- C. Through the Krebs's cycle followed by lactic acid fermentation.
- D. In the presence of oxygen followed by fermentation.

Question 14

The function of guide RNA in the CRISPR-Cas9 system is:

- A. Unwind the target DNA.
- B. Provide bacteria with innate immunity.
- C. Identify the position where the target DNA is to be cut.
- D. Cut the double-stranded DNA at the site upstream from the PAM sequences.

The following information applies to the two questions that follow.

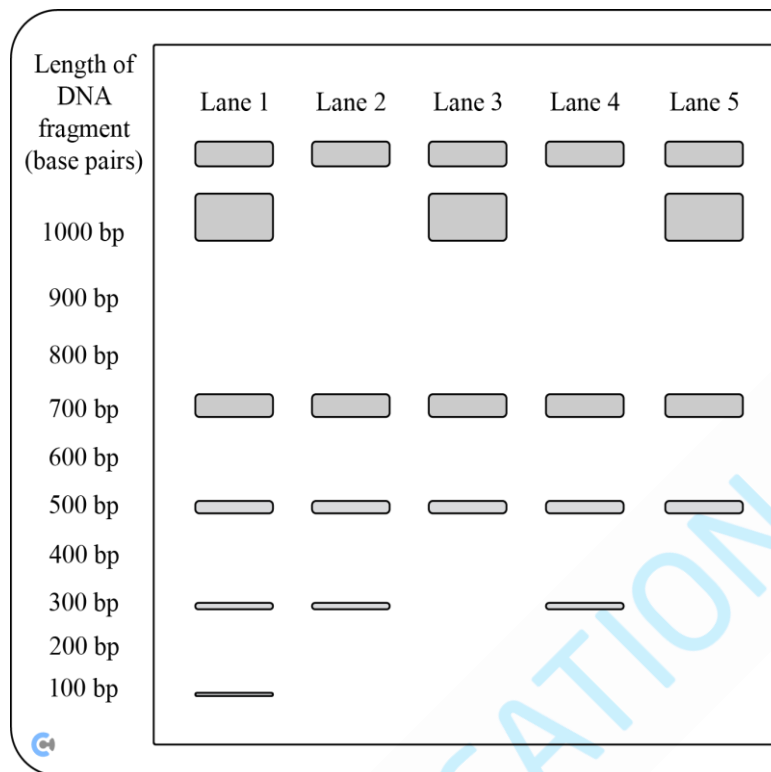
A forensic team is analysing DNA samples from a crime scene to identify the suspect. They run gel electrophoresis on the DNA samples, which include the suspect's DNA, the victim's DNA, and DNA samples were collected from the crime scene. The results of the gel electrophoresis are shown below:

Gel Electrophoresis Results:

Lane	Sample	Band Pattern (in bp)
1	DNA Ladder	1000, 700, 500, 300, 100
2	Suspect's DNA	700, 500, 300
3	Victim's DNA	1000, 700, 500
4	Crime Scene DNA Sample 1	700, 500, 300
5	Crime Scene DNA Sample 2	1000, 700, 500

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Schematic of the Gel:



Question 15

Based on the gel electrophoresis results, which DNA sample(s) match the suspect's DNA?

- A. Only Crime Scene DNA Sample 1.
- B. Only Crime Scene DNA Sample 2.
- C. Both Crime Scene DNA Sample 1 and Crime Scene DNA Sample 2.
- D. Neither Crime Scene DNA Sample 1 nor Crime Scene DNA Sample 2.

Question 16

What is the significance of the DNA ladder in Lane 1, and how does it help in interpreting the gel results?

- A. It serves as a control to ensure the experiment was performed correctly.
- B. It provides a reference for estimating the size of DNA fragments in other lanes.
- C. It contains the suspect's DNA for comparison with crime scene samples.
- D. It shows the DNA from the victim to identify any contamination.

Question 17

Identify the correct statement below.

- A. Plasmids are found in the eukaryotic mitochondria.
- B. Plasmids are sections of DNA part of the prokaryotic genome.
- C. Plasmids are technically not considered part of the genome.
- D. Plasmids are enzymes that protect bacteria from viral infections.

Question 18

Recombinant DNA technology is used in many applications to produce human proteins in bacteria, for use in primarily medical applications. Which of the following correctly identifies the type of cut required from an endonuclease to a plasmid in the process of adding the gene of interest to it?

- A. Sticky ends, as the complementary ends allow for specificity in the orientation of the insertion of the gene of interest.
- B. Blunt ends, as most plasmids do not have the correct recognition sites for insertion.
- C. Sticky ends, as they allow the plasmid to rejoin itself via DNA ligase, while blunt ends do not.
- D. Blunt ends, as they allow for any end to join without specificity, which means you can keep trying until you get the join the right way around.

Question 19

The final electron acceptor during the electron transport chain is:

- A. Oxygen
- B. Water
- C. Carbon dioxide
- D. ATP

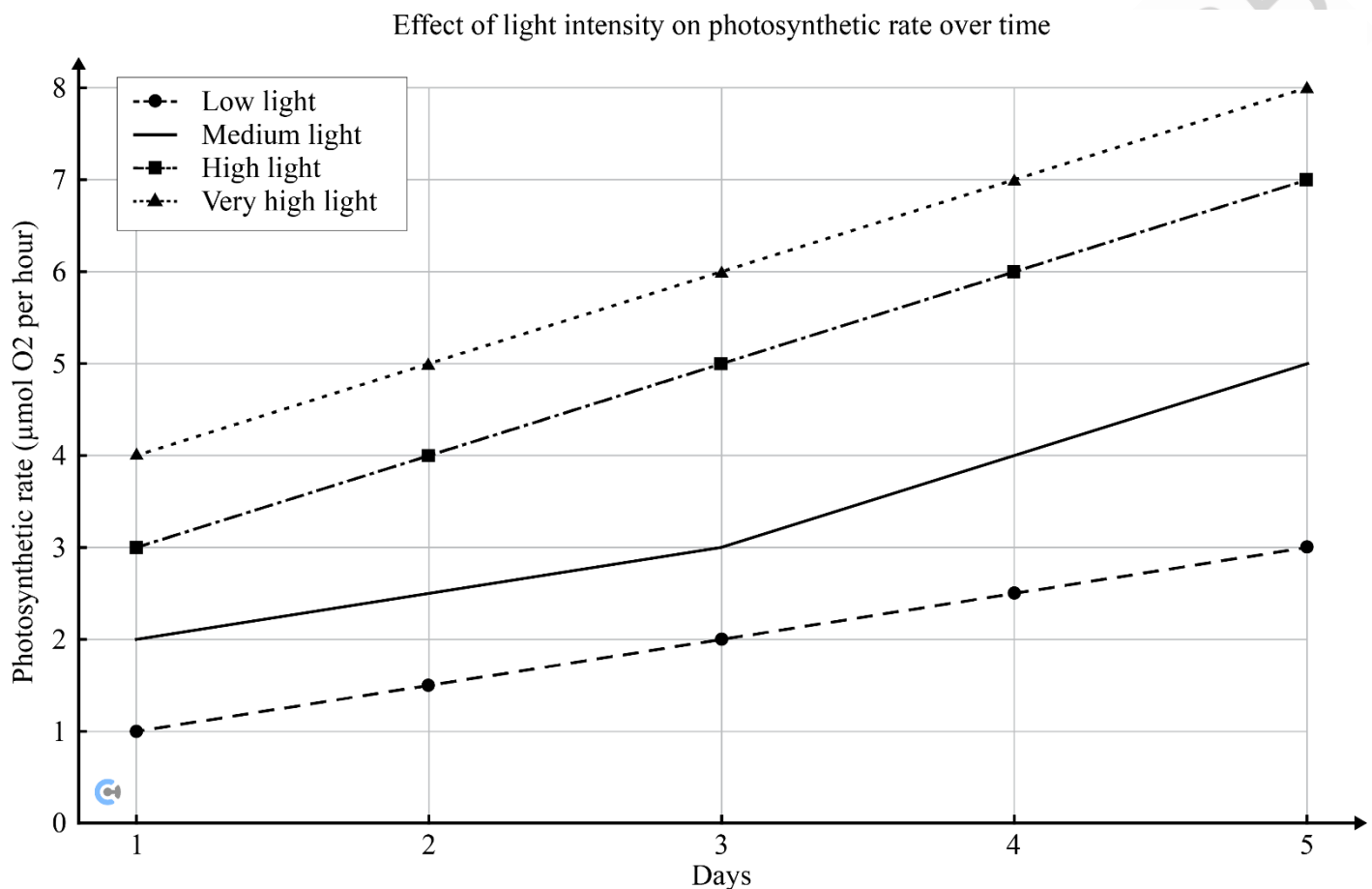
Question 20

Thirty minutes later, ^{18}O is provided to photosynthesising plants in water molecules, it will be found as:

- A. Glucose
- B. Carbon dioxide
- C. Gaseous oxygen
- D. Starch

The following information applies to the two questions that follow.

A new experiment is conducted on the effect of light intensity on the photosynthetic rate of a plant over a five-day period. The plant is subjected to four different light intensity levels: **low**, **medium**, **high**, and **very high**. The *Y*-axis measures the **photosynthetic rate** (measured in $\mu\text{mol O}_2$ released per hour) and the *X*-axis represents the days of the experiment (Day 1, Day 2, Day 3, Day 4, and Day 5).



Question 21

Which of the following conclusions can be drawn from the graph of light intensity v/s photosynthetic rate?

- A. The photosynthetic rate increased consistently under all light intensities over the five days.
- B. The photosynthetic rate was highest under the "very high" light intensity on day 5.
- C. The "medium" light intensity showed the lowest rate of photosynthesis across all time points.
- D. The photosynthetic rate under "low" light intensity was higher than under "high" light intensity by day 5.

Question 22

Which of the following would be a reasonable controlled variable in this experiment?

- A. Temperature at which the plant is kept.
- B. The type of plant used in the experiment.
- C. The intensity of the light used.
- D. The length of time the experiment lasts.

Question 23

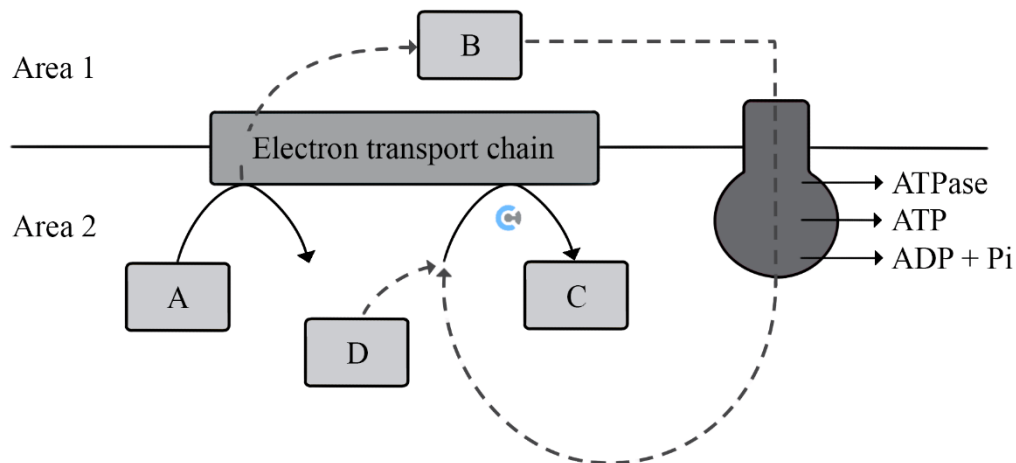
Methotrexate is a medication used to treat a variety of conditions, such as rheumatoid arthritis, due to its ability to bind to and competitively inhibit dihydrofolate reductase, an enzyme that facilitates cell division by binding to folic acid. Based on this information, it would be reasonable to conclude that:

- A. Increasing the dose of Methotrexate (ignoring toxicity) would block more dihydrofolate reductase active sites, causing a reduction in cell division.
- B. Methotrexate would be more effective than a non-competitive inhibitor in the same scenario.
- C. A low dose of methotrexate would allow for the treatment to be successful because all the active sites would be occupied.
- D. Methotrexate and folic acid have the same three-dimensional shape.

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The following information applies to the three questions that follow.

The diagram below shows a reaction that occurs in most eukaryotic cells. Chemicals A-D are involved in the process.



Question 24

Which one of the following identifies chemicals A-C?

	Chemical A	Chemical B	Chemical C
A.	NADPH	Hydrogen	Oxygen
B.	Oxygen	NADH	Water
C.	Water	Carbon dioxide	Oxygen
D.	NADH	Hydrogen	Water

Question 25

Which one of the following identifies Area 1 and Area 2?

	Area 1	Area 2
A.	Cytosol	Matrix
B.	Intermembrane space	Matrix
C.	Nucleoplasm	Cytoplasm
D.	Matrix	Intermembrane space

Question 26

Identify the ATP yield for the reaction depicted in the diagram.

- A. 26 or 28
- B. 30 or 32
- C. 32 or 34
- D. 36 or 38

Question 27

CRISPR-Cas9 technology has been used to improve the efficiency of photosynthesis in crop plants. There are two main methods that successfully change the genome of a plant.

- Method 1 aims to disable an undesired gene in a plant, which may lead to a commercial advantage.
- Method 2 aims to insert a gene into a plant without disrupting other genes.

Which one of the following assumptions could be made about methods 1 and 2?

- A. Method 1 is easier than Method 2 as it only involves cutting DNA, whereas Method 2 involves both cutting and pasting DNA.
- B. Method 2 is faster to complete than Method 1.
- C. Method 1 is easier than Method 2 as it involves cutting RNA, which has only one nucleic acid strand, whereas Method 2 involves cutting DNA, which has two nucleic acid strands.
- D. Method 1 and 2 are equally viable for future use, but CRISPR-Cas9 technology will never be widely implemented due to the ethical concept of non-maleficence.

Question 28

Enzymes play an important role in metabolic pathways. Which one of the following statements about enzymes is **incorrect**?

- A. All enzymes are affected by changes in pH.
- B. More enzymes have a limited number of substrates.
- C. Enzymes increase the average energy of reactant molecules.
- D. Enzymes lower the activation energy of the reactions they catalyse.

Question 29

The *lac* operon is an example of a regulatory process in *E.coli* that is regulated by the action of repressor proteins.

Where on the operon will the repressor protein bind?

- A. Operator region
- B. Terminator region
- C. Promoter region
- D. The TATA box

Question 30

If a plasmid is cut and has restriction sites for 3 restriction enzymes, how many fragments will remain after it has been cut?

- A. 2
- B. 3
- C. 4
- D. 5

Question 31

When exercising, to make up for the extra energy that is required by the body, another reaction pathway takes place alongside cellular respiration. Which of the following is true about this pathway?

- A. Produces ethanol.
- B. Decreases the pH of the blood.
- C. Produces CO₂.
- D. Results in the formation of water.

Question 32

What would happen if the electrode were placed at the incorrect end during gel electrophoresis?

- A. There would be no separation of the fragments as they all collect at the end with the wells.
- B. The fragments would all move at the same speed.
- C. Cannot tell what happens.
- D. Forms a phosphodiester bond.

The following information applies to questions 33 to 36.

The use of genetically modified soybeans is becoming increasingly popular, especially with the adoption of this standard by the Growers Association for Soybeans in Australia. This is a genetically modified crop, as it includes a pesticide-resistance gene from a soil bacterium.

Question 33

Which of the following correctly describes this soybean?

- A. Transgenic
- B. Cisgenic
- C. Cyborg
- D. Monogenic

Question 34

"The pesticide resistance nature results in over spraying of insecticide."

Which of the following correctly identifies the ethical concept relating to this statement?

- A. Integrity
- B. Justice
- C. Beneficence
- D. Non-maleficence

Question 35

These seeds are only present to the farmers with the financial means of accessing them, particularly in Western nations. Which of the following correctly identifies the ethical concept relating to this statement?

- A. Justice
- B. Respect
- C. Non-maleficence
- D. Integrity

Question 36

There is no legal requirement to publish products that are made from GMO soybeans. Which of the following correctly identifies the ethical concept relating to this statement?

- A. Respect
- B. Justice
- C. Beneficence
- D. Non-maleficence

Question 37

In the light-independent reactions (Calvin Cycle) of photosynthesis, ATP and NADPH are used in the reduction of 3-phosphoglycerate to glyceraldehyde-3-phosphate. Which of the following correctly describes the roles of ATP and NADPH in these reactions?

- A. ATP provides the energy for converting ribulose-1,5-bisphosphate to 3-phosphoglycerate, while NADPH carries the electrons required for carbon fixation.
- B. ATP supplies the energy needed to convert 3-phosphoglycerate into glyceraldehyde-3-phosphate, while NADPH donates electrons and protons to reduce 3-phosphoglycerate.
- C. ATP is used to regenerate ribulose-1,5-bisphosphate, while NADPH carries energy for carbon fixation.
- D. ATP is used to phosphorylate ribulose-1,5-bisphosphate, while NADPH supplies electrons for the reduction of carbon dioxide.

Question 38

Certain plants combine carbon dioxide with a three-carbon compound (C₃) to produce a four-carbon compound (C₄) during the night, which can be used in photosynthesis during daylight hours. This kind of plant is called a:

- A. C₃ plant.
- B. CAM plant.
- C. C₄ plant.
- D. Rubisco plant.

Question 39

In the process of making recombinant plasmids, the role of the reporter gene and the antibiotic-resistance genes can be used for:

- A. Making sure the colonies survive after transformation.
- B. To determine which bacterial colony has been transformed with the recombinant plasmid.
- C. To determine which bacterial colony has been transformed with the non-recombinant plasmid.
- D. To help purify the protein product produced by the bacterial cell.

Question 40

Consider the conversion of isocitrate into α -ketoglutarate. When ATP is produced in excess amounts for the needs of this cell, some ATP attaches to isocitrate dehydrogenase. The role of the ATP that attaches to isocitrate dehydrogenase is to act as a:

- A. Catalyst
- B. Coenzyme
- C. Source of hydrogen ions
- D. Non-competitive inhibitor

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Section B

Instructions

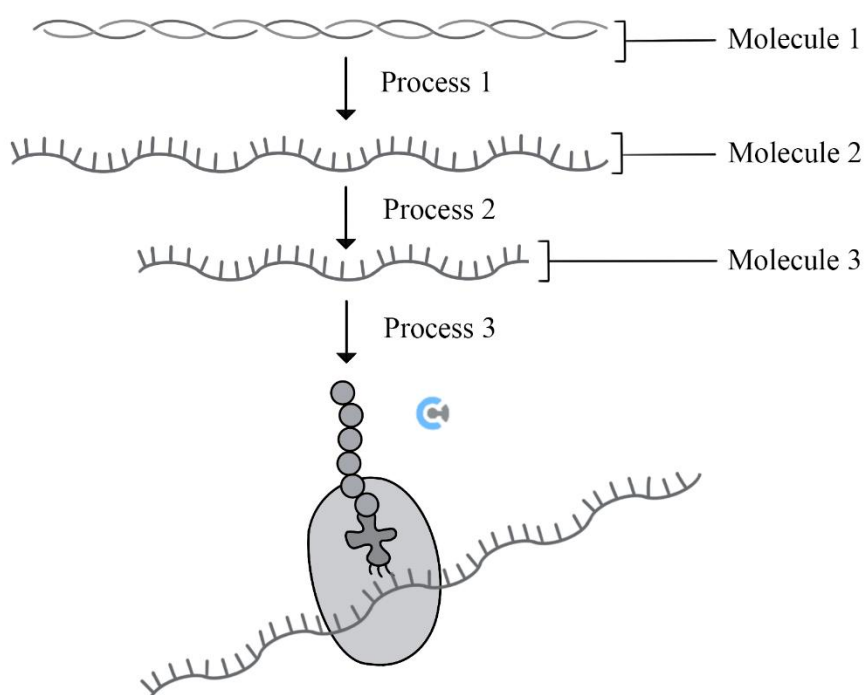
- Answer all questions in the spaces provided.
- Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Question 1 (11 marks)

In a small village, there lived a family with a rich history of farming. The youngest child, Elena, a lively and spirited five-year-old, began to show signs of muscle weakness. Her parents, noticing her difficulty in walking and frequent falls, grew increasingly concerned. Visits to local doctors provided little insight, as the symptoms seemed perplexing and out of place for a child so young.

After months of uncertainty, they decided to seek help from a specialist in a nearby city. Dr. Patel, a renowned neurologist, conducted a series of genetic tests. The results revealed that Elena had spinal muscular atrophy (SMA), a genetic disorder characterised by the loss of motor neurons and progressive muscle wasting. Dr. Patel explained that SMA is caused by a deficiency in the survival motor neuron (SMN) protein due to a mistake in process 2 of the SMN2 gene.

The diagram below shows the steps of normal gene expression sequence that occur to produce the SMN protein. The process and molecules (1-3) involved in the sequence are indicated.



- a. Complete the table below by naming the processes and molecules indicated in the diagram. 3 marks

Process	Process name	Molecule	Molecule name
1		1	
2		2	
3		3	

- b. Describe the steps of process 1. 3 marks

- c. Describe how a mistake in process 2 could lead to the production of a defective SMN protein. 3 marks

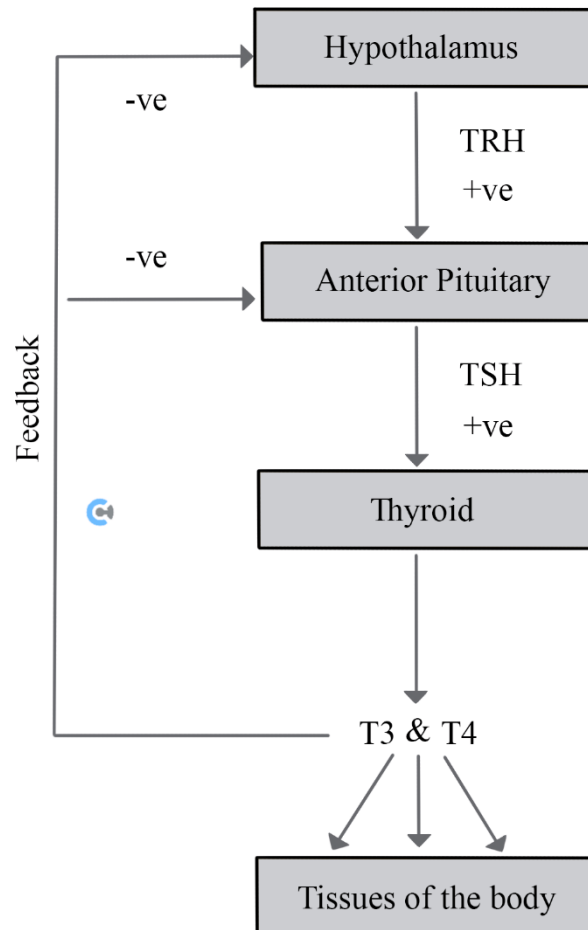
- d. Name the location and level of protein structure that is present at the completion of process 3, in a patient with normal SMN. 2 marks

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Question 2 (7 marks)

Hyperthyroidism occurs when there is an issue in the TRH-TSH-T₃/T₄ axis as mediated by the hypothalamus, anterior pituitary gland and thyroid gland respectively, resulting in excess production of thyroid hormone (T₃/T₄). This is a diagram representing the relationship between the different hormones.



- a. What would happen in the body if there is an increase in the level of TSH in the body? 2 marks

Thyroxine (T_4) is synthesised by the follicular cells of the thyroid gland before being exported out of the cell.

- b.** Describe the steps and organelles that are involved in the export of thyroxine from the follicular cells of the thyroid gland. 3 marks

Enzymes that are known as deiodinases are responsible for the conversion of T_4 into T_3 (which is actually responsible for the function of thyroid hormone). Some medications work by acting as inhibitors.

- c.** Compare competitive and non-competitive enzyme inhibition. 2 marks

Question 3 (14 marks)

The *trp* operon is the process by which bacteria are able to regulate the production of the amino acid tryptophan in the cell.



- a. What is meant by an operon, and why might they be useful?

2 marks

- b. Explain how, through the action of repressor proteins, *E. coli* is able to regulate the production of tryptophan. Include a labelled diagram in your answer.

5 marks

Do not write in this area.

- c.** Explain, through the process of attenuation, how post-transcriptional regulation of tryptophan can occur. 4 marks

- d.** Why cannot the process described in **part c.** be performed by eukaryotes? In your answer, compare the process of gene expression in prokaryotes such as *E. coli* and eukaryotes. 3 marks

Question 4 (16 marks)

CRISPR-Cas9 is an exciting and revolutionary gene-editing tool that has recently been isolated from bacteria, ushering in a new age of medical treatments. The CRISPR system is part of the bacterial immune response, where it provides resistance to viral infections. Researchers have adapted this natural process to allow for precise gene editing in a variety of organisms, including humans.

- a. Describe the process by which CRISPR-Cas9 functions in bacteria.

3 marks

- b. Describe the significance of the PAM sequence in bacterial CRISPR-Cas9 function, identifying two reasons.

2 marks

Do not write in this area.

Recent trials are investigating the use of CRISPR-Cas9 directly infused into patients for a hereditary blindness condition known as Lemer's congenital amaurosis, caused by a single mutation in the CEP290 gene coding for a photoreceptor. This is expressed in the retina, preventing accurate reception of light. Research has shown that accurate vision can still be maintained with an absent photoreceptor, as opposed to the mutated version. This is the first time CRISPR-Cas9 has been injected into a patient, with previous trials focusing on taking cells out, editing them *ex vivo* and then returning them to the patient.

- c. Describe how scientists could use CRISPR-Cas9 technology to cure Lemer's congenital amaurosis. 4 marks

James and Marcus are discussing the delivery of the CRISPR-Cas9 complex into a patient's bloodstream to treat a genetic disorder involving the CEP290 gene. James is concerned that the infusion might edit cells outside the retina, as the CEP290 gene is found in all cells. Marcus disagrees, suggesting that only the retina will be affected, as the proteome (the proteins expressed in cells) determines which cells will be impacted by the editing.

d. Who is correct, James or Marcus, and why?

3 marks

In your answer, explain the difference between the genome and proteome, and how this affects the CRISPR-Cas9 system's impact on different cells.

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Some enterprising individuals have seen this evolution of CRISPR-Cas9 technology and realised it may be an opportunity to create a gene-editing service targeted to immigrant parents allowing them to edit their child so they get straight raw 50s in all their VCE subjects.

- e. Using the ethical concepts you have studied this year, discuss using a consequences-based approach to the ethics of genetically editing humans for 'designer', or non-medically necessary edits. 4 marks

Question 5 (13 marks)

In an effort to become closer to his cultural roots, Micah chooses to undergo genetic testing and profiling. He takes a sample of his DNA and sends it off to the lab, as he goes off to buy a kurta, confident that he'll have at least 25% brown DNA (owing to his grandfather).

Unfortunately for Micah, the police intercepted his sample and are instead using it to test him as a prime suspect in a spree of international bank robberies.

- a. Describe, the process that the forensic scientists could use in order to increase his DNA sample. Reference the significance of each step in your answer. 4 marks

Once they do have a large sample of his DNA, they need to compare it with the rest of the samples that they have received, including the samples collected from the crime scene. They achieve this using gel electrophoresis techniques, which involve cutting the DNA into fragments with the same endonuclease prior to running the gel.

- b. What property of DNA allows it to move through the gel? 1 mark

- c. Describe two factors that influence the rate at which the fragments move through the gel. 2 marks

- d. Explain how gel electrophoresis can be used to tell the difference between two DNA samples. 3 marks

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With the results of the gel now back, it becomes clear that Micah was in fact responsible for the crimes. In court, however, choosing to be his own lawyer, he states:

“These Interpol dogs have actually acted unethically by getting the genetic testing company to send them my sample! I would NEVER have given up my DNA at all!”

- e. With reference to the ethical concepts studied, such as integrity, respect and beneficence, discuss the ethics of Interpol using this DNA sample as part of their investigation to put away a bank robber.

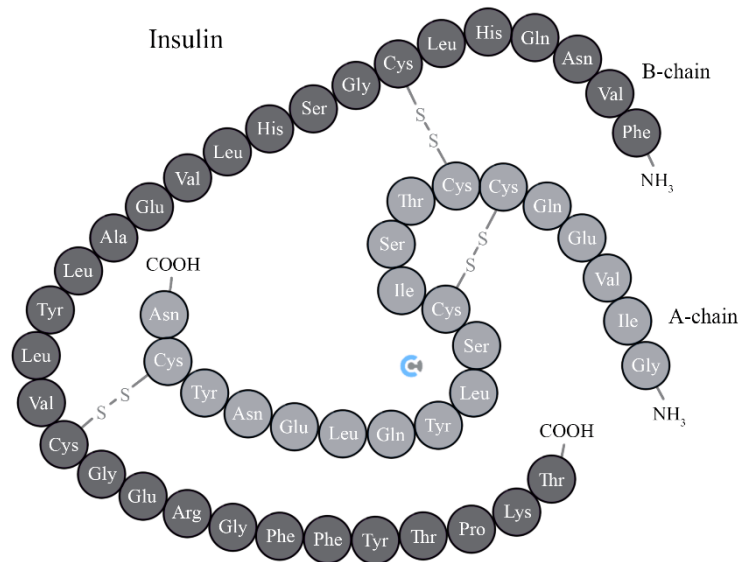
3 marks

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Question 6 (5 marks)

Insulin is an incredibly important protein that is required for many functions in the body, most notably the uptake of glucose by cells via glucose transporters in order to reduce the blood glucose level.

The structure of insulin is given below:



- a. What level of protein structure is insulin?

1 mark

Recombinant plasmids have been widely floated as a way to get synthetically produced human insulin.

- b. Explain 2 methods that could be used to insert a plasmid into a bacterial cell.

2 marks

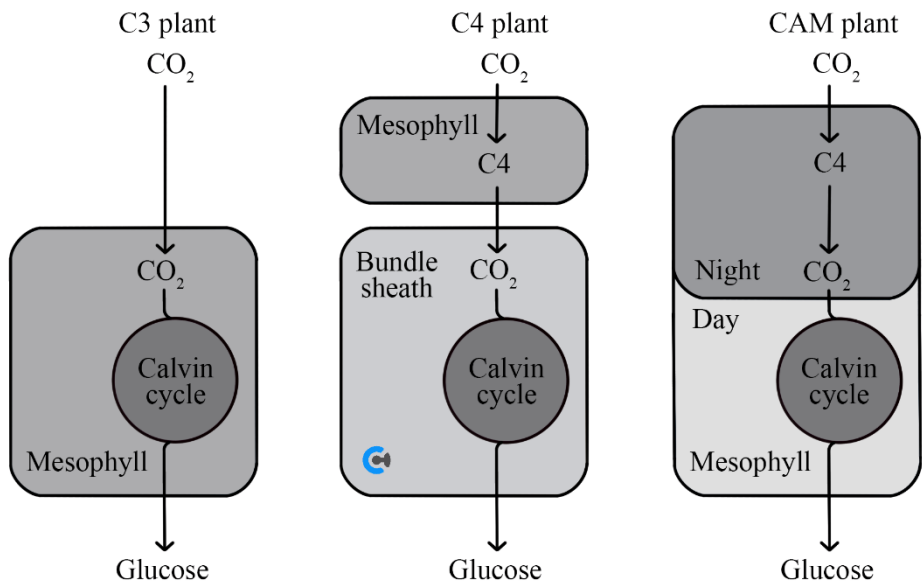
A lack of insulin can lead to cell death due to a lack of energy, despite hyperglycaemia (high blood glucose) being present.

- c. Account for this, with reference to the pathway by which human cells produce energy. 2 marks

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Question 7 (4 marks)

Plants have the unique ability to photosynthesise and utilise sunlight. They are able to produce high-energy-containing molecules that fix carbon dioxide (CO₂) into forms of carbohydrates that can be stored or used by the plant cells. Most plants use C₃ pathways to fix CO₂ and some use the C₄ pathways. A small group of plants use a combination of both pathways. This smaller number of plants is called CAM plants.



Condition	Plant Type	Photosynthesis Rate ($\mu\text{ mol CO}_2/\text{m}^2/\text{s}$)	Water use Efficiency ($\mu\text{ mol CO}_2/\text{mmol H}_2\text{O}$)	Biomass Production (g/m^2)
Cool and Wet	C3	25	2.5	600
	C4	30	4.5	650
	CAM	15	5.0	400
Warm and Wet	C3	20	2.0	500
	C4	35	4.8	700
	CAM	18	5.2	450
Hot and Dry	C3	10	1.5	300
	C4	25	5.0	600
	CAM	22	8.0	500

With reference to the data, explain why C3 plants are poorly adapted for hot and dry conditions as compared to C4 and CAM plants.

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Question 8 (10 marks)

As part of their practical investigation into cellular respiration, a group of students decided to test germinating wheat seeds under varying temperature conditions. For their experimental setup, they placed a CO₂ sensor inside each of four sealed containers, each containing 100 germinating wheat seeds. The containers were then placed in different controlled environments, with temperatures set to 10°C, 20°C, 30°C, and 40°C respectively. The CO₂ sensors were used to measure the concentration of carbon dioxide produced by the seeds over a 30-minute period, indicating the rate of cellular respiration. The data collected from the experiment is presented in the table below:

Time (min)	CO ₂ Concentration (ppm) at 10°C	CO ₂ Concentration (ppm) at 20°C	CO ₂ Concentration (ppm) at 30°C	CO ₂ Concentration (ppm) at 40°C
0	400	400	400	400
5	410	420	430	450
10	420	440	460	500
15	430	460	490	550
20	440	480	520	600
25	450	500	550	650
30	460	520	580	700

- a. Explain and describe a possible hypothesis for this experiment.

2 marks

- b.** Describe and explain the results of this experiment, with reference to concepts studied this year. 4 marks

After their investigation of cellular respiration, one particularly bright student wonders if modifications to another biochemical pathway can be used to usher in a new form of renewable energy in our vehicles and homes, using biomass from plants.

- c.**
- i.** Naming this biochemical process, explain how fuels may be produced from biomass. 2 marks

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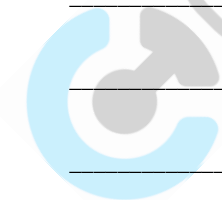
ii. List two advantages of biofuel production using this process.

2 marks

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