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Draw a cross through the box (☒) if you have NOT written in this booklet

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NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Biology 2025

91159 Demonstrate understanding of gene expression

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of gene expression.	Demonstrate in-depth understanding of gene expression.	Demonstrate comprehensive understanding of gene expression.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in the margins (▨). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 13

QUESTION ONE: Mutation effects on protein – cystic fibrosis

Cystic fibrosis is a genetic disorder caused by mutations in the cystic fibrosis transmembrane conductance regulator (CFTR) gene, which encodes a protein that helps regulate salt and water balance in cells. Mutations in this gene can disrupt the function of the CFTR protein, leading to the build-up of thick mucus in the lungs and other organs.

Table 1. mRNA (codon): Amino Acid

First Position	Second Position: U	Second Position: C	Second Position: A	Second Position: G	Third Position
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA STOP	UGA STOP	A
	UUG Leu	UCG Ser	UAG STOP	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

(a) Part of a DNA sequence and its associated mRNA and amino acid sequence are shown in Table 2 below. Complete the mRNA and amino acid sequences for both mutated sequences in the table. The DNA mutations are underlined.

Table 2

	Normal sequence	Mutated sequence 1	Mutated sequence 2
DNA template strand	TTA TGC AAT CCG	TTA TGC GAT CCG	TTA TGC AAG CCG
mRNA	AAU ACG UUA GGC	AAU ACG CUA GGC	AAU ACG UUC GGC
Amino acid	Asn Thr Leu Gly	Asn Thr leu Gly	Asn Thr Phe Gly

(b) Discuss the effects of these mutations on the amino acid sequence and final protein.

In your answer, include discussion of:

- the type of point mutations shown, and the severity of these mutations compared to other types, such as frame shift or stop codons (nonsense mutations)
- the effects of these mutations on the amino acid sequence and final protein produced
- the effect of these mutations on the final functioning of the CFTR protein and how this relates to the symptoms of cystic fibrosis.

Mutation is a permanent change in DNA sequence.
The mutation 1 is silent mutation due to one base is swapped but the amino acid doesn't change.
The mutation 2 is substitution (missense mutation) due to only one base is swapped. and the one amino acid changed.

Other types of mutation.:
Nonsense mutation : one base is swapped. and changed into stop codon.

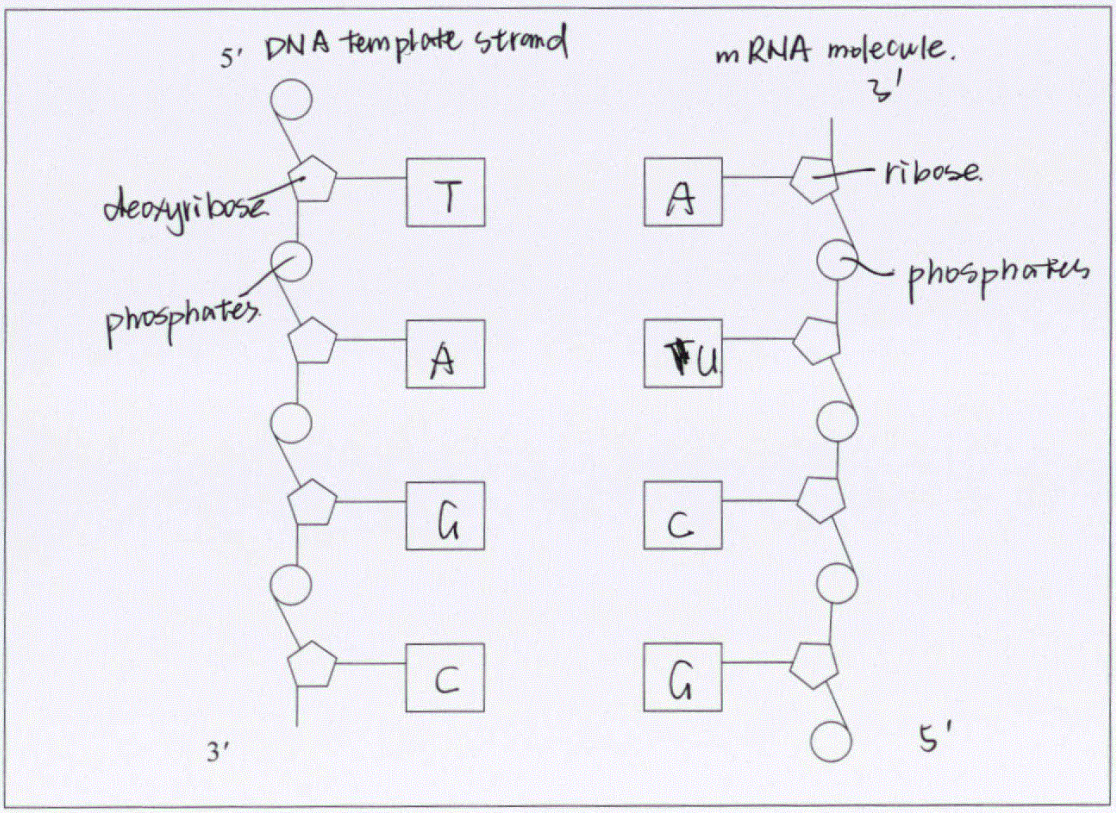
The effect of mutation 1 : There is no effect be caused by mutation 1 due to no amino acid is changed.
Therefore. the protein is same with the normal sequence.
The effect of mutation 2 : There is only one base is changed so only one amino acid is changed., and the folding structure may slightly changed.
Finally, the function of the protein is changed.

QUESTION TWO: Protein synthesis

(a) Complete the diagram of transcription below.

In your answer:

- fill in the DNA template strand containing the bases thymine (T), adenine (A), guanine (G), and cytosine (C)
- complete the corresponding mRNA strand, showing complementary base pairing
- label the ribose and deoxyribose on the DNA and mRNA strands
- label the phosphates on both the DNA and mRNA strands
- label the 5′ and 3′ ends of the mRNA molecule
- label the DNA template strand and the mRNA molecule.



(b) Discuss the importance of transcription and translation, and why the DNA strand is not directly translated into a polypeptide chain.

In your answer, include discussion of:

- the purpose of transcription and translation, and the steps involved with each
- the relationship between codons, anticodons, tRNA, mRNA, and amino acids during translation
- TWO reasons why the DNA strand cannot be directly translated into a polypeptide chain, focusing on the roles of transcription and mRNA in this process.

The purpose of transcription is to produce a strand of mRNA which contain base sequence. which is identical to genetic code.
The purpose of translation is ~~to make~~ that the genetic code on mRNA is converted into amino acid., ~~The of tRNA~~

In the transcription. an enzyme unwind DNA strands. and one. DNA strands as a template strands. Triplet is a three consecutive nucleotide base in DNA strand. ~~The free nucle~~
The free nucleotide bases. complementary to the triplets. ~~due to the~~ by the base-pairing rule ~~(A-U, C-G)~~
" T-A A-U C-G G-C " to form the mRNA, and the. codon is the sequence of three consecutive nucleotide base. on mRNA (complementary to triplet)..
The mRNA move to the ribosome, the traslation occurs.
In the translation., the tRNA carry a specific amino acid. which. have anticodons. complementary to the codon on mRNA.,
~~It let amino acid attached to each other in genetic sequence.~~
Anticodon is the three consecutive nucleotide base. on tRNA which. complementary to the codon on mRNA.
It let amino acid attached to each other in a genetic sequence.
The amino acid attached each other by peptide chain., and they folding into a specific shape. to form a protein.

DNA can not directely translated into polypeptide chain.
because the traslation need to take place as the mRNA. which produced in the ~~first~~ transcription.
Transcription is the first step of protein synthesis.
Translation is the second step of protein synthesis.

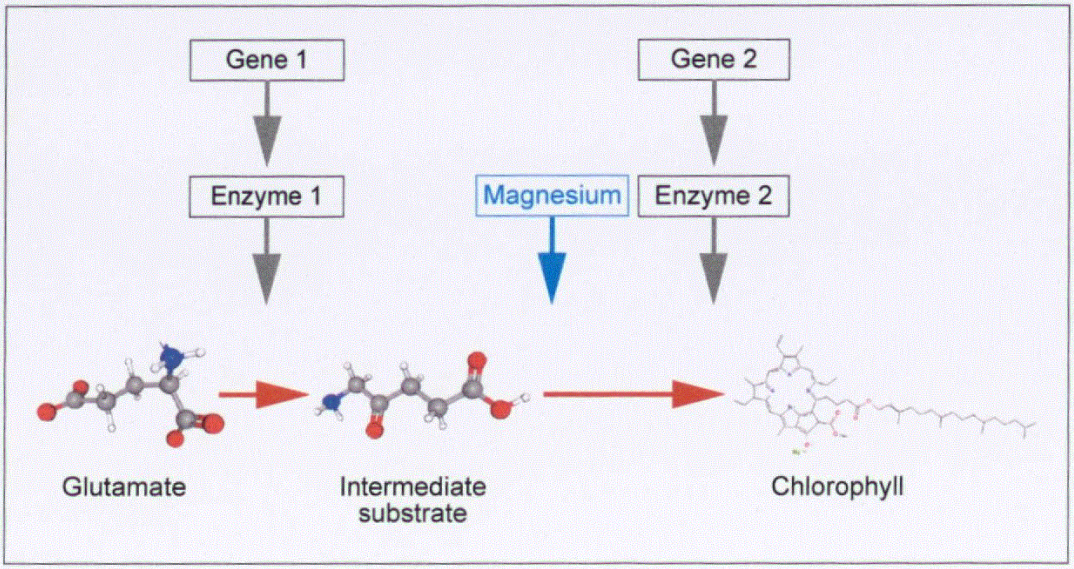
QUESTION THREE: The environment and gene expression in plants

Chlorophyll is the pigment responsible for the green colour in leaves. The production of chlorophyll is influenced by both genetic factors and environmental conditions such as magnesium availability. In plants with chlorosis, genetic mutations or the lack of magnesium availability can lead to reduced chlorophyll production, resulting in yellow or pale leaves.

Strawberry leaf showing chlorosis symptoms.

Healthy strawberry leaf.

A simplified metabolic pathway that makes chlorophyll is shown below:



Discuss how genes, enzymes, and the environment regulate the production of chlorophyll in plants and cause the yellowing of leaves due to chlorosis.

In your answer include discussion of:

- a metabolic pathway
- the metabolic pathway shown above, using the terms substrate, enzyme, gene, and final product
- how DNA mutations and magnesium availability can affect chlorophyll production and leaf colour.

A metabolic pathway is a series of enzyme-controlled reaction, where the production of one reaction is the substrate for the next.
Substrate is a substance the enzyme act on.
Enzyme is a biological catalyst to speed up biological reactions.
Gene is a section of genetic information.

~~Enzyme 1 (a protein)~~

Protein synthesis create a protein "Enzyme 1" from Gene1.
The Glutamate react with enzyme1 and the product of this reaction is intermediate substrate. The enzyme1, creact from gene2 can act on the intermediate substrate, to form Chlorophy II what is responsible for the green colour.

But when genetic mutation occur, enzyme 2 may can not be formed or its function is changed, so it doesn't work. ~~for green colour~~. with ~~out~~ the normal substrate.
~~either~~ And the over available magnesium is plants can destory the protein structure eg enzyme 2.. So the enzyme 2's function is changed.
Therefore ~~mutati~~ & DNA mutation and magnesium availability can effect the leaf colour.

Achievement

Subject: Biology

Standard: 91159

Total score: 13

Q	Grade score	Marker commentary
One	A4	The response identified: • the amino acid resulting from the mutation in the table • the mutations as substitution The response described: • a mutation • mutation 1 as silent and mutation 2 as missense.
Two	M5	The response explained: • the structure of DNA and mRNA molecules • the complementary nature of mRNA and DNA triplet • that tRNA carries a specific amino acid.
Three	A4	The response described: • a metabolic pathway • an enzyme • a substrate • how a gene produces enzymes.