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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.

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 <u>G</u>AT CCG	TTA TGC AA<u>G</u> CCG
mRNA	AAU ACG UUA GGC		
Amino acid	Asn Thr Leu 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.

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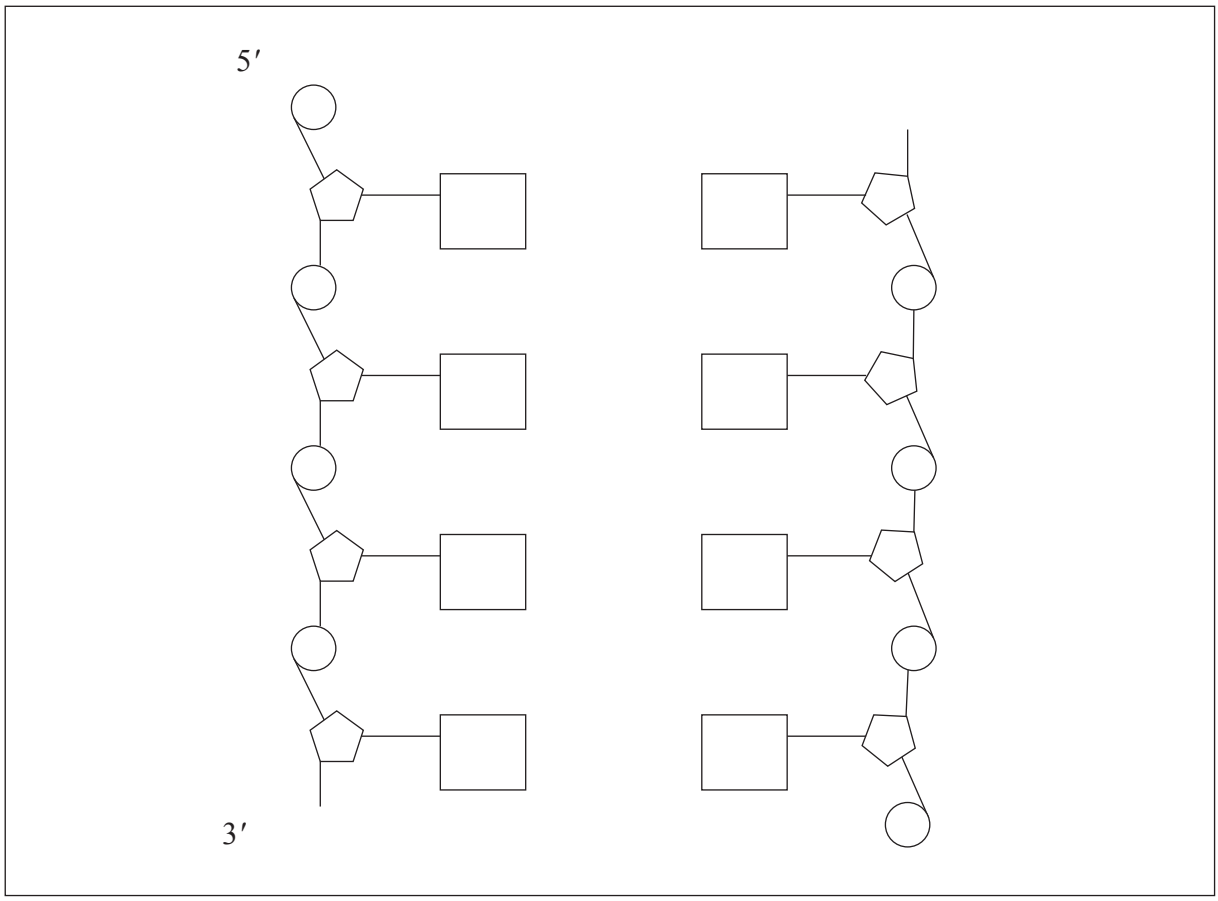
The assessment continues on the following page.

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.

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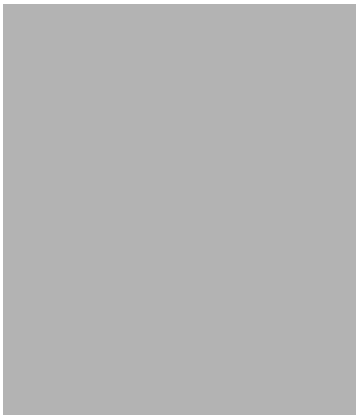
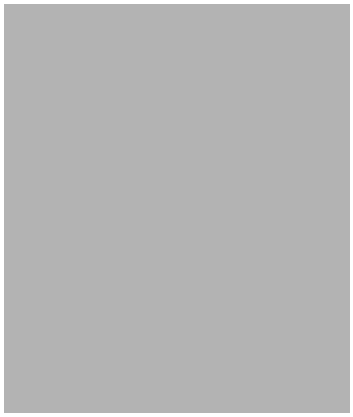
QUESTION THREE: The environment and gene expression in plants

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.

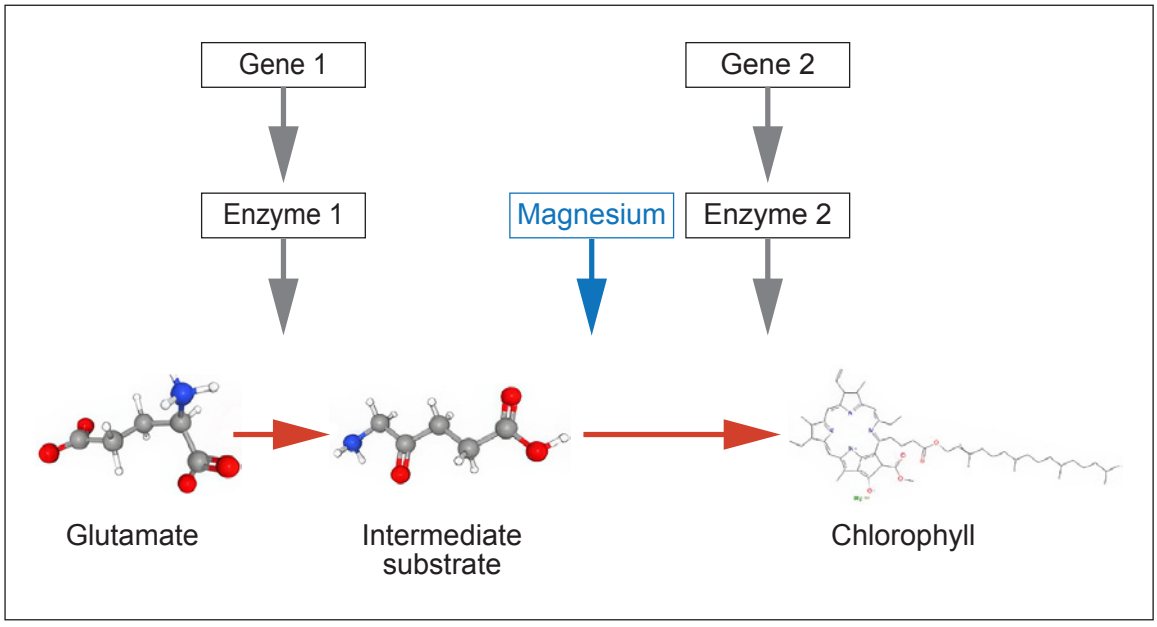


Strawberry leaf showing chlorosis symptoms.



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.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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Acknowledgements
Material from the following sources has been adapted for use in this assessment:

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https://www.mdpi.com/2077-0472/11/3/217
https://pubchem.ncbi.nlm.nih.gov/compound/glutamate#section=3D-Conformer
https://pubchem.ncbi.nlm.nih.gov/compound/chlorophyll