



Mana Tohu Mātauranga o Aotearoa New Zealand Qualifications Authority

Level 2 Biology 2024

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 $(\frac{1}{2})/\frac{1}{2}$. 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: Protein synthesis

(a) Complete the table below to describe three ways in which mRNA and DNA are different from each other.

Difference	DNA	mRNA
1		
2		
3		



Overview of protein synthesis.

Compared to mRNA, the structure of tRNA increases its stability, which increases the period of time that tRNA lasts in the cytoplasm. In contrast, the majority of mRNA molecules break down within a few hours after their release from the nucleus into the cytoplasm.

(b) Compare mRNA and tRNA, including their function, structure, stability, and role in protein synthesis.

In your answer, include discussion of:

- the function of both mRNA and tRNA
- how mRNA and tRNA work together to carry out protein synthesis
- the significance of tRNA being stable and mRNA being unstable.

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QUESTION TWO: Mutations

The table below shows the abbreviations for some of the amino acids and DNA triplets that code for them.

Amino acid	Abbreviation	Triplets on the DNA template strand
Valine	val	CAA, CAC, CAG, CAT
Proline	pro	GGA, GGC, GGG, GGT
Threonine	thr	TGA, TGC, TGG, TGT
Histidine	his	GTA, GTG
Glutamic acid	glu	CTC, CTT
Leucine	leu	AAC, AAT, GAA, GAC, GAG, GAT

One function of haemoglobin is to assist with transport of oxygen.

There are many different variants of haemoglobin.

The sequence of bases in DNA for the normal gene and for the mutated version that codes for the β -globin polypeptide are shown in table (i) below.



- (a) Complete the following TWO tables to show the mRNA, tRNA, and amino acid sequences, using the resource information above.
 - (i) Code for **normal** β -globin polypeptide

Triplet number	1	2	3	4
DNA template strand	TGA	GGA	CTC	CTC
mRNA (codon)				
tRNA (anticodon)				
Amino acid				

(ii) Code with **mutated** β -globin polypeptide

Triplet number	1	2	3	4
DNA template strand	TGA	GGA	C <u>A</u> C	СТС
mRNA (codon)				
tRNA (anticodon)				
Amino acid				

(b) Discuss the effect of this mutation on the amino acid sequence and the functioning of the final β-globin polypeptide.

In your answer, include discussion of:

- the causes of mutations
- the mutation type and the severity of this type of mutation compared to other types
- the effect of this mutation on the functioning of the final haemoglobin beta polypeptide.

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QUESTION THREE: Environment and gene expression

Anaemia is a condition that develops when a person's blood produces a lower-than-normal amount of healthy red blood cells.

Iron is an essential element in all living cells. Approximately 75% of an individual's total iron is associated with a compound called 'haem' (a part of haemoglobin found in red blood cells), which is responsible for oxygen transport. Part of the metabolic pathway for haem synthesis is shown below.

Haem synthesis.

A lack of iron and high levels of lead in the body can limit the synthesis of haem. Lead is a known poison that inhibits enzymes. If haem synthesis does not occur when needed, anaemia can develop.

Discuss how genes, enzymes and materials in the environment can change the rate of haem production. In your answer, include discussion of:

- a metabolic pathway
- how the metabolic pathway for haem synthesis occurs, using the terms: substrate, enzyme, gene, and final product
- how DNA mutations, low iron, and high lead can all cause anaemia.

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Acknowledgements

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

Page 3

https://www.ck12.org/c/chemistry/protein-synthesis/lesson/Protein-Synthesis-CHEM/

Page 6

https://www.nature.com/articles/s41598-017-11259-0#Fig1

Page 9

https://www.youtube.com/watch?v=Q_WkjA4ZcjY (at 7:00)

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