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NZQA

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 (▨). 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.

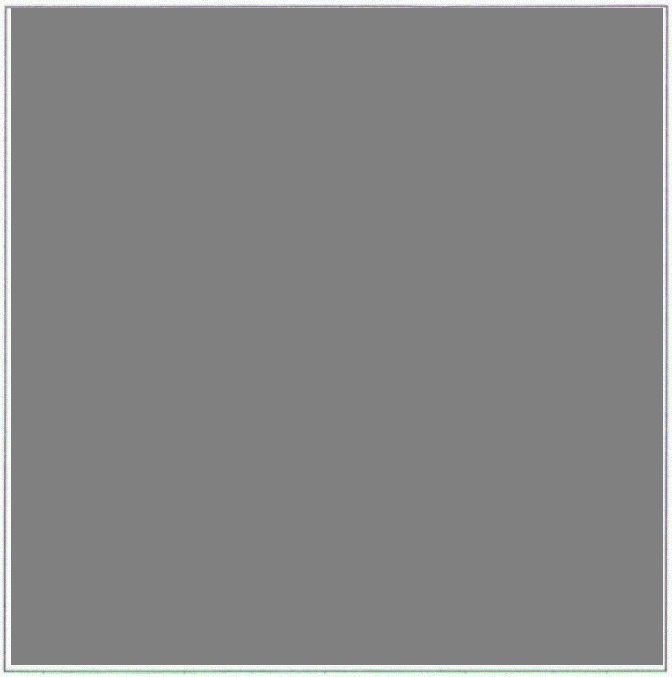
Achievement

TOTAL 11

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	DNA contains deoxyribose sugar, a phosphate and bases	mRNA contains ribose sugar, a phosphate and bases
2	DNA consist of Adnine, thymine, guanine, and Cytosine. (A, T, G, C) A pairs with T G pairs with C	~~mRNA~~ In a mRNA chain, the Thymine (T) bases are swapped out by uricle. (U) ~~mRNA~~ like DNA, mRNA has Adnine, guanine and Cytesine too.
3	DNA has two strands in a double helix (double stranded	MRNA is only one strand (single stranded) which combines with one of DNA's strands.



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.

mRNA (messanger RNA) is a type of RNA which sends signals (or messages) to parts of the body. Like mRNA, tRNA (transfer RNA) is also a type of RNA which plays a role in the ~~transport~~ transfer of bases. ~~Messanger RN~~ They are both used in protein synthesis. Protein synthesis is the prosess where ~~proteins~~ amino acids (made from proteins) are formed and polypeptide (amino acid chains are created. Proteins code for different

Transcription is the first phase of protein synthesis
traits and functions throughout the body.
~~Protein synthesis~~ and begins in the nucleus with DNA.
DNA is made up of two strands held together by bases in a double helix shape. The ~~str~~ top strand is called the coding strand and runs from 5' to 3' and the other is the template strand which runs in the opposite direction: from 3' to 5'.
An enzyme called ~~primase~~ DNA polymerase unzips these two strands allowing a new complementary strand (MRNA) to ~~come~~ combine with the ~~orginal~~ template ~~coding~~ strand. The ~~bases~~ mRNA strand compliments itself with the ~~coding~~ template strand following the base-pairing rule that states Adidine pairs with Thymine and Guanine pairs with Cytosine except in the mRNA strand, thymine is swapped out for Uricle.
From here the mRNA is ~~transferred~~ ported to the cytoplasm for the ~~first~~ second major ~~step~~ phase of protein synthesis to occur.
There are two ~~phases~~ of protein synthesis: transcription and translation. ~~Translation~~ the mRNA is then transported to the ribosome where transport RNA (tRNA) takes each "codon" of bases (set of three bases)

~~And~~ ~~X~~ These sets of three bases or 'triplets' are turned into ~~amino~~ proteins which are the building blocks to amino acids. ~~make up~~ amino acids

tRNA continues to do this in the translation phase ultimately resulting in a polypeptide chain (large chain of amino acids.)

It is important that mRNA is unstable and tRNA is stable as mRNA needs to be able to adapt itself to complement the template strand of DNA and be transfered around the body, whereas tRNA has a more careful and percise role of forming codons and triplets

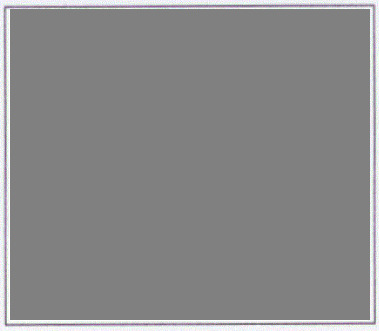
QUESTION TWO: Mutations

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.



Haemoglobin molecule.

(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)	ACU	CCU	GAG	GAG
tRNA (anticodon)	TGA	GGA	CTC	CTC
Amino acid	thr	pro	glu	glu

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

Triplet number	1	2	3	4
DNA template strand	TGA	GGA	CAC	CTC
mRNA (codon)	ACU	CCU	GUG	GAG
tRNA (anticodon)	TGA	GGA	CAC	CTC
Amino acid	thr	pro	val	glu

(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.

A mutation is a perminant change in the base sequence of DNA and are caused by mutagens (factors that can alter DNA). Some mutagens include UV light, ~~enzu~~ and radiation, and chemicals. These can cause point mutations ~~re~~ which can result it different proteins being formed and could also cause harm. however, some mutations do not. The three point mutations are insertion, deletion and substitution. Insertion is where a base in the template strand of DNA gets added or 'inserted' into the code. Deletion is the opposite and occurs when an already existing base from the template strand of DNA is removed or 'deleted' from the code. Substitution is where a base from the template strand of DNA gets swapped out with another base. For exarmple: AGC → AAC the guanine base is replaced with a adinine base.

~~M~~ A codon is a set of three bases (eg: TGA) that code for a specific protein or amino acid. (eg: threonine). These proteins have different important rules throughout the body. When mutations occur, they can disrupt the sequence of bases resulting in different

proteins/amino acids being formed. This can be harmful as certain proteins may not be able to form or new proteins could arrise. Other times, mutations like these can be silent mutations meaning they have no observbal effect on an individual. The mutation in the exarmple on page 6 is a substition mutation as the ~~Adinine~~ Thymine base is swapped for an Adinine. This has resulted as, instead of glutmaic acid, Valine being created. Because of this mutation, ~~glutmic~~ the amino acid glutamic acid isn't being produced and unable to forefill its purpose in the body. ~~Valine~~

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.

A metabolic pathway is a series of enzyme reactions ~~events~~ which lead to a^n end product ~~protein~~ being formed. The diagram above is a metabolic pathway as it includes the chain enzymes, and substrates leading to the final product (Haem). The pathway begins with the substrate precursor which combines with the active site of ~~a~~ enzyme 1. From there, the intermediate substrate is formed ~~created~~ and combines via the active site with enzyme 2. Eventually, the metabolic pathway will come to ~~the~~ a end resulting in a product (in this case Haem).

However, we can see that enzyme 2 is met with lead and iron which can alter the outcome of the final product. lead is a known poison that inhibits enzymes and is able to limit the production of haem. ~~Other factors that~~ This is a limiting factor in a metabolic pathway. ~~high levels of lead are~~ low iron and Another ~~factor~~ are ~~enzyme~~ mutations and can be harmful for many reasons. High levels of lead, low iron or mutations may ~~cause~~ result in a build up of substrate, in this case the intermediate substrate which can be very harmful and toxic, as too much of anything can overwhelm the body. This could also result in future enzymes and substrates being made and ultimatley, preventing a final product at all. This ~~is extremely~~ can be very bad as haem synthesis won't be able to occur resulting in the development of anaemia. and less red blood cells.

Achievement

Subject: Biology

Standard: 91159

Total score: 11

Q	Grade score	Marker commentary
One	A4	This response outlines two differences between DNA and mRNA, describes protein synthesis, details the function of mRNA, and describes the transcription process.
Two	A4	This response explains what a mutation is, describes a substitution mutation, connects a negative consequence of a mutation to the final protein, and details a deletion mutation.
Three	A3	This response describes what a metabolic pathway is, describes a substrate, and identifies how lead inhibits the functioning of enzymes.