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91159

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NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 2 Biology, 2016

91159 Demonstrate understanding of gene expression

9.30 a.m. Friday 18 November 2016
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 space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

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

Excellence

TOTAL 22

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QUESTION ONE: NUCLEIC ACIDS

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(a) Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are both involved in protein synthesis.

Describe the structure of DNA and RNA.

You may use diagrams in your answer.

DNA is a double stranded molecule ~~of the contains~~ coated made up of ~~a~~ nucleotides that include the deoxyribose sugar and the bases Adenine, Guanine, Cytosine and Thymine, while RNA is a single stranded, more base ~~structure~~ molecule made up of nucleotides ~~the~~ that include the ~~deoxyribose~~ ribose sugar and the bases Adenine, Guanine, Cytosine and uracil.

(b) DNA, mRNA, and tRNA are all involved in the formation of proteins.

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Discuss the significance of these molecules in forming proteins, and why the cell continually makes mRNA molecules, but not DNA molecules, during protein synthesis.

In your answer include:

- an explanation of the function of DNA, mRNA, and tRNA molecules
- an explanation of how mRNA is produced
- a discussion of the significance of DNA, mRNA, and tRNA in forming specific proteins.

Protein synthesis is the process by which DNA, the molecule (comes double-stranded) that is essential to an organism because it which contains the organism's genetic code that determines (transcripted into mRNA then translated) its characteristics, is ~~made~~ into a protein that plays a part in determining an organism's phenotype. mRNA is a (type) ~~basic~~ molecule that DNA is transcribed into so that (mRNA can carry) the genetic code from the nucleus ~~to the~~ to a ribosome for translation into a protein. Transcription, the first part of protein synthesis, occurs in the nucleus; the helicase enzyme unwinds the DNA double helix to expose ~~the~~ its two strands. One of these strands, known as the template strand, is used as a template for the ~~R~~ RNA polymerase enzyme to complimentary base pair ~~CAUG~~ RNA nucleotides, to in order to make an mRNA copy of the other strand of DNA, known as the coding strand. Once this copy has been made, the last part of transcription is to remove the introns from DNA that are not significant or needed in the function of a protein, and to splice (rejoining) ~~put~~ the exons together - this is called splicing. The cell continues this process of making mRNA molecules in transcription, but not DNA molecules, because one strand of mRNA = one protein, (of the same) whereas the cell needs many proteins to ~~defend~~ make up an organism's phenotype. DNA is not made again because its only significance ~~for~~ the synthesis of proteins is

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to be the template for the mRNA copy of DNA that will be used in translation - DNA itself is not directly translated into a protein. Once mRNA leaves the nucleus through a nuclear pore after transcription, it goes to a ribosome in the cytoplasm or endoplasmic reticulum which carries out translation. In translation, the ribosome latches on to the mRNA strand and reads it one codon (a sequence of 3 bases on mRNA) at a time, starting with the start codon AUG. ~~The codon~~ the ribosome the brings in the tRNA molecule with the corresponding anticodon - a sequence of three bases on a tRNA molecule. (transfer RNA) These tRNA molecules are essential to the process of protein synthesis as their job is to transfer the amino acid that the codon on the mRNA strand has coded for to the ribosome, which matches the codon and its corresponding anticodon on the tRNA together and then adds the ~~tRNA molecule~~ ~~e~~ amino acid to a growing polypeptide chain coming out of the ribosome, and, it is this ~~pp~~ polypeptide chain that makes up the final protein. Therefore, tRNA is essential in the formation of specific proteins because ~~it~~ without the correct amino acid it carries that corresponds with the ~~the~~ what the codon has coded for, there would be no polypeptide chain of amino acids, or this chain would have amino acids in completely the wrong order.

E7

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QUESTION TWO: ENVIRONMENTAL FACTORS AND GENE EXPRESSION

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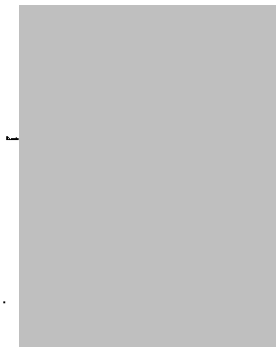
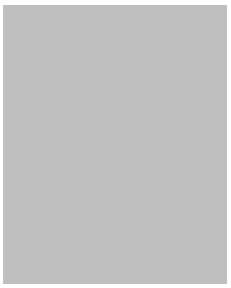
The honey bee (*Apis mellifera*) has two female phenotypes.

Female type	Larvae Diet	Adult phenotype	Genotype
Queen bee 	royal jelly	• increased ovary size • large body mass • live for 2 years	the same
Worker bee 	royal jelly for 3 days, then only pollen and honey	• infertile ovaries • smaller body mass • live for 3 – 6 weeks	

www.britannica.com/media/full/171791/141787

(a) Describe the term gene expression.

Gene expression is the process by which a gene of DNA is transcripted and translated into a protein in order for this protein to determine the phenotype that the gene has coded for.

(b) Explain why comparing worker and queen honey bee females is ideal for experiments on environmental factors and gene expression.

Because they have the same genotype and therefore DNA, and it is only how they are affected by their environment, that determines phenotype traits such as ovary size and functionality.

(c) Experiments have confirmed that royal jelly is not a mutagen.

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Discuss the effect the environment has on the expression of the phenotype in honey bee females.

In your answer include:

- a description of the environmental factor that affects honey bee phenotype
- using an example, an explanation of the difference between environmental factor and mutagen
- a discussion of how honey bee phenotype can change without changing the genotype
- a discussion of why the queen bee's phenotype is fully expressed, but the worker bee's phenotype is not.

The environmental factor that affects the honey bee phenotype is royal jelly, as there is a great difference between a mutagen and an environmental factor. A mutagen is something that results in a change in the base sequence of an organisms DNA, while an environmental factor is an abiotic or biotic factor that changes the phenotype of an organisms characteristics. An environmental factor of royal jelly does not change the organisms genotype as a mutation does. However, it can change the organisms phenotype because it can affect the availability of precursors and the activity of enzymes in one of the organisms metabolic pathways that makes a product needed by the organism that determines the resultant phenotype of this organism. Thus, the phenotype can be altered without affecting the genotype. In the case of the queen bee and the worker bee, the royal jelly contains a precursor needed by the bee in order for it to fully develop its ovaries, body mass and therefore its lifespan. Because the worker bee only eats the royal jelly for three days, the metabolic pathway that produces the products needed

There is more space for your answer to this question on the following page.

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for its development only is only active for ~~this~~ ~~long~~ this period of time. This means that while the worker bee's DNA gives it the potential for it to have the phenotypic traits of a queen bee, the lack of the precursor substance present in the royal jelly beyond this time in the bee means that it can only be developed into a worker bee, and so its phenotype is not fully expressed. The queen bee, on the other hand, eats the royal jelly throughout its life, and so the precursor of the metabolic pathways that determine its queen size, body mass and lifespan is always available, and so the products of this pathway that ~~exist~~ results in the expression of this phenotype are always produced, allowing the queen bee's phenotype to be fully expressed. ~~so that~~

E8

QUESTION THREE: MUTATIONS

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(a) Describe what a mutation is.

A mutation is a sudden, permanent change in the base sequence of an organism's DNA that alters its genotype and maybe phenotypic trait(s)

Question Three continues on the following page.

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(b) There are over 1000 mutations that can cause cystic fibrosis. A common mutation is a deletion mutation that results in the absence of one amino acid in the final protein. Another mutation is a substitution mutation that results in a different amino acid in the final protein. mis-sense

Cystic fibrosis gene

Chromosome 7

Discuss how these two mutations affect the cystic fibrosis gene's final protein and resulting phenotype.

In your answer include:

- an explanation of why the deletion mutation causes one amino acid to be absent in the final protein, and how this affects protein folding
- an explanation of why the substitution mutation causes a different amino acid to be present in the final protein, and how this affects protein folding
- a discussion of why the deletion mutation causes severe cystic fibrosis disease, whereas the substitution mutation causes milder cystic fibrosis disease.

A deletion mutation is ~~the~~ when one ~~A~~ base in an organisms DNA is incorrectly taken out of the base sequence. This results in a frameshift of all the triplets downstream of the mutation, thus changing all the codons and therefore amino acids that are coded for past this point. Due to this ~~from~~ frameshift, the final codon in the gene/RNA sequence that encodes for amino acids is incomplete, and therefore does not produce an amino acid. Because ~~the~~ the amino acids of a protein ~~effect~~ determine its structure, the absence of amino acid(s) mutates the proteins folding, and thus almost always the protein is non-functional. A substitution mutation is when a base in the DNA sequence is incorrectly exchanged for one that shouldn't be there. This only affects the codon/codon in which the mutation takes place, and the effects on this codon vary. In the case of this cystic fibrosis mutation, the substitution mutation is a mis-sense mutation that codes for a different amino acid, and so there is a different amino acid present in the final protein. Because ~~amino~~ acids ~~effect~~ determine the shape and structure of a protein, the coding of

an incorrect amino acid would mutate the protein's structure, and thus ~~could~~ [could] change the protein's folding and ~~protein~~ possibly make it non-functional. However, this substitution does not cause as severe a version of the cystic fibrosis ~~the~~ disease, because only ~~the~~ one amino acid has been changed. This means that while the folding of the protein has potentially been affected, it may only be a small mutation that means the protein is still functional, ~~However,~~ and so ~~the production of a normally thick mucus that~~ [and] ~~causes~~ cystic fibrosis is not as severe. However, because the deletion mutation ~~affects the~~ changes all codon amino acids upstream of the mutation, a large number of amino acids have been ~~affect~~ affected, the folding of the protein has severely changed [is affected] and so the gene [i.e. the mutation] is completely non-functional, and so the cystic fibrosis is far more severe and more likely to be lethal.

E7

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

QUESTION NUMBER

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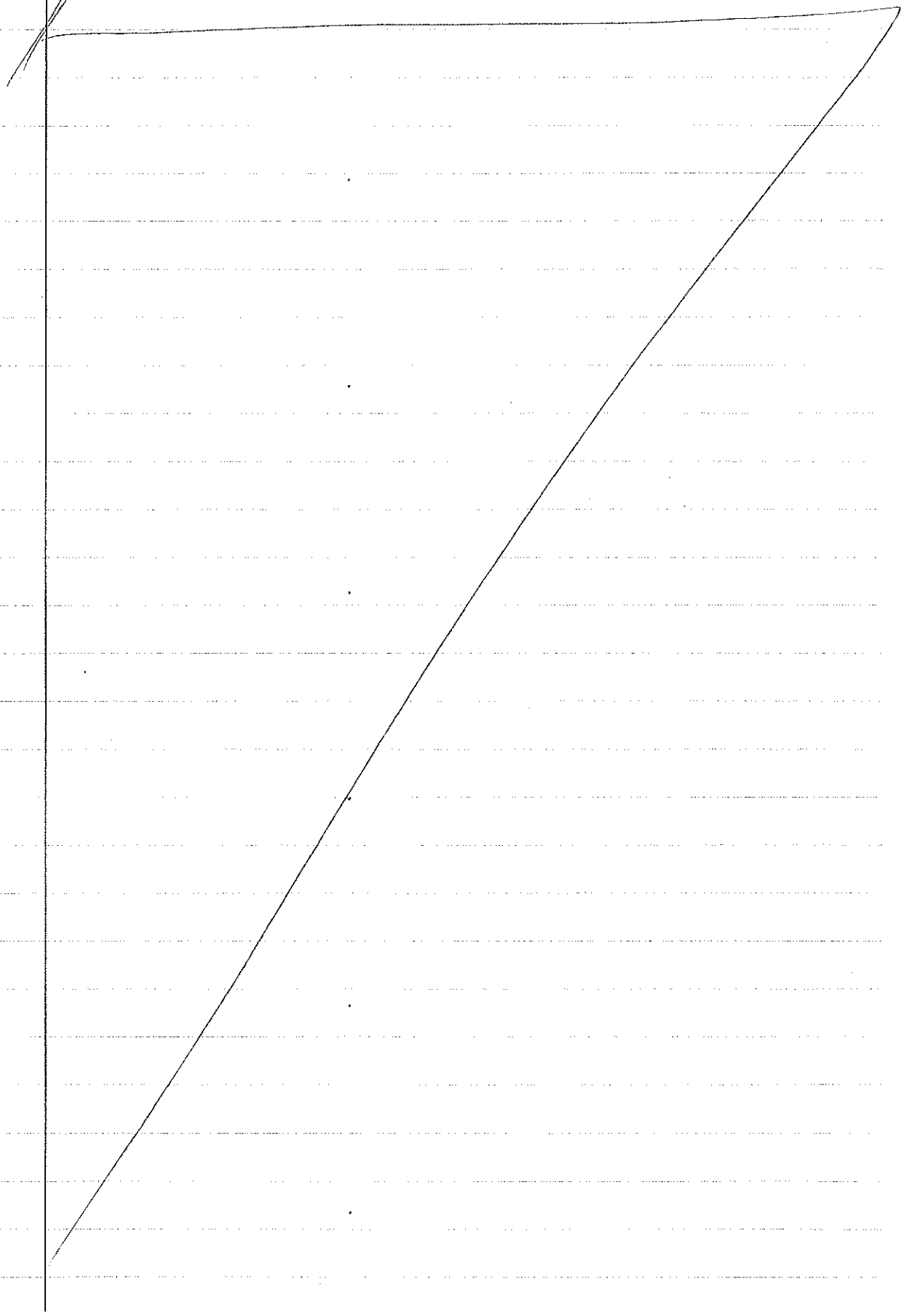

91159

Excellence exemplar for 91159 2016		Total score	22
Q	**Grade score**	**Annotation**	
1	E7	This is an E7 because it identifies the processes of transcription and translation. Key terms are used correctly such as template strand, enzyme (RNA polymerase) and coding strand. They have addressed each part of the question and show understanding of the links between tRNA, mRNA and the ribosome. For E they could have used complimentary rather than corresponding and also wrote when DNA is replicated.	
2	E8	There is unpacking of the term gene expression and the components that influence it. They are clear in their understanding of how the environment can be a mutagen or not and have considered how the queen is influence by the diet to full express their phenotype potential.	
3	E7	There is evidence of clear understanding of a mutation being a base change and the effect this will have if there is a reading frame shift. The context of the question is clearly discussed as to the two phenotypes for CF. The protein made after each mutation is linked to the phenotype of the effected CF patient through use of key ideas around the form the protein will take linked to the functionality of the protein.	