Level 3 Biology, 2006

90715 Describe the role of DNA in relation to gene expression

Credits: Four
9.30 am Thursday 30 November 2006

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 answer 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 2–9 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.

For Assessor's use only	**Achievement Criteria**		
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Describe the role of DNA in relation to gene expression. ☑	Explain the role of DNA in relation to gene expression. ☐	Discuss the role of DNA in relation to gene expression. ☐
Overall Level of Performance A		

Response shows need to make identical copy of original DNA for cell division.

Ignore incorrect last sentence confusing replication & protein synthesis.

- bases labelled correctly
- new nucleotides added to 3' end.
- incorrectly labelled 3' & 5' ends but still illustrates antiparallel nature.
- H bonds wrong.

You are advised to spend 40 minutes answering the questions in this booklet.

Assessor's use only

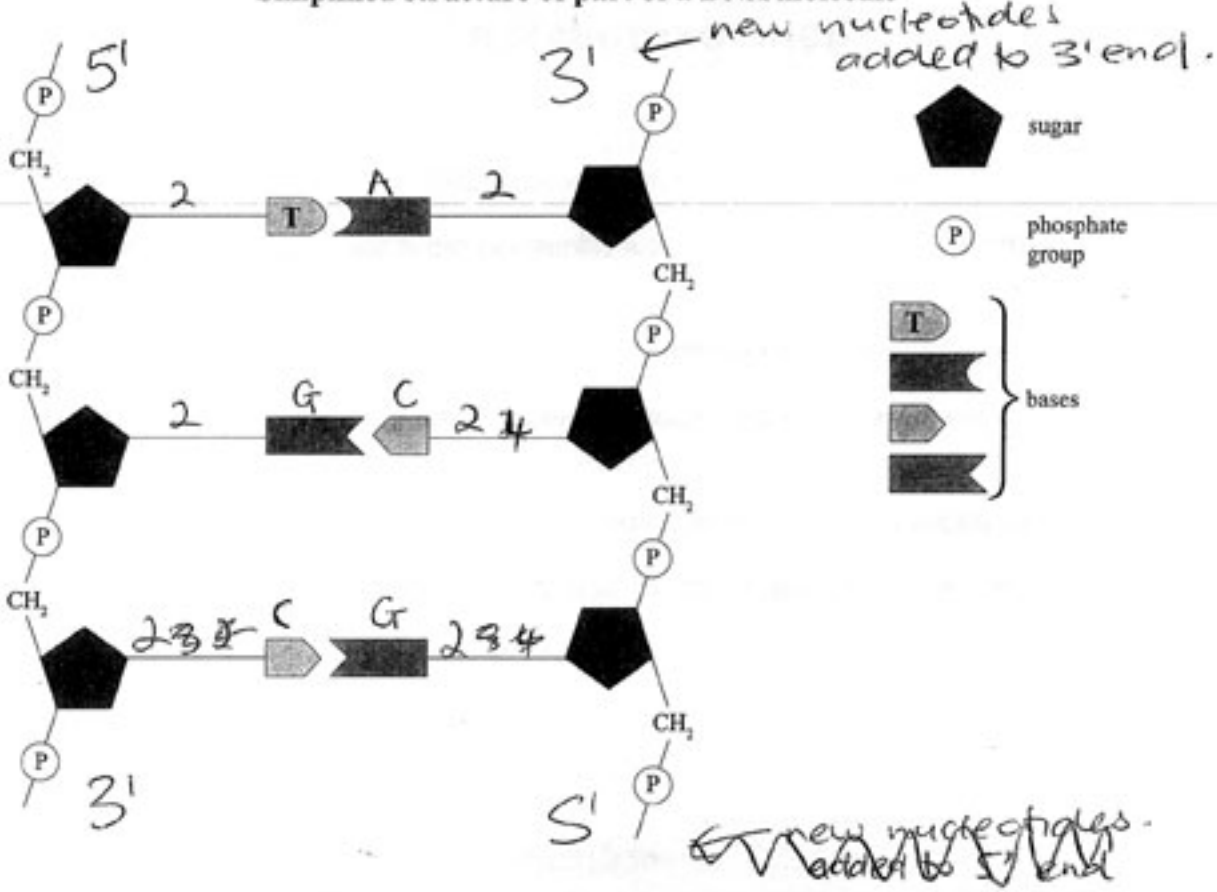
QUESTION ONE: DNA STRUCTURE, FUNCTION, AND REPLICATION

DNA is a polymer, made up of a large number of sub-units (nucleotides).

(a) The unlabelled diagram below shows the basic structure of a DNA molecule. Complete the diagram by giving information that clearly identifies:

- the four bases and their positions (one base has been identified in the diagram)
- the number of hydrogen bonds between bases
- the anti-parallel nature of the molecule
- which end of the DNA strand new nucleotides are added to.

Simplified structure of part of a DNA molecule



A

(b) Explain why DNA replication is necessary.

To make identical copies of the original DNA strand so that mitosis and meiosis can occur. DNA replication is necessary to make a new copies of the DNA so transcription and translation can take place.

m

Candidate has:

- clearly described the process of DNA replication.
- explained why Okazaki fragments are necessary
- explained the semi-conservative nature of the replication.

(c) Discuss how DNA replicates. In your discussion, you should explain:

- how replication begins
- the roles of the main enzymes involved
- leading and lagging strands
- Okazaki fragments
- the source of materials for replication.

Assessor's use only

Replicatons begin with ~~helico~~ the enzyme helicase unwinding the double stranded DNA molecule exposing the two strands. The leading strand is continuously replicated by DNA polymerase III. from 5' to 3'. The lagging strand is made up of Okazaki fragments (short lengths approx up to 1000 bases). Since replicaton can not take place from 3' to 5' it is made in Okazaki fragments RNA polymerase puts RNA primers down which DNA polymerase I digests RNA primer and replaces it with DNA. DNA polymerase III then elongates ~~the~~ it. Ligase then ~~joins~~ acts like a 'glue' and joins the Okazaki fragments together thus making two new templates. ~~They~~ They then join with the orginal and ~~the~~ histones help them coil up forming 2 copies of the DNA helix. It is semi conservative as each new ~~Double~~ DNA molecule has 1 strand from the orginal DNA molecule and one new one.

E

This response has described that a triplet codes for an amino acid which forms protein but has failed to highlight the significance of the order or sequence of bases ~~that~~ therefore the amino acids.

This answer is entirely descriptive. It describes all of

① place
② purpose
③ nucleic acid structure
~~④ associated molecules~~
~~④ nucleic acid structure~~

however, at no point does the candidate provide an explanation as to how or why any of those things occur or are significant.

ie: how does transcription occur compared to translation
- why does transcription occur in nucleus & translation in cytoplasm.
- why are the nucleic acid structure different.

L23

QUESTION TWO: GENE EXPRESSION AND PROTEIN SYNTHESIS

Assessor's use only

Deoxyribonucleic acid (DNA) is found in almost all cells, and carries the genetic code that controls many aspects of cellular structure and function.

(a) Explain how the DNA molecule carries genetic information.

The DNA molecule is a long nucleic acid. It is made up of nucleotides which consist of a phosphate, sugar and one of the four bases (A,T,G,C). A group of 3 nucleotides is called a triplet. Each triplet codes for an amino acid, which then forms a protein

A

(b) Compare and contrast the processes of **transcription** and **translation**.

(2) Transcription is making an MRNA molecule from a DNA molecule.
Translation is attaching the correct tRNA molecule with the right anticodon to the MRNAs codons.

(1) Transcription occurs in the nucleus whereas translation occurs in the cytoplasm.

(3) They both contain nucleotide bases. DNA are called triplets, MRNA are codons and tRNA is called anticodons.
DNA in transcription contains deoxyribose sugars and is a deoxyribonucleic acid whereas MRNA contains ribonucleic sugars and is a ribonucleic acid.

Both take place in the cell.
They can only be synthessed from 5' to 3' prime. They both use enzymes such as to help with the process.

A

Response illustrates some understanding of binding between enhancer / RNA polymerase/ transcription units & that this allows transcription to occur.
Does not explain how/ why this is important.

Candidate has described:

① role of repressors
② role of inducers

AND

③ the significance of these interactions in terms of energy conservation

Gp 4

The proteins that some genes code for are constantly expressed, eg those involved in cellular respiration. Other proteins are produced only as needed, ie the expression of these genes is controlled.

Assessor's use only

(c) Explain the role of **enhancers** in **eukaryote** gene expression.

Enhancers are transcription units which are a ~~series~~ series of proteins. When these proteins are joined to the RNA polymerase and other transcription units through a hairpin loop in the DNA transcription is able to take place.

A

(d) Discuss reasons for the role of **inducers** and **repressors** in **prokaryote** gene expression.

Inducers bind to the repressors. The repressor is made from the regulator gene. The repressor binds on to the operator site which means transcription can not take place. When there is a lot of an enzyme in a cell transcription needs to take place. when there is not there is no need ~~for~~ for transcription to occur as it is a waste of energy, ~~To~~ this ~~st~~ is when a repressor will bind to the operator which means RNA polymerase can not bind and start transcription. An inducer will bind to the repressor which changes the repressors shape. This means it can ~~not~~ no longer bind to the operate which means RNA polymerase can bind thus allowing transcription to take place.

(1) (2) (3)

E

G 5

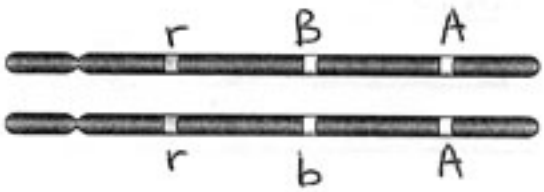
QUESTION THREE: PHENOTYPE DETERMINATION

Assessor's use only

Genes are found on chromosomes, and eukaryote cells usually contain two copies of each chromosome.

The members of a pair of chromosomes have the same sequence of genes, but the genes may come in slightly different forms.

(a) On the diagram below, show the position of alleles for an individual who is:
- homozygous dominant for gene A
- heterozygous for gene B
- homozygous recessive for gene R.



A

People affected by Duchenne muscular dystrophy (DMD) lose muscle function from an early age and rarely survive to adulthood. The disease is caused by a mutation in a gene found on the short arm of the human X chromosome. The dominant allele (M) results in normal muscle function, while the recessive allele (m) produces the slow, irreversible muscle wasting that is characteristic of this disease.

(b) Give ALL the possible genotypes for the phenotypes listed below:

(i) female not affected X^MX^M X^MX^m

(ii) female affected X^mX^m

(iii) male affected X^mY

(iv) male not affected X^MY

A

(c) (i) A female who is heterozygous for the DMD allele has children with an affected male. Use a Punnett square to show all possible genotypes for the offspring of this couple.

	X^M	X^m
X^m	X^MX^m	X^mX^m
Y	X^MY	X^mY

A

Candidate ~~does~~ ~~explains~~ does not clearly explain how sex linkage works for those unaffected.
ie. in female X^M can mask presence of X^m in heterozygote.

GP6

(ii) From your Punnett square, list the phenotypic and genotypic proportions for male and for female offspring.

Assessor's use only

Phenotypic proportions

male: 1 male not affected : 1 male affected

female: 1 female not affected : 1 female affected

Genotypic proportions

male: 1 X^mY : 1 X^mY

female: 1 X^mX^m : 1 X^mX^m

A

(d) Explain why more males than females are affected by Duchenne muscular dystrophy.

DMd is a sex linked mutation found on the X chromosome. Since a male only has one X chromosome it has a 50% chance of getting X^m. as it gets whatever allele comes with the X chromosome as it doesn't matter wether it is homozygous or heterozygous. A female on the other hand only has a 1 in 3 chance of getting affected by the mutation as they have 2 X chromosomes and both need to carry the mutation for a female to be affected

A

Note that this question continues on the next page.

Q6

Many metabolic pathways are controlled by multiple genes. An example is the metabolic pathway that produces normal skin pigmentation. Albinism, which is the total lack of pigment, can be caused by a mutation in any one of the genes controlling this pathway.

Assessor's use only

(e) Discuss the fact that it is possible for two albino parents to have a child with normal skin pigmentation.

Since multiple genes are responsible for albinism, ~~it could be a form of of polygeny This is when~~ it could be any one of the genes causing the albinism. If two albino parents have a child with normal skin it is possible. This is because ~~for~~ for example two genes A and B could be responsible for skin colour. ~~It a~~ It could be a form of complementary genes when both alleles need to be dominant for albinism to occur. If both parents were heterozygous, AaBb They could produce offspring with the genotype aabb which would mean since neither gene; or only one gene is dominant ~~of~~ a child with normal skin can occur. (or Aabb or aaBb)

A

Candidate shows understanding that multiple genes lead to albinism and that parents may be affected at different genes but they have ~~ignored the~~ failed to show clear link ~~of~~ between this and a pathway.