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	E				

Clearly shows:

- the 4 bases
- number of H bonds
- that new nucleotides are added at 3' end.

Incorrectly label 3' & 5' ends ~~but~~

but still illustrates antiparallel nature.

Clearly states that replication is needed so that after cell division the new cells will have identical copies of DNA

Gp1

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

Assessor's use only

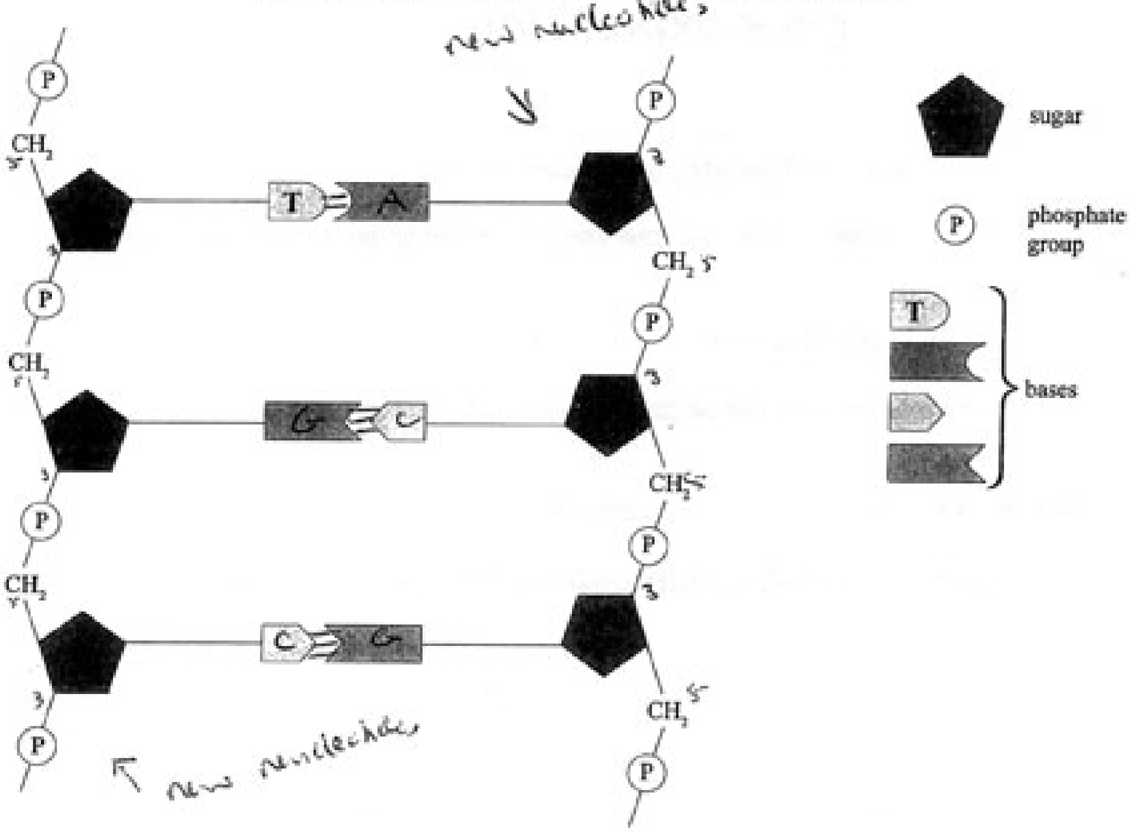
QUESTION ONE: DNA STRUCTURE, FUNCTION, AND REPLICATION

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.

~~For cells to~~ For an organism to grow it also needs for its cells to divide to produce more (mitosis), in order for these cells to contain the correct code so that the right proteins are made to run the cell DNA replication is necessary. This ensures each cell has an identical copy of DNA. DNA replication is also needed for meiosis to ensure that the correct and ~~exact~~ [illegible] chromosomal number is given to the offspring

M

Candidate has described the process of replication

PLUS

explained why Okazaki fragments form

PLUS

~~explained~~ that the ~~is meant by the~~ strand formation is semi conservative & what this means.

Gr 7

(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

DNA replication begins in the ~~nucleus~~ nucleus. First the double helix strand has to unwind and split to reveal the nucleotides, this is done by the enzyme helicase and the parts where the DNA is unwinding are called replication forks. Another enzyme, primase then adds a primer, a short sequence of RNA to a free 3' end. This is so that DNA polymerase can attach to something in order to form the new side. DNA polymerase uses free nucleotides in the nucleus to build the new strands. The new strands are built using the base pairing rule so that adenine matches with thymine and cytosine matches with guanine, this helps to ensure that the strands made have no mistakes. Nucleotides exist in the nucleus have ATP attached, energy that is used to bond them to the old strand, this process is semi conservative but the strand remained half old. However one strand is the leading strand which is in a 3'→5' direction so that DNA polymerase can easily build the new strand in a 5'→3' direction, as they are anti-parallel. The other old DNA strand is in a 5'→3' direction and so DNA polymerase must build this in fragments called okazaki fragments. These are then joined together by ligase, an enzyme and the two new strands can coil up in to the normal double helix shape.

E

Clearly makes the link from order to nucleotides (triplets) to the complementary mRNA & then protein.

Explanation of the differences is given in terms of

Process
& associated molecules.

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 made up of ~~many~~ monomers called nucleotides. In the DNA these are in triplets, 3 nucleotides together. The code order of these nucleotides how the DNA molecule carries ~~is used as instructions for~~ its genetic information. The genes are expressed using proteins and a the cell knows how to make a protein because of the order of the nucleotides in the DNA. This code is transfered onto the complementary mRNA which carries it to the ~~the~~ ribosomes so that it can be translated into a protein.

M

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

Transcription and translation are similar in that they are both involved in gene expression, both involve mRNA, ribonucleic acid, both occur in the cell and both involve a change in code. However transcription occurs in the nucleus as well as both involving enzymes. and involves mRNA being made from the nucleotides and a template strand off the DNA using RNA polymerase. This is a change in code from DNA to RNA and sees ~~no~~ more changes ~~to~~ made. By contrast translation occurs ~~in the~~ outside the nucleus as mRNA is carried to the ribosomes. tRNA then carries the appropriate amino acid to the ribosome to attach in order to make the correct polypeptide, protein by following the code on the mRNA codons. This, unlike transkription, involves a change in code from RNA to amino acids, while also involving ribosomes, which contain rRNA and enzymes, that are not used in transcription.

M

Candidate has clearly linked enhancers to the role of transcription factors and the subsequent increase in the rate of transcription

Response clearly explains:

① How repressors work.

② How inducers

AND

③ the significance of these interactions.

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.

Exact Enhancers are segments on the DNA that help a gene to be expressed, when it is needed. This enhancers area can be attached to activators a kind of enzyme which are attached to further enzymes known as co-activators. The coactivators also attach to more transcription factors called basal factors which trap the RNA polymerase so that it can attach to the promoter on the DNA and begin transcription in order to make a protein. Although basal factors can trap the RNA polymerase it is the reactions caused by the connection with enhancers that speeds up the gene expression and they are therefore vital in Eukaryotes

M

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

Inducers and repressors are part of gene expression in prokaryotes through, induction and repression. Repressors attach to the operator site on the DNA so that RNA polymerase cannot attach to the promoter and then transcribe the structural genes, thereby stopping gene expression. Inducers are substrates in the cell. These are normally substrates at the beginning of a metabolic pathway. If they exist in high enough quantities in the cell then the cell may need to break them down to prevent too much of the substrate existing. In order to do this the cell will also need to produce a enzyme, a protein to break it down and therefore will need RNA polymerase to be able to transcribe the gene DNA. So if in large enough quantities inducers will attach to a repressor and make it inactive so that it can no longer attach to the operator in order to stop transcription. As the inducer is then broken down by the enzyme

1

3

P

(go to back)

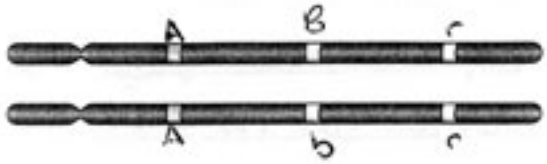
QUESTION THREE: PHENOTYPE DETERMINATION

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 $X^M X^M$ or $X^M X^m$

(ii) female affected $X^m X^m$

(iii) male affected $X^m Y$

(iv) male not affected $X^M Y$

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.

parental genotypes $X^M X^m$ and $X^m Y$

so

	X^M	X^m
X^m	$X^M X^m$	$X^m X^m$
Y	$X^M Y$	$X^m Y$

genotypes possible $X^M X^m$, $X^m X^m$ or $X^M Y$, $X^m Y$

A

Candidate's response explains both how males are affected & unaffected & how females are affected & unaffected. Also links them in terms of the likelihood of them occurring.

Male cannot be homozygous dominant/recessive for this ~~thea~~ ~~trait~~ genotype. Implies more than one all present.

GP 1

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

Assessor's use only

Phenotypic proportions

male: ½ unaffected ½ affected

female: ½ unaffected ½ affected

Genotypic proportions

male: ½ homozygous dominant ½ homozygous recessive

female: ½ heterozygous ½ homozygous recessive

NS

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

Duchenne muscular dystrophy is a sex linked disease, This means that it is found on a part of the X chromosome that males do not have on their Y chromosome. Because of this males cannot block the gene if it is on their X chromosome and will show the disease if they have it on their X chromosome, needs only one recessive allele. However females can have a dominant gene to block the trait even if they are heterozygous at the end there for they need two recessive genes for it to show. This means that females are less likely to be affected as they are less likely to have the number of recessive genes required

M

Note that this question continues on the next page.

GP1

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 use only

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

If multiple genes affect a pathway such as that for creating normal skin pigmentation then it is possible for two albino parents to have a child with normal skin. This would of course be possible if the gene for albino trait was dominant as then both of the albino parents were heterozygous they could pass on recessive normal genes to their child. If the mutation for the gene for albinism in both was controlled by a number of genes then several alleles might be needed to create the eventual phenotype. This is called polygenes where several genes code for a simpler trait and the more of these alleles for that trait an individual has the more severe the phenotype is. In this way if the albino parents each had some alleles for the trait but other that were 'normal' these could be passed on so that the child had a lesser number of 'normal' alleles and not then the trait of this if the albinism in the parents was caused by a different mutation a child might receive a dominant normal gene for the mutation from the other parent which would enable them to block out these mutations if they were active and show a normal phenotype.

NS

Candidate confuses multiple genes on a pathway with polygenes.

No clear description of the impact of a mutant gene on a pathway.

Extra paper for continuation of answers if required.
Clearly number the question.

Assessor's use only

Question number

2 d) it will decrease in concentration and because repressors are still being made then eventually they will be able to attach to the operator again, preventing further gene expression and making sure that not too much of the inducer is left.

E