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VCE Biology ¾

Gene Expression & The trp Operon [1.3]

Test

40 Marks. 1 Minute Reading. 32 Minutes Writing.

Results:

Test Questions	_____ / 35
Extension	_____ / 5

Section A: Test Questions (35 Marks)

INSTRUCTION: 35 Marks. 1 Minute Reading. 28 Minutes Writing.

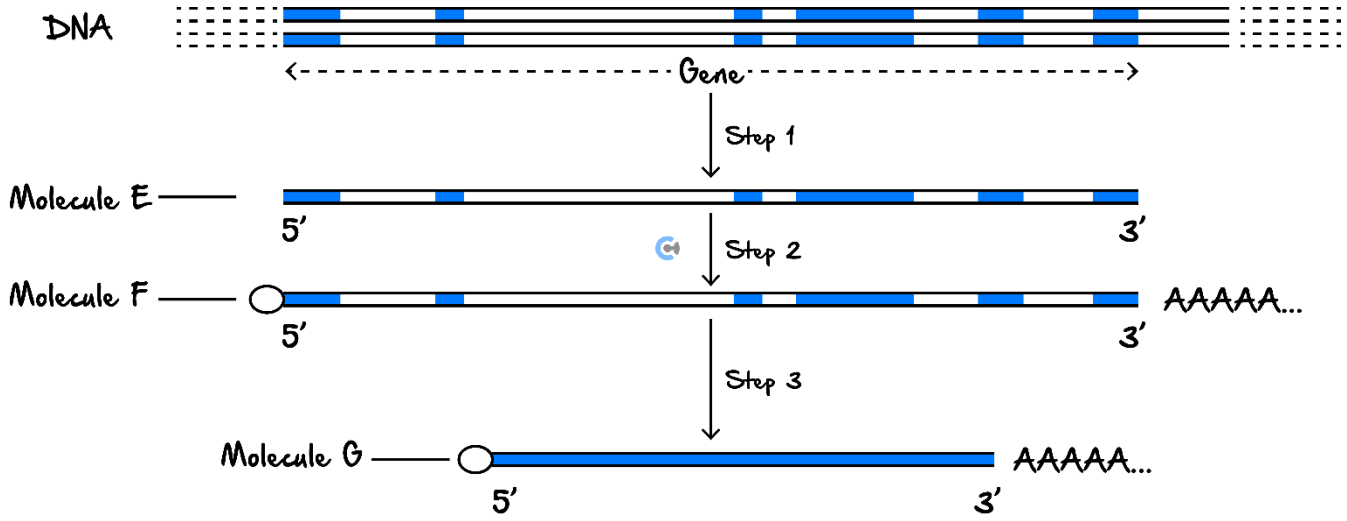
Question 1 (4 marks)

Tick whether the following statements are **true** or **false**.

	True	False
a. Transcription is the process by which DNA is copied into mRNA.		
b. RNA polymerase catalyses the binding of DNA nucleotides during transcription.		
c. The mRNA strand produced during transcription is complementary to the DNA template strand.		
d. The addition of a methyl cap to the 5′ end of mRNA prevents degradation and facilitates translation.		
e. Translation involves the synthesis of polypeptides from mRNA templates.		
f. Ribosomes read mRNA in the 5′ to 3′ direction during translation.		
g. A tRNA molecule with the anticodon complementary to the mRNA start codon binds to the ribosome during initiation.		
h. The attenuator loop in the trp operon forms when tryptophan is scarce.		
i. Regulatory genes code for proteins that influence the expression of structural genes.		
j. The small subunit of the ribosome is responsible for catalysing peptide bond formation.		
k. Transcription and translation occur simultaneously in eukaryotic cells.		

Question 2 (1 mark)

The following diagram shows some of the steps in the production of a protein within a cell.



Which one of the following is a correct statement?

A. Step 1 represents the process of transcription.

B. Molecule F undergoes alternative splicing during processing.

C. RNA polymerase is involved in the addition of the poly-A tail.

D. Step 3 represents the export of mature mRNA from the nucleus.

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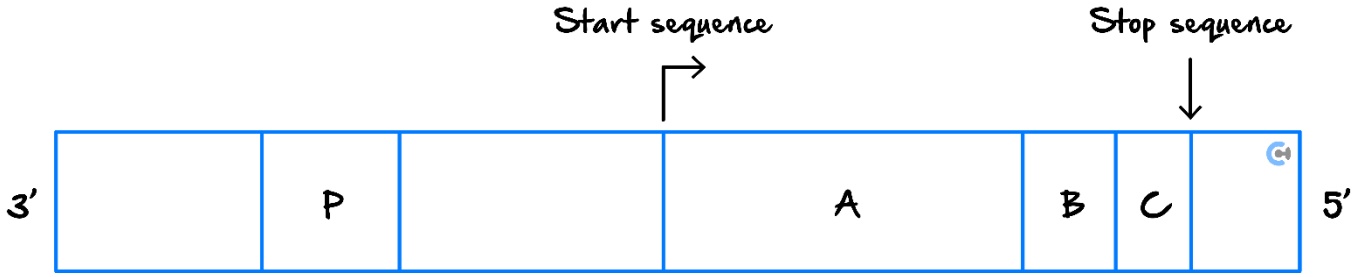
Question 3 (1 mark)

The diagram below shows the processes of gene expression.



Which of the following modifications ensures the stability of mRNA after transcription?

A. Removal of introns by splicing.

B. Addition of a methyl cap at the 5′ end.

C. Binding of RNA polymerase to the promoter.

D. Formation of peptide bonds between amino acids.

Question 4 (1 mark)

A mutation occurs in the spliceosome that prevents introns from being removed. Which of the following is the most likely consequence?

A. Translation of a functional protein occurs normally.

B. Transcription stops before pre-mRNA is produced.

C. mRNA is exported to the ribosome but contains incorrect sequences.

D. A poly-A tail cannot be added to the pre-mRNA molecule.

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Question 5 (1 mark)

In the trp operon of *E. coli*, what would happen if a mutation occurred in the regulatory gene preventing the repressor protein from binding to tryptophan?

A. The operon would be permanently repressed, regardless of tryptophan levels.

B. The operon would be permanently active, regardless of tryptophan levels.

C. Transcription of the operon would occur only when tryptophan is present.

D. The attenuator loop would fail to form, causing continuous transcription.

Question 6 (1 mark)

Which of the following correctly describes the role of attenuation in regulating the trp operon?

A. It prevents transcription from starting when tryptophan levels are high.

B. It halts the translation of the structural genes when tryptophan levels are low.

C. It allows transcription to terminate prematurely when tryptophan levels are high.

D. It enables the repressor protein to bind more tightly to the operator.

Question 7 (8 marks)

Gene expression is the process by which proteins are able to be produced from DNA.

a. Describe the role of complementary base pairing in transcription. (2 marks)

_____

_____

_____

_____

b. After transcription, the DNA template sequence is modified and then leaves the nucleus of a eukaryotic cell.

Identify **two** events that occur during the modification of the DNA template sequence. (2 marks)

_____

_____

_____

_____

c. Nucleotides 9-15 are removed from the DNA template sequence prior to translation.

i. Determine the nucleotide sequence after this modification. (1 mark)

_____

_____

ii. The table below lists codons and their corresponding amino acids.

First base	Second base: U	Second base: C	Second base: A	Second base: G	Third base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

Using the information in the table, determine the polypeptide sequence after translation. (1 mark)

_____

_____

d. The polypeptide formed from the DNA template sequence is coded by a single gene; however, there are multiple different polypeptides that can be coded for by this gene.

Identify and explain the process that allows this to occur. (2 marks)

_____

_____

_____

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Question 8 (6 marks)

a. There are several cellular activities that directly alter the proteins within a yeast cell. These include transcription, RNA processing, translation, and protein.

For each cellular activity listed in the table state the immediate end product of the activity. (2 marks)

Cellular activity	**Immediate end product**
Transcription	
RNA processing	
Translation	
Breakdown of protein	

b. Four genes from *D. melanogaster* and the functions of their gene products are outlined in the table below.

Gene	**Function of Gene Product**
HSP70	Assists in protein folding under stress conditions.
TEIID	Binds to the promoter region and assists in transcription initiation.
DSP542	Prevents transcription of neural genes via factors.
AquaPl	Forms water channels in cell membranes.

Identify the regulatory genes in the table and justify your response. (2 marks)

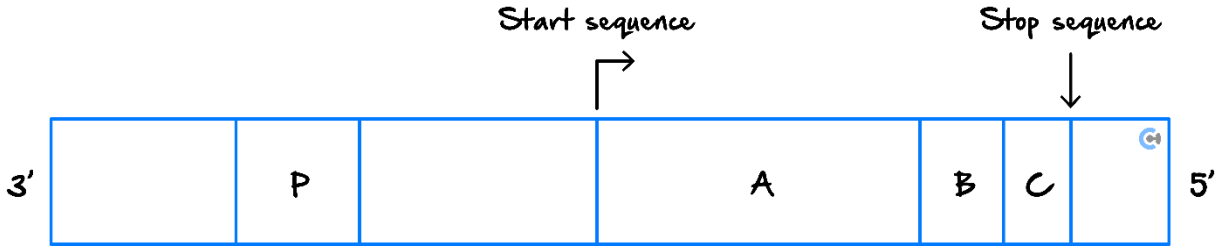
_____

_____

_____

_____

c. One particular *D. melanogaster* protein, Actin-A1, plays a role in cytoskeleton formation. Below is a diagram of the gene for Actin-A1, showing a promoter region (labelled *P*), start and stop sequences, and one intron (labelled *B*).



Give the general name of the sections labelled *A* and *C* and outline the function of these sections. (2 marks)

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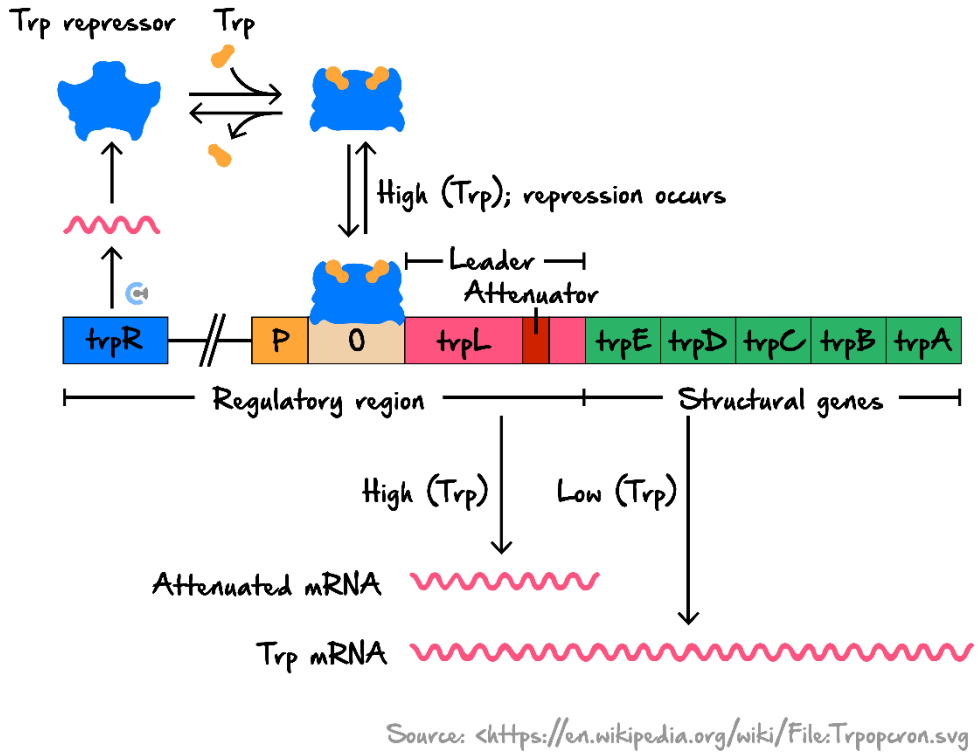
Question 9 (6 marks)

The diagram below shows the trp operon.



Source: <https://en.wikipedia.org/wiki/File:Trpopcron.svg

In $E.coli$ there are two mechanisms that repress the genes E, D, C, B and A in the trp operon.

a. Explain how one of these mechanisms prevents the formation of tryptophan in a high tryptophan environment. (3 marks)

If the level of tryptophan is low, the *E.coli* will transcribe and translate the operon. Three forms of RNA are involved in these processes.

b. Describe the role of each type of RNA. (3 marks)

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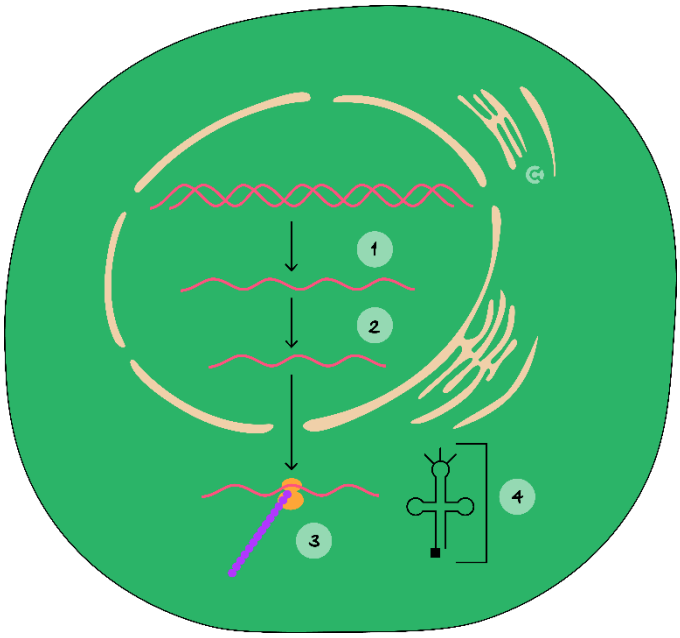
Question 10 (6 marks)

The following diagram outlines events associated with the production of a polypeptide chain in a eukaryotic cell.



a. What is the name of the process at step 1? (1 mark)

_____

b.

i. Name the product of step 1. (1 mark)

_____

ii. Outline what occurs at step 2. (1 mark)

_____

_____

_____

_____

c. Name the event that occurs at structure 3. (1 mark)

_____

d.

i. Name the structure at 4. (1 mark)

_____

ii. Outline the function of the structure you named in **part d.i.** (1 mark)

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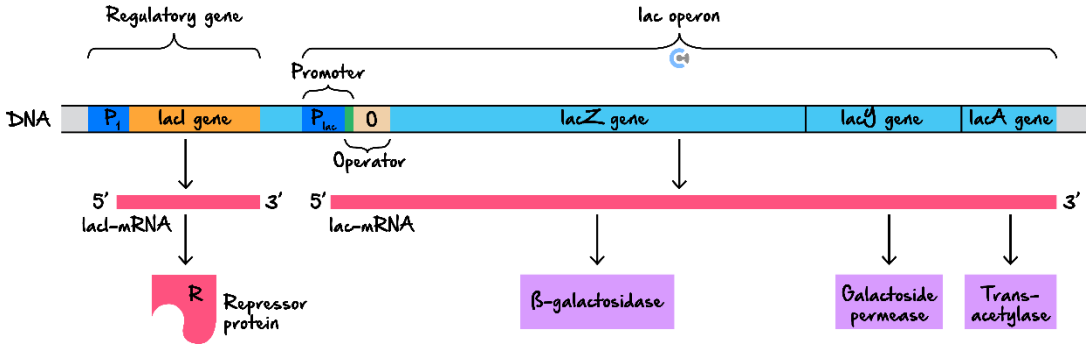
Section B: Extension (5 Marks)

INSTRUCTION: 5 Marks. 4 Minutes Writing.

Question 11 (5 marks)

The diagram below shows gene regulation in the lac operon.



a. State one benefit of gene regulation to the cells of an organism. (1 mark)

_____

_____

b. Explain the function of the repressor protein in gene regulation in the lac operon. (2 marks)

_____

_____

_____

_____

c. Explain why there is a low basal rate of production of the repressor protein. (2 marks)

_____

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