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VCE Biology ¾
Gene Expression & The trp Operon [1.3]
Homework

Homework Outline:

Compulsory Questions	Pg 02 – Pg 20

Section A: Compulsory Questions (53 Marks)

Sub-Section [1.3.1]: Identify and Recall the Process of Gene Expression in Eukaryotes, Comparing How it Differs in Prokaryotes

Question 1 (1 mark)

Which of the following correctly describes the order of gene expression?

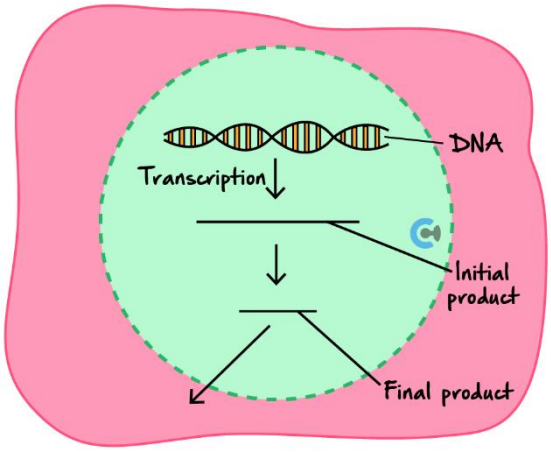
A. Transcription → Translation

B. Translation → RNA Processing → Translation

C. Translation → RNA Processing → Transcription

D. Transcription → RNA Processing → Transposition

The following diagram applies to the two questions that follow.



Question 2 (1 mark)

What is the name of the process that turns the "initial" product into the "final" product?

A. RNA Processing

B. Translation

C. Synthesis

D. Condensation Polymerisation

Question 3 (1 mark)

Why is the final product shorter in length than the initial product?

A. The spliceosome removes the introns leaving a shorter length.

B. Room is required to add the poly-A tail.

C. It is representative of the degeneracy of the genetic code.

D. Exons are spliced out, therefore leaving a shorter mRNA sequence.

Question 4 (1 mark)

Which sequence describes the correct order for the transcription of eukaryotic DNA?

A. DNA polymerase attaches, complementary nucleotides are attached, pre-mRNA, introns are removed, and mRNA leaves the nucleus.

B. RNA polymerase attaches, complementary nucleotides are attached, pre-mRNA, introns are removed, and mRNA leaves the nucleus.

C. RNA polymerase attaches, complementary nucleotides are attached, pre-mRNA, exons are removed, and mRNA leaves the nucleus.

D. RNA polymerase attaches, complementary nucleotides are attached, mRNA, introns are removed, and pre-mRNA leaves the nucleus.

Question 5 (3 marks)

Compare the process of gene expression in eukaryotes and prokaryotes.

Sub-Section [1.3.2]: Describe the Processes of Transcription, mRNA Processing, and Translation, Recognising the Significance of Each Step to the Final Product

Question 6 (1 mark)

Which of the following accurately describes 'alternative splicing'?

A. The process by which exons are shuffled around during the splicing of introns.

B. The process of transcription when RNA polymerase begins to transcribe the non-template strand.

C. The process by which the ribosome shuffles codons.

D. The process during RNA processing in which a poly-A tail is added.

Question 7 (1 mark)

During the synthesis of a polypeptide, the molecules most commonly associated with the ribosomes would be:

A. tRNA, mRNA, rRNA

B. tRNA, mRNA, pRNA

C. DNA, mRNA, tRNA

D. cDNA, mRNA, rRNA

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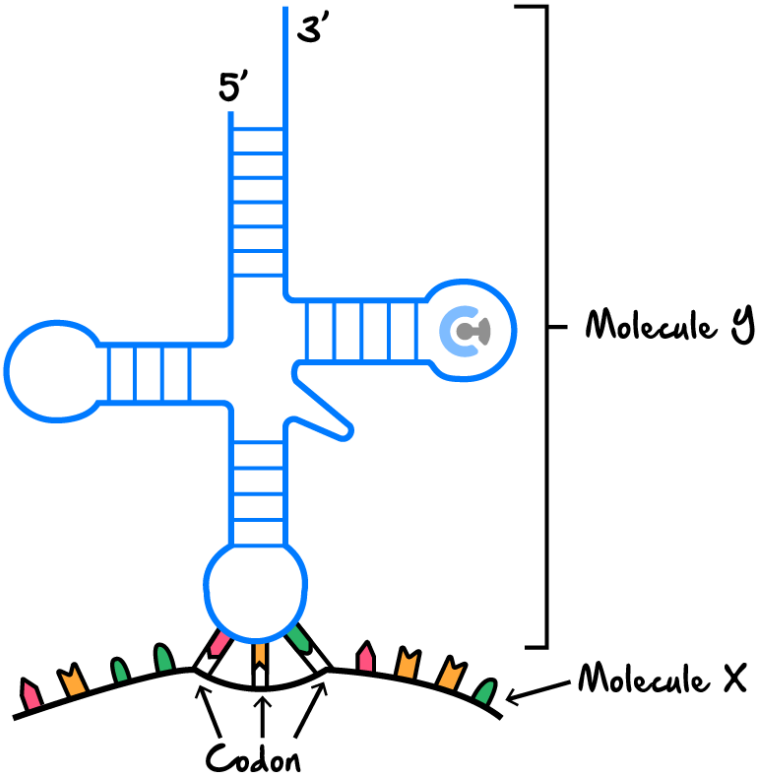
The following diagram applies to the three questions that follow.



Question 8 (1 mark)

Which of the following correctly identifies molecule *X* and molecule *Y* respectively?

A. tRNA, mRNA

B. rRNA, mRNA

C. tRNA, rRNA

D. mRNA, tRNA

Question 9 (1 mark)

At which location in a cell might you expect to see this arrangement?

A. Nucleus

B. Golgi Apparatus

C. Smooth Endoplasmic Reticulum

D. Rough Endoplasmic Reticulum

Question 10 (1 mark)

What is the product of this process?

A. Exons

B. mRNA

C. A polypeptide

D. Amino acid

Question 11 (1 mark)

The function of the ribosome in gene expression is:

A. Read mRNA and synthesise a polypeptide chain.

B. Splice introns out of pre-mRNA.

C. Package and fold proteins for export from the cell.

D. Read DNA and convert it into mRNA.

Question 12 (1 mark)

Following transcription, pre-mRNA is formed. Before pre-mRNA can leave the nucleus, post-transcriptional modification must occur. This included:

A. Addition of a methyl cap at the 3' end.

B. Addition of a poly-A tail at the 5' end.

C. Removal of introns.

D. Removal of exons.

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Question 13 (1 mark)

The following diagram shows a sequence of pre-mRNA. The white regions code for introns, with the black regions coding for exons.

During transcription, a mutation occurred with the nitrogenous base uracil being substituted for a guanine in the white region.

The effect on the protein product:

A. Would be minimal as it is a single base change.

B. Is unable to be determined, as it may create a nonsense mutation.

C. Would have no effect.

D. Would create a non-functional protein.

Question 14 (1 mark)

Which of the following describes the termination of translation correctly?

A. A release factor binds to the stop codon, signalling the termination.

B. tRNA delivers a termination amino acid to the stop codon.

C. A hairpin loop is formed in the chain which cuts it off from the ribosomal structure.

D. Once the stop codon is reached, the ribosome binds the repressor terminating translation.

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Question 15 (3 marks)

Translation occurs within the cytosol of a cell. Outline the steps that normally occur in translation. Use specific terms and names of the molecules involved. Name the final product of the process.

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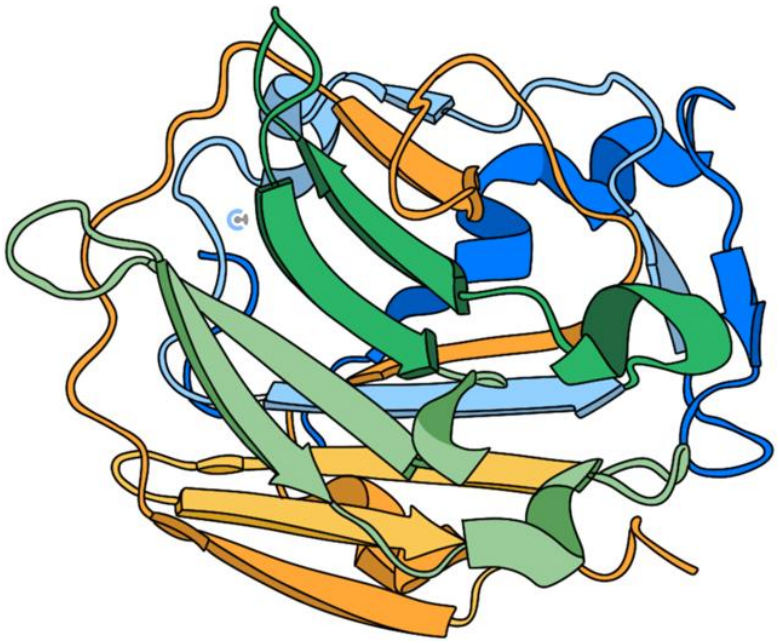
Question 16 (7 marks)

The COL1A1 gene provides instructions for synthesising collagen proteins, such as the one shown below.



Collagens are a family of proteins that strengthen and support many tissues in the body, including cartilage, bone and skin. The COL1A1 gene is 18 kb (18,000 base pairs) in length and codes for the production of a protein that is made up of 1464 amino acids. The image above shows an example of the structure of collagen.

a. Identify the sub-units that make up type I collagen and explain how these sub-units are linked together to form type I collagen. (2 marks)

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b. Based on the information provided, calculate the length of the mRNA that was translated to produce the type I collagen. Explain how this answer was determined. (2 marks)

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Two students are discussing the information provided and they conclude that the mRNA is much shorter than expected compared with the DNA.

c. Use the information provided to explain how they reached this conclusion. (1 mark)

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d. Produce an annotated diagram to describe how and why the difference between the length of the DNA and the mRNA occurred. Refer to the appropriate cellular processes in your answer. (2 marks)

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Sub-Section [1.3.3]: Explain How a Single Gene Can Give Rise to Multiple Proteins

Question 17 (1 mark)

The genetic code contains codons that code for the 20 amino acids that are used to assemble proteins. Humans are believed to produce approximately 20,000 different proteins that perform a wide variety of functions.

This functional diversity of proteins is explained by:

A. Multiple codons coding for the same amino acid.

B. Amino acids being assembled into a variety of polypeptide chains.

C. Proteins being able to change shape, which enables them to carry out many different functions.

D. Post-translational modification of a polypeptide enabling it to be folded into several different forms.

Question 18 (2 marks)

Explain how a single gene can give rise to many different proteins.

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Sub-Section [1.3.4]: Identify and Recall the General Principles and Reasons for Gene Regulation in Both Prokaryotes and Eukaryotes

Question 19

Definitions:

a. Regulatory gene.

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b. Structural gene.

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c. Repressor protein.

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d. Activator protein.

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e. Operon.

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Question 20 (1 mark)

In order for a gene to be able to be transcribed, RNA polymerase must be able to bind to the gene's:

A. Promotor.

B. Repressor.

C. Operator.

D. Regulator.

Question 21 (1 mark)

Repressor proteins regulate the production of protein by binding to the:

A. Promotor region, preventing RNA polymerase from functioning.

B. Operator region, preventing RNA polymerase from functioning.

C. RNA polymerase, preventing it from binding to the promotor region.

D. DNA polymerase, preventing it from binding to the promotor region.

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Question 22 (5 marks)

The trp operon is a method of gene regulation in some species of bacteria. It contains a series of three genes that code for the production of enzymes that facilitate the ability of the bacteria to metabolise tryptophan. These genes are switched on or off depending on whether tryptophan is present or absent.

a. Draw a labelled diagram to illustrate how the trp operon regulates the expression of the structural genes in the presence and absence of tryptophan. (2 marks)

b. The trp operon is an example of gene regulation.

Explain how the bacterium benefits by being able to regulate the expression of the three genes that code for the production of the enzymes that facilitate the metabolism of tryptophan. (1 mark)

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c. Outline the role played by structural and regulatory genes in the trp operon system.

Include a reference to the functional distinction between structural and regulatory genes in your answer. (2 marks)

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Sub-Section: Describe the Regulation of the trp Operon Through the Action of the Repressor Protein

Question 23

Definition: Repression.

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Question 24 (1 mark)

In reference to the trp operon, the gene is expressed when trp is not present because:

A. RNA polymerase is able to bind to the promotor.

B. trp is able to bind to the repressor.

C. The trp is able to block the action of RNA polymerase.

D. There is the formation of an attenuation loop due to the pause in translation at the leader sequence.

Question 25 (1 mark)

When trp is present in $E. coli$:

A. It binds directly to the trp repressor, causing a conformational shape change.

B. It binds directly to the operator, preventing RNA polymerase from binding.

C. It causes the formation of hairpin loops disabling the process of attenuation.

D. It does nothing.

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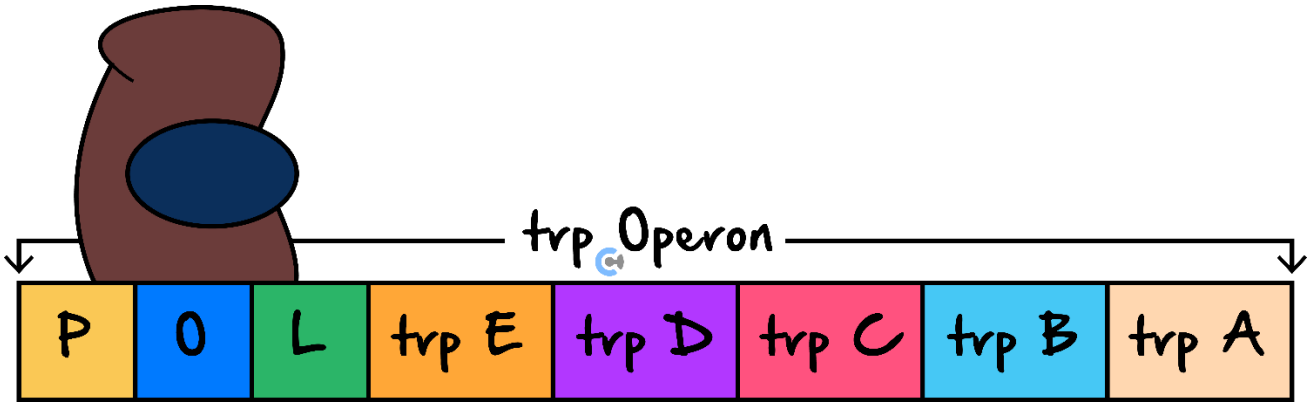
Question 26 (8 marks)

Repression is used by *E. coli* in order to regulate the levels of tryptophan that is present in the cell.

a. In the figure below, draw where a repressor protein would bind when tryptophan levels are high in the bacterial cell. (2 marks)



b. Explain why bacteria regulate the gene expression of enzymes involved in the synthesis of tryptophan. (1 mark)

c. Explain the role of the trpR gene in the regulation of the trp operon. (3 marks)

d. Andy thinks that once the trp production has stopped, it cannot be restarted. Is this true? (2 marks)

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Sub-Section: [1.3.6] Describe the Regulation of the trp Operon Through Attenuation in High trp Environments

Question 27

Definition: Attenuation.

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Question 28 (1 mark)

In the process of attenuation in the trp operon, which of the following determines whether the attenuator loop or anti-terminator loop forms?

A. The presence of the trp repressor protein bound to the operator.

B. The availability of tryptophan affecting ribosome stalling during translation.

C. The rate at which RNA polymerase binds to the promoter region.

D. The interaction between the leader sequence and the structural genes.

Question 29 (1 mark)

What happens during attenuation in the trp operon when tryptophan levels are high?

A. The ribosome stalls at the leader sequence, allowing the anti-terminator loop to form.

B. The ribosome moves quickly through the leader sequence, causing the attenuator loop to form.

C. The trp repressor protein binds to the operator, stopping transcription completely.

D. RNA polymerase skips over the leader sequence, allowing the transcription of structural genes.

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Question 30 (5 marks)

Describe the process of attenuation of the trp operon.

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