7.3 Translation

Question Paper

Course	DP IB Biology
Section	7. Nucleic Acids (HL Only)
Topic	7.3 Translation
Difficulty	Hard

Time allowed: 60

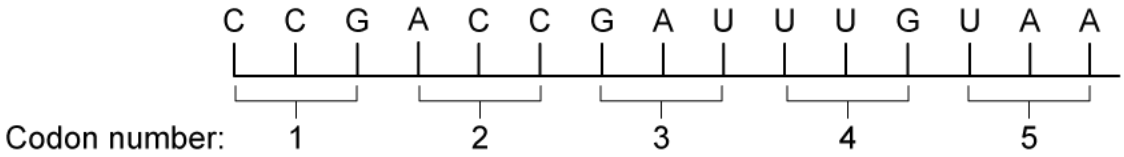
Score: /47

Percentage: /100

Question 1a

a)

The following diagram shows a section of mRNA containing five codons.



The triplets of bases in a DNA molecule that codes for some of the amino acids are listed in the table below.

Amino acid	Abbreviation	DNA triplets on the coding polynucleotide
Aspartic acid	Asp	CTA, CTG
Glycine	Gly	CCA, CCG, CCT, CCC
Leucine	Leu	AAC, AAT, GAA, GAC, GAG, GAT
Proline	Pro	GGA, GGC, GGG, GGT
Threonine	Thr	TGA, TGC, TGG, TGT
STOP	STOP	ATT, ATC, ACT

Identify the amino acid sequence on this section of the mRNA molecule, using the information in the diagram and table.

[1 mark]

[1 mark]

Question 1b

b)

The five codons in the diagram at part **a)** are near the start of the sequence coding for a polypeptide. A mutation led to the deletion of one of the bases from codon 3.

Explain the possible consequences of this mutation.

[4 marks]

[4 marks]

Question 1c

c)
Guanine (G) in codon 4 changed to adenine (A) due to a mutation.

i)
Describe the effect this mutation would have on the amino acid sequence in the diagram of part a).

[1 mark]

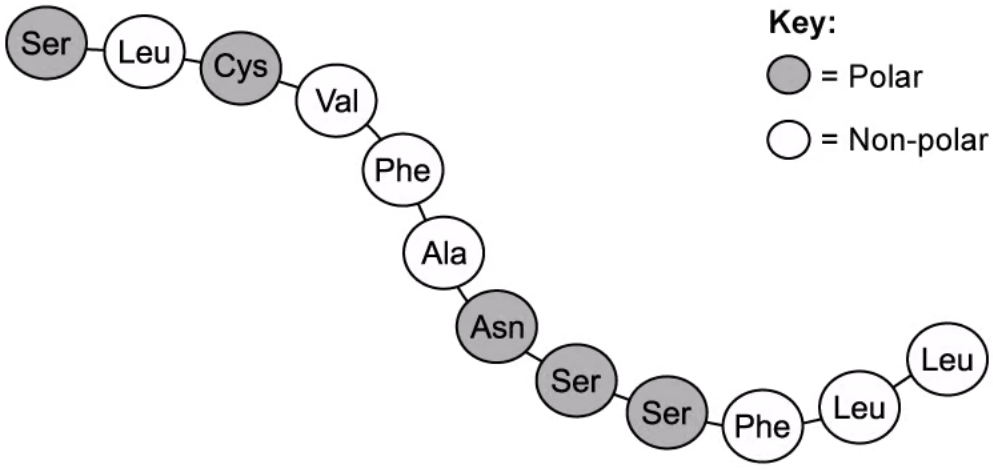
ii)
Explain your answer.

[1 mark]

[2 marks]

Question 1d

d)
The following diagram shows a section of a polypeptide, indicating the polarity of the amino acid R-groups.



Describe the possible interactions that could contribute to the tertiary structure of this polypeptide, by using the information in the diagram.

[2 marks]

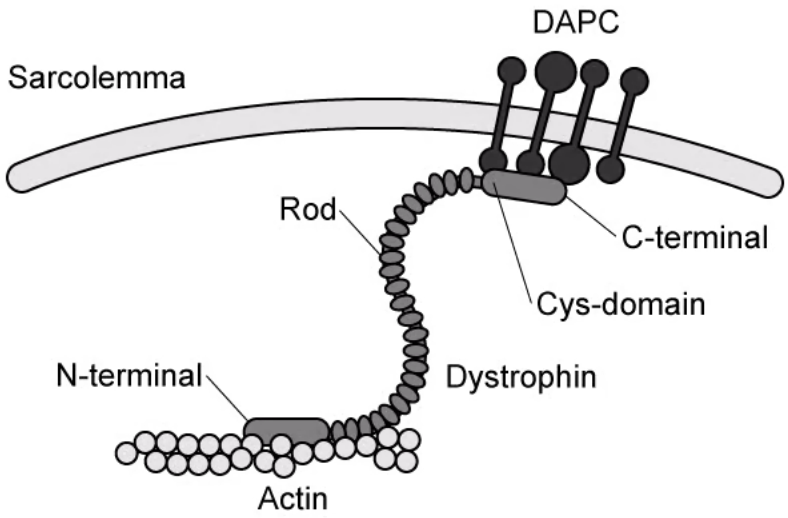
[2 marks]

Question 2a

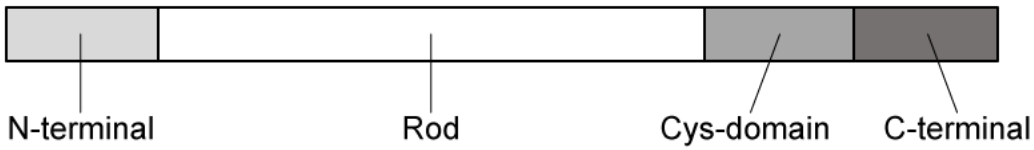
a)
Duchenne muscular dystrophy (DMD) is a genetic disorder that leads to the degeneration of muscle tissue over time due to changes in a protein called dystrophin.

Dystrophin is a rod-shaped protein that acts as a link connecting actin filaments in muscle fibres to the extracellular matrix by attaching to a protein complex (DAPC) located in the sarcolemma.

Dystrophin is coded for by the DMD gene, and the complete protein consists of four domains (N-terminal, Rod, Cys-domain and C-terminal), as shown in the diagram below.



The following diagram shows the regions of the DMD gene that codes for the different domains of dystrophin.



One of the causes of Duchenne muscular dystrophy is a substitution mutation that leads to the formation of a stop codon in the rod domain of the DMD gene.

Explain the impact this mutation would have on the resulting dystrophin protein by using the information in the diagrams.

[3 marks]

[3 marks]

Question 2b

b)
After transcription of the DMD gene, the pre-mRNA measures about 2.1 megabases (Mb) while the mature mRNA consists of about 14 kilobases (kb). Note that 1 Mb = 10^3 kb.

Calculate the percentage decrease in size of the mRNA molecule after modification. Show your working and give your answer to three significant figures.

[2 marks]

[2 marks]

Question 2c

c)
Dystrophin contains many hydrophobic regions that plays an important role in maintaining its structure. Some of the mutations leading to DMD replaces amino acids within the hydrophobic regions with ones containing polar or charged R-groups.

Suggest the effect that this would have on the structure of dystrophin.

[2 marks]

[2 marks]

Question 3a

a)
Hereditary transthyretin (hATTR) amyloidosis is an inherited condition that is caused by a mutation of a gene that codes for the blood protein transthyretin.

This mutation results in the protein forming clumps in different areas of the body, such as the cardiovascular system, digestive system and around nerve fibres.

Certain drugs that are designed to bind to mRNA molecules are used as treatment for this condition.

Suggest why these drugs could be used as a treatment for hATTR.

[3 marks]

[3 marks]

Question 3b

b)

The gene that codes for transthyretin is known as the TTR gene. The following diagram shows a section of this gene in a normal individual and someone suffering from hATTR.

Normal TTR gene	GGTCCGATTAACCACTTA
Mutated TTR gene	GGTCCGATTAACTACTTA

The table below shows the genetic code and the amino acids that it codes for.

Second letter

First letter	U	C	A	G	Third letter
U	UUU, UUC: Phe; UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr; UAA: Stop; UAG: Stop	UGU, UGC: Cys; UGA: Stop; UGG: Trp	U C A G
C	CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His; CAA, CAG: Gln	CGU, CGC, CGA, CGG: Arg	U C A G
A	AUU, AUC, AUA: Ile; AUG: Met	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn; AAA, AAG: Lys	AGU, AGC: Ser; AGA, AGG: Arg	U C A G
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp; GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	U C A G

Use the information in the diagram and table to describe the effect the mutation would have on transthyretin.

[2 marks]

[2 marks]

Question 3c

c)
Mitochondrial diseases (MD) are a group of genetic disorders where body cells cannot aerobically respire properly.

One example of an MD is caused by the mutation of a mitochondrial gene that codes for a tRNA molecule. The mutation leads to the replacement of a guanine base with adenine in the anticodon of the tRNA molecule. This results in the formation of a non-functional protein in the mitochondrion.

Suggest how the change in the anticodon of a tRNA molecule leads to an MD.

[3 marks]

[3 marks]

Question 3d

d)
Explain the role of ATP in translation.

[1 mark]

[1 mark]

Question 4a

a)
Ricin is a protein produced by castor beans. In animal cells, ricin acts as an enzyme which removes the adenine base from one of the nucleotides in the RNA of ribosomes. As a result, the ribosome changes shape. Ricin causes the death of cells and is very poisonous to certain animals.

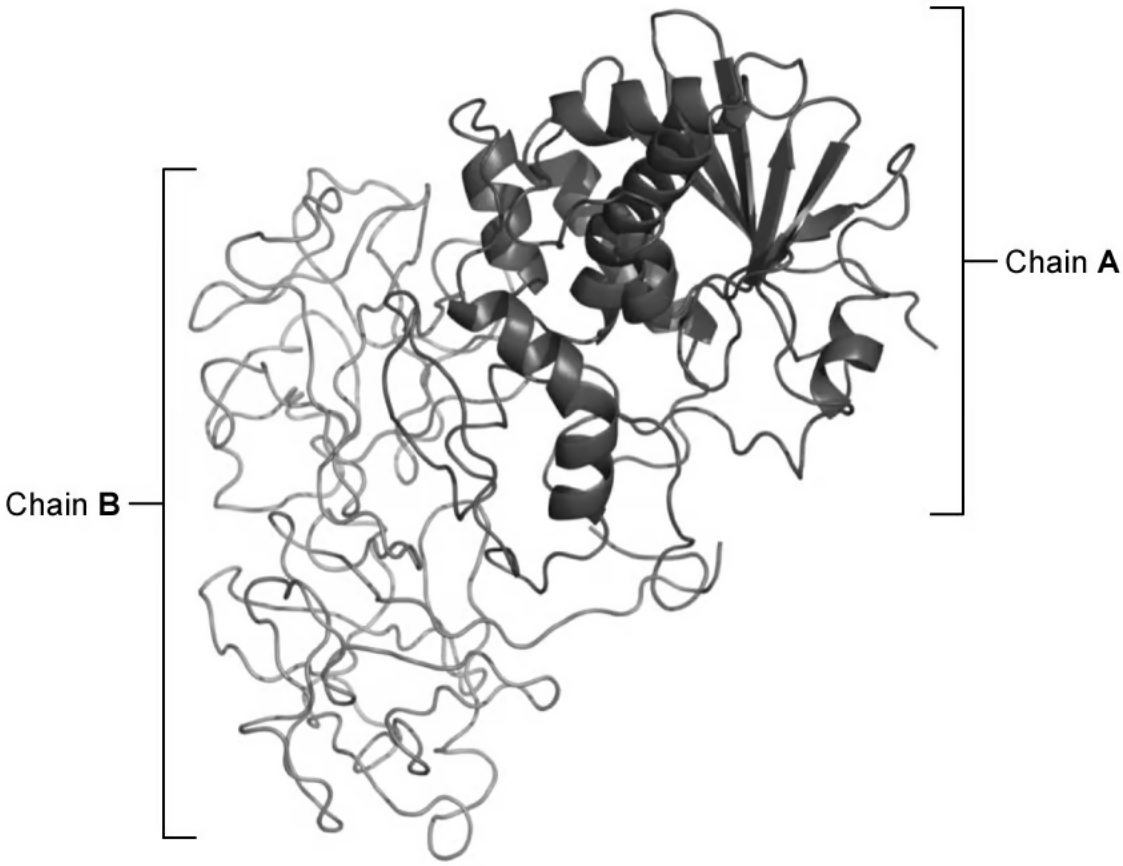
Suggest how the action of ricin on ribosomes could cause the death of cells.

[2 marks]

[2 marks]

Question 4b

b)
The image below shows the structure of ricin.



Discuss the level(s) of protein structure visible in the diagram.

[2 marks]

[2 marks]

Question 4c

c)
The Flavr Savr tomato plant was genetically engineered to ripen and soften more slowly than a normal tomato. The inserted gene prevents the enzyme *Beta polygalacturonase* from breaking down pectin which softens the tomatoes.

The diagram below shows the matching parts of the base sequences for the mRNA produced from the transcription of the softening gene in a normal tomato and that of the inserted gene.

Softening gene	....AAUCGGAAU....
Inserted gene	....UUAGCCUUA....

Suggest how the inserted gene reduces the production of the softening enzyme.

[2 marks]

[3 marks]

Question 5a

One mark is available for clarity of communication throughout this question.

a)
Discuss the importance of hydrogen bonds in the process of translation.

[4 marks]

[4 marks]

Question 5b

b)
Outline the uses of bioinformatics in scientific research.

[7 marks]

[7 marks]

Question 5c

c)
Draw labelled diagrams contrasting the structure of an mRNA and tRNA molecule.

[4 marks]

[4 marks]