IB · DP · Biology

2 hours 15 questions

Structured Questions: Paper 2

7.3 Translation

7.3.1 Translation / 7.3.2 Ribosomes / 7.3.3 Translation in Prokaryotes / 7.3.4 Bioinformatics / 7.3.5 Levels of Protein Structure / 7.3.6 Skills: Polysomes & Ribosomes

Easy (5 questions)	/36
Medium (5 questions)	/49
Hard (5 questions)	/47
Total Marks	**/132**

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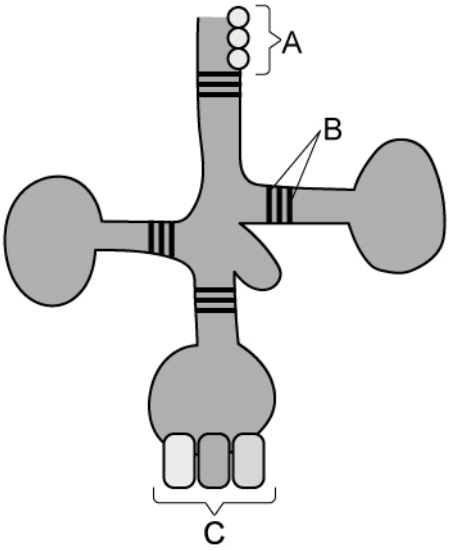
Easy Questions

1 (a) The diagram below shows the structure of a tRNA molecule.



Identify the type of molecule that would bind to site **A**.

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(1 mark)

(b) (i) Identify the type of bond present at **B**.

[1]

(ii) State the purpose of these bonds in a tRNA molecule.

[1]

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(2 marks)

(c) Describe the role of **C** in the process of translation.

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(2 marks)

(d) Before tRNA molecules can partake in translation, they bind to tRNA-activating enzymes.

State the purpose of tRNA-activating enzymes.

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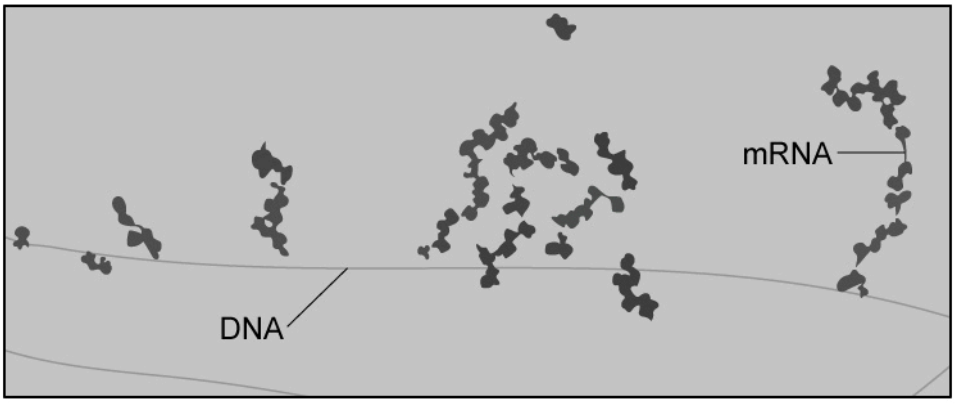
(1 mark)

2 (a) The following diagram shows polysomes.



Define the term 'polysome'.

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(1 mark)

(b) Polysomes are present in both prokaryotic and eukaryotic cells.

(i) Identify whether the polysomes in the diagram at part **a)** are prokaryotic or eukaryotic.

[1]

(ii) State a reason for your answer at part **b) i).**

[1]

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(2 marks)

(c) Describe **one** advantage of polysomes.

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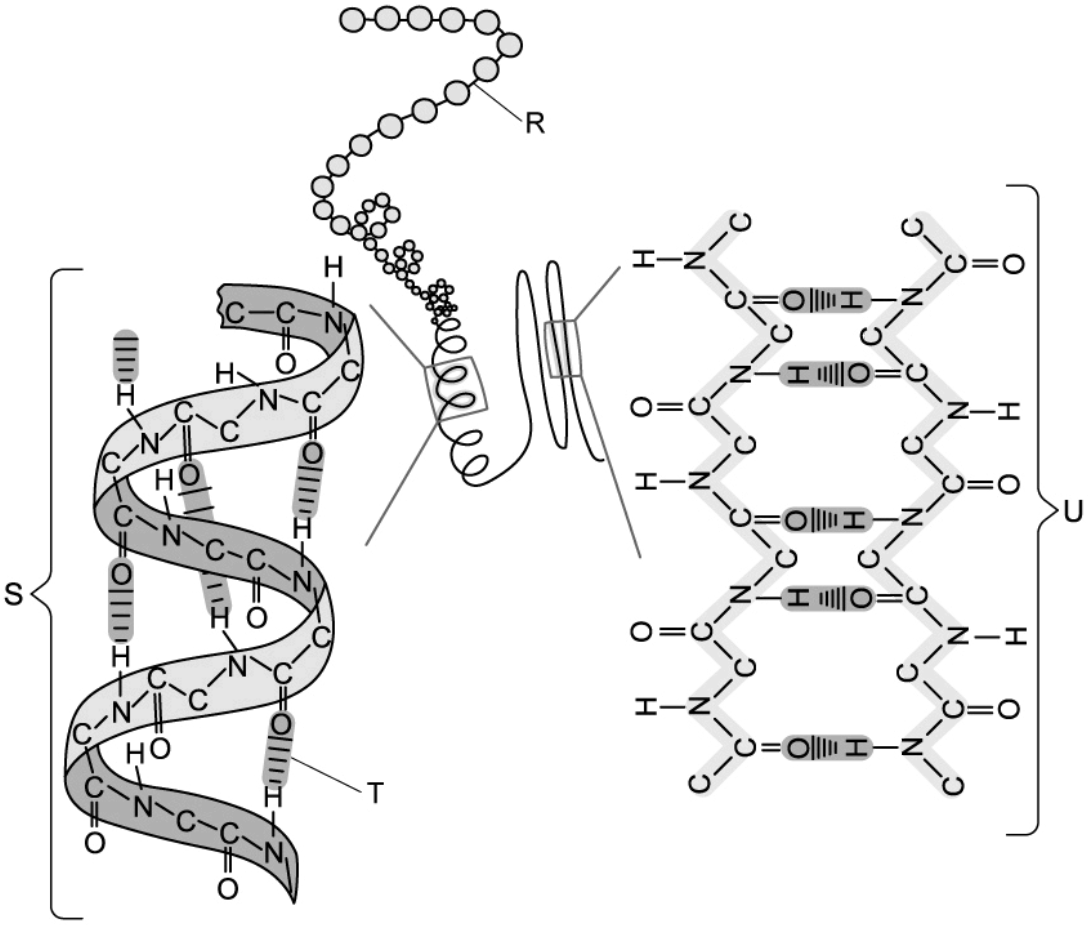
(1 mark)

3 (a) The diagram below shows the secondary structure of a protein.



Identify structures **S** and **U**.

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(2 marks)

(b) The structure of a protein is held together by different types of chemical bonds.

Label the bonds **R** and **T** in the diagram.

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(2 marks)

(c) Describe how the bond at **T** forms and the way it contributes to the secondary structure of a protein.

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.....

(2 marks)

(d) Explain how a mutation would affect the primary structure of a protein.

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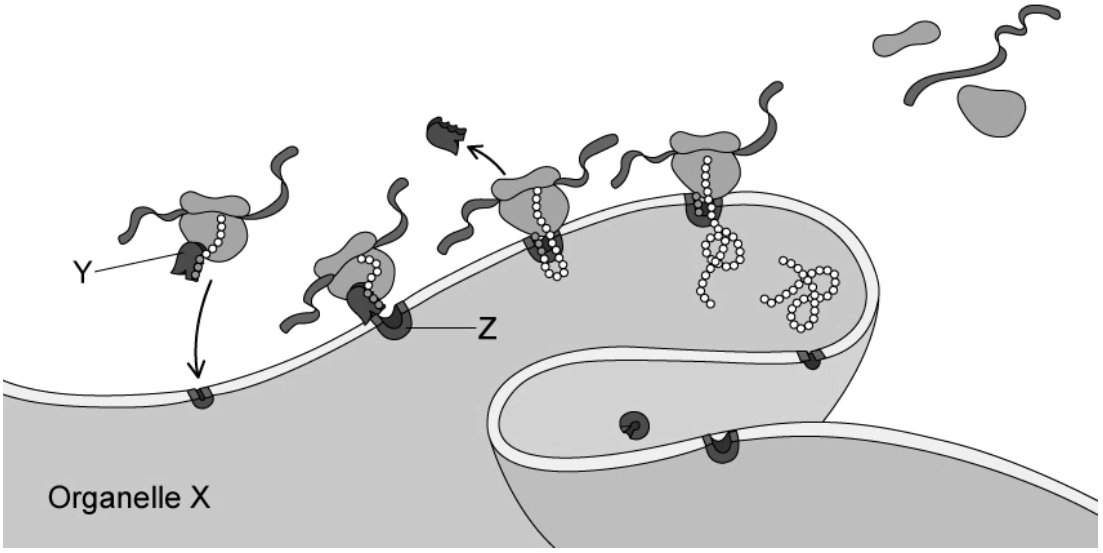
(1 mark)

4 (a) The diagram below shows a ribosome producing proteins that are to be secreted from the cell. In order for this to occur, the ribosome must bind to organelle **X**.



State the name of organelle **X**.

.....

(1 mark)

(b) Binding to **Y** will result in the ribosome moving towards organelle **X** and binding to **Z**.

Identify **Y** and **Z** in the diagram.

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.....

(2 marks)

(c) State the effect that binding to **Y** would have on the process of translation.

.....

(1 mark)

(d) Describe the path of the protein after it is produced, until it is secreted out of the cell.

.....

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(2 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Ribosomes play an important role during the process of translation.

Describe the structure of ribosomes.

(4 marks)

(b) Outline the steps involved in the initiation of translation.

(3 marks)

(c) Proteins are large, complex molecules that have several levels comprising their structure.

Describe the tertiary structure of proteins.

(6 marks)

Medium Questions

1 (a) Messenger RNA (mRNA) and transfer RNA (tRNA) are important molecules required for the transcription and translation of proteins.

Contrast the structures of mRNA and tRNA.

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.....

(2 marks)

(b) Describe the role of tRNA in the process of translation.

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(3 marks)

(c) Tobacco plants have been genetically modified to produce human haemoglobin. The first three triplets of the antisense strand of the human haemoglobin gene are:

ATG GTG CAT

Identify the anticodons of the corresponding tRNA molecule.

.....

(1 mark)

(d) The base sequence below is found in a section of the mRNA strand used to synthesise an enzyme found in tobacco plants.

G U U A A A G U U U C A A C G A A A A A C

Using the diagram, deduce how many different **types** of tRNA molecules would attach to the section of mRNA shown in the diagram?

.....

(1 mark)

2 (a) The table below shows some of the events which take place in protein synthesis.

A	mRNA nucleotides join with exposed DNA bases and form a molecule of mRNA
B	Peptide bonds form between the amino acids
C	tRNA molecules bring specific amino acids to the mRNA molecule
D	The introns are spliced from the pre-mRNA to produce mRNA
E	A ribosome attaches to the mRNA molecule
F	The two strands of a DNA molecule separate
G	The mRNA molecule leaves the nucleus

Identify the correct order of letters to show the sequence of events during protein synthesis, starting with the earliest.

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(3 marks)

(b) Haemoglobin is a protein made of alpha and beta polypeptides. Each alpha polypeptide has 141 amino acids and each beta polypeptide has 146 amino acids.

Deduce the total number of peptide bonds present in one alpha polypeptide **and** one beta polypeptide.

.....

(1 mark)

(c) Haemoglobin is a quaternary protein.

Describe the structures of haemoglobin that make it a quaternary protein.

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(2 marks)

(d) State the types of bonding present in the different levels of protein structure.

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(3 marks)

3 (a) Describe the function of ribosomes in protein synthesis.

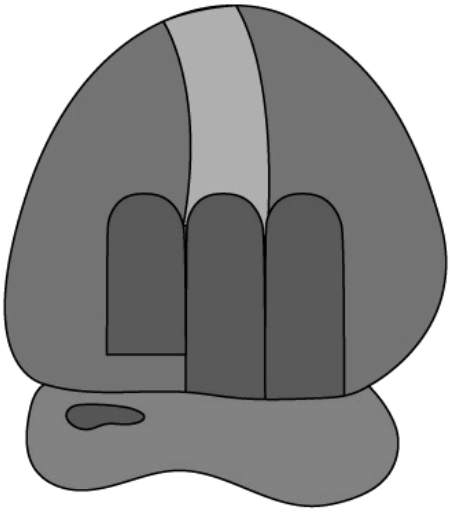
(4 marks)

(b) Within a cell ribosomes can be found free or bound to structures.

Contrast free ribosomes with bound ribosomes.

(2 marks)

(c) The image below shows the structure of a ribosome. Ribosomes contain an **A** site, an **E** site, and a **P** site.



Label the **A** site, the **E** site, and the **P** site on the image above.

(1 mark)

(d) Ribosomes are made of ribosomal RNA (rRNA). Messenger RNA (mRNA), transfer RNA (tRNA) and DNA are all involved in the synthesis of proteins.

Complete the table to show the differences between DNA, mRNA and tRNA.

Type of nucleic acid	Number of polynucleotide strands in the molecule	The nitrogenous base uracil present (✓) or not present (X)
DNA		
mRNA		
tRNA		

.....

.....

(2 marks)

4 (a) Enzymes play an important role during transcription and translation.

Discuss the importance of enzyme-substrate specificity in the activation of tRNA molecules.

(4 marks)

(b) The tRNA-activating enzyme relies on phosphorylation.

Outline the role of phosphorylation during translation.

(3 marks)

(c) Enzymes, such as the tRNA-activating enzyme, are proteins.

State, with named examples, **two** functions of proteins.

(2 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Describe how the process of translation leads to the production of a polypeptide.

(6 marks)

(b) Explain why cellular enzymes are made predominantly from protein.

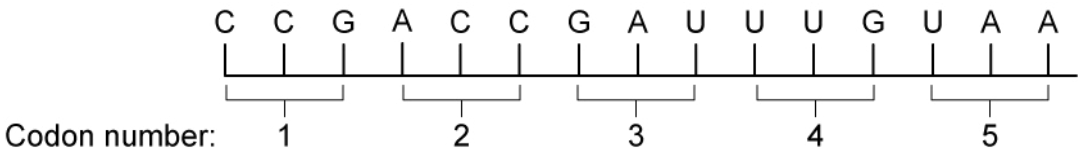
(5 marks)

(c) Contrast protein synthesis in eukaryotes with protein synthesis in prokaryotes.

(4 marks)

Hard Questions

1 (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.

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(1 mark)

(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.

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(4 marks)

(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).

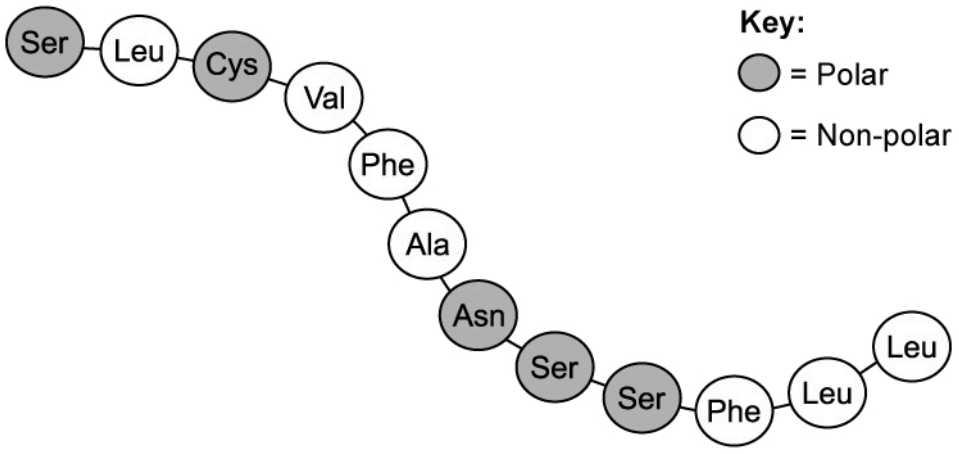
[1]

(ii) Explain your answer.

[1]

(2 marks)

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



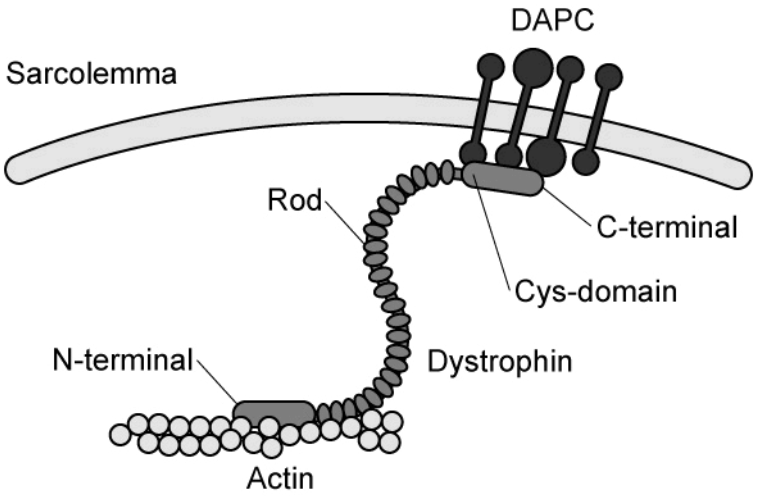
Describe the possible interactions that could contribute to the tertiary structure of this polypeptide, by using the information in the diagram.

(2 marks)

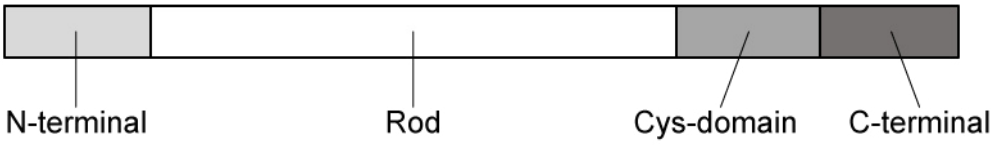
2 (a) Duchenne muscular dystrophy (DMD) is a genetic disorder that leads to the degeneration of muscle tissue over time due to changes in a protein called dystrophin.

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)

(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)

(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)

3 (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.

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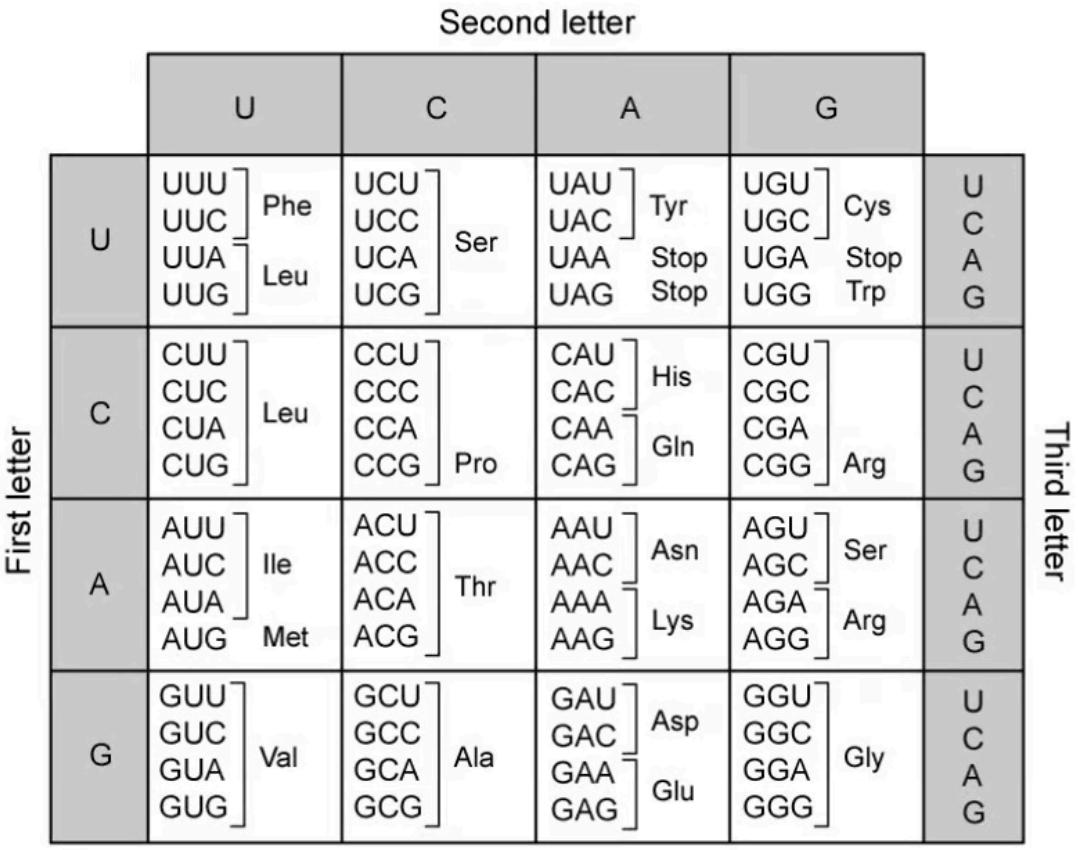
(3 marks)

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

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



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

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(2 marks)

(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.

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(3 marks)

(d) Explain the role of ATP in translation.

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(1 mark)

4 (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.

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(2 marks)

(b) The image below shows the structure of ricin.

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

.....

(2 marks)

(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.

(3 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

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

(4 marks)

(b) Outline the uses of bioinformatics in scientific research.

(7 marks)

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

(4 marks)