

Structured Questions

Protein Synthesis

Transcription in Protein Synthesis / Translation in Protein Synthesis / The Genetic Code / Protein Structure & Mutations

Easy (6 questions)	/37
Medium (11 questions)	/64
Hard (5 questions)	/38
Total Marks	/139

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Easy Questions

- 1 (a) When a polypeptide is synthesised it is important that the amino acids are combined in the correct order to produce a functional protein.

Outline the process that allows the amino acids to be added to the polypeptide in the correct order.

(3 marks)

- (b) After a polypeptide has been synthesised it must undergo a series of changes before it can become a functional protein.

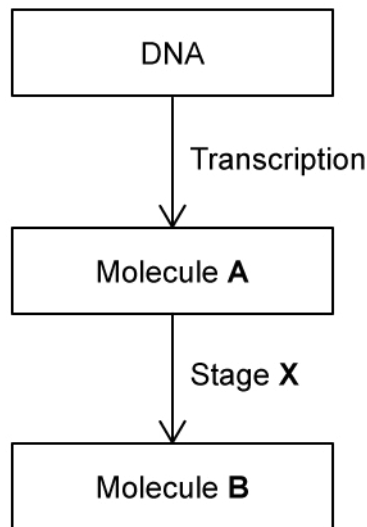
Describe the changes that occur between polypeptide synthesis and the formation of the functional protein.

(3 marks)

- (c) How might a change in the DNA affect the way that the process of protein folding occurs?

(2 marks)

2 (a) The following diagram shows the process of protein synthesis.



(i) Identify stage **X**.

[1]

(ii) State where in the cell stage **X** occurs.

[1]

(2 marks)

(b) Label molecule **A** and **B** in the diagram.

(2 marks)

(c) State **one** difference in structure between DNA and molecule **A** identified at part b).

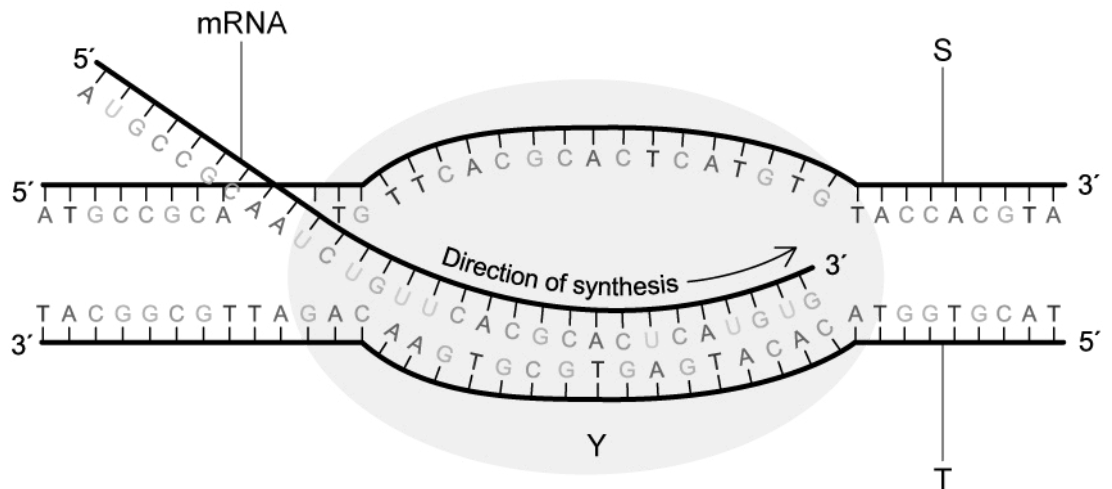
(1 mark)

(d) Molecule **B** is synthesised from monomers.

Identify the monomers of molecule **B**.

(1 mark)

3 (a) The diagram below shows one of the stages in protein synthesis.



(i) Identify the stage of protein synthesis represented by the diagram.

[1]

(ii) State **one** reason for your answer in part i).

[1]

.....

.....

(2 marks)

(b) Enzyme **Y** plays an important role during the stage of protein synthesis identified at part a) i).

(i) Identify enzyme **Y**.

[1]

(ii) State the role of this enzyme during protein synthesis.

[1]

.....

.....

(2 marks)

(c) Label strands **S** and **T** of the DNA molecule.

.....

.....

(2 marks)

(d) Explain the purpose of creating an mRNA copy of the genetic code on the DNA molecule.

.....

.....

(2 marks)

4 (a) The following DNA base triplets form part of a gene coding for a polypeptide.

CCC ATA CTT GGA

State the mRNA codons that would be transcribed from this section of the gene.

.....
.....

(2 marks)

(b) The gene mentioned in part a) formed an mRNA molecule that consisted of 180 nucleotides.

Calculate the number of amino acids that will be coded for by this gene. Show your working.

.....
.....

(2 marks)

(c) The table below shows mRNA codons and their corresponding amino acids.

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

Use this table to state the amino acid sequence of the section of the gene given in part a).

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(2 marks)

5 (a) Describe the role of a ribosome in the process of protein synthesis.

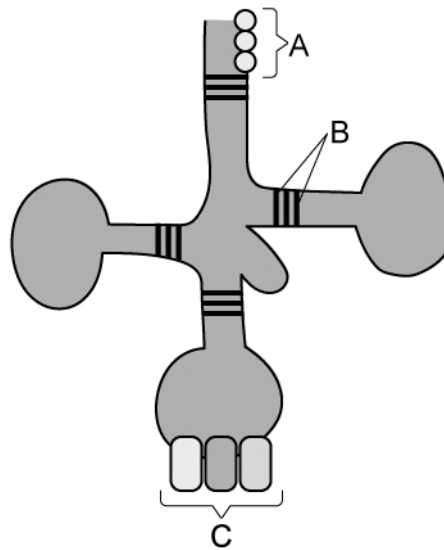
(2 marks)

(b) The mRNA molecule that is shown in the diagram at part a) carries the genetic code in the form of codons.

Define the term 'codon'.

(1 mark)

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



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

.....
(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]

.....
.....
(2 marks)

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

.....
.....
(2 marks)

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

State the purpose of tRNA-activating enzymes.

(1 mark)

Medium Questions

1 (a) The following base sequences represent sections of two different alleles of the gene which determines an individual's ability to roll their tongue.

Allele A (tongue roller): GCCGTAAC
Allele B (non-tongue roller): GCGCTTAC

Outline why two different alleles result in different expressions of a gene.

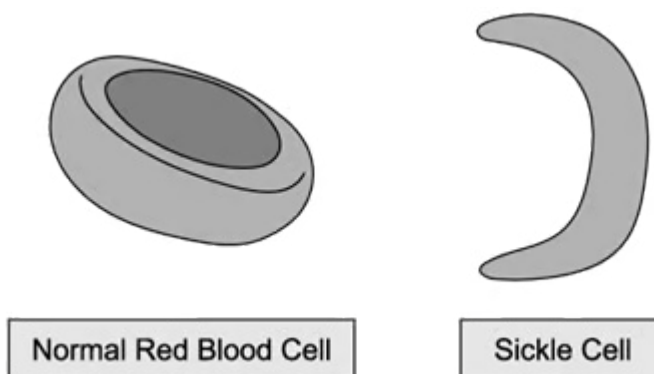
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(3 marks)

(b) Sickle cell anemia is a genetic disorder with symptoms such as dizziness, a rapid heart rate and fatigue. It is caused by an allele that leads to altered haemoglobin proteins. These altered proteins undergo aggregation (sticking together), an event which changes the shape of red blood cells. This can be seen in the image below.



Suggest how sickled red blood cells may result in the symptoms noted above.

.....

.....

.....

(3 marks)

(c) Suggest why the shape of white blood cells is not affected by sickle cell anaemia.

(1 mark)

(d) Mutations such as the one seen in sickle cell patients are usually caused by an error during DNA replication.

Identify the enzyme that is responsible for catalysing the process of DNA replication.

(1 mark)

- 2 (a)** Myoglobin is a eukaryotic protein consisting of a single polypeptide chain of 153 amino acids.

Calculate the minimum number of DNA bases needed to code for Myoglobin.

(1 mark)

- (b)** Haemoglobin is another eukaryotic protein; it contains both α and β polypeptide chains. Some of the first seven amino acids of an α chain of haemoglobin, along with the corresponding bases in the sequence are shown below. An mRNA codon and amino acid table is also provided.

Amino acid sequence	Met	(i)	Leu	(ii)	(iii)	Ala	Asp
Base sequence in DNA antisense strand (3'→5')	TAC	CAC	GAC	AGA	GGA	CGG	CTG

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

Use the information provided to identify the missing amino acids from the sequence of seven shown above.

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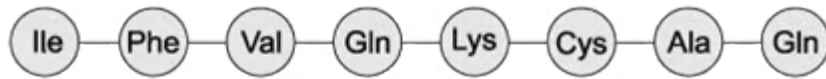
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(3 marks)

- (c) A third eukaryotic protein, cytochrome c, is involved in the process of aerobic respiration. The diagram below shows part of the mRNA sequence and its corresponding amino acid sequence for cytochrome c in *Mus musculus* (house mouse) and *Loxodonta africana* (African elephant).

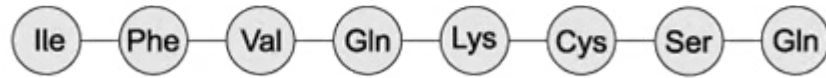
Amino acid
sequence of
mouse



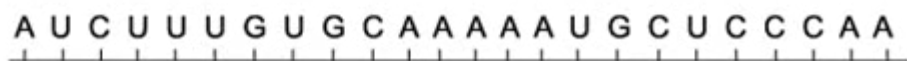
mRNA of
mouse



Amino acid
sequence of
elephant



mRNA of
elephant



Identify the tRNA anticodon that corresponds to the amino acid serine (Ser).

.....
(1 mark)

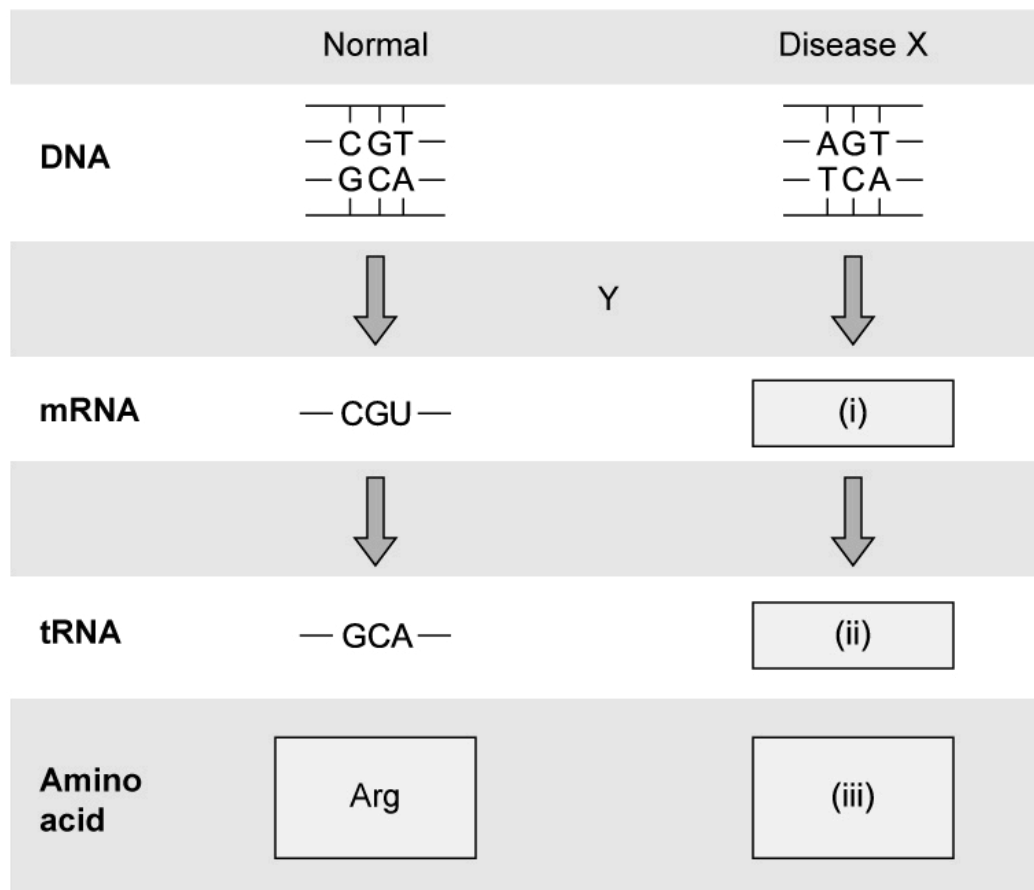
- (d) The triplet codes for the amino acid Ile in part (c) demonstrate a property of the genetic code known as degeneracy, or redundancy.

Use the information in part (c) to:

- (i) Suggest what is meant when we say that the genetic code is degenerate/redundant.
- (ii) Identify one **other** amino acid that demonstrates this property.

.....
.....
(2 marks)

3 (a) Disease X is a genetic condition. It is caused by various mutations, one of which is shown in the diagram below.



Identify the process marked **Y** in the diagram.

(1 mark)

(b) The table below shows mRNA codons and their corresponding amino acids.

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

Use the table above and your knowledge of protein synthesis to identify the contents of boxes (i)-(iii) in the diagram in part (a).

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.....

(3 marks)

(c) Outline the role of transfer RNA in the process of protein synthesis.

.....

.....

(2 marks)

(d) Explain why the protein produced as a result of the disease X mutation shown in part (a) does not function as it should.

.....

.....

(2 marks)

4 (a) The table below shows the exposed bases of two tRNA molecules involved in the synthesis of a protein.

Bases of tRNA anticodon	UAU	GAC
Bases of corresponding DNA antisense strand	(i)	(ii)

Identify the base sequences found on the corresponding sections of the DNA antisense strands.

.....

.....

(2 marks)

(b) Outline how a gene codes for a polypeptide.

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.....

.....

(3 marks)

(c) A polypeptide is formed when a series of amino acids join to form a chain.

Identify the following:

- (i) The chemical reaction that joins two amino acids together in a polypeptide.
- (ii) The type of bond that joins two amino acids together in a polypeptide.

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(2 marks)

5 Draw an annotated diagram to illustrate the structure of a DNA double helix. You do not have to show the helical shape in your diagram.

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(5 marks)

- 6 (a)** The human genome is approximately 3 billion, or 3 000 000 000, base pairs long. A DNA sequencing machine allows for 5.5×10^8 base pairs to be sequenced per hour.

Using this information calculate the number of days it would take to sequence 1500 genomes of hospital patients using this machine. Give your answer to the nearest day.

(2 marks)

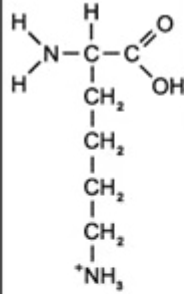
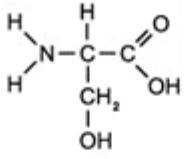
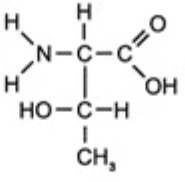
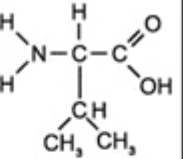
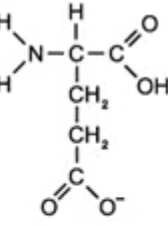
- (b)** The table below shows part of the DNA base sequence coding for β -haemoglobin and two mutations of this sequence detected in a sickle cell sufferer.

DNA base sequence coding for β -haemoglobin												
mRNA sequence for β -haemoglobin	A	C	U	C	C	U	G	A	G	G	A	G
DNA base sequence with mutation 1												
mRNA base sequence with mutation 1	A	C	U	C	C	U	G	U	G	G	A	G
DNA base sequence with mutation 2												
mRNA base sequence with mutation 2	A	C	U	C	C	U	G	A	A	G	A	G

Complete the table with the DNA sequences that will undergo transcription to produce β -haemoglobin, mutated protein **1**, and mutated protein **2**.

(3 marks)

- (c) The table below shows some examples of amino acids, their structures, and the mRNA codons that code for them.

Amino Acid					
	Lys	Ser	Thr	Val	Glu
mRNA codons	AAA AAG	AGU AGC	ACU ACG ACA ACC	GUU GUG GUC GUA	GAA GAG

Suggest why mutation **2** from part (b) is of no concern to the scientists studying this patient's DNA

(2 marks)

- (d) A karyogram, such as the one shown in the image below, can be used to detect some Mutations



State why this karyogram could not be used to detect sickle cell anaemia.

(1 mark)

7 Describe the role of tRNA in the process of translation.

(3 marks)

8 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)

9 (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)

10 Contrast protein synthesis in eukaryotes with protein synthesis in prokaryotes.

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.....
(4 marks)

- 11** Radiation and mutagenic chemicals can cause mutations in DNA that result in new alleles.

Explain how mutations in DNA can affect the final protein product.

.....
.....
.....
(3 marks)

Hard Questions

- 1 (a) The sequence below shows the DNA bases coding for seven amino acids in the enzyme papain. Note that the sequence shown is from the **sense** strand.

C A A T T T C A A A G T T G C T T T T G

The image shows the genetic code (mRNA codons).

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

Use the image to identify the sequence of amino acids in this part of the enzyme.

(1 mark)

- (b) **Table 1** below shows some mRNA codons and the amino acids for which they code.

Table 1

Codon	Amino Acid
ACG	Threonine
UUA	Leucine
CCA	Proline
GUA	Valine
GCU	Alanine
AAU	Asparagine

(i) Identify the DNA coding strand sequence for leucine.

[1]

(ii) Identify the amino acid carried by the tRNA with the anticodon CAU.

[1]

(2 marks)

2 (a) As enzyme **Y** in part a) moves along the DNA, the base sequence on the **template** strand is as follows:

A T G G C A A C T C T A

Identify the **tRNA anticodons** that would bind with the mRNA produced from this section of DNA.

.....

.....
(2 marks)

(b) The transcription factor shown in part a) is a protein.

Suggest, with a reason, how a mutation in the gene that codes for the transcription factor protein might affect the expression of the gene shown in part a).

.....

.....
(2 marks)

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

Compare and contrast the processes of DNA replication and transcription.

(8 marks)

(b) Explain the relationship between the genetic code and proteins.

(6 marks)

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

(4 marks)

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

(4 marks)

5 (a) Part of the gene coding for a specific polypeptide contains the following base sequence:

CATAGTTGGCCA

The following table contains some of the codons on messenger RNA and the amino acids that they code for:

Codons	Amino acid coded for by codons
AUU / AUC / AUA	Isoleucine (Ile)
UUA / UUG / CUU / CUC / CUA / CUG	Leucine (Leu)
GGU / GGC / GGA / GGG	Glycine (Gly)
ACU / ACC / ACA / ACG	Threonine (Thr)
UCU / UCC / UCA / UCG	Serine (Ser)
GUU / GUC / GUA / GUG	Valine (Val)
UAA / UAG / UGA	STOP

Using the information provided, identify the amino acid sequence for this part of the polypeptide.

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.....

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(3 marks)

(b) The cells that synthesise this polypeptide was exposed to a mutagen that caused a substitution mutation that changed the DNA base sequence in the following way:

CATACTTGGCCA

Using the table from part a), explain the effect this mutation will have on the polypeptide produced.

.....

.....

.....

(3 marks)

- (c) This polypeptide forms part of the active site of an enzyme that catalyses a metabolic reaction.

Suggest the effect that the mutation mentioned in part b) would have on the enzyme.

.....

.....

(2 marks)

- (d) Based on the information provided in part a), explain how it could be possible for a mutation to have no effect on the polypeptide.

.....

(1 mark)