IB · DP · Biology

2 hours 15 questions

Structured Questions: Paper 2

2.6 Transcription & Translation

2.6.1 Transcription / 2.6.2 Translation / 2.6.3 Biotechnology / 2.6.4 Skills: DNA, RNA & Protein Synthesis / 2.6.5 Skills: Interpreting Sequences

Easy (5 questions)	/41
Medium (5 questions)	/45
Hard (5 questions)	/44
Total Marks	**/130**

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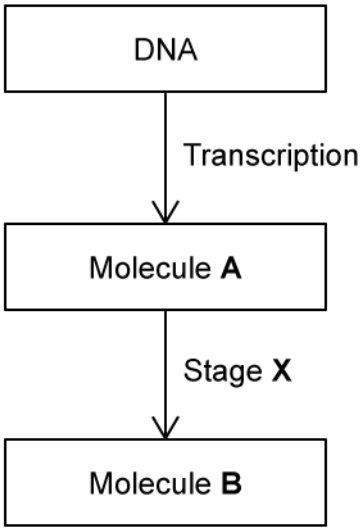
Easy Questions

1 (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]

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(2 marks)

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

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.....

(2 marks)

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

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(1 mark)

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

Identify the monomers of molecule **B**.

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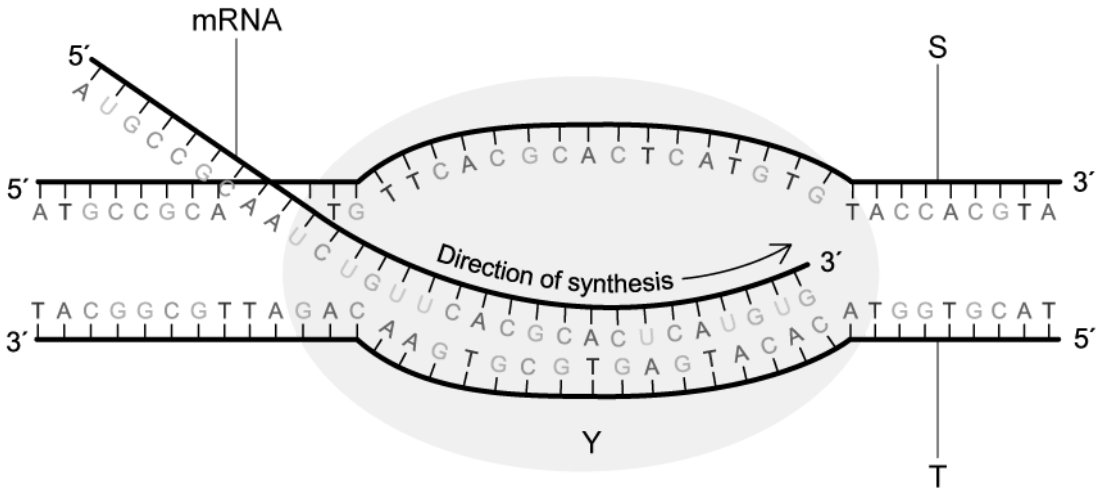
(1 mark)

2 (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]

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(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]

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(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)

3 (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.

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(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.

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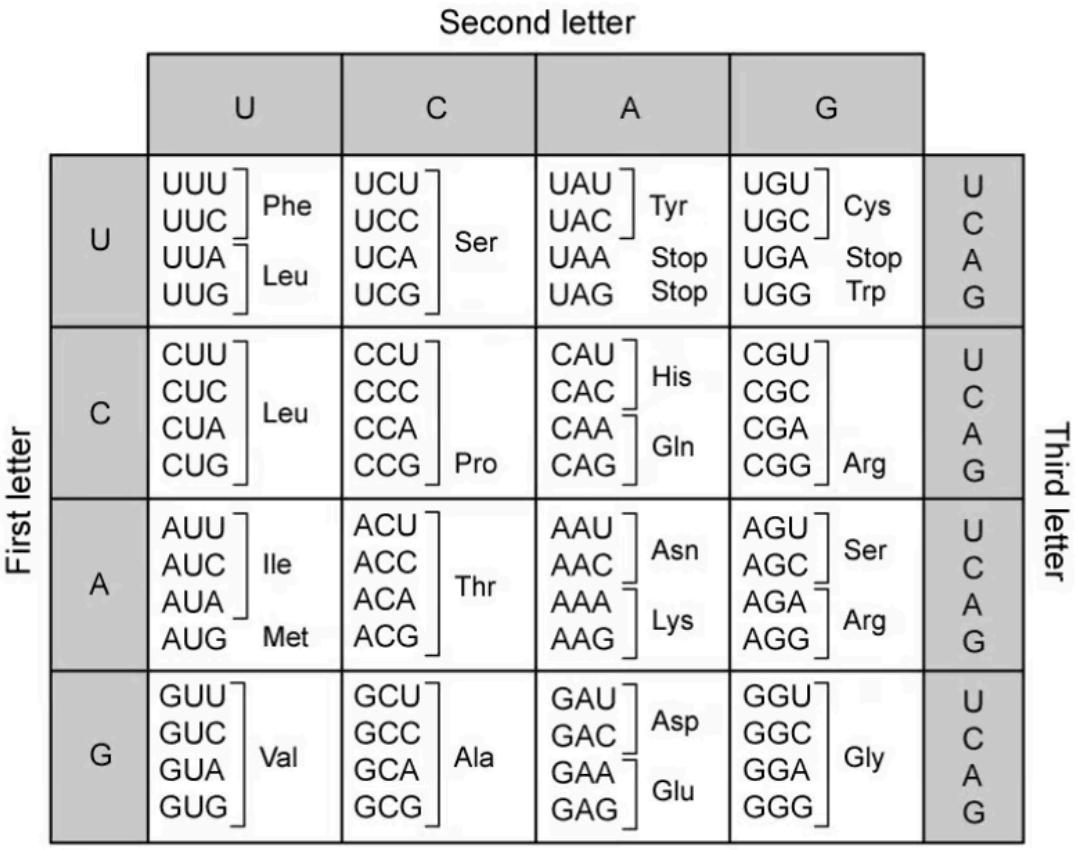
(2 marks)

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



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

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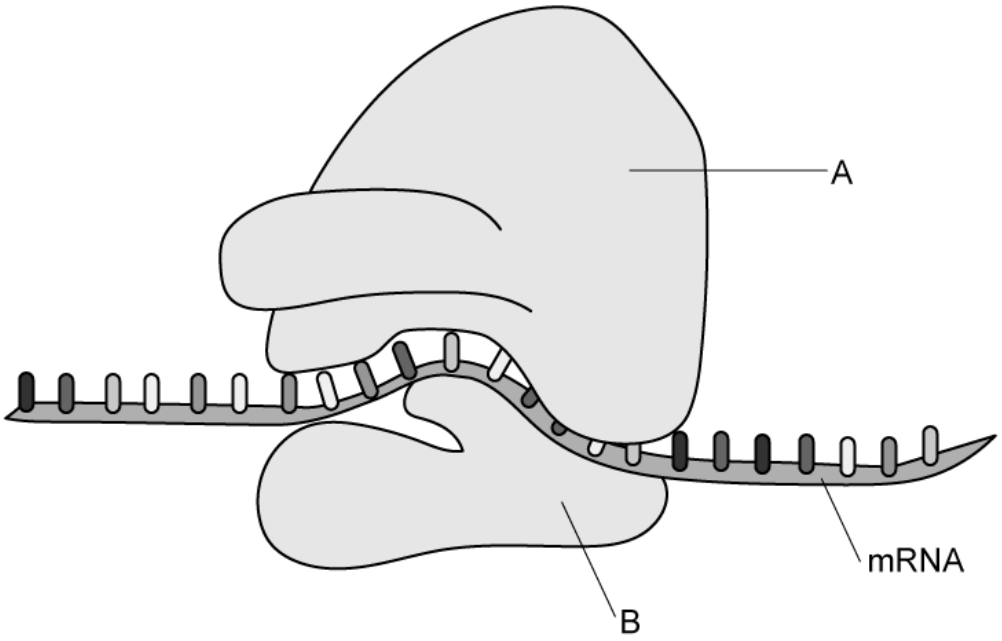
(2 marks)

4 (a) The diagram below shows the structure of a ribosome.



Identify parts **A** and **B** of the ribosome.

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(2 marks)

(b) State **one** substance that a ribosome is composed of.

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(1 mark)

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

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(2 marks)

(d) 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'.

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(1 mark)

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

Describe how the structure of a tRNA molecule contributes to the accuracy of the translation.

(3 marks)

(b) Draw a labelled diagram of two nucleotides bonded together within the same DNA strand.

(5 marks)

(c) Outline the three stages of polymerase chain reaction (PCR).

(7 marks)

Medium Questions

1 (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.

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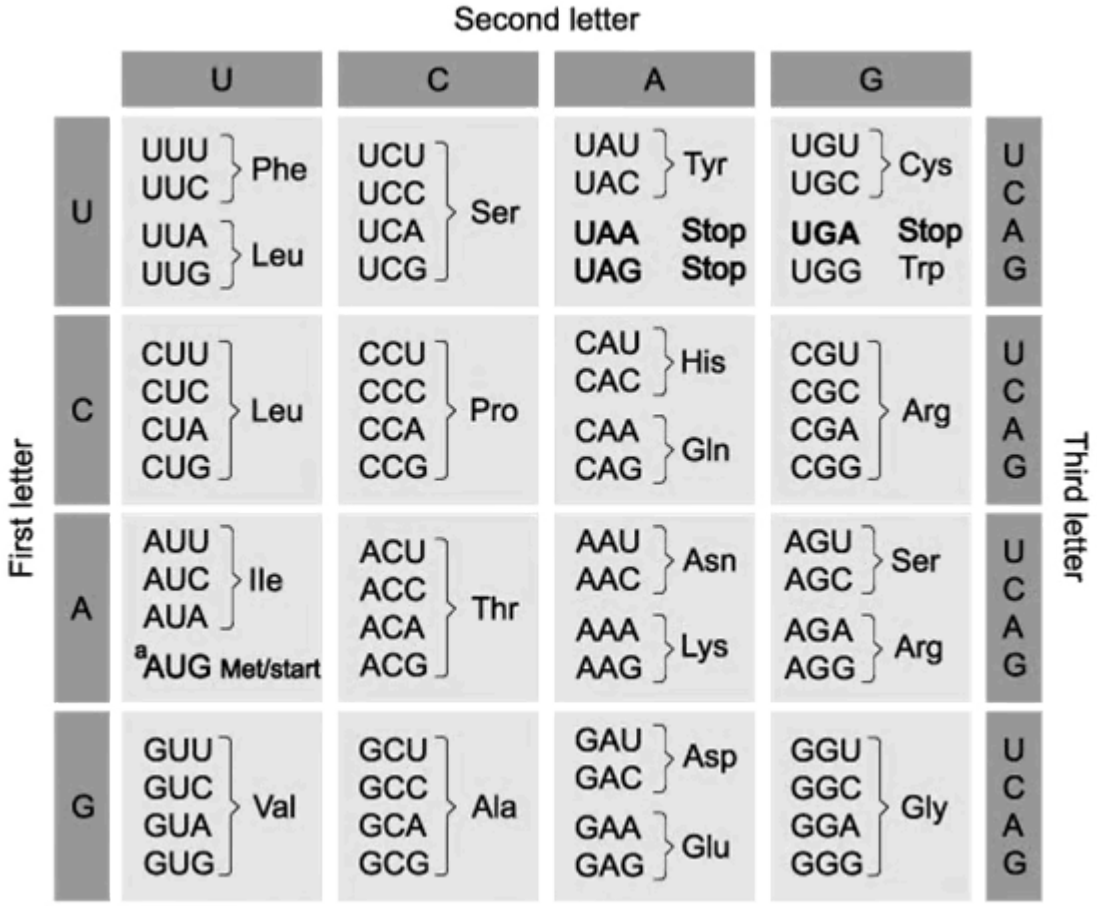
(1 mark)

(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



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

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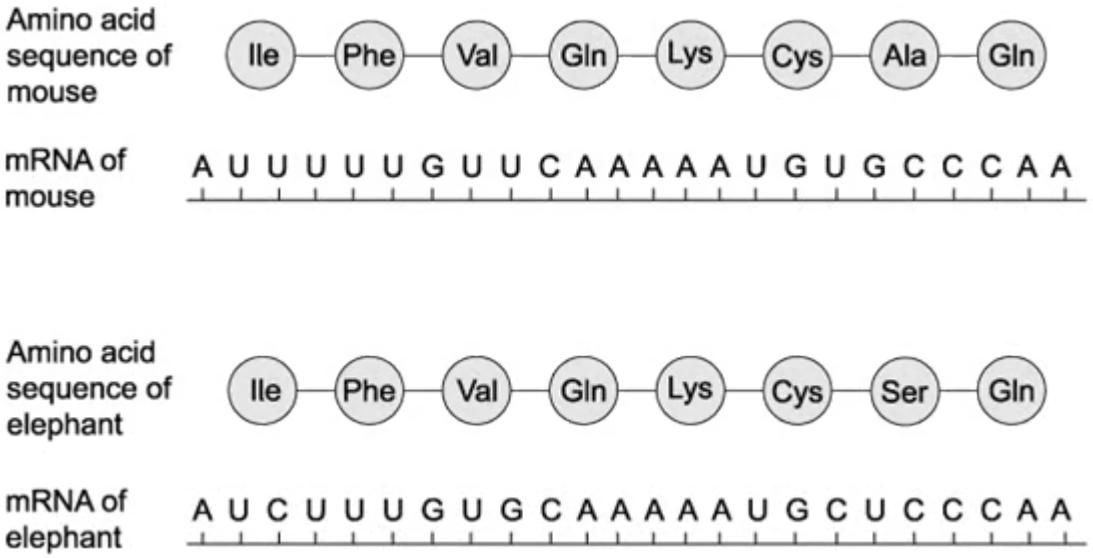
(3 marks)

(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).



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

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(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.

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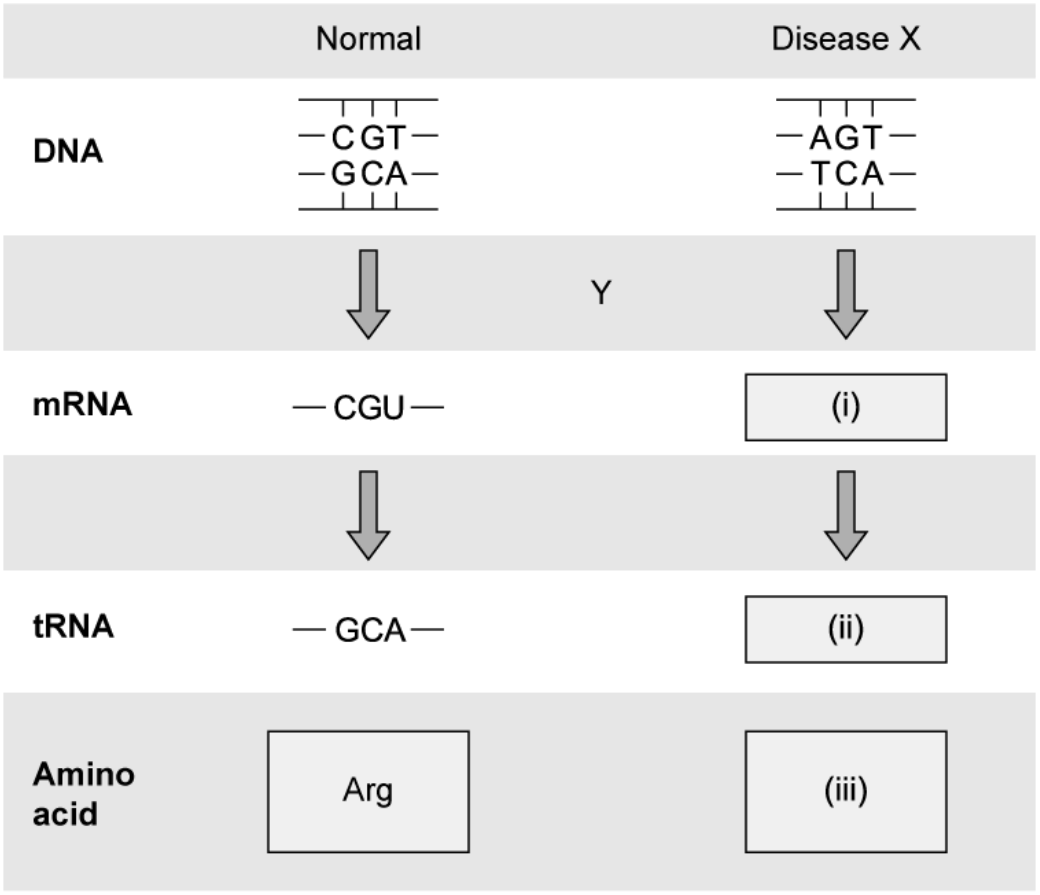
(2 marks)

2 (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.

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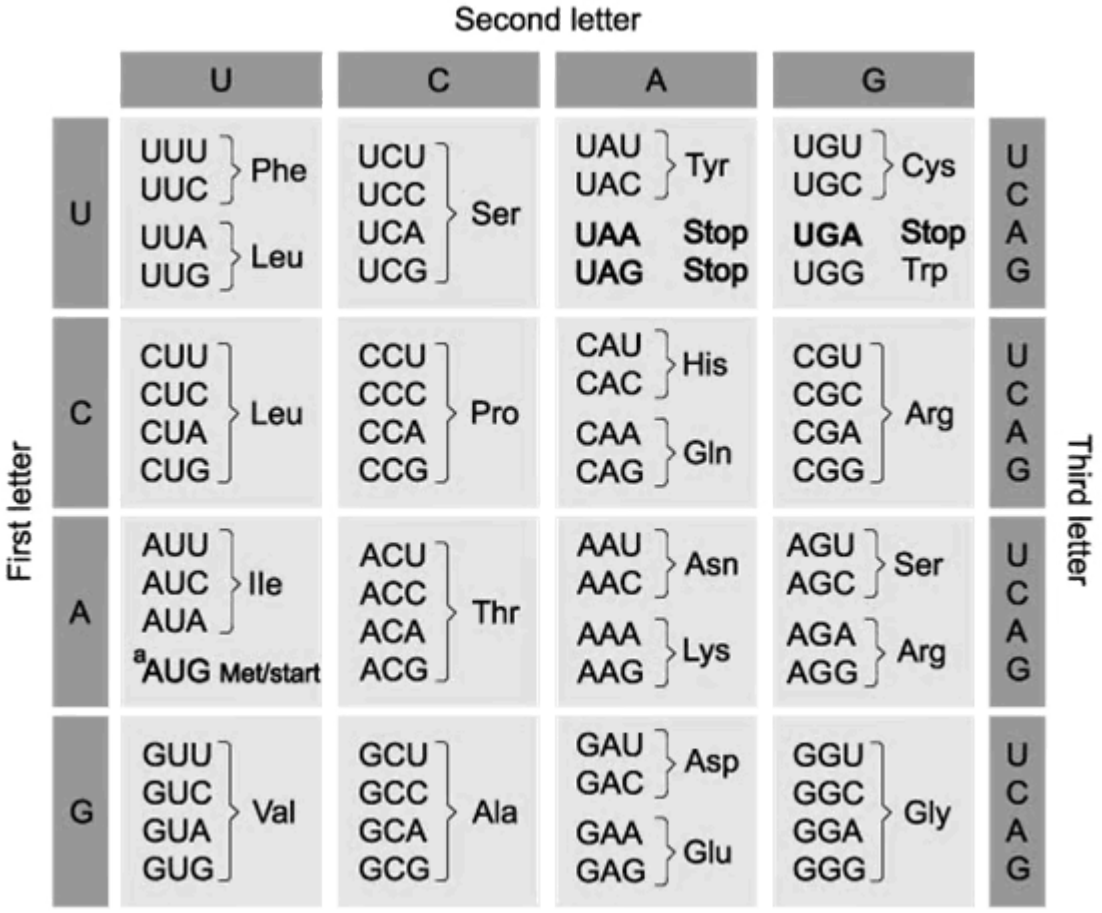
(1 mark)

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



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

(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.

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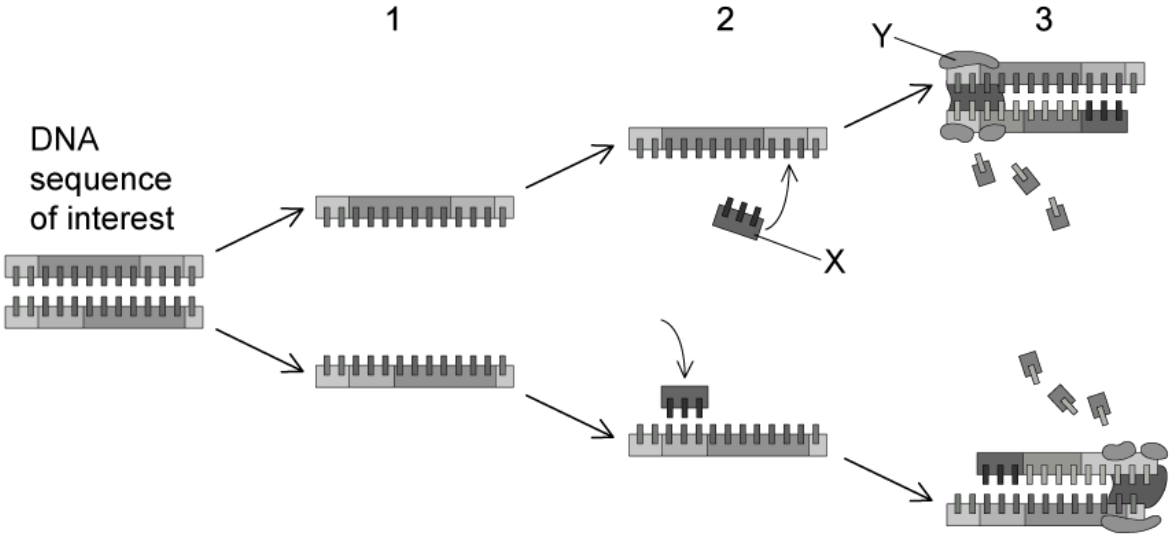
(2 marks)

3 (a) The diagram below shows one cycle of the polymerase chain reaction (PCR).



Outline the events that are taking place during stage 1 in the diagram.

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(3 marks)

(b) Molecule **X** in the diagram shown in part (a) is a DNA primer.

State the role of a DNA primer in PCR.

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(1 mark)

(c) Stage 3 in PCR involves an enzyme.

Explain how the enzyme is suitable for its role in PCR.

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(2 marks)

(d) State **two** applications of PCR.

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(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.

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

Draw an annotated diagram to illustrate the structure of a DNA double helix.

(5 marks)

(b) Outline the advantages of producing insulin in bacteria.

(4 marks)

(c) Describe the process of transcription in eukaryotic cells.

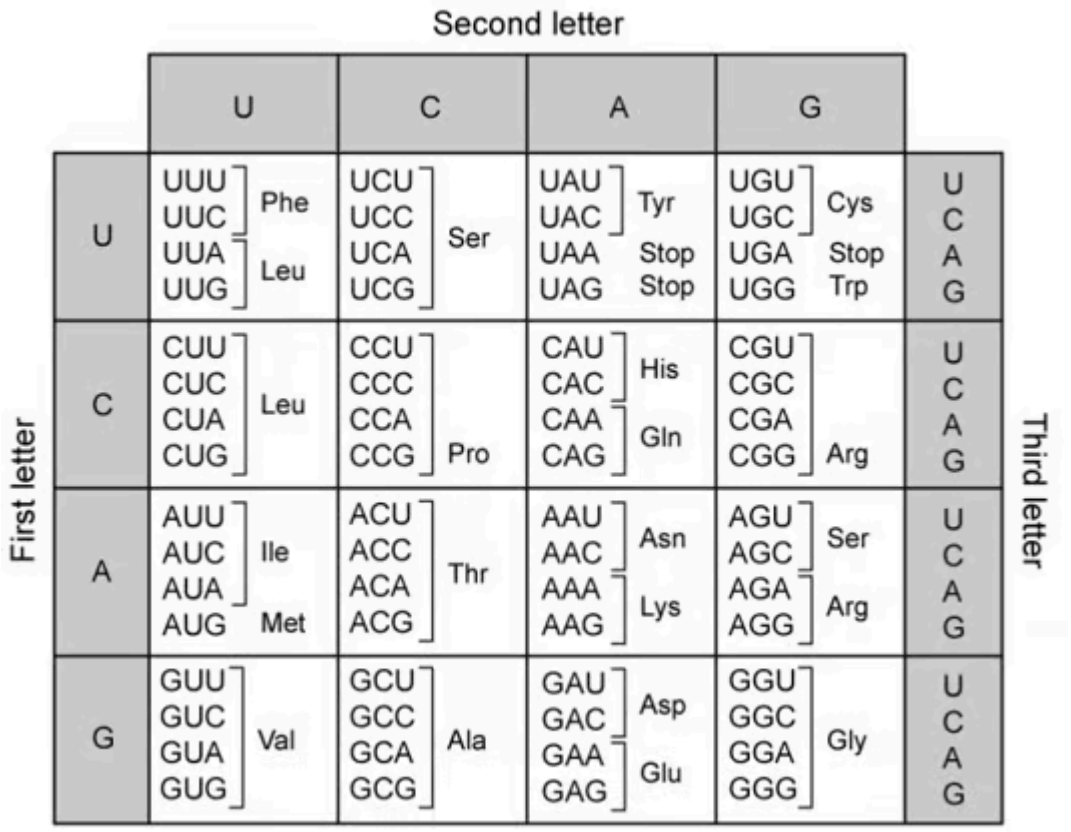
(6 marks)

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 T G

The image shows the genetic code (mRNA codons).



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

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(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 **sense** strand sequence for leucine.

[1]

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

[1]

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(2 marks)

(c) Ricin is a protein produced by castor beans. In animal cells, ricin acts as an enzyme. This enzyme removes the adenine molecule from one of the nucleotides in the RNA that makes up the structure of ribosomes. As a result, the ribosome changes shape. Ricin causes the death of cells and is highly toxic to many animals.

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

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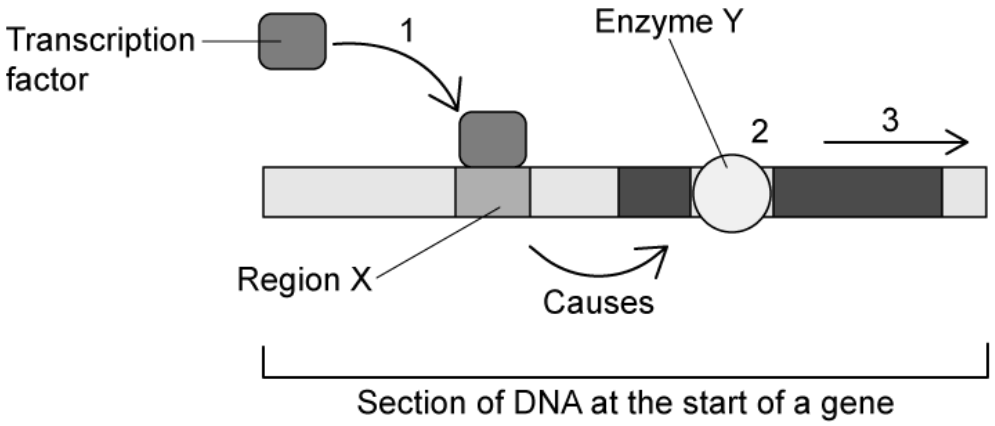
(3 marks)

2 (a) Transcription factors are proteins that influence the process of transcription. One mechanism by which transcription factors affect transcription is illustrated and described below.



1. The transcription factor binds to region **X** at the start of a gene, also known as a promoter region.
2. This causes enzyme **Y** to bind to the DNA.
3. Transcription is initiated and enzyme **Y** moves along the DNA in the direction shown.

(i) Identify enzyme **Y**.

[1]

(ii) State the precise role of enzyme **Y**.

[1]

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(2 marks)

(b) 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.

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(2 marks)

(c) 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).

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(2 marks)

(d) The transcription factor shown in part a) is an example of a type of transcription factor known as an activator. This means that it initiates transcription or increases the rate at which transcription takes place.

Use the illustration in part a) to suggest how a transcription factor might have the opposite effect and function as a repressor.

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(2 marks)

3 (a) Scientists have modified the DNA of maize plants to enable them to resist attack by insects known as stem borers. The scientists transferred a gene from *Bacillus thuringiensis* (Bt), a soil bacterium, into the maize plants. The gene codes for proteins that are highly toxic to the stem borer insects. The toxic proteins bind to the cell-surface membranes of the insects, increasing the passage of ions through the membrane and into the insect cells.

Suggest how the Bt toxin causes the death of insect cells.

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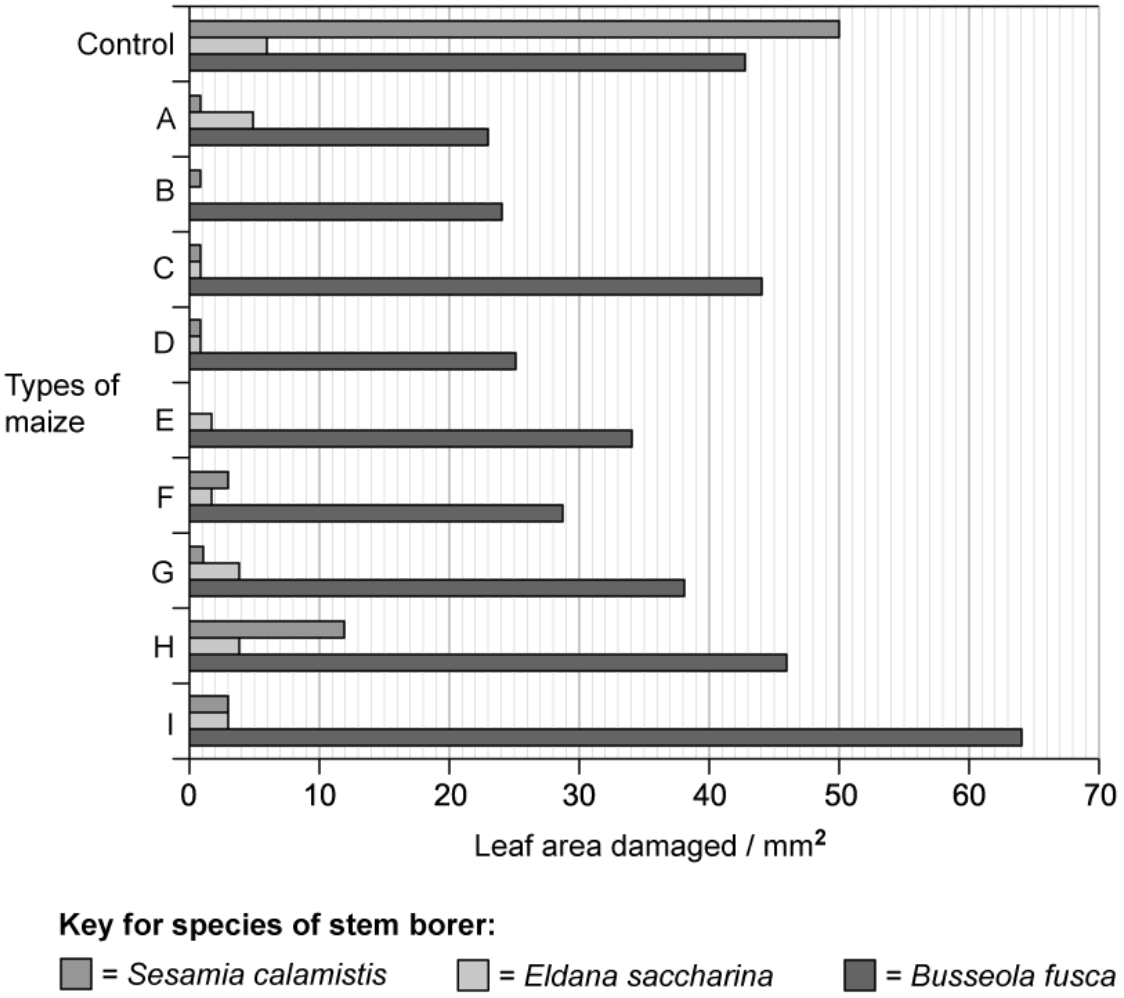
(2 marks)

(b) A study was carried out to investigate which of several Bt toxin gene variants was most effective against three species of stem borer insect. The stem borers were allowed to feed on nine maize varieties (A–I), each modified with a different variant of the Bt toxin gene. The graph below shows the leaf area damaged by the stem borers after feeding on maize leaves for five days.



Calculate the percentage difference in leaf area damaged by *Busseola fusca* between the control and maize type H.

(2 marks)

(c) A farmer read the results of the study in part b) and concluded that they should buy maize variety B to achieve maximum resistance against stem borer damage in their maize crop.

Evaluate the farmer's conclusion.

(3 marks)

(d) Another example of a genetically altered organism is the 'Flavr Savr' tomato. This tomato variety is genetically engineered to ripen and soften more slowly in order to increase its shelf-life.

The new gene is inserted into the tomato DNA alongside the normal gene that causes softening. The inserted gene prevents production of the softening enzyme beta polygalacturonase, which is coded for by the softening gene.

Parts of the base sequences for the mRNA produced during transcription of the softening gene and the inserted gene are shown below.

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

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

(3 marks)

4 (a) Until the development of genetic modification technology to produce human insulin on a large scale, diabetic patients had to use bovine-derived (from cattle) or porcine-derived (from pigs) insulin to help control their blood sugar levels. This insulin is extracted from the pancreas left over from animal slaughter in commercial abattoirs.

Outline **two** drawbacks of using porcine-derived insulin for an insulin-dependent diabetic patient.

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(2 marks)

(b) The ability to produce human insulin by using a genetically modified bacterium demonstrates the universality of the genetic code.

Explain the meaning of the term, 'universality of the genetic code'.

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(2 marks)

(c) The strain of *Escherichia coli* (*E. coli*) used to produce human insulin has to be weakened in some way before it can be used to produce large quantities of insulin in industrial fermenters. This weakening step is only applicable to strains of *E. coli* designed for this process.

Suggest why this weakened strain is required.

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(2 marks)

5 (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)