2.6 Transcription & Translation

Question Paper

Course	DP IB Biology
Section	2. Molecular Biology
Topic	2.6 Transcription & Translation
Difficulty	Hard

Time allowed: 60

Score: /44

Percentage: /100

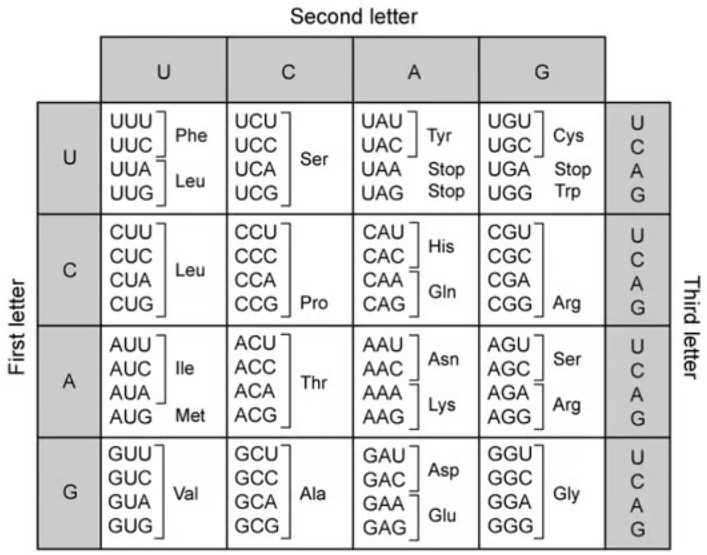
Question 1a

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).



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

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

[1 mark]

[1 mark]

Question 1b

b)

Table 1 below shows some mRNA codons and the amino acids for which they code.

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 mark]

ii)

Identify the amino acid carried by the tRNA with the anticodon CAU.

[1 mark]

[2 marks]

Question 1c

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.

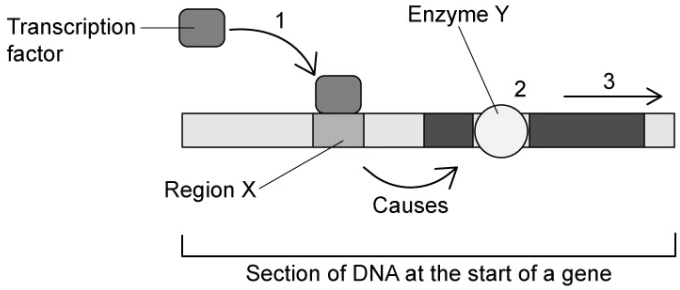
[3 marks]

[3 marks]

Question 2a

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 mark]

ii)

State the precise role of enzyme **Y**.

[1 mark]

[2 marks]

Question 2b

b)

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

ATGGCAACTCTA

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

[2 marks]

[2 marks]

Question 2c

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).

[2 marks]

[2 marks]

Question 2d

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.

[2 marks]

[2 marks]

Question 3a

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.

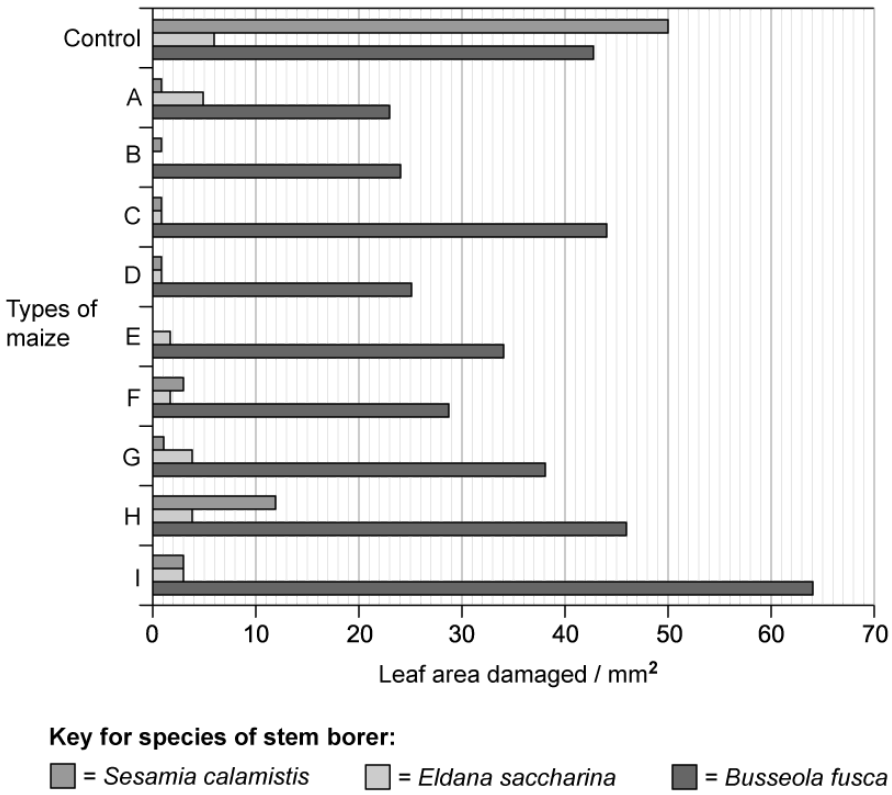
[2 marks]

[2 marks]

Question 3b

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]

[2 marks]

Question 3c

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]

[3 marks]

Question 3d

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]

[3 marks]

Question 4a

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.

[2 marks]

[2 marks]

Question 4b

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'.

[2 marks]

[2 marks]

Question 4c

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.

[2 marks]

[2 marks]

Question 5a

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

a)
Compare and contrast the processes of DNA replication and transcription.

[8 marks]

[8 marks]

Question 5b

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

[6 marks]

[6 marks]