Helicate

HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.4.2 DNA and protein synthesis

Topic question bank

Version 1 · 9 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
7	60	No time limit	/ 60

Contents

Subtopic	Questions	Marks
Genome, proteome and the structure of RNA Specification 3.4.2	01	6
Transcription and splicing Specification 3.4.2	02–04	24
Translation Specification 3.4.2	05–07	30
Total		**60**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA AS and A-level Biology (7401/7402), specification section 3.4.2. Not affiliated with or endorsed by AQA.

Do not write outside the box

Genome, proteome and the structure of RNA 3.4.2

0 1 . 1 Which statement describes the proteome of a cell?
Tick (✓) one box.

[1 mark]

- The number of genes in the cell that code for proteins ☐
- The full range of proteins that the cell is able to produce ☐
- The sequence of amino acids in one polypeptide ☐
- The total mass of protein in the cell ☐

0 1 . 2 Give the meaning of the term **genome**.

[1 mark]

.....

.....

.....

0 1 . 3 Complete the table by putting a tick (✓) in each box where the feature applies to that molecule. You may tick more than one box in each row.

[2 marks]

Feature	DNA	mRNA	tRNA
Contains ribose			
Has hydrogen bonds between complementary bases			
Is double-stranded			
Has an anticodon			

Question 1 continues on the next page

Do not write outside the box

Cells of one species of bacterium cannot break down the antibiotic penicillin. Some of these cells take up a plasmid from a different species of bacterium. The plasmid contains a gene that codes for an enzyme that breaks down penicillin.

0 1 . 4 Explain how taking up this plasmid changes the genome **and** the proteome of a bacterial cell.

[2 marks]

6

Turn over for the next question

Not affiliated with or endorsed by AQA.

Do not write outside the box

Transcription and splicing 3.4.2

0 2 A species of fungus (a eukaryote) and a species of bacterium both make an enzyme that digests cellulose.
Describe how the fungus produces mRNA from the gene for this enzyme. In your answer, explain how the bacterium's production of this mRNA is different.

[6 marks]

6

Turn over for the next question

Not affiliated with or endorsed by AQA.

Do not write outside the box

Scientists studied a gene in mouse cells. Table 1 shows the length of each region of the gene.

Table 1

Region of gene	Length / base pairs
Exon 1	312
Intron 1	1450
Exon 2	186
Intron 2	2210
Exon 3	402

0 3 . 1 The whole of this gene is transcribed to form pre-mRNA.
Calculate the percentage of the nucleotides in this pre-mRNA that are removed when it is spliced to form mRNA.
Give your answer to **one** decimal place.

[2 marks]

Answer _____ **%**

Question 3 continues on the next page

Do not write outside the box

The scientists extracted RNA from the nucleus and from the cytoplasm of these cells. They separated the RNA molecules transcribed from this gene according to their length.

Table 2 shows their results.

Table 2

Part of cell	Lengths of RNA molecules transcribed from the gene / nucleotides
Nucleus	4560, 3110, 2350, 900
Cytoplasm	900

0 3 . 2 Use Table 1 and Table 2 to explain why RNA molecules 4560 nucleotides long were found in the nucleus but only RNA molecules 900 nucleotides long were found in the cytoplasm.

[3 marks]

0 3 . 3 RNA molecules 3110 and 2350 nucleotides long were also found in the nucleus. Use Table 1 to suggest what these molecules were.

[2 marks]

7

Turn over for the next question

Do not write outside the box

Scientists investigated the effect of compound Z on mammalian cells grown in culture. They thought that compound Z might stop RNA polymerase working.

- They added compound Z to one group of cells at time 0. Another group of cells was left untreated.
- They measured the rate of RNA synthesis from the rate at which radioactively labelled uracil was taken into RNA.
- They measured the rate of protein synthesis from the rate at which radioactively labelled amino acids were taken into protein.
- They expressed each rate in the treated cells as a percentage of the rate in the untreated cells at the same time.

0 4 . 1 Explain why the scientists used radioactively labelled uracil, and **not** radioactively labelled thymine, to measure the rate of RNA synthesis.

[2 marks]

0 4 . 2 Suggest why the scientists expressed each rate as a percentage of the rate in the untreated cells.

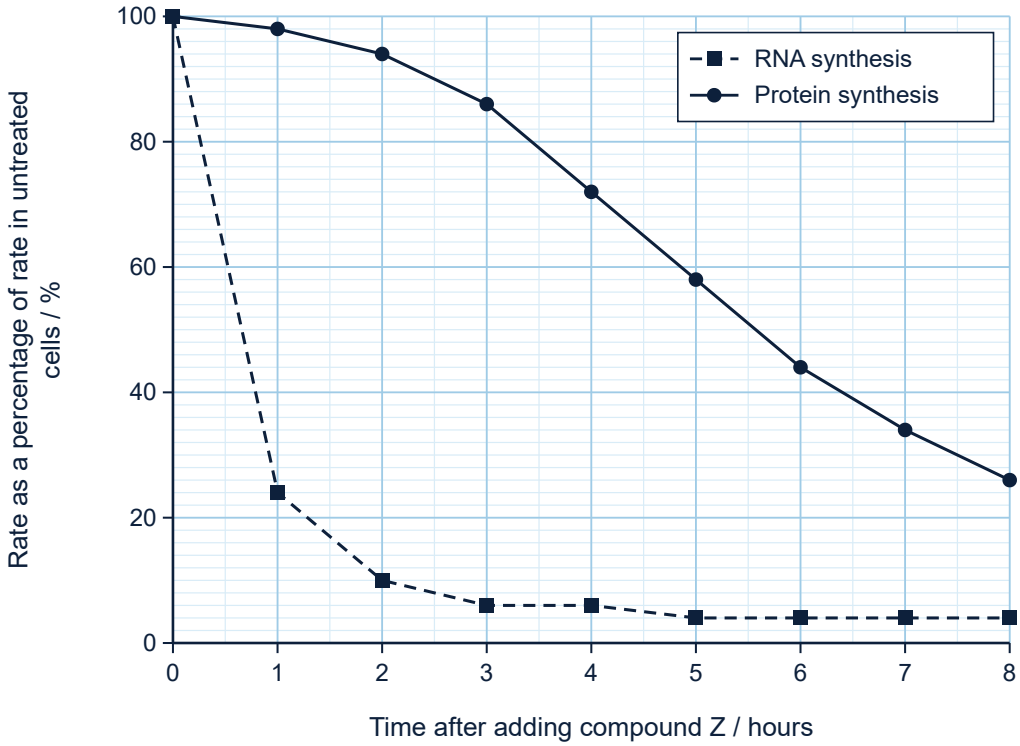
[1 mark]

Question 4 continues on the next page

Do not write outside the box

Figure 1 shows the scientists' results.

Figure 1



0 4 . 3 Use Figure 1 to calculate the percentage decrease in protein synthesis rate between 2 hours and 6 hours.
Use the rate at 2 hours as the starting value.

[2 marks]

Answer ..... **%**

Question 4 continues on the next page

Do not write outside the box

mRNA molecules in these cells are broken down a few hours after they are made.

0 4 . 4 Use this information and Figure 1 to explain why the rate of protein synthesis changed in the way shown after compound Z was added.

[4 marks]

0 4 . 5 A student concluded that compound Z stops RNA polymerase working.
Evaluate this conclusion.

[2 marks]

11

Turn over for the next question

Not affiliated with or endorsed by AQA.

Do not write outside the box

Translation 3.4.2

Scientists made an extract from bacterial cells. The extract contained ribosomes, tRNA molecules and enzymes. The scientists removed all the DNA and most of the ATP from the extract.

They set up four tubes. Each tube contained the extract and a mixture of amino acids labelled with a radioactive isotope. They added other substances, as shown in Table 3. A ribonuclease is an enzyme that hydrolyses RNA.

After 30 minutes at 37 °C, they added acid to each tube. The acid made the polypeptides form a solid but left free amino acids in solution. They collected and washed the solid, then measured its radioactivity.

Table 3

Tube	Added to the tube			Radioactivity of polypeptides / counts per minute
	ATP	mRNA	Ribonuclease	
1	✓	✓	✗	4850
2	✗	✓	✗	310
3	✓	✗	✗	455
4	✓	✓	✓	190

0 5 . 1 Explain why the scientists washed the solid before measuring its radioactivity.

[1 mark]

Question 5 continues on the next page

Do not write outside the box

The background count in the laboratory was 40 counts per minute.

0 5 . 2 Calculate the radioactivity of the polypeptides in tube 2 as a percentage of the radioactivity in tube 1.
Subtract the background count from both values before calculating the percentage.
Give your answer to **one** decimal place.

[2 marks]

Answer ..... **%**

0 5 . 3 Use your knowledge of the role of ATP in translation to explain the result for tube 2.

[2 marks]

0 5 . 4 Explain the result for tube 4.

[2 marks]

Question 5 continues on the next page

Do not write outside the box

0 5 . 5 No mRNA was added to tube 3, but the polypeptides in tube 3 were radioactive. Suggest why.

[1 mark]

8

0 6 . 1 Describe how the structure of a tRNA molecule is related to its role in translation.

[2 marks]

Question 6 continues on the next page

Do not write outside the box

Table 4 shows some mRNA codons and the amino acids they code for.

Table 4

mRNA codon	Amino acid	mRNA codon	Amino acid
ACA	Threonine	GCU	Alanine
AAG	Lysine	GGA	Glycine
CCU	Proline	UGU	Cysteine
CGA	Arginine	UUC	Phenylalanine

Figure 2 shows the base sequence of part of the template strand of a gene.

Figure 2



0 6 . 2 Give the base sequence of the mRNA transcribed from the DNA in Figure 2.
Use Table 4 to give the sequence of amino acids coded for by this mRNA.

[2 marks]

mRNA base sequence .....

.....

Amino acid sequence .....

.....

0 6 . 3 Which anticodon is found on the tRNA that carries glycine to this mRNA?
Tick (✓) one box.

[1 mark]

GGA ☐

CCU ☐

CCT ☐

GGU ☐

Question 6 continues on the next page

Do not write outside the box

Each type of tRNA normally carries one specific amino acid. Scientists took tRNA molecules with the anticodon ACA, each carrying cysteine. They used a chemical treatment to change the cysteine on these tRNA molecules into alanine. The tRNA molecules themselves were not changed.

The scientists added the altered tRNA molecules to a cell-free system containing ribosomes, ATP, the mRNA from Figure 2 and tRNA molecules carrying each of the other amino acids. The only tRNA molecules with the anticodon ACA were the altered ones.

The polypeptide produced had the amino acid sequence: Alanine, Alanine, Glycine, Lysine, Alanine, Phenylalanine.

0 6 . 4 What do these results show about how the position of an amino acid in a polypeptide is determined? Explain your answer.

[2 marks]

0 6 . 5 Explain why it was important that the only tRNA molecules with the anticodon ACA in the cell-free system were the altered ones.

[2 marks]

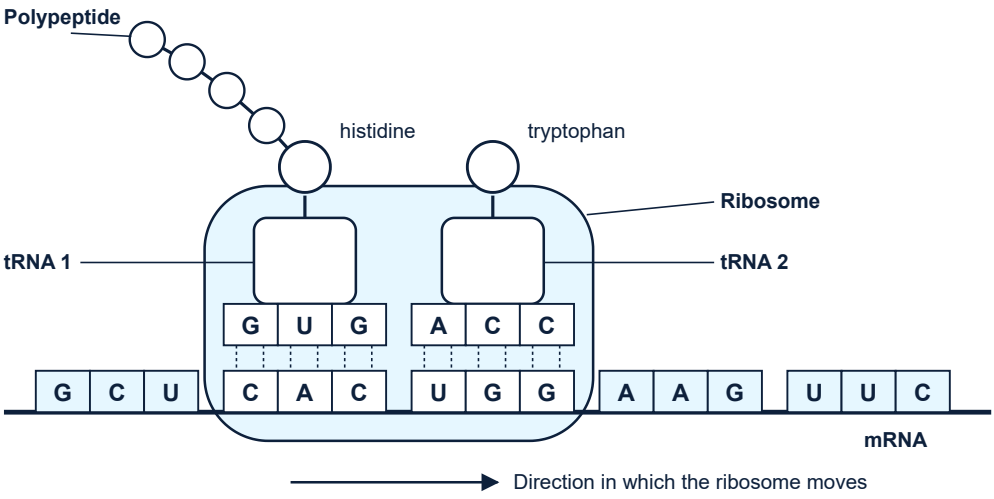
9

Turn over for the next question

Do not write outside the box

Figure 3 shows part of a polypeptide being made at a ribosome.

Figure 3



0 7 . 1 Use Figure 3 to describe how tryptophan becomes part of the polypeptide, and what happens next so that another amino acid can be added.

[5 marks]

Question 7 continues on the next page

Do not write outside the box

Antibiotic Q binds to bacterial ribosomes. It blocks the site on the ribosome where tRNA 2 is shown in Figure 3.

0 7 . 2 Explain how antibiotic Q stops the growth of bacteria.

[3 marks]

Scientists measured the rate of protein synthesis in bacterial cells and in human cells grown with and without antibiotic Q. Table 5 shows their results.

Table 5

Type of cell	Rate of protein synthesis / arbitrary units	
	Without antibiotic Q	With antibiotic Q
Bacterial cells	1.8×10^3	2.7×10^2
Human cells	9.6×10^2	9.4×10^2

0 7 . 3 By what percentage did antibiotic Q lower the rate of protein synthesis in the bacterial cells?

[2 marks]

Answer ..... **%**

Question 7 continues on the next page

Do not write outside the box

0 7 . 4 Use Table 5 and your knowledge of cell structure to suggest why antibiotic Q could be used to treat bacterial infections in humans.

[3 marks]

13

END OF QUESTIONS

Copyright © 2026 Helicate. All rights reserved.