

Protein Synthesis

Mark Scheme



www.scienceexamssorted.co.uk

1. Protein synthesis is the process within cells of converting the DNA within a gene into a functional protein, using mRNA and ribosomes. Circle the letter of the correct answer for each.

a) The genetic code in a DNA molecule is a sequence of bases. What does a sequence of three bases, a triplet or codon, directly code for?

B – is the only correct answer.	1 mark
	Total: 1 mark

b) DNA is found in the nucleus, but proteins are assembled in the cytoplasm. Which molecule is responsible for carrying the genetic code from the nucleus to the ribosome?

C – is the only correct answer.	1 mark
	Total: 1 mark

c) The first stage of protein synthesis involves making a copy of a gene.
What is this process called and where does it occur?

D – is the only correct answer.	1 mark
	Total: 1 mark

d) During the second stage of protein synthesis, the protein chain is assembled.
What is the role of tRNA (transfer RNA) in this process?

C – is the only correct answer.	1 mark
	Total: 1 mark

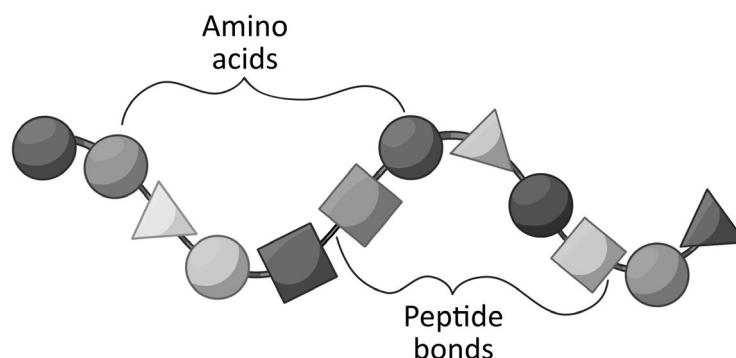
e) RNA is a different type of nucleic acid to DNA. Which of the following is a key difference in the bases found in RNA compared to DNA?

A – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 5 marks)

2. The enzyme lysozyme is found in human tears and saliva.
It consists of a single polypeptide chain made of 130 amino acids.

The figure below shows a section of the polypeptide chain that makes up lysozyme.



- a) Describe the role of mRNA in the production of lysozyme.

A description to include the following three points:	
It is a copy of the gene / DNA base sequence for lysozyme.	1 mark
Allow: template / transcript.	
It moves out of the nucleus (as DNA is too large to leave).	1 mark
It attaches to a ribosome / its sequence of codons is read by the ribosome.	1 mark
	Total: 3 marks

- b) A ribosome can join amino acids together at a rate of 15 amino acids per second.
Calculate the **minimum time** required for a ribosome to synthesise one molecule of lysozyme.
Give your answer to two significant figures.

Correct substitution into formula: $130 \div 15$	1 mark
Allow sight of 8.66... or 8.67 for the first mark.	
Correct answer rounded to two significant figures = 8.7 (s)	1 mark
	Total: 2 marks

- c) The time calculated in part (b) is the time for translation only.
Explain why the total time taken from reading the DNA code to producing a functional lysozyme enzyme is longer than your calculated value.

An explanation that includes any three from:	
Transcription must occur first, which takes time.	1 mark
Allow: the process of making the mRNA takes time.	
The mRNA molecule needs to travel from the nucleus to the ribosome (in the cytoplasm), which takes time.	1 mark
The chain of amino acids must fold into a specific 3D shape / tertiary structure.	1 mark
Allow: it has to form its active site.	
This folding process is what makes the enzyme functional, and it takes time.	1 mark
	Total: 3 marks

(Total for Question 2 is 8 marks)

3. A specific human protein is made from a chain of 50 amino acids.

a) Calculate the minimum number of bases on the mRNA strand needed to code for this protein.

States that 3 bases code for 1 amino acid OR shows the correct calculation: 50×3	1 mark
Correct answer = 150 (bases)	1 mark
	Total: 2 marks

b) Describe how the mRNA code is used to assemble a protein at the ribosome.

A description to include any three from:	
• The ribosome moves along the mRNA strand. • It 'reads' the code in triplets / codons. • tRNA molecules bring specific amino acids to the ribosome. • The anticodon on the tRNA is complementary to the codon on the mRNA. • The amino acids are joined together in the correct sequence.	
	Total: 3 marks

c) A mutation occurs which changes a single base in the DNA sequence that codes for this protein.
Explain how this one change could result in a non-functional protein.

An explanation that links the following points:	
The change in the DNA base sequence changes the triplet / codon on the mRNA.	1 mark
This may cause a different amino acid to be brought (by tRNA) to the ribosome.	1 mark
This changes the amino acid sequence, causing the protein to fold into a different shape, so it no longer works.	1 mark
	Total: 3 marks

(Total for Question 3 is 8 marks)

4. Describe the key events of transcription and translation that occur in a cell to produce a protein from the code in a gene.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Simple, relevant statements are made. The answer identifies one or two key events from either transcription or translation but provides little or no detail or logical sequence. The answer may confuse the two processes.
Level 2	3 - 4	A good description is provided that identifies key stages in both transcription and translation. The answer may lack some detail, or the sequence of events may have some omissions or be less coherent.
Level 3	5 - 6	A detailed and coherent description is provided, which is logically structured and explains the key events of both transcription and translation in the correct sequence. Correct scientific terminology is used throughout.

Indicative content: Transcription (in the nucleus): • The DNA double helix for a specific gene unwinds / unzips. • One of the DNA strands acts as a template. • Free RNA nucleotides pair up with the exposed bases on the DNA template. • The base Uracil (U) pairs with Adenine (A) on the DNA strand. • This forms a molecule of messenger RNA (mRNA). • The mRNA molecule is single-stranded and leaves the nucleus. Translation (at the ribosome): • The mRNA molecule attaches to a ribosome in the cytoplasm. • The ribosome 'reads' the sequence of bases on the mRNA in triplets, called codons. • Transfer RNA (tRNA) molecules, each carrying a specific amino acid, are brought to the ribosome. • The tRNA molecule with the complementary anticodon matches up with the codon on the mRNA. • The ribosome joins the amino acids together in the correct sequence. • This forms a chain of amino acids / a polypeptide, which then folds to form a specific protein.	Total: 6 marks
---	-----------------------

(Total for Question 4 is 6 marks)

5. Ricin is a highly toxic protein found in the seeds of the castor oil plant.
A single molecule of ricin can kill a cell by inactivating its ribosomes.

a) Describe the function of a ribosome in a healthy cell.

A description to include the following two points:	1 mark
It is the site of protein synthesis / translation.	
It joins amino acids together in a specific order (determined by mRNA).	
	Total: 2 marks

b) Using your knowledge of protein synthesis, explain why the inactivation of ribosomes by ricin is lethal to a cell.

An explanation that links the following points in a logical sequence:	
If ribosomes are inactive, translation / protein synthesis stops.	1 mark
The cell cannot make new proteins.	1 mark
This includes essential proteins like enzymes.	1 mark
Without enzymes, metabolic reactions (e.g., respiration) cannot occur, leading to cell death.	1 mark
	Total: 4 marks

c) Ricin itself is a protein. Suggest why heating castor oil seeds to a very high temperature makes them safe to eat, even though the ricin protein is still present.

An explanation that links the following points:	
High temperatures break the bonds holding the protein (ricin) in its specific 3D shape.	1 mark
This denatures the ricin, changing its shape so it can no longer bind to / inactivate ribosomes.	1 mark
	Total: 2 marks

(Total for Question 5 is 8 marks)

6. During protein synthesis, two types of RNA molecule, messenger RNA (mRNA) and transfer RNA (tRNA), work together at the ribosome.

Explain how mRNA and tRNA molecules interact at the ribosome to ensure a protein is assembled with the correct sequence of amino acids.

An explanation that links the following points in a logical sequence:	
mRNA attaches to the ribosome and provides the template / code.	1 mark
The code on the mRNA is read in triplets / codons.	1 mark
tRNA molecules bring specific amino acids to the ribosome.	1 mark
The anticodon on a tRNA molecule is complementary to / pairs with the codon on the mRNA, ensuring the correct amino acid is delivered.	1 mark
	Total: 4 marks

(Total for Question 6 is 4 marks)