

Exemplar exam questions – Chapter 7, Nucleic acids and proteins**Essay questions**

Here are some key points to consider before you begin this type of question.

- Look at the command words in the question. For example, in the question below, ‘Describe’ is asking for you to communicate facts on the subject. ‘Discuss’ requires an account of solubility including the assessment of relative importance of the various factors involved. ‘Explain’ requires an account including the mechanism for the relationship in this case.
- Consider the number of marks allocated for each section of the question and allocate your time accordingly.
- Remember that essays are marked out of 20 – the two marks in addition to the allocation shown in the question are given for presentation and construction of the answers.

Exemplar question

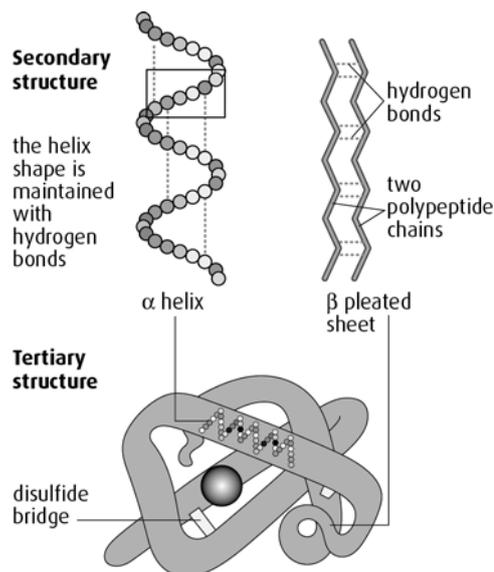
- a Describe the structure of proteins. (9)
- b Discuss the factors affecting the solubility of proteins in water. (4)
- c Explain the relationship between genes and polypeptides. (5)

Student response

- a Proteins are built up of amino acids, which are linked together by peptide bonds to form a long chain known as a polypeptide. This chain forms the primary structure of the protein.



Different amino acids have different side chains and interactions between these can make the primary structure fold into either an alpha helix or a beta-pleated sheet. The secondary structure is held in place by many weak hydrogen bonds. Tertiary structure is formed when the secondary structure is further folded into a three-dimensional arrangement held in place by disulfide bridges. Some proteins have quaternary structure, which occurs when several subunits with tertiary structure are associated together. Hemoglobin has four subunits in its quaternary structure.



- b** Solubility is affected by the polar side groups found in the R groups of amino acids. A protein that has many polar side groups will be more soluble than one that does not. Small proteins are likely to be more soluble than large ones because they are able to fit between water molecules in a solution.
- c** Genes are sequences of DNA that code for proteins. One gene codes for each polypeptide. DNA is transcribed into mRNA and protein is synthesized by ribosomes, which translate the mRNA. Ribosomes and tRNA bring the correct amino acid into position in the polypeptide as they move along the mRNA molecule. mRNA contains sequences that do not code for the polypeptide – these are called introns and are removed before the ribosomes translate the mRNA. Sometimes mutations occur in DNA and these affect the sequence of amino acids and change the protein structure.

Commentary

- a** This is a well-structured answer. It includes nine separate pieces of information about protein structure, which are correct and relevant. The use of diagrams is very important here. A correctly labelled diagram can show clearly what you want to say. The candidate could have mentioned an enzyme as an example of a protein that has tertiary structure and said why the tertiary structure is important.

Marks awarded for:

Primary structure is a sequence of amino acids; which are linked by peptide bonds.

Secondary structure is formed by interactions between amino acids, between amino and carboxyl groups ($-\text{NH}_2$ groups and $-\text{COOH}$ groups).

Hydrogen bonds are formed (these are weak).

Form may become an α helix; or a β pleated sheet.

Tertiary structure is the folding of the polypeptide; disulfide bridges give the structure stability.

Quaternary structure is formed when several polypeptides are joined together.

This answer would be awarded 9 marks.

- b** This response is quite short but there are only 4 marks on this section so the candidate has chosen wisely to spend more time on the other sections. Three points have been made correctly and the candidate has said why they are important and so has ‘discussed’ them.

Marks awarded for any four of the following:

Solubility depends on the R groups present on the amino acids.

Proteins with many polar R groups are more soluble.

Proteins with hydrophilic (polar) side groups on the outside are soluble.

Small proteins are more soluble than large ones.

Globular proteins are more soluble than fibrous proteins.

This answer would be awarded 3 marks.

- c** This section is less well written. The points made are correct but the candidate has confused protein and polypeptide in the first sentence. He or she has also written about the removal of introns after the sentence on translation. It would have been better to keep the sequence correct.

Marks awarded for:

Genes code for polypeptides – one gene codes for one polypeptide.

Genes are transcribed to form mRNA.

mRNA has introns removed before it is translated.

Polypeptides are synthesized by ribosomes, which translate mRNA.

A change in a gene (mutation) can alter the structure of a protein.

This answer would be awarded 4 marks.

Additional marks

All three sections have been answered and the amount the candidate has written is appropriate in each case. Despite the small confusion in the last section, two additional marks would be awarded.

Total marks awarded: 16 out of 18, + 2 additional marks = 18

Multiple choice questions

It is important to take time to read all the options given in this type of question, as they may be quite complex and not immediately obvious.

Exemplar questions

- 1 What would be transcribed from this DNA base sequence?

3' –C–C–G–A–A–T–G–T–C– 5'

A 3' –G–G–C–U–U–A–C–A–G– 5'

B 3' –G–G–C–T–T–A–C–A–G– 5'

C 5' –G–G–C–U–U–A–C–A–G– 3'

D 5' –G–G–C–T–T–A–C–A–G– 3'

Answer is **C**. Transcription produces mRNA from DNA, and RNA does not contain T so answers **B** and **D** can be rejected. The strands of RNA and DNA will be antiparallel so the mRNA strand will begin with 5'.



- 2 The enzyme responsible for separating the DNA double helix during replication is:
- A DNA polymerase I.
 - B DNA polymerase III.
 - C helicase.
 - D ligase.

Answer is C. Helicase unwinds the two strands. DNA polymerase I and III add nucleotides and ligase joins the breaks in Okazaki fragments.

- 3 Which bonds would you find in the primary structure of a protein?
- I peptide bonds
 - II ionic bonds
 - III hydrogen bonds
- A I only
 - B II only
 - C I and II only
 - D I, II and III

Answer is A. Ionic bonds are found in tertiary structure and hydrogen bonds occur in secondary structure.

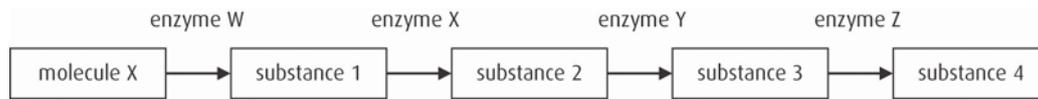
- 4 Which of the following processes involves the removal of introns?
- A binding of ribosomes to mRNA
 - B the reactions catalysed by RNA polymerase
 - C formation of mature mRNA
 - D activation of reverse transcriptase

Answer is C. mRNA formed after transcription in eukaryotes contains coding areas (exons) and non-coding areas (introns). Introns are removed to leave mature mRNA ready for translation.

- 5 Which of these statements about eukaryotic DNA is true?
- A It contains the complementary base pair A–U.
 - B The majority of the molecule comprises repetitive sequences.
 - C It does not contain histone proteins.
 - D The majority of the molecule codes for genes.

Answer is B. Reject A as U is only found in RNA. Reject C as eukaryotic DNA does contain histones. Reject D because much of the DNA molecule does not comprise genes.

- 6 In the enzyme-controlled pathway shown here, which substance is most likely to inhibit enzyme W?



- A substance 1
- B substance 2
- C substance 3
- D substance 4

Answer is **D**. Substance 4 will inhibit enzyme W. This will turn off the entire metabolic pathway and save the most energy for the cell.