IB Biology D1.2 Protein synthesis - Worksheet 02

Complementary base pairing, hydrogen bonding and mRNA synthesis

Name: _____ Class: _____ Date: _____
Time suggested: 50 minutes Total: 40 marks Level: SL core

Instructions: Answer all questions. Show working for sequence questions. Questions marked HL assess higher level content from D1.2. Command terms such as state, outline, explain, deduce and evaluate should guide the depth of your answer.

Section A: Multiple choice [6 marks]

Choose the best answer for each question.

1. During transcription, adenine on the DNA template pairs with which base in RNA?

A. Adenine
B. Thymine
C. Uracil
D. Guanine

2. What type of bond forms temporarily between the DNA template and incoming RNA nucleotides?

A. Peptide bond
B. Hydrogen bond
C. Disulfide bond
D. Glycosidic bond

3. Which feature identifies a nucleic acid molecule as RNA rather than DNA?

A. It contains uracil
B. It contains phosphate groups
C. It contains nitrogenous bases
D. It has a sugar-phosphate backbone

4. Which base pair is correct for transcription from DNA to RNA?

A. DNA C -> RNA G
B. DNA G -> RNA U
C. DNA T -> RNA C
D. DNA A -> RNA T

5. Which statement explains the reliability of transcription?

A. Any RNA base can join to any DNA base
B. The shape and bonding pattern of bases restrict pairing
C. RNA polymerase chooses amino acids directly
D. The mRNA is double-stranded

6. What happens to the mRNA after transcription in a eukaryotic cell?

A. It may leave the nucleus through a nuclear pore
B. It becomes a chromosome
C. It is translated inside the nucleus
D. It permanently binds to the DNA template

Section B: Short answer [12 marks]

1. Deduce the mRNA sequence transcribed from the DNA template strand 3-TAC GGA TTC CAA ACT-5. [3 marks]

2. Explain why RNA contains uracil instead of thymine in a transcribed strand. [2 marks]

3. Outline the role of hydrogen bonding during transcription. [3 marks]

4. A molecule contains ribose and the base uracil. Identify the molecule type and justify your answer. [4 marks]

Section C: Data response / case study [14 marks]

A short DNA template strand is transcribed. Use the sequence and codon reference to answer the questions. DNA template strand: 3-TAC GGA TTC CAA ACT-5.

Useful codons for this worksheet: AUG = methionine/start; UUU/UUC = phenylalanine; UUA/UUG/CUU/CUC/CUA/CUG = leucine; GCU/GCC/GCA/GCG = alanine; GAA/GAG = glutamic acid; GUU/GUC/GUA/GUG = valine; CCU/CCC/CCA/CCG = proline; AAG/AAA = lysine; CGU/CGC/CGA/CGG/AGA/AGG = arginine; UAC/UAU = tyrosine; GGA/GGG/GGU/GGC = glycine; UAA/UAG/UGA = stop.

(a) Write the mRNA sequence produced. [3 marks]

(b) Separate the mRNA into codons. [1 marks]

(c) Deduce the amino acid sequence produced until translation stops. [3 marks]

(d) Explain why UGA does not add an amino acid to the chain. [2 marks]

(e) Predict the effect if the DNA template triplet CAA changed to CAT. [3 marks]

(f) Explain why complementary base pairing contributes to reliable protein synthesis. [2 marks]

Section D: Extended response [8 marks]

Explain how complementary base pairing links the base sequence in DNA to the amino acid sequence in a polypeptide. [8 marks]

Answer key and marking guidance

Use this guidance flexibly. Award credit for scientifically correct answers expressed in different wording. Do not award marks for contradictory statements in the same answer unless the mark point is still clearly demonstrated.

Section A: Multiple choice

1. C - RNA contains uracil, so DNA adenine pairs with RNA uracil.
2. B - Complementary bases are held together by hydrogen bonds during base pairing.
3. A - Uracil is found in RNA; thymine is found in DNA.
4. A - C pairs with G. T pairs with A, and A pairs with U in RNA.
5. B - Specific chemical structures and hydrogen bonding patterns allow only specific base pairs.
6. A - mRNA exits the nucleus and is translated at ribosomes in the cytoplasm.

Section B: Short answer

1. [3 marks] mRNA sequence is 5-AUG CCU AAG GUU UGA-3 (award 1 mark for complementary bases; 1 for replacing T with U in RNA; 1 for correct 5 to 3 orientation or complete sequence).

2. [2 marks] RNA uses uracil as one of its bases (1); therefore adenine on DNA pairs with uracil during RNA synthesis rather than thymine (1).

3. [3 marks] Hydrogen bonds between DNA strands are broken as the gene opens (1); temporary hydrogen bonds form between DNA template bases and complementary RNA nucleotides (1); these bonds help position correct nucleotides before RNA polymerase links them (1).

4. [4 marks] It is RNA (1); RNA contains ribose (1); RNA contains uracil instead of thymine (1); DNA would contain deoxyribose and thymine (1).

Section C: Data response / case study

(a) [3 marks] 5-AUG CCU AAG GUU UGA-3. Award 1 for correct base-pairing rule, 1 for uracil instead of thymine, 1 for correct sequence/orientation.

(b) [1 marks] AUG / CCU / AAG / GUU / UGA.

(c) [3 marks] Methionine - proline - lysine - valine, then stop. Award 1 for Met/start, 1 for Pro/Lys/Val, 1 for recognizing UGA as stop and not an amino acid.

(d) [2 marks] UGA is a stop codon (1); stop codons do not have a complementary tRNA carrying an amino acid/trigger termination (1).

(e) [3 marks] Original CAA transcribes to GUU = valine (1); CAT transcribes to GUA = valine (1); no amino acid change because the genetic code is degenerate/silent mutation (1).

(f) [2 marks] It ensures mRNA is an accurate complementary copy of the DNA template (1); the codon sequence then determines the correct amino acid order during translation (1).

Section D: Extended response

Award up to 8 marks. DNA template base sequence determines mRNA sequence by complementary base pairing (1). A in DNA pairs with U in RNA; C with G; G with C; T with A (1). RNA polymerase positions and links RNA nucleotides (1). mRNA codons are read in groups of three (1). Each codon specifies an amino acid or stop signal (1). tRNA anticodons pair with mRNA codons during translation (1). tRNA brings specific amino acids to the ribosome (1). Amino acids are joined in that order by peptide bonds to form the polypeptide (1).

General extended-response level guidance: 7-8 marks = accurate, detailed, logically sequenced and uses correct terminology throughout; 5-6 marks = mostly accurate with minor omissions; 3-4 marks = some correct ideas but limited links or detail; 1-2 marks = very limited relevant biology; 0 marks = no relevant response.