IB Biology D1.2 Protein synthesis - Worksheet 01

Transcription foundations: DNA templates, genes and RNA polymerase

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. Which statement best defines transcription?

A. The synthesis of DNA using an RNA template
B. The synthesis of RNA using a DNA template
C. The assembly of amino acids at a ribosome
D. The folding of a polypeptide into a functional protein

2. Why is mRNA needed in eukaryotic protein synthesis?

A. DNA is destroyed after every gene is expressed
B. Ribosomes cannot bind amino acids
C. DNA remains in the nucleus while ribosomes are in the cytoplasm
D. mRNA stores proteins inside the nucleus

3. What is the role of RNA polymerase during transcription?

A. It opens the DNA locally and links RNA nucleotides
B. It joins amino acids into a polypeptide
C. It removes introns from mature mRNA
D. It breaks down proteins marked with ubiquitin

4. In transcription, which DNA strand is used to build mRNA?

A. Both strands of the whole chromosome
B. Only the non-template strand
C. Only the template strand of the gene
D. Neither strand because mRNA copies itself

5. A gene is best described as...

A. any protein found in the cytoplasm
B. a sequence of amino acids in a ribosome
C. a specific DNA base sequence at a particular location
D. a chromosome that leaves the nucleus

6. Where does transcription occur in a eukaryotic cell?

A. At free ribosomes only
B. In the nucleus
C. Inside lysosomes
D. On the Golgi apparatus

Section B: Short answer [12 marks]

1. State two differences between DNA and RNA that help identify whether a molecule is DNA or RNA. [2 marks]

2. Outline how RNA polymerase begins transcription at a gene. [3 marks]

3. Explain why only a short region of DNA needs to unzip during transcription. [3 marks]

4. The central dogma describes information flow from DNA to RNA to protein. Explain this statement using transcription and translation. [4 marks]

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

A student investigates the expression of a gene for an enzyme. The gene region opens briefly and an RNA strand is produced. The student records observations from the process below.

Observation	Interpretation requested
Only one DNA strand is copied.	Which strand is used?
RNA polymerase is present at the beginning of the gene.	Which DNA region did it bind?
Free RNA nucleotides are added one at a time.	What determines their order?
The RNA transcript is shorter than the chromosome.	Why is it shorter?

(a) Identify the DNA strand copied during transcription. [1 marks]

(b) Name the DNA region that RNA polymerase must bind before transcription begins. [1 marks]

(c) Explain what determines the order of RNA nucleotides in the transcript. [3 marks]

(d) Explain why the RNA transcript is shorter than the DNA molecule from which it is produced. [3 marks]

(e) Suggest why the DNA base sequence is not changed by being used as a template. [2 marks]

(f) State two reasons why stable DNA templates are important in non-dividing somatic cells such as nerve cells. [4 marks]

Section D: Extended response [8 marks]

Compare transcription with DNA replication, focusing on template use, enzymes, products and purpose. [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. B - Transcription is the production of RNA from a DNA template.
2. C - mRNA carries the coded message from nuclear DNA to cytoplasmic ribosomes.
3. A - RNA polymerase has a helicase-like role and catalyses RNA nucleotide bonding.
4. C - Only one strand of the gene acts as the DNA template.
5. C - A gene is a specific sequence of DNA bases, often coding for a polypeptide or functional RNA.
6. B - The DNA template is in the nucleus, where transcription takes place.

Section B: Short answer

1. [2 marks] Award 1 mark for each valid difference, for example: DNA contains thymine while RNA contains uracil; DNA contains deoxyribose while RNA contains ribose; DNA is usually double-stranded while RNA is usually single-stranded.

2. [3 marks] Promoter near the gene is recognized/bound (1); RNA polymerase binds to the promoter (1); DNA is locally opened/unzipped and RNA nucleotides begin complementary base pairing with the template strand (1).

3. [3 marks] Transcription copies one gene rather than the whole DNA molecule (1); only the gene being expressed must be exposed (1); keeping the rest of the DNA closed helps protect/stabilize the genome or avoids unnecessary transcription (1).

4. [4 marks] DNA base sequence stores the genetic information (1); transcription produces an RNA copy of the gene (1); mRNA travels to ribosomes/cytoplasm (1); translation uses the mRNA codons to assemble amino acids into a polypeptide (1).

Section C: Data response / case study

(a) [1 marks] The template strand/antisense strand.

(b) [1 marks] Promoter/promoter region.

(c) [3 marks] Complementary base pairing with the DNA template (1); A on DNA pairs with U in RNA and C pairs with G (1); RNA polymerase links the correctly paired nucleotides into the growing RNA strand (1).

(d) [3 marks] The chromosome contains many genes/non-coding regions (1); transcription copies only the gene or transcription unit being expressed (1); RNA is a complementary copy of a limited region rather than the entire DNA molecule (1).

(e) [2 marks] The DNA strands are not chemically altered by base pairing (1); hydrogen bonds form temporarily and RNA detaches while the DNA strands rewind (1).

(f) [4 marks] Such cells may last a long time (1); they still need to make proteins throughout life (1); unchanged DNA allows repeated transcription of the same genes (1); mutations could disrupt essential protein production/cell function (1).

Section D: Extended response

Award up to 8 marks. Similarity: both require DNA opening and complementary base pairing (1). Transcription uses RNA polymerase; replication uses DNA polymerase and helicase (1). Transcription copies one gene/one strand; replication copies the whole DNA molecule/both strands (1). Transcription produces single-stranded RNA; replication produces double-stranded DNA (1). RNA uses uracil instead of thymine (1). Transcription supports gene expression/protein synthesis; replication prepares for cell division (1). DNA template sequence remains unchanged in both processes (1). Clear comparison using correct terminology and organized structure (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.