

Introduction to Biology – Monsoon 2022

End Semester Examination

(Course outcomes: CO-2, CO-4 and CO-5)

Max. Time: 3.0 hrs

Max. Marks: 65

1. The following is the DNA sequence for the transcription initiation region of Gene A. *Note: Part of the promoter region is boxed. Transcription begins at and includes the bold and underlined A/T base pair.*

5' ---TGGACTGCTA TAATAGCAGG GCTGCCGAAT GTGCTGCCAT ACGGCCATGG TTCTTAAAGT----3'
3' ---ACCTGACGAT ATTATCGTCC CGACGGCTTA CACGACGGTA TGCCGGTACC AAGAATTTCA----5'

- (A) Which DNA strand (*choose from top or bottom*) serves as the template strand for transcription? Explain. [2 marks]
- (B) Fill in the first 6 nucleotides of the primary/ nascent mRNA transcribed from Gene A. [1 mark]

5' _____ 3'

- (C) Fill in the first four amino acids of Protein A encoded by Gene A. *Note: A codon chart is provided on the last page.* [1 mark]

N _____ C

- (D) The last 5 amino acids (amino acid105- amino acid109) at the C- terminus of wild-type Protein A are indicated below. Each of these amino acids is critical for the proper folding of this protein.

N - pro¹⁰⁵-asn¹⁰⁶-ser¹⁰⁷-met¹⁰⁸-leu¹⁰⁹-C

The DNA sequence encoding the above 5 amino acids is included within the sequence below

Wild-type

5'-AACCGAATTCCATGTTATAGC-3'
3'-TTGGCTTAAGGTACAATATCG-5'

You isolate and sequence the following two different mutant alleles of Gene A that encode the above 5 amino acids. Each mutant allele is due to a point mutation that is bold and underlined. Which of these mutants will ALTER the folding of Protein A

Mutant 1 5' - AACC**AA**ATTCCATGTTATAGC - 3' Mutant 2 5' - AACCG**T**ATTCCATGTTATAGC - 3'
3' - TTGGTTTAAGGTACAATATCG - 5' 3' - TTGGC**A**TAAAGGTACAATATCG - 5'

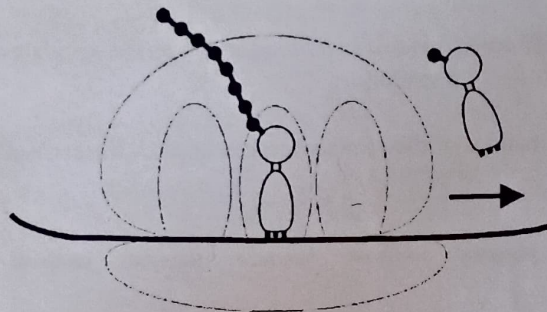
Explain, in terms of the change in the reading frame and/ or amino acid sequence, why you selected this mutant and NOT the other. [3 marks]

2. What is the sequence (1 to 4) in which these proteins function during DNA replication

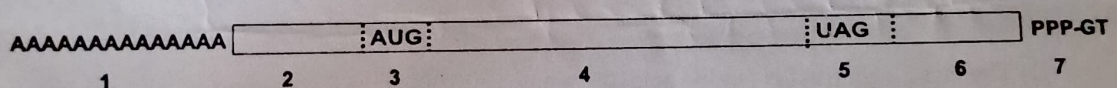
- ____ RNA primase
 ____ DNA ligase
 ____ DNA polymerase
 ____ DNA helicase

Briefly explain their functions. Which enzyme relieves a replicating segment of DNA from super-coiling? [5 marks]

3. In the diagram, label the three tRNA sites, codons and anticodons, peptide and mRNA. List the sequence of events that will occur when the in-coming tRNA sets into its binding site. Redraw the diagram as it will appear immediately after the next peptide bond is formed. [4 marks]



4. The diagram below shows an mRNA molecule with various regions labelled:



(A) There is a problem with above diagram. True or False. Explain your choice [1.5 marks]

(B) Identify by number the region(s) that is/are: [2.5 marks]

- a) coding (i.e. contains codons that are part of the peptide) ____
 b) non-coding ____
 c) 3' end ____
 d) 5' end ____
 e) ribosome binding site ____

5. Draw and explain the (a) pattern of chromosome segregation in mitosis and meiosis and (b) the contrasting regulation of recombination during mitotic and meiotic programs. [4 marks]

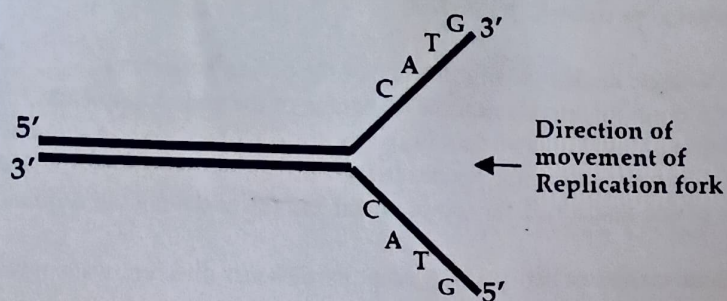
6. Explain the underlying principle of: [4 marks]

- (a) Polymerase chain reaction
 (b) Sanger Sequencing

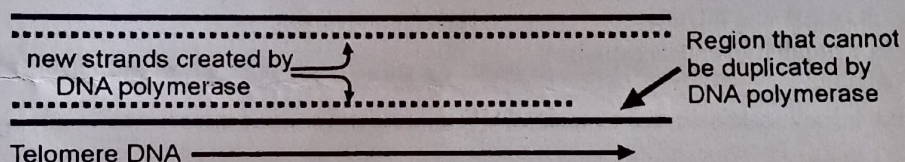
7. In response to hypoxia (lack of oxygen), mammalian cells induce expression of group of genes. How will you identify the transcription factor regulating them? [3 marks]

8. Explain the process of translation initiation [3 marks]

9. Shown below is a segment of replicating DNA



- (A) On the schematic, draw the elongating DNA strands and label their 5' and 3' ends
 (B) To which strand (*choose from top, bottom or both*) can primer 5'CATG3' bind during replication?
 (C) Which strand (*choose from top or bottom*) is the template for discontinuous (lagging) strand synthesis? [3 marks]
10. Explain how telomerase and DNA polymerase operate together to lengthen the chromosomes. Label the 3' and 5' ends of the strands and modify this diagram to show where DNA polymerase and telomerase will lengthen the strands. Also, explain why DNA polymerase alone cannot accomplish the task of telomere DNA synthesis. [3 marks]



11. During protein synthesis, the thermodynamics of base pairing between tRNAs and mRNAs sets the upper limit for the accuracy with which protein molecules are made. True or False. Explain your choice. [3 marks]
12. One indication of the relative importance of various ATP-producing pathways is the V_{\max} of certain enzymes of these pathways. The values of V_{\max} of several enzymes from chest muscles used for flying of pigeon and pheasant are listed below.

Enzyme	V_{\max} ($\mu\text{mol substrate/min/g tissue}$)	
	Pigeon	Pheasant
Hexokinase	3.0	2.3
Glycogen phosphorylase	18.0	120.0
Phosphofructokinase-1	24.0	143.0
Citrate synthase	100.0	15.0
Triacylglycerol lipase	0.07	0.01

- (a) Discuss the relative importance of glycogen metabolism and fat metabolism in generating ATP in the chest muscles of these birds.
 (b) Compare oxygen consumption in the two birds.
 (c) Judging from the data in the table, which bird is the long-distance flyer? Justify your answer. [3 marks]

1. Insertion of a single nucleotide near the end of the coding sequence.
2. Removal of a single nucleotide near the beginning of the coding sequence.
3. Deletion of three consecutive nucleotides in the middle of the coding sequence.
4. Deletion of four consecutive nucleotides in the middle of the coding sequence.
5. Substitution of one nucleotide for another in the middle of the coding sequence.

15. DNA polymerization happens in 5' to 3' direction while proof reading happens in 3' to 5' direction. What will be the consequence(s) if the directions are interchanged? [2 marks]

- ☐ Translation ☐ Transcription ☐ Polyadenylation ☐ Capping
☐ RNA processing ☐ Nuclear export

- A. AUG and UGG
B. AAA and UUU
C. GGA and GGC
D. UAG and UGA

[2 marks]

- 19) What is genomic imprinting? [2 marks]

21. Although oxygen does not participate directly in the citric acid cycle, the cycle operates only when O_2 is present. Why? [2 marks]

GCA	AGA									UUA
GCG	AGG									UUG
GCG	CGA									CUA
GCG	CGC									CUC
GCU	CGG	GAC	AAC	UGC	GAA	CAA	GGA		AUA	CUG
	CGU	GAU	AAU	UGU	GAG	CAG	GGC	CAC	AUC	CUU
							GGU	CAU	AUU	
Ala	Arg	Asp	Asn	Cys	Glu	Gln	Gly	His	Ile	Leu
				AGC						
				AGU						
			CCA	UCA	ACA			GUA		
AAA		UUC	CCC	UCC	ACC			GUC		UAA
AAG	AUG	UUU	CCG	UCG	ACG			GUG		UAG
			CCU	UCU	ACU	UGG	UAU	GUU		UGA
Lys	Met	Phe	Pro	Ser	Thr	Trp	Tyr	Val		stop