2021113009

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 - pro^{105}-asn^{106}-ser^{107}-met^{108}-leu^{109}-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'-AACCAAATTCCATGTTATAGC-3'
3'-TTGGTTTAAGGTACAATATCG-5'
```

Mutant 2

```
5'-AACCGTATTCCATGTTATAGC-3'
3'-TTGGCATAAGGTACAATATCG-5'
```

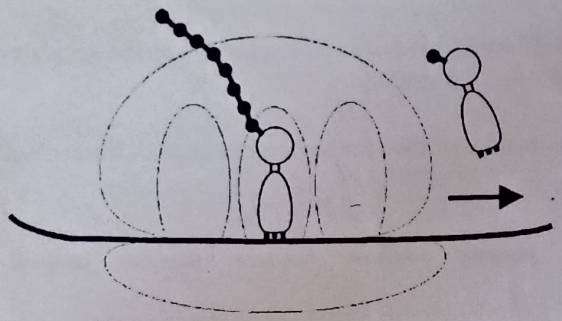
Explain, in terms of the change in the reading frame and/ or amino acid sequence, why you selected this mutant and NOT the other. [3 marks]

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

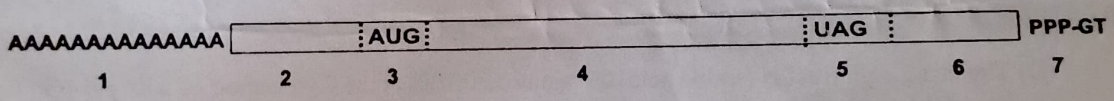
____ RNA primase
____ DNA ligase
____ DNA polymerase
____ DNA helicase

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 ____

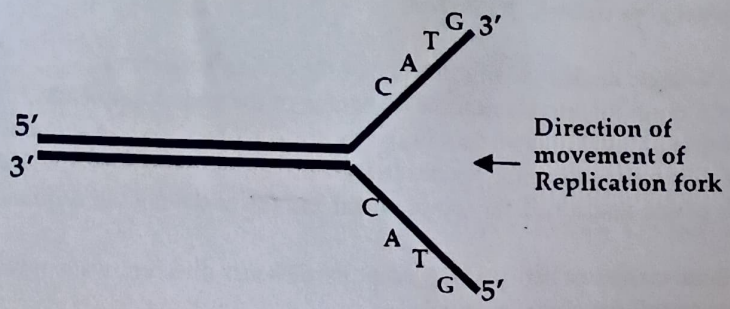
5. Draw and explain the (a) pattern of chromosome segregation in mitosis and meiosis and (b) the contrasting regulation of recombination during mitotic and meiotic programs. [4 marks]

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]

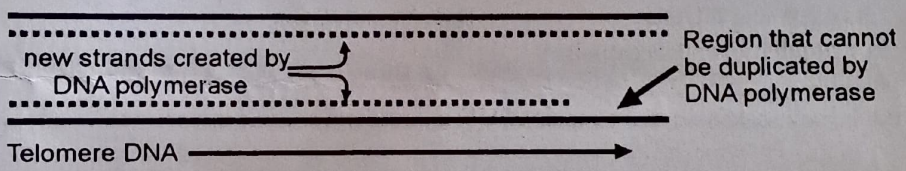
8. Explain the process of translation initiation [3 marks]

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 paring 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} (μmol 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]

13. Which of the following mutational changes would you predict to be the most deleterious to gene function? Explain your answer. Rank them. [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.

14. What are the three classes of cell-surface receptors? Discuss different ways how cells become adapted to an extracellular signal molecule. [2 marks]

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]

16. Place the following events in their correct sequence: [2 marks]

___ Translation ___ Transcription ___ Polyadenylation ___ Capping
___ RNA processing ___ Nuclear export

17. Wobble base pairing' will occur for which one of the following pairs codons?

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

What does wobble hypothesis explains? [2 marks]

18. Explain the basic mechanism for repair of UV induced pyrimidine dimer. [2 marks]

19. What is genomic imprinting? [2 marks]

20. Why does mitochondria need to operate the *Q cycle?* [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]

Codon table

Ala	Arg	Asp	Asn	Cys	Glu	Gln	Gly	His	Ile	Leu
GCA	AGA	GAC	AAC	UGC	GAA	CAA	GGA	CAC	AUA	UUA
GCC	AGG	GAU	AAU	UGU	GAG	CAG	GGC	CAU	AUC	UUG
GCG	CGA						GGG		AUU	CUA
GCU	CGC						GGU			CUC
	CGG									CUG
	CGU									CUU

Lys	Met	Phe	Pro	Ser	Thr	Trp	Tyr	Val	stop
AAA	AUG	UUC	CCA	AGC	ACA	UGG	UAC	GUA	UAA
AAG		UUU	CCC	AGU	ACC		UAU	GUC	UAG
			CCG	UCA	ACG			GUG	UGA
			CCU	UCC	ACU			GUU	
				UCG					
				UCU					