MOLECULAR BIOLOGY
(BIOT 2203)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The 30 S subunit of RNA can bind to Shine-Dalgarno sequence because:
(a) The 16 S rRNA contains the anti-SD sequence
(b) The 18 S rRNA contains the anti-SD sequence Reconstruction
(c) Complementary sequence is present in the small subunit
(d) All of these

(ii) The ρ protein in *E. coli* is responsible for termination because of the following property:
(a) ATPase activity (b) Helicase activity
(c) ATP-dependent helicase activity (d) ATP-independent helicase activity

(iii) The -35 box in *E. coli* is responsible for:
(a) Melting of DNA strand (b) Recognition by RNA polymerase
(c) Recognition and binding of σ factor (d) All of these

(iv) Wobble position is the
(a) 3rd nucleotide of a codon (b) 1st nucleotide of anticodon
(c) 1st nucleotide of codon (d) 3rd nucleotide of anticodon

(v) Which of the following is not required for transcription in vivo?
(a) rNTP (b) dNTP (c) a polymerase (d) DNA template

(vi) If a 1000 kb fragment of DNA has 10 evenly spaced and symmetric replication origins and DNA polymerase moves at 1kb per minute, how many minutes will it take to produce two daughter molecules ignoring the potential problem at the end of the linear piece of DNA? Assume that the 10 origins are evenly spaced from each other, none starting from the end of the chromosome.
(a) 100 (b) 30 (c) 20 (d) 50

(vii) We want to run a centrifugation of a sample with 10,000g in a centrifuge with fixed angle rotor of radius 8.0cm. Calculate the speed of centrifugation in r.p.m.
(a) 15000 (b) 51000 (c) 10050 (d) 10500

(viii) Which one of the following is not important for regulation of the tryptophan operon by attenuation?
(a) Coupled transcription-translation
(b) Presence of two adjacent codons for tryptophan in the leader peptide
(c) Concentration of tRNA charged with tryptophan
(d) The operator sequence of tryptophan operon.

(ix) What is the difference between a structural gene and a regulator gene?
(a) Structural genes are transcribed into mRNA but regulator genes are not
(b) Structural genes encode proteins that function in the structure of the cell; regulator genes carry out metabolic reactions
(c) Structural genes have complex structures; regulator genes have simple Structures
(d) Structural genes encode proteins; regulator genes control the transcription of structural genes.

(x) In eukaryotic replication, helicase loading occurs at all origins during
(a) G2 phase (b) G0 phase (c) G1 phase (d) S phase

Fill in the blanks with the correct word

(xi) A few cycles of _____ initiation happens during prokaryotic transcription initiation.

(xii) The antibiotic _____ blocks the exit channel of growing RNA chain.

(xiii) The 5' end of a mature eukaryotic mRNA contains _____ cap.

(xiv) The Okazaki fragment occurs in _____ strand.

(xv) Chromosomes would be shortened with each new generation, in _____ of telomerase in eukaryotic cell.

Group - B

2. (a) After discovery of *E.coli* DNA Pol-I, explain how scientist predicted that there may be other DNA polymerase enzyme present for DNA replication in E.coli? How that prediction was confirmed through and experiment, explain with labelled diagram. *[(CO1)(Explain/IOCQ)]*

(b) What are the protein involves in eukaryotic replisome? Describe their function with a labelled diagram. *[(CO1)(Understand/LOCQ)]*

(c) One species of tree has a very large genome consisting of 2.0×10^{10} base pairs of DNA. (i) If this DNA was organized into a single linear molecule, how long (meters) would this molecule be? (ii) If the DNA is evenly distributed among 10 chromosomes and each chromosome has one origin of DNA replication, how long would it take to complete the S phase of the cell cycle, assuming that DNA polymerase can synthesize 2×10^4 bp of DNA per minute? (iii) An actively growing cell can complete the S phase of the cell cycle in approximately 300 minutes. Assuming that the origins of replication are evenly distributed, how many origins of replication are present on each chromosome? (iv) What is the average number of base pairs between adjacent origins of replication?
[(CO1)(Apply/HOCQ)]

(2 + 2) + (1 + 3) + 4 = 12

3. (a) Describe the mechanism of recombination by Holiday junction model, stepwise with labelled diagram. *[(CO2) (Understand/LOCQ)]*

(b) Write names of different types of DNA repair system present in *E.coli*. Explain the significance and steps of SOS repair system in *E.coli* with labelled diagram. *[(CO2)(Explain/IOCQ)]*

(c) A circular molecule of DNA contains 1 million base pairs. (i) If the rate of DNA synthesis at a replication fork is 100,000 nucleotides per minute, how much time will theta replication require to completely replicate the molecule? (ii) How long will replication of this circular chromosome take by rolling-circle replication? Ignore replication of the displaced strand in rolling-circle replication. *[(CO1)(Apply/HOCQ)]*

4 + 6 + 2 = 12

Group - C

4. (a) A segment of DNA in *E. coli* has the following sequence of nucleotide pairs:

+1

5'-TATAATGACGTT**A**CCCGACATAGC-3'

3'-ATATTACTGCAATGGGCTGTATCG-5'

When this segment is transcribed by RNA polymerase, what will be the sequence of the mRNA? *[(CO3)(Understand/IOCQ)]*

(b) Analyse your answer by mentioning the following:

(i) Location of promoter sequence

(ii) Transcription initiation sequence

(iii) Identify the sense and template strand

(iv) Role of non-template strand. *[(CO3)(Analyse/IOCQ)]*

(b) Explain the mechanism of transcription initiation in *E. coli.* *[(CO3)(Remember/LOCQ)]*

2 + (1.5 × 4) + 4 = 12

5. (a) Discuss the assembly of transcription initiation complex in eukaryotic organism. *[(CO3)(Understand/LOCQ)]*

(b) Discuss the molecular mechanism of RNA editing by Base substitution. *[(CO4)(Explain/IOCQ)]*

(c) Name the role of any two transcriptional inhibitor common to both pro and eukaryote. Mention their molecular mechanism of action. *[(CO3)(Apply/HOCQ)]*

4 + 4 + (2 + 2) = 12

Group - D

6. (a) Which of the following nuclear pre-mRNA nucleotide sequences potentially contains an intron? Explain your answer giving the molecular mechanism of intron splicing.

(i) 5'-UGACCAUGGCGUAACACUGCCUUGGCAAACUUGAAUCAGCCAAA-3'

(ii) 5'-GUUUGUCACUGAGGUCACUAUCGUAACCUGUAAUGCAAGCACA-3'

[(CO3)(Analyse/HOCQ)]

(b) How the 5'-end of the growing RNA chain is protected? Discuss the molecular mechanism by mentioning the different catalytic functions present in it. *[(CO2)(Apply/IOCQ)]*

6 + 6 = 12

7. (a) A partial (5' subterminal) nucleotide sequence of a prokaryotic mRNA is as follows:
5'-AGGAGGCUCGAACAUGUCAAUAUGCUUGUUCCAAUCGUUAGCUGCGCAA…-3'
(i) Locate the ORF.
(ii) Identify the ribosome binding site.
(iii) How many amino acid are coded by this region and why? Explain your logic. *[(CO5)(Analyse/HOCQ)]*

(b) Explain the role of 30S subunit in translation initiation. *[(CO4)(Remember/LOCQ)]*

(c) What is the role of start codon in an ORF? *[(CO5)(Apply/IOCQ)]*

6 + 4 + 2 = 12

Group - E

8. (a) What is epigenetics? Write the names of different processes for epigenetic gene regulation. Explain the mechanism of transcriptional gene silencing by methylation of DNA with labelled Diagram. *[(CO6) (Remember/LOCQ)]*

(b) Write the names of two types of small RNA which regulates gene expression. Explain molecular mechanism of gene regulation by anyone small RNA that you have mentioned. *[(CO6)(Explain/IOCQ)]*

(c) Molecular weight of a prokaryotic double stranded DNA molecule is 6.0×10^6 bp. If a polypeptide chain contains 1,000 amino acid residues, calculate the number of such polypeptide chains that can be synthesised from the above DNA. [(CO6)(Analysis/HOCQ)]

(1 + 2 + 3) + (1 + 3) + 2 = 12

9. (a) Explain the mechanism of eukaryotic gene regulation by eukaryotic gene non-steroid hormone with a labelled diagram. *[(CO6)(Explain/IOCQ)]*

(b) Explain how does antisense RNA control gene expression in eukaryote? *[(CO6)(Explain/IOCQ)]*

(c) (i) Explain the experimental techniques used to find out the DNA binding sequence of a repressor molecule with a labelled diagram. (ii) The dissociation constant for a particular repressor-operator complex is very low, about 10^{-13} M. An *E. coli* cell (volume 2×10^{-12} ml) contains 10 copies of the repressor. Calculate the cellular concentration of the repressor protein. How does this value compare with the dissociation constant of the repressor operator complex? What is the significance of this result. *[(CO6)(Explain-Apply/HOCQ)]*

3 + 3 + (4 + 2) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	27	41.67	31.25

Course Outcomes (CO):

After completion of this course, the students will be able to:
CO1. Identify and analyze the different components and mechanism of replication.
CO2. Describe different types of DNA damage and repair systems and recombination process.
CO3. Comment on various components and detailed process of transcription.
CO4. Comment on various components and mechanism of translation.
CO5. Understand the rational of genetic code.
CO6. Comprehend on models of gene regulation and apply the knowledge of gene regulation as genetic switch.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*