

MOLECULAR BIOLOGY
(BTC2203)

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 2020 Nobel prize in Chemistry was awarded to Jennifer Doudna and Emmanuel Charpentier for their work on developing CRISPR-Cas system for gene editing. This system is naturally:
 - (a) An anti-viral defense mechanism found in plants
 - (b) An anti-viral defense mechanism found in bacteria
 - (c) An anti-bacterial defense mechanism found in plants
 - (d) An anti-bacterial defense mechanism found in simple eukaryotes such as fungi.
- (ii) Biologist Lynn Margulis is a proponent of the theory of endosymbiosis, which suggests that the mitochondria of modern eukaryotic cells evolved from bacteria living symbiotically within early eukaryotic cells. Which of the following is supporting evidence for this theory?
 - (a) Mitochondria require the internal environment of the eukaryotic cell to replicate.
 - (b) Mitochondrial rRNA is more similar to bacterial rRNA than to eukaryotic rRNA transcribed from nuclear DNA.
 - (c) Mitochondria are morphologically indistinguishable from free-living bacteria.
 - (d) Mitochondria that are removed from eukaryotic cells and placed in a growth medium can generate fully functioning free-living cells.
- (iii) During DNA replication, Okazaki fragments are used to elongate
 - (a) The leading strand towards replication fork
 - (b) The lagging strand towards replication fork
 - (c) The leading strand away from replication fork
 - (d) The lagging strand away from the replication fork.
- (iv) Function of eukaryotic RNA polymerase II is to synthesize
 - (a) rRNA
 - (b) mRNA
 - (c) tRNA and 5S rRNA
 - (d) 5S rRNA

- (v) Prokaryotic core promoter contains conserved sequences at around
 (a) +1, -10 and -35 region (b) +1, -10, -35 and -80 region
 (c) -10, -35 and -80 region (d) -10 and -35 region
- (vi) 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
- (vii) The peptidyl transferase activity lies in the
 (a) 30S subunit (b) 50S subunit
 (c) 40S subunit (d) All of these
- (viii) While culturing a eukaryotic cell line, you add radio-labelled methionine in the culture media. After addition, you are able to cleanly separate individual organelles at different times. In which organelle would you detect radioactivity first?
 (a) Rough Endoplasmic Reticulum (b) Lysosome
 (c) Mitochondria (d) Nucleus.
- (ix) In the trp operon, Attenuation _____.
 (a) Enhances transcription
 (b) Terminates translation
 (c) Reduces mRNA stability
 (d) Prevents the completion of transcription.
- (x) The expression of a gene is regulated by a transcription factor. Which of the following techniques can be used to identify the region in its promoter where the transcription factor binds?
 (a) SDS-PAGE. (b) Agarose gel electrophoresis.
 (c) Electrophoretic mobility shift assay. (d) DNase I footprinting.

Fill in the blanks with the correct word

- (xi) Unidirectional replication of a circular DNA molecule like a plasmid that involves nicking one DNA strand and displacing it while synthesizing a new strand is called _____.
- (xii) The enzyme used in light dependent repair to split thymine dimers is called _____.
- (xiii) The 5' end of a mature eukaryotic mRNA contains _____ cap.
- (xiv) Eukaryotic transcription by RNA pol II is blocked by _____ antibiotics.
- (xv) A few cycles of abortive initiation happen in prokaryotes until _____ factor remains associated with RNA polymerase

Group - B

2. (a) Describe the mechanism of recombination by Holiday junction model, stepwise with labelled diagram. [[CO3](Analyse/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. [[CO4](Remember/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.

[[C01](Apply/HOCQ)]

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

3. (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.

[[C01](Explain/IOCQ)]

- (b) What are the protein involves in eukaryotic replisome? Describe their function with a labelled diagram.

[[C01](Remember/LOCQ)]

- (c) One species of tree has a very large genome consisting of 2.0×10^9 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?

[[C01](Apply/HOCQ)]

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

Group - C

4. (a) If the non-template strand of a gene in *E.coli* had the following sequence: 5' TTGACA—(18 bases)—TATAAT—(8 bases)—GCCTTCCAGTG 3'; then, What nucleotide sequence would be present in the RNA transcript of this gene? Explain.

[[C03](Analyze/IOCQ)]

- (b) Why this above DNA strand is called so?

[[C03](Analyze/LOCQ)]

- (c) If this non-template strand shown above were part of a gene in *Drosophila* rather than in *E.coli*, would the same transcript be produced? If not, then explain why.

- (d) Discuss the assembly of Transcription initiation complex in *Drosophila* with a diagram.

[[C03](Understand/HOCQ)]

$$2 + 2 + 3 + 5 = 12$$

5. (a) Explain the mechanism of transcription initiation in *E. coli*. [[C03](Remember/LOCQ)]

- (b) What is the significance of CTD of the largest subunit of RNA pol II in the transition of the enzyme from the initiation to elongation phase? [[C03](Understand/IOCQ)]

- (c) Mention the functions of the following enzymes in capping enzyme complex: RNA terminal phosphatase, Guanylyl transferase.

[[C03](Explain/HOCQ)]

$$5 + 3 + 4 = 12$$

Group - D

6. (a) Write the detailed molecular mechanism for prokaryotic translation initiation mentioning the role of the following: IF1, IF2 and IF3. [[CO4](Understand/IOCQ)]
- (b) Mention any three characteristic of genetic code. [[CO4](Remember/LOCQ)]
- (c) What the role of start codon in an ORF? [[CO4](Analyze/HOCQ)]
- 6 + 4 + 2 = 12**
7. (a) Refer to the following nuclear pre-mRNA nucleotide sequence:
5'-UGACCAUGGCGUAACACUGCCUUGGCAAACUUGAAUCAGCCAAA-3'
- (i) Does this contain an intron? Mark it in the above sequence.
- (ii) Does the intron remain in the mature mRNA or removed? How? Discuss the molecular mechanism. [[CO4](Apply/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 CEC. [[CO4](Apply/IOCQ)]
- (2 + 2 + 4) + 4 = 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-explain/IOCQ)]
- (b) Write the names of two types of small RNA which regulates gene expression, explain molecular mechanism of gene regulation by any one small RNA that you have mentioned. With a labelled diagram [[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](Apply/HOCQ)]
- (1 + 2 + 3) + (1 + 3) + 2 = 12**
9. (a) Which experimental techniques will be used to find out the operator DNA binding protein molecule in a prokaryotic organism? Describe that technique you have mentioned with a labelled diagram. [[CO6](Remember, Explain/IOCQ)]
- (b) Write the names of different DNA-binding domain (DBD) structural motif present in the proteins that are involved in the regulation of eukaryotic gene expression. Describe each of them with example and labelled diagram. [[CO6](Remember/LOCQ)]
- (c) A messenger RNA is 636 nucleotide long, including the initiator and termination codons. Calculate the number of amino acids in the protein translated from this mRNA with justification. [[CO6](Apply/IOCQ)]
- (1 + 3) + (1 + 4) + 3 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	25	42.7	32.3