

Ex/SC/BT/PG/332T/2025

M. Sc. BIOTECHNOLOGY EXAMINATION, 2025

(2nd Year, 1st Semester)

BIOTECHNOLOGY

PAPER : SC/BT/PG/332T

(Genomics and Proteomics)

Time : 2 Hours

Full Marks : 40

GROUP—A

Answer question **1** and *any two* questions from each Part :

1. Answer *any six* questions : 1×6=6

- (i) Present a logical argument that suggests that the mechanism of determination of sex in human is different from that in *Drosophila*.
- (ii) State “One gene-One Enzyme” hypothesis. Also, state whether this hypothesis is still valid today. If not, how would you modify it?
- (iii) What do you mean by Tiled Microarray technique? What is the benefit of this technique over the conventional microarray?
- (iv) Explain how the use of “barcode” helps in multiplexing during the library preparation for RNA sequencing.
- (v) Distinguish between intragenic and extragenic suppressors with examples of each of them.

BIOTECH-**1012**

[Turn Over]

(2)

- (vi) Differentiate between biological replicates and technical replicates with examples.
- (vii) What is the function of 'TOPHAT' Pipeline in the context of RNA-Seq data analysis?
- (viii) Explain why single cell transcriptomics has become more informative than conventional transcriptomics.
- (ix) Using necessary diagram explain what is 'Bridge Amplification'.
- (x) Explain how 'Hierarchical Clustering' plays a pivotal role in the analysis of microarray or RNA-Seq Data.
[CO1]

PART—I

Answer *any two* questions :

2. (a) In *Drosophila*, the gene for bobbed bristles (recessive allele bb , bobbed bristles; wild type alleles bb^+ normal bristles) is located on the X chromosome and on a homologous segment on the Y chromosome. Give the genotypes and phenotypes of the offspring from the following crosses :

- (i) $X^{bb} X^{bb} \times X^{bb} Y^{bb+}$
- (ii) $X^{bb} X^{bb} \times X^{bb+} Y^{bb}$
- (iii) $X^{bb+} X^{bb} \times X^{bb+} Y^{bb}$
- (iv) $X^{bb+} X^{bb} \times X^{bb} Y^{bb+}$

2

(9)

15. (a) Write the similarities and dissimilarities between atmospheric pressure chemical ionization and atmospheric pressure photo ionization methods in mass spectrometry.
3 [CO1]
- (b) Tryptic digest of a heptapeptide (composed of 3 lysine, 2 alanine, 1 tyrosine and 1 phenylalanine) yielded tri and tetrapeptide. Based on the above information write down the probable sequence of the heptapeptide.
2 [CO2, CO3]
16. (a) How does quadrupole analyze the mass of a peptide in a mass spectrometry?
2 [CO1]
- (b) What are molecular ions, fragment ions and base peak in mass spectrometric analysis?
3 [CO1]
17. (a) What is surface-enhanced laser desorption ionization (SELDI)?
2 [CO1, CO2]
- (b) What are the basic components required for a mass spectrometry?
3 [CO1]
18. (a) What are the soft and hard ionizations? Give one example of each.
2 [CO2]
- (b) Explain briefly the basis of MALDI-TOF for the analysis of proteins.
3 [CO2]

★ ★ ★

(8)

- 12.** (a) Briefly explain why a combination of perfectly matched and a mismatched oligonucleotide is used to design a probe set in the microarray experiment. 1
- (b) Briefly outline the pipeline involved in RNA Sequencing technology. You may present a workflow diagram of RNA sequencing technique with a brief description of individual steps within small boxes without long description. 3
- [CO2, CO3]**

- 13.** Write short notes on *any two* from the following : 2×2=4
- (a) ChIP Sequencing
 - (b) Spatial Transcriptomics
 - (c) Index Sequence
 - (d) Single End (SE) vs. Paired End (PE) RNA-Seq
- [CO1, CO2, CO3]**

GROUP—B

Answer *any* **two** questions, each question carry **5** marks :

- 14.** (a) What is the function of electron multiplier in mass spectrometry? 2 [CO1]
- (b) The following disulphide bond containing peptide was digested using trypsin. Write down the peptide fragments that will be produced by the digestion. 3 [CO3]

MTPQKAVILNSCTYRPYPM

NQGCLKVCVNPCGRLTDEH

BIOTECH-1012

[Continued]

(3)

- (b) In *Drosophila*, the allele for white eyes is sex-linked and recessive to the wild-type allele, red eyes. When white-eyed males were crossed with red-eyed females, the F1 progeny consisted of 433 red-eyed females and 420 red-eyed males. The F2 progeny showed the following results :

Red-eyed males 105

Red-eyed females 204

White-eyed males 96

White-eyed females 0

Do these data fit for the appropriate genetic hypothesis?

2
[CO2, CO3]

3. In sweet peas, the synthesis of purple anthocyanin pigment in the petals is controlled by two genes, *B* and *D*. The pathway is given below :

White Intermediate $\xrightarrow[\text{Enzyme } B]{\text{Gene } B}$ Blue Intermediate $\xrightarrow[\text{Enzyme } D]{\text{Gene } D}$ Anthocyanin (Purple)

- What colour petals would you expect in a pure breeding plant unable to catalyze the first reaction?
- What colour petals would you expect in a pure breeding plant unable to catalyze the second reaction?
- If the plants in the question (a) and (b) are crossed, what petals will be observed in the F_1 plants?
- What ratio of purple : blue : white plants would you expect in the F_2 plants?

[C02, C03]

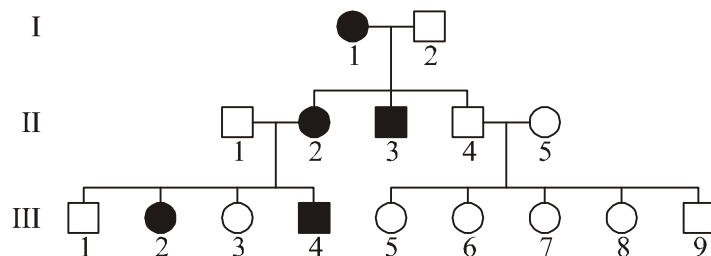
[Turn Over]

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[Turn Over]

(4)

4. The following is a pedigree of a rare human trait :



(a) What kind of inheritance pattern is reflected in the pedigree?

(b) Give the genotype of each of the following persons :
II-1, II-3, III-2, III-4.

(c) What sort of genetic cross is represented by the pedigree, if there is marriage between II-2 and II-3? 4

5. Sickle cell anemia is a recessive genetic disease caused due to a point mutation in the 6th codon abolishing one of the MspII endonuclease digestion site present in β -globin gene. MspII digested DNA from a normal person gives two bands, 1150 bp and 200 bp in β -globin gene. The MspII digestion pattern of β -globin gene from the blood samples from the members of a family is given below :

(7)

PART—III

10. You identified a new protein in *Saccharomyces cerevisiae*. A preliminary bioinformatic analysis is indicating that this protein could be a transcription factor, because it has a putative leucine zipper domain (which can potentially bind DNA) and a stretch of polyglutamine (PolyQ) towards the c-terminal end of the primary sequence that enhances the transcription activation by facilitating protein-protein interaction. Suggest an experimental approach to identify (i) the comprehensive (complete) list of the target genes in the genome (at the genome-wide scale) of this newly identified protein factor. (ii) How would you validate if the protein truly binds the target DNA sequence? 2+2=4

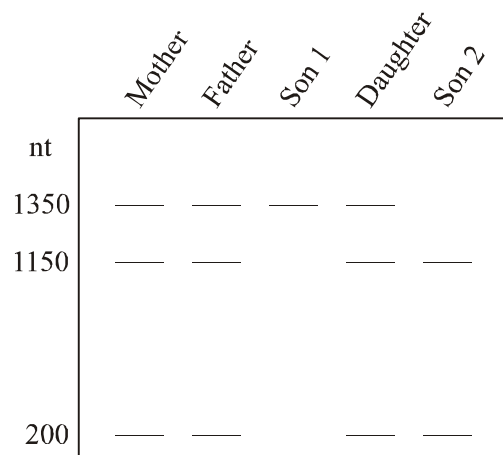
[CO2, CO3]

11. (a) Why does RNA-Seq technique offer more technical and financial advantages over the DNA microarray technique? 1

(b) You want to determine the total pool of 'antisense' transcripts that are stabilized (increased) in yeast *Saccharomyces cerevisiae*, when it is grown in presence of a metal ion in the medium with respect to the absence of that metal ion. Which technique will be appropriate to find out the answer of this question? Since, you are looking to determine the anti-sense transcripts, what specific step you must carry out when designing your experiment? 3

[CO2, CO3]

(5)



Explain the MspII digestion data and provide the genotype (with respect to Sickle cell anemia) of each of the family member.

4

[CO2, CO3]

PART—II

6. Mention two basic strategies which are used in massive sequencing projects to construct the sequence of the whole genome. Which approach would you apply to sequence the genome of a newly discovered mammalian species? 2+2=4

[CO1, CO2]

7. (a) Fingerprints of three cloned inserts labeled *P*, *Q* and *R* were obtained. Clone *P* has no bands in common with clone *Q* but has two bands in common with clone *R*. *Q* has three bands in common with *R*. What is the order of these three inserts in the genome? Show how they overlap.

1

BIOTECH-1012

[Turn Over]

(6)

- (b) Explain how the use of dideoxynucleotides triphosphates facilitates generation of the sequencing reads in Sanger's sequencing methods.

2

- (c) What do you mean by emulsion PCR reaction? How does this method differ from the conventional PCR reaction?

1

[CO2, CO3]

8. (a) Using necessary diagrams, describe the experimental rationale of the sequencing chemistry used in the Illumina platform.

3

- (b) What is 'interrogation probe'? Describe its features and working principle in the SOLiD sequencing chemistry.

1

[CO2, CO3]

9. (a) How the release of pyrophosphate during the new DNA synthesis is coupled to the production of light (flashes) in the pyrosequencing reaction? Explain with the help of chemical equation.

2

- (b) Using necessary diagrams, describe various features of the adapters (both forward and reverse) used to create the library in the Illumina platform.

2

[CO2, CO3]

BIOTECH-1012

[Continued]