

Date : October 11, 2025
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 Minutes (prior to writing time)

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
 - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
 Part II - 4 Short Answer Questions

All questions under SECTION A are COMPULSORY.
 - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **7 printed pages**, including this instruction page.

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SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. Edouard Chatton made a fundamental classification of living organisms. What was the basis of this classification?
 - a) Mode of reproduction
 - b) Presence or absence of a nucleus
 - c) Type of metabolism
 - d) Ability to move
2. Which of the following statements best explains how a proto-oncogene becomes an oncogene.
 - a) A proto-oncogene undergoes a loss-of-function mutation, leading to defective apoptosis
 - b) Loss-of-function mutation in proto-oncogene resulting in reduced protein degradation
 - c) Chromosomal translocation placing the proto-oncogene under control of a highly active promoter
 - d) Alternative splicing of proto-oncogene transcripts leading to apoptosis activation
3. Which of the following best serves as a selectable marker by conferring survival advantage to host cells during antibiotic selection in cloning experiments?
 - a) lacZ gene enabling blue-white screening
 - b) Ampicillin Resistant Gene providing β -lactam antibiotic resistance
 - c) MCS enabling insertion of foreign DNA sequences
 - d) ori sequence facilitating plasmid replication
4. Which statement about yeast fermentation is MOST accurate?
 - a) Yeast ferments glucose to ethanol and CO₂ anaerobically but can respire aerobically if oxygen is present
 - b) Yeast always produces ethanol and CO₂ no matter the sugar or conditions
 - c) Yeast converts pyruvate to lactic acid or ethanol depending on oxygen
 - d) Yeast fermentation works better with oxygen because more ATP is made
5. Which of the following statements about bacterial transformation is TRUE?
 - a) Transformation requires direct cell-to-cell contact between bacteria
 - b) Transformation involves the uptake of naked DNA from the environment by a bacterial cell
 - c) Only plasmid DNA can be taken up during transformation
 - d) All of the above
6. Which of the following element is most abundant in organic molecules essential for life?
 - a) Na
 - b) Zn
 - c) Na and Cl
 - d) C

7. What does the BLAST tool do in bioinformatics?
 - a) Predicts protein 3D structure
 - b) Predicts protein 2D structure
 - c) Visualizes metabolic pathways
 - d) Compares nucleotide or protein sequences to find similarities
8. Fill in the blank with the appropriate answer from the choices given. _____ is a technique used to separate proteins based on their size and charge
 - a) Yeast two-hybrid assay
 - b) Northern blotting
 - c) Gel electrophoresis
 - d) Southern blotting
9. Post-translational modifications such as phosphorylation are important in proteomics because:
 - a) They change the amino acid sequence, leading to altered protein synthesis
 - b) They regulate protein function and activity by reversible chemical changes affecting signaling pathways
 - c) They occur only during protein degradation to mark proteins for destruction
 - d) None of the above
10. In a solution with a pH of 3, the concentration of hydrogen ions $[H^+]$ is:
 - a) 10^{-3} mol/L
 - b) 10^3 mol/L
 - c) 3 mol/L
 - d) 10^{-7} mol/L
11. Which of the following is NOT an application of plant tissue culture in genetic engineering?
 - a) Clonal propagation of elite genotypes
 - b) Somaclonal variation for generating genetic diversity
 - c) Direct insertion of DNA into the plant nucleus
 - d) Production of transgenic plants through regeneration from transformed cells
12. Which molecule serves as the final electron acceptor in aerobic cellular respiration?
 - a) Oxygen
 - b) NAD^+
 - c) Carbon dioxide
 - d) Water
13. Fill in the blank with the appropriate answer from the choices given. _____ is an example of a database used for storing nucleotide sequences.
 - a) Bio-nucleotide Data Bank
 - b) KEGG
 - c) Swiss-prot
 - d) GenBank
14. What type of bond is responsible for stabilizing the α -helix and β -pleated sheet structures in proteins?
 - a) Hydrogen bonds
 - b) Ionic bonds
 - c) Covalent bonds
 - d) All of the above

15. In glycolysis, what is the net gain of ATP molecules per glucose molecule?
- a) 1 ATP
 - b) 2 ATP
 - c) 4 ATP
 - d) 6 ATP
16. The purpose of a genomic library in rDNA technology is to:
- a) Store all DNA sequences of an organism
 - b) Store mRNA molecules for reuse
 - c) Store Protein
 - d) All of the above
17. What is the role of vir genes located outside the T-DNA region on the Ti plasmid?
- a) They integrate into the plant genome to express antibiotic resistance
 - b) They code for plant growth regulators in the transformed plant
 - c) They synthesize secondary metabolites in plant cells
 - d) They encode the proteins that mediate the transfer of T-DNA into plant cells
18. Agrobacterium is more effective in dicots than monocots because:
- a) Monocots lack the receptors required for Agrobacterium attachment
 - b) Dicots express higher levels of plant defense genes
 - c) T-DNA cannot integrate into monocot genomes
 - d) Monocots do not undergo tissue culture step
20. The role of myeloma cells in hybridoma production is to:
- a) produce antibodies on their own
 - b) serve as feeder cells for B lymphocytes
 - c) enable unlimited cell division in fused hybrid cells
 - d) suppress immune responses during fusion
21. The function of single-strand binding proteins during replication is to:
- a) synthesize RNA primers
 - b) remove supercoiling
 - c) stabilize unwound DNA and prevent reannealing
 - d) repair mismatches during proofreading
22. Which of the following statements about peptidoglycan and bacterial cell walls is TRUE.
- a) Beta-lactam antibiotics target the bacterial peptidoglycan synthesis
 - b) Gram-positive bacteria are more sensitive to lysozyme than Gram-negative bacteria
 - c) The composition of peptidoglycan consists of repeating units of N-acetylglucosamine and N-acetylmuramic acid linked by peptide cross-bridges
 - d) All of the above

23. Which of the following best characterizes a fed-batch bioreactor and its advantage in industrial biotechnology?
- a) It involves the intermittent or continuous addition of nutrients without removing culture fluid, enabling extended production phases and controlled metabolite accumulation
 - b) It operates under anaerobic conditions only and is used exclusively for antibiotic production
 - c) It allows all nutrients to be added at the beginning, preventing nutrient limitation throughout the process
 - d) It continuously removes and replaces the culture medium to maintain constant volume and cell density
24. What structural form of DNA is most common under physiological conditions?
- a) A-DNA
 - b) R-DNA
 - c) Z-DNA
 - d) B-DNA
25. The enzyme Exonuclease III is used in molecular biology for:
- a) Removing terminal nucleotides from RNA
 - b) Cleaving DNA at restriction sites
 - c) Generating nested deletions in double-stranded DNA
 - d) Methylating cytosine residues
26. In the absence of lactose, the lac operon is:
- a) Actively transcribed
 - b) Repressed by the lac repressor binding to the operator
 - c) Induced by allolactose
 - d) Activated by cAMP-CAP complex
27. The insecticidal activity of *Bacillus thuringiensis* toxins depends on the alkaline pH of the insect midgut because:
- a) It activates protoxins to toxic forms
 - b) Alkaline toxin degrades the toxin
 - c) It inhibits toxin binding to receptors
 - d) It causes toxin precipitation
28. The key advantage of using a bacteriophage λ vector over a plasmid vector is:
- a) Faster replication rate
 - b) Higher transformation efficiency in mammalian cells
 - c) Ability to carry larger DNA inserts
 - d) Ability to replicate without host cells
29. The lytic cycle of a bacteriophage results in:
- a) Integration of phage DNA into the host genome
 - b) Dormant prophage state
 - c) Production of new phage particles and host cell lysis
 - d) Formation of a lysogen without killing the host

30. A mutation that changes a codon to a stop codon, resulting in premature termination of translation, is called:

- a) Nonsense mutation
- b) Missense mutation
- c) Silent mutation
- d) Frameshift mutation

PART II

Short Answer Questions [20 marks]

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. Draw a well-labeled diagram of the Ti plasmid used in plant genetic engineering. In your diagram, clearly indicate three important regions of the plasmid and briefly describe the function of each. **(5 marks)**
2. Explain the mode of action of the Cry protein produced by *Bacillus thuringiensis* in insect pest control. **(5 marks)**
3. What are restriction enzymes and how are they different from the general endonucleases. **(5 Marks)**
4. Explain the main steps involved in the Southern Blotting. **(5 marks)**

SECTION B

CASE STUDY [50 MARKS]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks. Mark for each sub-question is indicated in the brackets.

CASE I

"Bhutan has less than 3% arable land but needs to feed its growing population. Limited farmland and challenging conditions require innovative ways to boost crop yields sustainably" In this context, answer the following questions.

1. How can genetic modification improve crop tolerance to environmental stresses? Discuss the potential risks and benefits of introducing GM crops in Bhutan's traditional farming systems. **(10 marks)**
2. Discuss the role of microbial biofertilizers and biopesticides in promoting sustainable agriculture in Bhutan. How can bioreactors be utilized to mass-produce these microbial inputs, and what key operational parameters must be controlled to ensure product efficacy and quality? **(10 marks)**
3. How can protoplast fusion be applied to combine desirable traits from different plant species or varieties to develop hybrids suited for Bhutan? Explain the steps involved in protoplast fusion. **(10 marks)**
4. What are inducible promoters, and how can they be used to control gene expression in genetically modified plants to improve environmental stress responses? **(10 marks)**
5. Describe the key steps involved in designing and performing a qRT-PCR experiment to analyze gene expression in genetically modified crops. **(10 marks)**

CASE II

"Modern biotechnology helps improve crop productivity and sustainability through advanced genetic techniques and microbial solutions. It also enhances healthcare by enabling the development of vaccines and precise diagnostic tools". In this context, answer the following questions.

1. What is gene therapy? Describe the difference between somatic and germline gene therapy. **(10 marks)**
2. Explain the molecular mechanisms behind allergenicity in genetically engineered foods and strategies to minimize it. **(10 marks)**
3. Discuss the role of mixed-culture fermentation in developing novel food flavors and textures. Further, explain the advantages of using mixed-culture fermentation over single-culture fermentation in food processing. **(10 marks)**
4. Explain the principle and application of recombinant DNA technology in producing therapeutic proteins. Name two commonly used vectors in producing therapeutic proteins. **(10 marks)**
5. Explain the concept of feedback inhibition and discuss its significance in the regulation of metabolic pathways. Illustrate your answer with an example, highlighting how this mechanism contributes to cellular efficiency and metabolic balance. **(10 marks)**

TASHI DELEK