Biotechnology Solved Paper 2024

SECTION A

1. The natural source of enzyme barnase and barstar, a system used to achieve male sterile plant is 1

(A) *Bacillus subtilis*
(B) *Bartonella henselae*
(C) *Bacillus amyloliquefaciens*
(D) *Barnesville coli*

2. Severe combined immunodeficiency disease is caused due to the absence of: 1

(A) Adenosine diphosphate
(B) Adenosine deaminase
(C) Adenosine cyclase
(D) Guanidine nitrate

3. Single nucleotide polymorphisms usually occur in _____ regions. 1

(A) Coding
(B) Non-coding
(C) Regulatory
(D) Exonic

4. Artificial seeds are produced by encapsulating the somatic embryos at the _____ stage in a protective coating. 1

(A) Torpedo
(B) Globular
(C) Cotyledon
(D) Triangular

5. The peptide hormones and growth factors to promote healthy growth of animal cells in vitro are often derived from: 1

(A) Phenol red
(B) Antibiotics
(C) Blood serum
(D) Amino acids

6. Identify the vector that infects E. coli cells containing F-plasmid and that has a single-stranded circular genome: 1

(A) Agrobacterium tumefaciens
(B) YEp
(C) pBR322
(D) M13

7. An example of secondary metabolites produced by microbial cells include: 1

(A) Vitamins
(B) Alcohol
(C) Acids
(D) Antibiotics

8. When a transgene from a Genetically Modified crop escapes through pollen to a related plant species, it is known as _____. 1

(A) Gene transfer
(B) Gene pollution
(C) DNA contamination
(D) Toxicity transfer

9. A protein ion with a molecular weight of 10,000 Daltons carried a charge of 5+ and was subjected to mass spectrometric analysis. Calculate its mass-to-charge ratio. 1

(A) 2001
(B) 2000
(C) 2501
(D) 5001

10. Embryonic stem cells derived from blastocyst stage of the embryo are __ in nature. 1

(A) Totipotent
(B) Pluripotent
(C) Multipotent
(D) Bipotent

11. An improved strain of Penicillium, capable of producing a higher concentration of antibiotic penicillin, is: 1

(A) *Penicillium notatum*
(B) *Penicillium chrysogenum*
(C) *Penicillium eutrophus*
(D) *Penicillium cerevisiae*

12. _____ cultures can be maintained for a prolonged period of time by repeated sub-culturing. 1

(A) Ovary
(B) Protoplast
(C) Callus
(D) Mass cell

For Questions number 13 to 16, two statements are given, one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C), and (D) as given below.

(A) Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of the Assertion (A). (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). (C) Assertion (A) is true, but Reason (R) is false. (D) Assertion (A) is false, but Reason (R) is true.

13. Assertion (A): Some experts believe that there must be more than 30,000 genes in human genome.

Reason (R): Unreliability of in silico gene prediction is responsible for reporting lesser number of genes in human genome. 1

Ans: (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

14. Assertion (A): The exact chemical composition of complex microbial growth media is known.

Reason (R): Complex nutrient media is used when specific growth requirement of a microorganism is unknown. 1

Ans: (D) Assertion (A) is false, but Reason (R) is true.

15. Assertion (A): The regulation of pH is essential for the survival of mammalian cells.

Reason (R): Animal cell cultures mostly make use of bicarbonate carbon dioxide buffering system to maintain pH. 1

Ans: (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

16. Assertion (A): During plant tissue culture, the explants are treated with sodium hypochlorite.

Reason (R): Sodium hypochlorite helps in acclimatization of the regenerated plants.

Ans: (C) Assertion (A) is true, but Reason (R) is false. 1

SECTION B

17. Illustrate steps to show the construction of a recombinant DNA molecule. **2**

Ans:

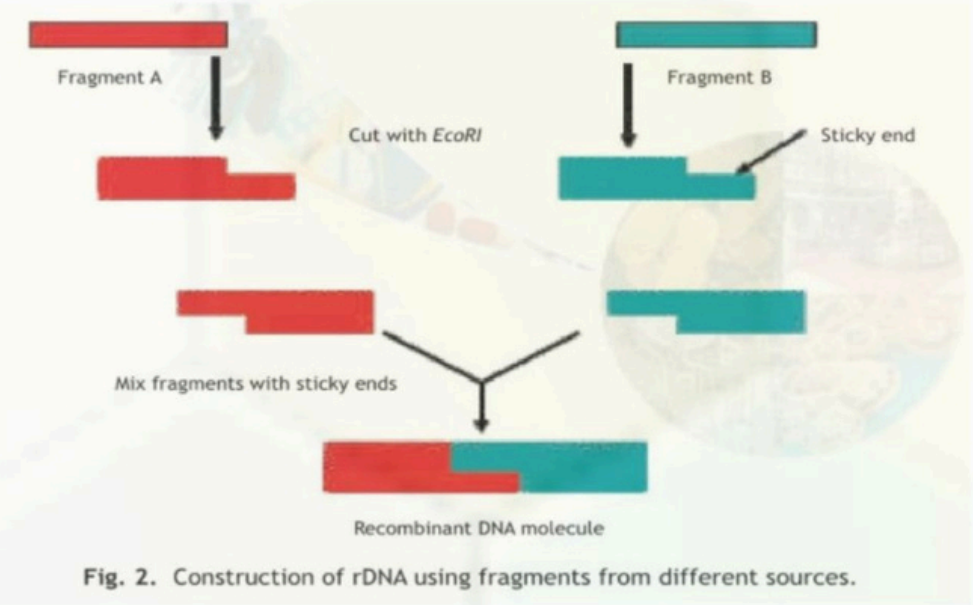


Fig. 2. Construction of rDNA using fragments from different sources.

18. What are the advantages offered by creating mouse model with gene knockout? **2**

Ans:

- To understand the genetic basis of a disease
- To search for new diagnostic methods
- To search for new therapeutic modality or uses (Any two)

19. Name the technique that helps to study the entire protein profile from a given cell type. Briefly explain the principle of this method. **2**

Ans: Two-dimensional Gel Electrophoresis Technique / Mass Spectrometry Technique

Principle of Two-dimensional Gel Electrophoresis Technique:

The separation of proteins is based on charge and size. First, proteins get separated on the basis of isoelectric pH (pI) by IEF technique and then based on molecular size by SDS PAGE technique.

Principle of Mass Spectrometry Technique:

It determines the molecular weight of a chemical compound or protein by separating the molecular ions according to the m/z ratio. (Any one technique with principle)

20. Write about any two strategies available to enhance the production of secondary metabolites in plant genetic engineering. **2**

Ans: -To overexpress a gene that encodes for the first enzyme in the biosynthetic pathway

-To use Agrobacterium rhizogenes to induce excessive secondary roots (hairy roots) in plants that normally produce useful secondary metabolites in this region.

21. (a) Give any two drawbacks of animal cell culture in vitro. **2**

OR

(b) (i) An oncologist is performing colony formation assay on tumour cells from a patient. What is he trying to determine? (ii) Animal cells growing in culture show the property of contact inhibition. Relate this to what happens in an adult human body. **2**

Ans:

(a) Drawbacks: Small size / scale-up is challenging / may not represent in vivo phenotype or genotype (Any two for 1 mark each)

OR

(b) (i) The oncologist is trying to determine whether the tumour is cancerous or not.
(ii) Cells comprising tissues and organs like the liver of an animal grow only to a certain size after which they cease to grow / Infant animals grow only to adulthood and not any further.

SECTION C

22. (a) Compare the techniques of FISH with Microarray in terms of principle and applications. **3**

OR

(b) Differentiate between Expression and Functional Proteomics. **3**

Ans:

(a) The principle involved in the FISH technique is the hybridization of DNA of metaphase chromosomes affixed to a microscopic slide with a fluorescent DNA probe. The principle of Microarray is that complementary sequences will bind to each other by base pairing or hybridisation. A fluorescently labelled single-stranded probe binds with a single-stranded DNA molecule spotted on the microarray plate. Applications of FISH are :

- Diagnosis of genetic diseases
- Locating specific DNA sequences
- Identification of presence or absence of a gene
- To study translocation of genes on chromosomes. (Any 1 point)

Applications of Microarray are :
To monitor the whole genome on a single chip for interactions among thousands of genes simultaneously. To compare the amounts of many different mRNA in two cell populations in tissue-specific genes to study the regulatory gene defects, cellular response to environment, and cell cycle variations. (Any 1 point)

OR

(b)

	Expression Proteomics	Functional Proteomics
1	Study of qualitative and quantitative expression of proteins in different environment or disease.	Identification and analysis of protein networks involved in a living cell/ nuclear pore complex/ study of protein functions and interactions/ molecular mechanisms and biological roles.
2	Used to identify disease specific proteins	To analyse the properties of molecular networks involved in a living cell.
3	To provide understanding of the basis of tumour development.	Identification of novel proteins which are important for translocating important molecules from cytoplasm of a cell to nucleus and vice versa.

23. Write the therapeutic use and the animal cell line employed in obtaining any three of the following protein pharmaceuticals: **3**

(A) Erythropoietin (B) Herceptin (C) Interleukin 2 (D) Tissue plasminogen activator

Ans:

S. No.	Protein Pharmaceutical	Therapeutic Use	Animal Cell Line
(A)	Erythropoietin	Anaemia	CHO cell line
(B)	Herceptin	Breast cancer therapy	CHO cell line
(C)	Interleukin 2	Cancer therapy	CHO cell line
(D)	Tissue plasminogen activator	Stroke	CHO cell line

Any Three

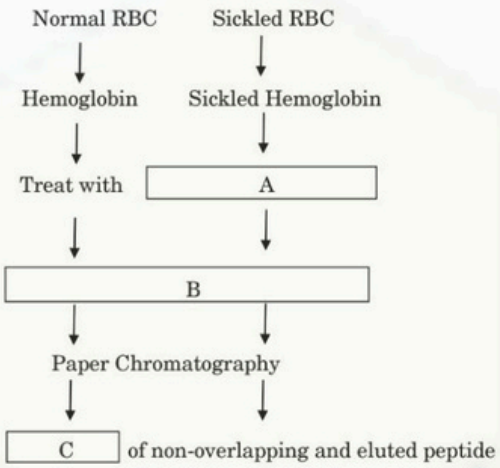
24. Explain the steps involved in PCR amplification method. **3**

Ans:

- Step 1 – Denaturation: The DNA duplex gets separated at temperatures above 80°C to form two single-stranded DNA templates.
- Step 2 – Annealing: Two primers bind to the 3' end of DNA templates at a temperature between 50 - 60°C
- Step 3 – Extension: Each primer is extended by Taq DNA polymerase in 5' 3' direction using dNTPs and the DNA strand as template at 70°C

25. A researcher performed protein fingerprinting on hemoglobin from both normal and sickled red blood cells. Complete the flowchart of the process by filling A, B, and C. **3**

Normal RBC Sickled RBC



Ans:
A – Trypsin
B – Paper Electrophoresis
C – Sequencing

26. Discuss any three ways that can be employed to measure microbial cell growth. 3

Ans:

Viable plate count method [colony forming units(CFU)]– counting the number of live cells

- Turbidity measurement – Absorbance at a particular wavelength is proportional to cell concentration
- Coulter counter – Direct counting of cells in suspension as they pass through the electrical field in a single file.
- Dry weight – to measure the constant weight of a fixed volume of culture after drying.
- Wet weight- to measure the weight of a fixed volume of culture.
- ATP measurement- to measure ATP in the beginning end at the end of the culture.

[Any Three ways with explanation]

27. What are zymogens? How is chymotrypsinogen different from chymotrypsin? 3

Ans: Inactive, harmless precursors of proteolytic enzymes are called zymogens.

Sl. No.	Chymotrypsinogen	Chymotrypsin
1	It is inactive precursor of chymotrypsin enzyme.	It is fully active enzyme.
2	The substrate-binding pocket is blocked/ not exposed.	The substrate-binding pocket is not blocked and is exposed.
3	Serine 195 is not acidic.	Serine 195 is acidic.
4	Charge relay doesn't operate	Charge relay operates

Any two points

28. Give the names of any three genes that are used as selectable markers in recombinant DNA technology. Also, mention the trait/protein they specify. **3**

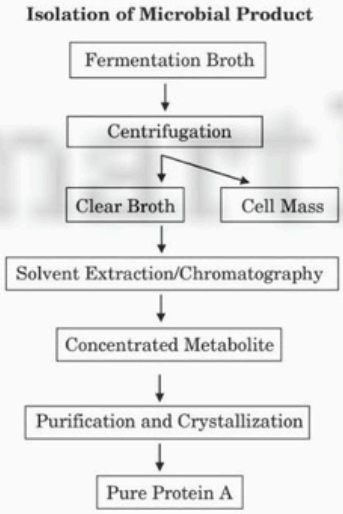
Ans:

- Ampicillin resistance gene- provides ampicillin resistance
- Lac Z gene -- produces β galactosidase enzyme
- GFP gene – Produces Green Fluorescent Protein
- Tetracycline resistance gene -----provides tetracycline resistance
- Leu 2 gene- codes for an enzyme needed for synthesis of amino acid leucine

Any three

SECTION D

29. Carefully read the below-mentioned flowchart and answer the questions that follow :
The flow-chart scheme for isolation of Protein A is as given below :



(a) Write whether Protein A is of intra or extra cellular origin. 1
(b) Which step in the given purification scheme is metabolite-specific? 1
(c) Give the purification scheme for isolation of Humulin from E. coli 2

OR

(c) Why is it advisable to use lesser number of steps for downstream processing ? 2

Ans:

(a) Protein A is extracellular

(b) Solvent extraction / Chromatography

(c) Fig 10, Pg. 100

(c) A lesser number of steps for downstream processing are advisable for :

- Less cost
- High yield

30. Consider the following table and answer questions: Given is a list of ingredients used for preparation of plant nutrient medium.

Plant Growth Media

Ingredients	Amount
NH_4NO_3	1650 mg/L
$CaCl_2$	440 mg/L
$MnSO_4$	22 mg/L
$FeSO_4$	27 mg/L
Glycine	2 mg/L
KNO_3	1900 mg/L
Sucrose	3 g/mL
Inositol	100 mg/L
EDTA	33 mg/L

(a) Which component in the given list is acting as the carbon source? 1
(b) Which ingredient has been used to fulfill the vitamin requirement? 1
(c) Name two phytohormones that are generally added to prepare plant nutrient media. 2

OR

(c) Explain how the sterilization of the growth media is achieved in the laboratory. 2

Ans:

(a) Sucrose (b) Inositol (c) Auxins and Cytokinins

OR

Ans: (b) Autoclaving: Sterilisation is performed at 15 pounds per square inch pressure for 20 minutes in an autoclave - Membrane filter sterilisation- Culture medium is forced through a membrane of very fine pore size.

SECTION E

31. (a) (i) Explain the reason for the therapeutic use of whey proteins. **2**
(ii) Name any two diseases that have been treated with whey. **2**
(iii) Curd is advised to be administered with antibiotics. Why? **1**

OR

(b) (i) Discuss the development of a novel protein. 3
(ii) Name any two properties that can be manipulated using Protein Engineering. 2
Ans:
(a) (i) Elevation of glutathione (a reducing compound) in cells that detoxifies xenobiotics. Protects cellular components from oxygen intermediates and free radicals.
(ii) Jaundice / Infected skin lesions / genito urinary tract infections / Intestinal infections.
(iii) Curd is used as a probiotic as it is a source of beneficial bacteria that can colonise the intestinal tract.

OR
(b) (i) Recombinant vaccine based on selected epitope: Synthetic gene for an epitope of a virus is assembled and introduced into host cells which are grown on a large scale. The epitope protein is isolated, purified, and used as a recombinant or subunit vaccine.
(ii) Thermal stability / pH stability / Solvent tolerance / Solubility / Catalytic potency/ Biological adaptation to environmental stresses such as high salinity, drought, cold, etc. Any two

32. (a) (i) In Sanger's chain termination method, incorporation of ddNTP causes the growing DNA chains to terminate prematurely. Explain how. 2
(ii) Briefly write the steps of Sanger's chain termination method of DNA sequencing. 3

Ans:
(a) (i) ddNTPs lack 3′Hydroxyl group so the phosphodiester bond between 3' hydroxyl group of the previous nucleotide cannot be formed with the 5' phosphate group of the incoming nucleotide and hence, the growing DNA chain cannot be further extended, and the chain gets terminated.

(ii) The sequencing technique is carried out in four test tubes, each carrying single stranded DNA template, deoxy nucleotide tri phosphates, primer and DNA polymerase. A small amount of four dideoxy nucleotide triphosphates, i.e. ddATP, ddTTP, ddGTP, and ddCTP, are added separately into the four test tubes, and the reaction is allowed to proceed.

Prematurely terminated strands in a given tube are separated on special gels by electrophoresis, wherein the bands can be resolved even if they differ by one nucleotide. The shorter fragments move faster towards the anode. The radioactive primers help in easy visualisation using autoradiography. The gel is read from bottom to top to arrive at 5′ to 3′ original DNA sequence.

OR

(b) (i) During DNA sequencing, why is the autoradiogram read from bottom to top to arrive at the original sequence ? 2

(ii) Why is single-tube DNA sequencing considered better and safer? 2

(iii) To perform DNA sequencing of a strand, we need to clone the sequence in a single-stranded form. Which vector will you prefer for this? 1

Ans:

(b) (i) - The shortest, fastest-moving DNA fragment is obtained at 5' position (towards anode).
- Since DNA synthesis occurs in 5' to 3' direction, the gel is read from 5' end (anode)

(ii) Single tube DNA sequencing uses fluorescent colours rather than radioactive isotopes, so it is safer. It is better as it is automated /faster /uses a single lane gel for electrophoresis/ result is directly displayed on a computer screen and data can be stored in a computer.

(iii) M13-based vector

33. (a) (i) Name three database retrieval tools available from the NCBI. What all do they allow us to access? 3

(ii) What kind of information is available in UniProtKB and PDB databases ? 2

OR

(b) (i) How is BLAST used to analyses sequence similarity? Explain. 3

(ii) Name the computer programmes that can perform gene prediction for bacterial and eukaryotic genomes. 2

Ans: (a) (i) Entrez allows us to access literature through abstracts, sequences, and structures.

Entrez provides comprehensive information on a given biological question. The taxonomy browser provides information on the taxonomic classification of various species. Locus link provides information on official gene names, descriptive information about genes, and on homologous genes

(ii) UniProtKB gives information about annotated protein sequences. PDB (Protein Database) contains information about three three-dimensional structures of proteins.

OR

Ans: (b) (i)In BLAST: - A given sequence is compared with the database sequences using matrices that give scores. They either reward a match or penalise a mismatch. - Top-scoring matches are ranked based on whether the match was due to an ancestral relationship or just a random chance. - True matches are examined through ENTREZ

(ii) GeneMark for bacterial genomes and GENSCAN for eukaryotic genomes.