Class 12 Biotechnology 2025 Solved Paper

SECTION – A

1. The DNA ligase enzyme that is frequently used to ligate different DNA fragments in order to generate rDNA molecules is isolated from: 1

(A) T2 Bacteriophage

(B) T4 Bacteriophage

(C) Lambda Bacteriophage

(D) M13 filamentous phage

2. Protein Efficiency Ratio (PER) is used as a measure of growth expressed in terms of: 1

(A) Weight gain of an adult by consuming 1 g of food protein.

(B) Weight gain of an adult by consuming 100 g of food protein.

(C) Protein nitrogen that is retained by the body by consuming 1 g of food protein.

(D) Protein nitrogen that is retained by the body by consuming 100 g of food protein.

3. At the end of one cycle of PCR, two DNA molecules will become _____. 1

(A) Eight

(B) Sixteen

(C) Four

(D) Two

4. Single base difference in ApoE gene is associated with: 1

(A) Resistance to HIV (Human Immunodeficiency Virus)

(B) Migraine

(C) Huntington disease

(D) Alzheimer's disease

5. One of the carbon sources used in microbial cell culture is: 1

(A) Olive oil

(B) Cereal grains

(C) Ammonium salts

(D) Growth factors

6. A biotechnologist wants to obtain a gene sequence in single-stranded form. Which bacteriophage-based vector should he choose to obtain the desired result? 1

(A) M13-based vector

(B) Bacteriophage Lambda-based vector

(C) Plasmid cloning vector of pUC family
(D) Plasmid vector pBR 322

7. Absence of the enzyme adenosine deaminase in humans causes: 1
(A) Thalassemia
(B) Sickle cell anaemia
(C) SCID
(D) Mad cow disease

8. The technique to isolate and grow human embryonic stem cells in culture was developed by: 1
(A) Cesar Milstein
(B) James Thomson
(C) George Kohler
(D) George Gay

9. Gene prediction for bacterial genomes can be done by using the computer program _____. 1
(A) GeneMark
(B) GENSCAN
(C) UniProtKB
(D) RefSeq

10. _____ can be categorized as a food source of nutraceutical proteins. 1
(A) Seed storage proteins
(B) Soya protein
(C) Milk proteins
(D) Whey protein concentrates

11. Identification of disease-specific proteins can be done by using the approach of: 1
(A) Functional proteomics
(B) Structural proteomics
(C) Expression proteomics
(D) Proteome mining

12. Herceptin is a monoclonal antibody approved for: 1
(A) Therapy of early-stage breast cancer.
(B) Reversal of acute rejection of transplanted organs.
(C) Stimulation of erythropoiesis.
(D) Use in certain patients having a heart attack.

For Questions 13 to 16, two statements are given – one labelled Assertion (A) and other labelled 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 the Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but the 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): CO2 incubators prevent the desiccation of the animal cell culture medium.
Reason (R): A pan of water is kept at all times in a CO2 incubator chamber to maintain high relative humidity. 1
Ans: (A) Both Assertion (A) and Reason (R) are true, and the Reason (R) is the correct explanation of the Assertion (A).

14. Assertion (A): Contact inhibition is absent in cancer cells.
Reason (R): Normal cells stop growing when they reach the walls of the container.
Ans: (B) Both Assertion (A) and Reason (R) are true, but the Reason (R) is not the correct explanation of the Assertion (A).

15. Assertion (A): Proteins have diverse functions.
Reason (R): All proteins are enzymes. 1
Ans: (C) Assertion (A) is true, but Reason (R) is false.

16. Assertion (A): One of the first attempts to study the molecular basis of sickle cell anaemia was to compare the electrophoretic mobility of normal haemoglobin (Hb) and sickle cell haemoglobin (scHb).
Reason (R): Sickle cell haemoglobin (scHb) moved faster than normal haemoglobin (Hb) in electrophoresis. 1
Ans: (C) Assertion (A) is true, but Reason (R) is false.

SECTION – B

17. (a) What is the principle of mass spectrometry? Write its important application. 2
Ans: (a) Principle: Mass spectrometry determines the molecular weight of chemical compounds by separating molecular ions according to their mass/charge (m/ z) ratio.

Application: To obtain protein structural information, such as peptide mass / amino acid sequence/ to identify the type and location of amino acid modification within proteins/ to provide the molecular weight of proteins. (any one)

OR

(b) Describe briefly the charge relay system that operates in chymotrypsin enzyme. 2

Ans: (b) The enzyme chymotrypsin is made up of a linear chain of 245 amino acids interrupted into three peptides. The protein folds into a globular structure, and the three important amino acid residues His(57), Asp(102), and Ser(195) come close together in space, which allows a 'charge relay system' to operate. The negatively charged aspartate (102) can form a hydrogen bond with the adjacent histidine (57), partially borrowing a hydrogen ion from the latter. The His (57) makes good its partial hydrogen ion loss to Asp(102) by attracting a hydrogen ion from the adjacent Ser(195) through the His(57) residue, making Ser(195) acidic.

18. With a suitable example, explain briefly why the number of predicted genes do not correlate with the genome size and the number of chromosomes in an organism. 2

Ans:

Organism	No. of chromosomes	Genome size in base pairs	The Number of Predicted genes	Part of the genome that encodes for protein
Bacteria *Escherichia coli*	1	500,000	5000	90%
Yeast *Saccharomyces cerevisiae*	16	12,068,000	6340	70%
Worm *Caenorhabditis elegans*	6	100,000,000	19,000	27%
Fly *Drosophila melanogaster*	4	175,000,000 - 196,000,000	13,600	20%
Weed *Arabidopsis thaliana*	5	157,000,000	25,498	20%
Human *Homo sapiens*	23	3,000,000,000	20,000 - 25, 000	< 5%

No correlation exists between the number of predicted genes, the genome size, and the number of chromosomes in an organism due to overlapping genes, splice variants.

19. Why is chronic myelogenous leukaemia caused? Name the technique used to know the status of this disease. 2

Ans: - Chronic myelogenous leukemia is caused due to 9 - 22 translocation in the chromosome, resulting in a shorter chromosome 22 (Philadelphia chromosome)

- Fluorescence In situ Hybridisation Technique/ Karyotype analysis (any one)

Alternative Question for Visually Impaired in lieu of Q. No. 19.

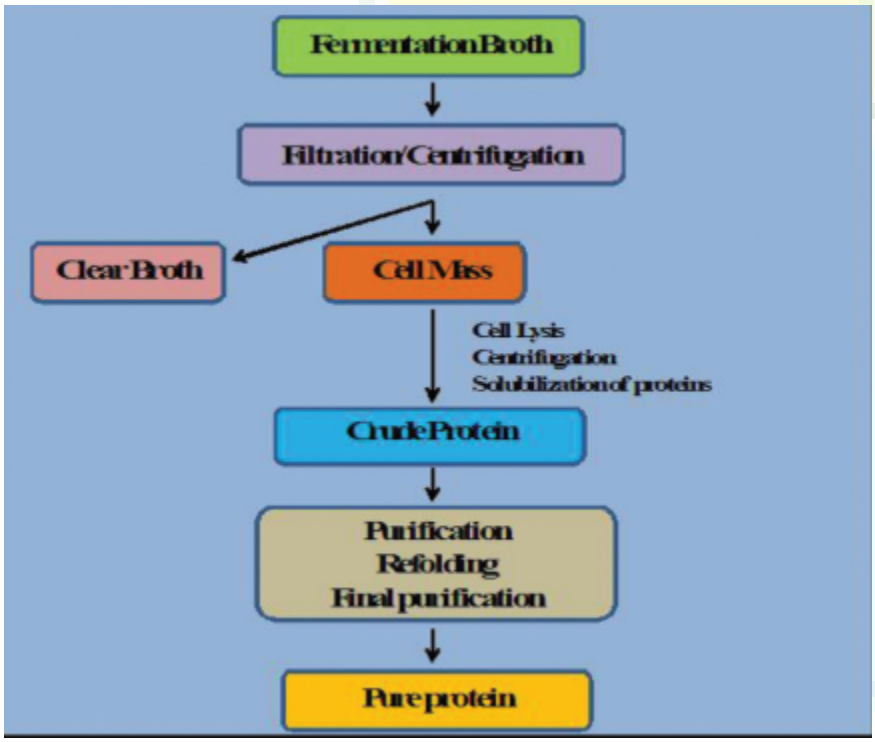
19. What are the uses of the data provided in RefSeq database ? 2

Ans: The uses of the data provided in the RefSeq database are:

1. Designing gene chips.
2. Describing the sequence features of the human genome.

20. Outline the important steps for isolation of recombinant insulin (Humulin) from Escherichia coli. 2

Ans: -Steps for isolation of recombinant Insulin (Humulin) from *Escherichia coli*



21. What is the most common cause of foaming in microbial culture medium? Which problems are created by foaming in microbiological processes? 2

Ans: - The Common cause of foaming in microbial culture medium is the presence of proteins in the culture medium.

- Foaming denatures proteins and provides a hindrance to the free diffusion of oxygen in the medium.

SECTION – C

22. Elaborate upon the scientific relevance for therapeutic usefulness of whey with specific examples. 3

Ans: - Whey proteins result in the elevation of tripeptide glutathione (gamma-glutamyl cysteinyl glycine) in cells. Glutathione is a reducing compound that detoxifies xenobiotics and protects cellular components from the effects of oxygen intermediates and free radicals
-Examples: Whey is used to treat various illnesses like jaundice, infected skin lesions, and genito-urinary tract infections. (Any two examples.)

23. (a) Mention the important features that were incorporated in each of the following vectors: 3

- **(i) COSMIDS**
- **(ii) Shuttle Vectors**
- **(iii) Expression Vectors**

Ans: (a) Important features that were incorporated in each of the following vectors are :

- (i) COSMIDS: COS-sites of phage lambda, and features of plasmid (origin of replication, selectable marker, suitable restriction enzyme sites).
- (ii) Shuttle Vectors: Two types of origin of replication and selectable marker genes, one set which functions in the eukaryotic cells and another which functions in *Escherichia coli*.
- (iii) Expression Vectors: Signals necessary for transcription and translation of the insert for expressing a foreign protein.

OR

(b) Explain the method of Blue-White selection used for screening of recombinant cells containing desired plasmid with gene of interest. 3

Ans:

- Blue –White selection method is based on the insertional inactivation of the lacZ gene present on the vector pUC 19.
- The lac Z gene expresses the enzyme beta galactosidase, which can cleave a colourless substrate called X-Gal into a blue coloured product
- If the LacZ gene is inactivated due to the presence of the insert, then the enzyme is not expressed.
- After a transformation experiment, the *E.coli* host cells are plated on an ampicillin and X-Gal containing solid media plate
- Colonies that appear blue are ampicillin resistant and have transformed cells but do not have the insert.
- Colonies that appear white are both ampicillin resistant and have the recombinant DNA.

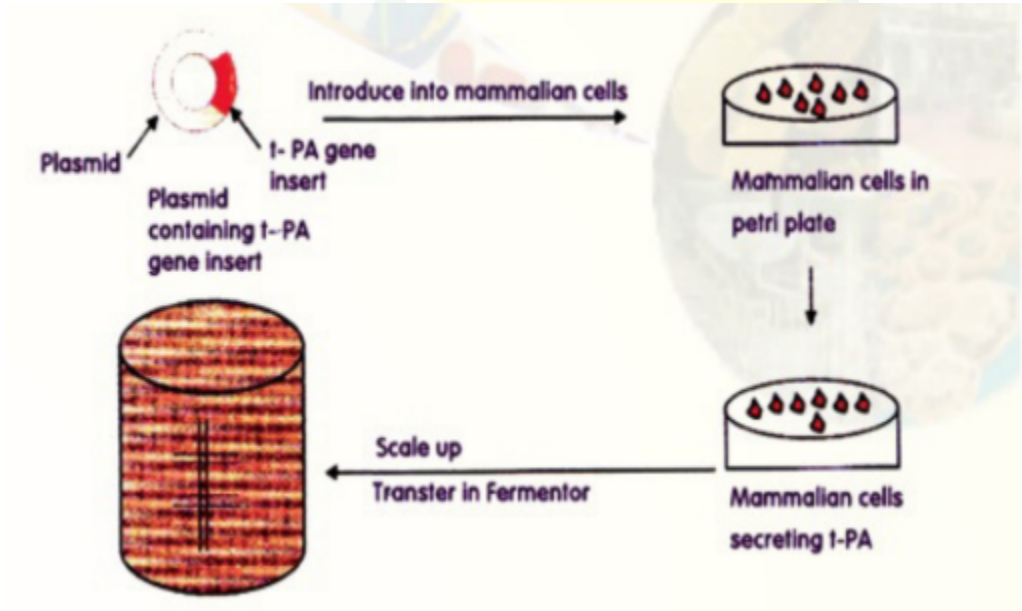
24. What is the mode of action of tissue Plasminogen Activator (tPA)? Draw a schematic representation to show the method of production of tPA through mammalian cell culture. 3

Ans: - Mode of action of tissue Plasminogen Activator (tPA):
tPA converts plasminogen to plasmin, which dissolves blood clots. /

tPA degrade

- Plasminogen ------→ Plasmin--------→ Fibrin ----------→ Dissolution of blood clot
(Inactive precursor enzyme)

Schematic representation to show the method of production of tPA through mammalian cell culture.



Alternative Question for Visually Impaired in lieu of Q. No. 24

24. What are stem cells? Write the two broad types of mammalian stem cells and an application of each. 3

Ans:

- Stem cells are cells that have the property of self-renewal through mitotic cell division and differentiation into a diverse range of specialized cell types.
- Two broad types of mammalian stem cells are: Adult stem cells and Embryonic stem cells.
- Application of Adult stem cells-
- Act as a repair system for the body by (/) maintaining the normal turnover of regenerative organs (such as blood, skin, or intestinal tissues).
- Can be grown and transformed into specialized cells (such as muscles or nerves) through cell culture and (/) used in medical therapies.
- Can be used in medical conditions / where cells are either dead or injured or abnormal such as leukemia (cancerous blood cells), heart disease, heart attack (cardiac tissue damage), paralysis (spinal cord injury) , Alzheimer's, Parkinson's, Huntington's (dead brain cells), burns (damaged skin cells). (Any one point)

- (Any other relevant point can be considered.)

Application of Embryonic stem cells –

- Can differentiate into cells of all types of specialized tissues.
- It can be maintained in cell culture in the presence of irradiated fibroblast cells, which can be reintegrated fully into embryogenesis if transferred.
- Can be used to create Chimeric mice.
- It can be used to create mouse models of human diseases.
- Can be used to create mouse models with gene knockouts. (Any one point) (Any other relevant point can be considered.)

25. Although not required for cell growth, antibiotics are added to animal cell culture medium. Give reason. Name two such antibiotics. 3

Ans: Antibiotics are added to animal cell culture medium to control the growth of bacterial and fungal contaminants.

- Two such antibiotics are Penicillin and Streptomycin

26. It is very difficult to produce hybrids in case of interspecific and intergeneric crosses. Why? Briefly describe the technique to obtain such novel hybrids. 3

Ans:

- It is very difficult to produce hybrids in the case of interspecific and intergeneric crosses because of the abnormal development of endosperm, which causes the premature death of the hybrid embryo and leads to the formation of sterile seeds.
- Explanation of any one technique to obtain such novel hybrids: - Embryo rescue / Protoplast fusion to produce somatic hybrids and cybrids/ organelle transfer/organelle uptake.

27. Transgenic plants can be used as factories to produce polyhydroxybutyrate (PHB) on a large scale. How was *Arabidopsis* plant engineered for the same? State the drawback of producing PHB by fermentation using bacterium *Alcaligenes eutrophus*. 3

Ans:

- Engineering of *Arabidopsis* plant:- Three genes involved in PHB synthesis from Alcaligenes eutrophus were expressed exclusively in the chloroplasts of the *Arabidopsis* plant (to produce PHB globules), without affecting plant growth and development.
- The drawback of producing PHB by fermentation using the bacterium *Alcaligenes eutrophus* is the high production cost.

28. A comparative microarray hybridisation experiment was performed between normal and cancerous cells. How will you interpret the result obtained on a microarray if red and green coloured fluors were used for labelling the cDNA probes of normal and cancerous cells, respectively? 3

Ans:

- Red spots show genes expressed in high amounts in normal cells.
- Green spots show genes expressed in high amounts in cancerous cells
- Yellow spots show genes expressed approximately equally in both normal and cancerous cells.

SECTION – D

Instructions: Q. Nos. 29 and 30 are case-based questions. Each of these questions has sub-parts [(i), (ii), and (iii)] with internal choice in one sub-part.

29. Sanger's method of DNA sequencing is a widely used technique to determine the nucleotide sequence of a DNA fragment. Primers are extended using the single-strand DNA template as a guide, where the normal substrates, i.e., deoxynucleotide 5′ triphosphates (dNTPs), are incorporated in the growing DNA chain. This method is based upon the principle of chain termination by ddNTPs (2′, 3′ dideoxynucleotide triphosphates), which, if incorporated into each extending chain (instead of the required dNTP), cause termination. Radioactive primers may be used to visualise separated strands in the gel by autoradiography. Nowadays, DNA sequencing has become automated, where ddNTPs are conjugated with fluorescent molecules, and the gels obtained are scanned by laser.

(i) Why are primers required in Sanger's method of DNA sequencing? 1

Ans: (i) Only primers can be extended using a single-stranded DNA template as a guide.

(ii) Write the difference between dNTPs and ddNTPs. What is the function of ddNTPs in Sanger's method of DNA sequencing ? 2

Ans: (ii) The 3′OH group is present in dNTPs, whereas the 3′OH group is absent in ddNTPs (Structures indicating correct labeling at 3' positions of dNTP and ddNTP can be considered. Function:- ddNTPs terminate the growing DNA chain where they are incorporated.

(iii) What is the advantage of using ddNTPs conjugated with fluorescent molecules in automated method of DNA sequencing? 1

Ans: (iii) Advantage:- Gels can be scanned by Laser / Danger of using radioisotopes is avoided / Single lane gel electrophoresis can be conducted instead of four lane gel. (Any one).

OR

(iii) Which enzyme is used in Sanger's method of DNA sequencing? 1

Ans: (iii) DNA Polymerase

30. Genetically modified or transgenic crops with improved agronomic traits have been developed by the introduction of foreign genes into crop plants, using cell and tissue culture systems. The explants are cultured on a suitable nutrient medium which provides macronutrients,

micronutrients, carbon source, vitamins, amino acids, along with plant hormones required for growth, cell division, and development of plant cells in culture. Plant cell culture and applications deal with various types of cultures, such as organ culture, explant culture, callus culture, cell suspension culture, protoplast culture, mass cell culture, and each of these has widespread uses in plant regeneration, genetic transformation studies, and many more applications of plant cell and tissue culture.

(i) What is meant by explant culture? 1
Ans: (i) The culture of any piece or a part of a plant (explant) is known as explant culture.

(ii) Mention hormones that are used for promoting growth and cell division of plant cells in culture. 2
Ans: (ii) Auxin / Cytokinin / [Gibberellin] (any two)

(iii) What is meant by "Protoplast" ? 1
Ans: (iii) Plant cells without a cell wall are known as " Protoplast"

OR
(iii) Write an application of callus culture. 1
Ans: (iii) Micropropagation / Plant Regeneration / Preparation of single cell suspensions/ Preparation of protoplasts / Genetic transformation studies. (Any one)

SECTION – E

31. (a) Explain the technique of peptide mapping used to compare normal haemoglobin with sickle cell haemoglobin. 5
Ans: (a) The technique of peptide mapping used to compare normal haemoglobin with sickle cell haemoglobin:-

- 1. Pure Hb and scHb are taken separately into test tubes and are digested with the proteolytic enzyme trypsin.
- 2. Two separate strips of Whatman filter paper are spotted with Hb and scHb tryptic peptides, and the peptides are allowed to separate using the technique of paper electrophoresis at pH 2.0.
- 3. The paper strips are dried and chromatographed at right angles to the electrophoretic direction using a solvent system, Butanol: Water: Acetic acid.
- 4. The chromatograms are dried and stained with a suitable visualisation reagent like Ninhydrin, wherein peptide-containing regions appear as orange-yellow spots.
- 5. The peptide map for Hb and scHb is compared, and the amino acid sequence of the peptide, differently placed in the scHb map, is determined.

OR

(b) Mention any five protein-based products with an example of each. 5

Ans: Any five protein-based products as given below, with one example of each:-

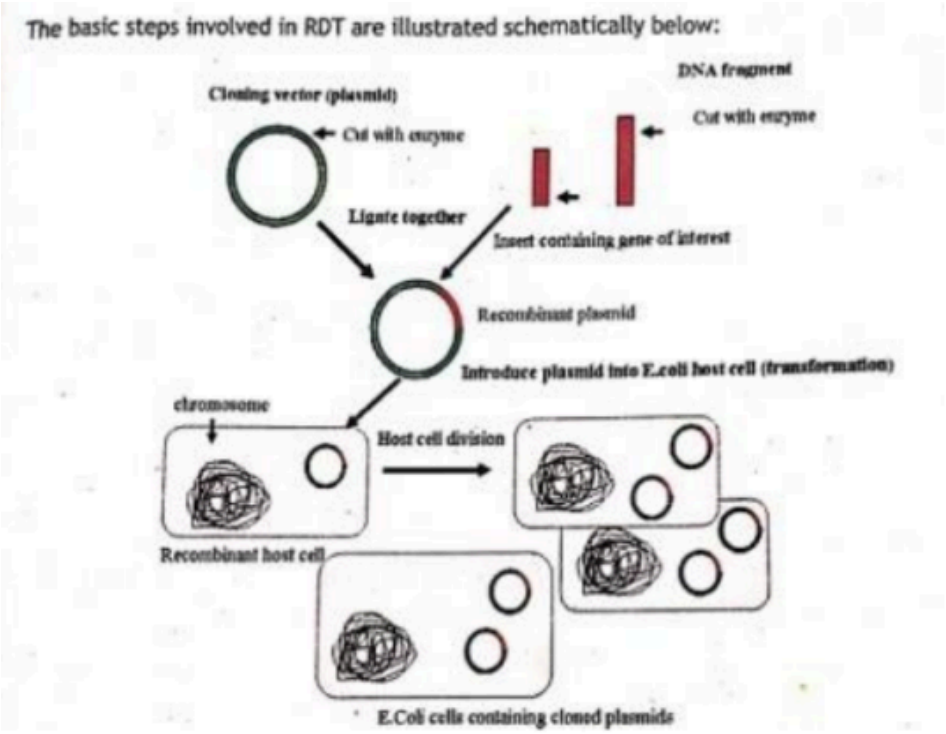
- 1. Blood products and vaccines.
- 2. Therapeutic antibodies and enzymes.
- 3. Therapeutic hormones and growth factors.
- 4. Regulatory factors.
- 5. Analytical application.
- 6. Industrial enzymes.
- 7. Functional non-catalytic proteins.
- 8. Nutraceutical proteins.

32. (a) Describe the basic steps of Recombinant DNA Technology. 5

Ans: (a) The Basic steps of Recombinant DNA Technology are:-

- 1. Isolation of a DNA fragment containing a gene of interest that needs to be cloned (called as insert).
- 2. Generation of a recombinant DNA (rDNA) molecule by insertion of the DNA fragment into a carrier DNA molecule called a vector (e.g., plasmid) that can self-replicate within a host cell.
- 3. Transfer of the rDNA into an E. coli host cell (process called transformation).
- 4. Selection of only those host cells carrying the rDNA
- 5. Allowing recombinant cells to multiply, thereby multiplying the rDNA Molecules/

Flowchart with explanation of basic steps of Recombinant DNA Technology



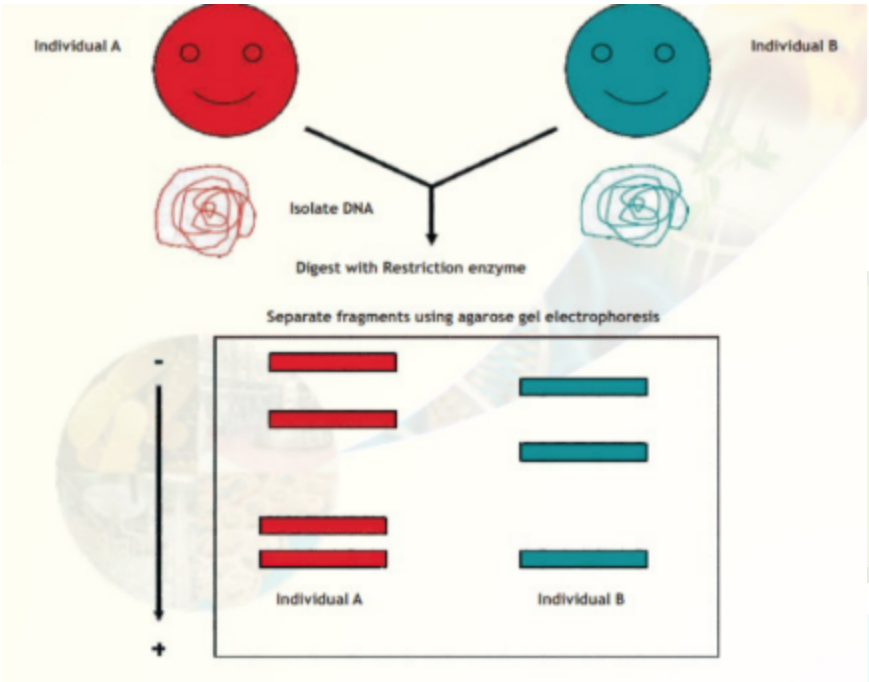
OR

(b) Describe the procedure involved in Restriction Fragment Length Polymorphism (RFLP) technique. Why is this technique used in forensic sciences ? 5

Ans: (b) Procedure involved in Restriction Fragment Length Polymorphism (RFLP) Technique:-

- 1. Isolate test DNA samples
- 2. Digest test DNA samples with the same restriction enzyme
- 3. Separate the DNA fragments by agarose gel electrophoresis
- 4. Analysis of gel pattern. /

Flowchart with explanation of steps



33. (a) What is a "metagenome"? Describe the metagenomics approach and write its importance to study microorganisms. 5

Ans: The genomes contributed by both the culturable and the non-culturable varieties of microbes together are termed as 'metagenome'.

Metagenomics approach:-

- The collective DNA is extracted from a sample of soil, water or any other environmental niche.
- The collective DNA is subjected to restriction digestion using restriction endonucleases.
- The DNA fragments obtained are cloned in suitable vectors.
- The clones are then screened for the presence of a variety of molecules with improved characteristics.

Importance of metagenomics approach to study microorganisms is:-

To cast a wider net on microbial resources present in the environment / to fish out genes of interest / to analyze the genomes of the microbes without culturing them in the laboratory / to study those microbes that are difficult to culture in the laboratory or have never been cultured in the laboratory as yet / analyze these microbes to see if they carry any genes which may be exploited for human use.

OR

(b) How is a continuous culture system maintained in microbial culture? What are its advantages over Fed-batch culture? 5

Ans: - In Continuous culture, the growth medium is designed in such a way that one of the nutrients is in limited quantity. Thus, during the exponential growth just before the nutrient is fully exhausted, fresh medium containing the limited nutrient is added, and this is repeated every time the limited nutrient is about to be exhausted.

- This system is also fitted with an overflow device so that the added volume displaces an equal volume of culture from the culture vessel.
- In a chemostat, a constant chemical environment is maintained, whereas in a turbidostat, constant cell concentration is maintained.

Advantages of Continuous culture over Fed-batch culture:-

- A steady state is achieved for an extended period of time.
- Higher productivity.
- Getting a continuous supply of microbial growth.
- Easier control of constant growth conditions.
- A continuous culture system can be maintained for a long period. (Any two advantages)