**KURUKSHETRA UNIVERSITY, KURUKSHETRA Curriculum for M.Sc. Biotechnology (CBCS) Scheme of Examination (Effective from the Academic Session 2016-2017)**

**Semester-1**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Paper No. | Nomenclature | Paper type | Credits | Contact hours per week | Internal Marks | External Marks | Total Marks | Duration of Exam(hours) |
| BT-101 | Biomolecules | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-102 | Microbiology | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-103 | Molecular Cell Biology | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-104 | Biotechniques | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-105 | Lab Course based on Biomolecules and Biotechniques | core | 4 | 8 | 20 | 80 | 100 | Six  (Two sessions of three hours each) |
| BT-106 | Lab Course based on Molecular cell Biology & Microbiology | core | 4 | 8 | 20 | 80 | 100 | Six  (Two sessions of three hours each) |
|  |  | Total Credits-24 | | | Total Marks -600 | | | |

**KURUKSHETRA UNIVERSITY, KURUKSHETRA Curriculum for M.Sc. Biotechnology (CBCS) Scheme of Examination (Effective from the Academic Session 2016-2017)**

**Semester – ll**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Paper No. | Nomenclature | Paper  type | Credits | Contact  hours  per week | Internal marks | External  marks | Total marks | Duration of exam(hours) |
| BT-201 | Genetic Engineering | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-202A | Animal Cell & Tissue Culture | core | 2 | 2 | 10 | 40 | 50 | Three |
| BT-202B | Plant Cell & Tissue Culture | core | 2 | 2 | 10 | 40 | 50 | Three |
| BT-203 | Bioinformatics | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-204 | Enzyme Technology | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-205 | Seminar | core | 1 | 1 | 25 | - | 25 | - |
| BT-206 | Biotechnology and Human Welfare-1 | \*open elective | 2 | 2 | 10 | 40 | 50 | Three |
| BT-207 | Lab Course based on Genetic Engineering & Cell and Tissue Culture Technology | core | 4 | 8 | 20 | 80 | 100 | Six  (Two sessions of three hours each) |
| BT-208 | Lab Course based on Enzyme Technology & Bioinformatics | core | 4 | 8 | 20 | 80 | 100 | Six  (Two sessions of three hours each) |
|  |  | Total Credits-27 | | | Total Marks- 675 | | | |

\*Would be offered to students of Life Sciences Faculty outside the department

**KURUKSHETRA UNIVERSITY, KURUKSHETRA Curriculum for M.Sc. Biotechnology (CBCS) Scheme of Examination (Effective from the Academic Session 2016-2017)**

**Semester – llI**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Paper No. | Nomenclature | | Paper  type | Credits | Contact  hours per week | Internal marks | External  Marks | Total marks | Duration of exam(hours ) |
| BT-301 | Plant Biotechnology | | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-302 | Microbial Biotechnology | | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-303 | Molecular Genetics | | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-304 | Immunology | Any one | elective | 4 | 4 | 20 | 80 | 100 | Three |
| BT-305 | Medical Biotechnology | elective | 4 | 4 | 20 | 80 | 100 | Three |
| BT-306 | Seminar | | core | 1 | 1 | 25 | - | 25 | - |
| BT-307 | Biotechnology and Human Welfare-II | | \*open elective | 2 | 2 | 10 | 40 | 50 | Three |
| BT-308 | Lab Course based on Plant Biotechnology & Microbial Biotechnology | | core | 4 | 8 | 20 | 80 | 100 | Six  (Two sessions of three hours each) |
| BT-309 | Lab Course based on Molecular Genetics, Immunology/ Medical Biotechnology | | core | 4 | 8 | 20 | 80 | 100 | Six  (Two sessions of three hours each) |
|  |  | | Total Credits-27 | | | Total Marks- 675 | | | |

\*Would be offered to students of Life Sciences Faculty outside the department

**KURUKSHETRA UNIVERSITY, KURUKSHETRA Curriculum for M.Sc. Biotechnology (CBCS) Scheme of Examination (Effective from the Academic Session 2016-2017)**

**Semester –IV**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Paper No. | Nomenclature | | Paper  type | Credits | Contact  hours per week | Internal marks | External  Marks | Total marks | Duration of exam(hours) |
| BT-401 | Food Biotechnology | | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-402 | Environmental Biotechnology | | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-403 | Animal Biotechnology | | core | 4 | 4 | 20 | 80 | 100 | Three |
| BT-404 | Genomics, Proteomics and Metabolomics | Any one | elective | 4 | 4 | 20 | 80 | 100 | Three |
| BT-405 | Biosafety,Bioethics and IPR Issues | elective | 4 | 4 | 20 | 80 | 100 | Three |
| BT-406 | Lab Course based on Food and Environmental Biotechnology | | core | 4 | 8 | 20 | 80 | 100 | Six  (Two sessions of three hours each) |
| BT-407 | \*Project Work /Field Training Report | | core | 4 |  |  | 100 | 100 |  |
|  |  | | Total Credits-24 | | | Total Marks- 600 | | | |

**Total Credits-102** **Grand Total of Marks-2550**

\*Candidates shall be allotted to teachers at the beginning of IInd semester to facilitate the students to carry work during semester break in house or in other institutes. Project report would be prepared under guidance of teacher.

**Semester – 1**

**Paper BT-101 Biomolecules**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs.**

**Objectives**: The objective of the course is to introduce students to the world of basic biochemistry. This course covers structure and function of biomolecules, and details of physical and chemical basis of biomolecules involved in life processes.

**Outcomes**: The programme aims at providing students with the methodological concepts and tools needed to acquire top-level skills in the field of biochemistry. After completing the course, the students will be able acquire an extensive and sound knowledge base for advanced biochemistry courses and research **NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit-I**

**Water :**Structure, hydrogen bonding, as a biological solvent, ionization and fitness of the aqueous environment for living organisms; pH; Buffers; Henderson-Hasselbalch equation; Physiological buffers.

**Carbohydrates :**Structure, occurrence and biological importance of important monosaccharides, oligosaccharides and polysaccharides; Ring structures and anomeric forms; mutarotation; sugar derivatives; reactions of monosaccharides; Glycosaminoglycans; Heteropolysaccharides of bacterial and algal cell walls; Proteoglycans; Glycoproteins; Lectins.

**Unit-II**

**Amino acids and Proteins**: Common structural features, classification by R group, Zwitter ion structures, acid-base properties and titration curves of amino acids; Essential amino acids; Separation of amino acids; Peptides including biologically active peptides; Classification and different structural levels (Primary, secondary, tertiary & quaternary) of proteins; Ramachandran plot; Determination of amino acid composition of proteins; Characteristic amino acid composition of proteins; Determination of amino acid sequences of proteins; Effect of amino acid sequence on the function of a protein and stability of α-helix; Protein folding and role of chaperons in protein folding; Chemical synthesis of polypeptides.

**Unit-III**

**Lipids :**Classification, structures, nomenclature and properties of fatty acids; Essential fatty acids; Acylglycerols; Characterization of fats-Saponification value, iodine number, rancidity, acid value,Reichert-Meisselnumber; Structure and properties of different types of phospholipids and sphingolipids (sphingomyelins, cerebrosides & gangliosides); Structure and functions of prostaglandins, Prostacyclins, Thromboxanes, and Leukotrienes; Terpenes of biological significance; Sterols and bile acids.

**Unit-IV**

**Nucleic Acids:**Structure and properties of purines and pyrimidine bases; Nucleosides and Nucleotides; Biologically important nucleotides; Nucleic acids as the genetic material – experimental evidences; Chargaff’s rules; The covalent backbone of nucleic acids; Double helical model of DNA structure; Structural polymorphism of DNA (A,B and Z-DNA) and RNA; Denaturation & annealing of DNA; Biological functions of nucleotides; Chemical synthesis of oligonucleotides.

**Recommended Books:**

1. Lehninger: Principles of Biochemistry, 5th edition, by David L. Nelson and M.M. Cox (2008) Maxmillan/Worth publishers/W.H. Freeman & Company

2. Biochemistry (2004) by J.David Rawn, Panima Publishing Corporation, New Delhi

3. Biochemistry, 5th edition, by R.H. Garrett and C.M. Grisham (2012).Michal Sabat, University of Virginia.

4. Biochemistry, 5th edition, by Jeremy M Berg, John L Tymoczko, and Lubert Stryer. (2002). W.H. Freeman & Co., N.Y.

5. Fundamentals of Biochemistry, 4 edition, by Donald Voet, Judith G.Voet and Charlotte W. Pratt (2006), John Wiley & Sons, INC

6. Biochemistry: The chemical reactions of living cells, 2nd edition, by David E.Metzler (2001), Harcourt Academic Press.

7. Principles of Peptide synthesis (1984), Miklos, Bodansky,Springer-Verlag Berlin, Heidelberg

**Semester – I**

**Paper BT-102 Microbiology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives**: This is the basic course that covers the microbial ecology; structure, nutrition, growth, salient features, classification and identification of microorganisms; Industrial importance of microbes; methods of their isolation, purification and preservation; Methods of sterilization, their validation; Disinfectants; Antibiotics and their potency; Food and water borne diseases and control of food spoilage; Toxins etc.

**Outcomes**: This fundamental course will help the students to get acquainted with the types of microbes, their isolation, storage, handling and safety measures; Aseptic techniques; Tests useful in taxonomy, nutritional and physical requirements of various types of microbes; Antimicrobial agents and their action; Industrial applications of microbes etc. This course will lay foundation to understand the applied part of Microbial Biotechnology very easily and clearly.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit – I**

Various branches and applications of Microbiology, History and contributions of various scientists to this science with particular reference to the contribution of the following scientists- A.V.Leeuwenhoek, Louis Pasteur, Edward Jenner, Robert Koch, Alexander Fleming and Joseph Lister.

Morphology and arrangement of bacterial cells, Bacterial- flagella, Fimbriae, capsule, spores and cysts, cell walls of Gram +ve and Gram –ve bacteria, Nutritional requirements and nutritional categories of microorganisms, Physical factors for growth, Enrichment culture techniques for isolation of microorganisms, pure culture techniques and preservation techniques, study of growth curve, measurement of growth.

**Unit – II**

Distinguishing features of bacteria, viruses, fungi, protozoa, algae. Introduction to Microbial Classification and Taxonomy, Taxonomic ranks, Various approaches for identification of microorganisms including molecular approaches; Gram (+) and Gram (-) bacteria of medical and industrial importance. Characteristics of Mycobacterium and Mycoplasmas; photosynthetic prokaryotes (purple bacteria, green bacteria, cyanobacteria) and actinomycetes; brief account of different types of viruses with special reference to lambda phage, herpes, adenoviruses and retroviruses, viriods and prions; fungi and algae of industrial importance.

**Unit – III**

Sterilization methods- dry heat, moist heat, radiations, filtration, gaseous sterilization. Validation of sterilization processes; Factors affecting antimicrobial action, Mode of action of antimicrobial agents, Antibiotics and their mode of action, Microbiological assay of antibiotics (ampicillin, streptomycin, tetracycline etc.), Disinfectants, Types of toxins and their mode of action.

**Unit – IV**

Microbial ecology: Biogeochemical cycles; Physical environment: Microenvironment & Niche, Microorganisms and ecosystems. Soil microbiology: Types & functions of microorganisms in soil. Microorganism associations with vascular plants (Mycorrhizae, Rhizobia), Microorganism growth in Foods. Methods to control food spoilage, Food born diseases.

**Recommended Books:**

1. Lim, D.V. (1989) Microbiology, West Publishing Company, New York.
2. Brock, T.D. (1990) Microbiology: A text book of Industrial Microbiology. 2nd edition, Sameur Association.
3. Tortora, G.J., Funke, B.R. and Case, (2013) Microbiology: An introduction, Benjamin Cummings.
4. Atlas, R.M. (1998) Microbiology: Fundamental and applications. 2nd edition,Macmillan Publishing Company, New York.
5. Pelczar, M.J., Chan, E.G.S. and Krieg, N.R. (1998) Microbiology.
6. Heritage, J., Evance, E.G.V. and Killington, R.A. (1999) Microbiology in action. Cambridge University Press.
7. Prescott, L.M., Harley, J.P. and Klein, D.A. (2008) Microbiology. McGraw-Hill Higher Education
8. Polasaa, H. Microbial gene technology. South Asian Publishers. New Delhi.

**Semester-I**

**Paper BT-103 Molecular Cell Biology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs.**

**Objectives:** The objective of the course is to make the students to understand the basic concepts of cell biology at molecular level and to have an insight of cellular and molecular aspects of life.

**Outcomes:** At the end of the course, it is expected that students have understood the fundamentals of molecular process of life. This would help them to appreciate life and to understand other courses in biotechnology in the subsequent semesters.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit-I**

**Overview of cells and cell research:**Origin and evolution of cells, Cells as experimental models, tools of cell biology.

**Fundamentals of Molecular Biology**: Heredity, Genes, and DNA, Expression of Genetic Information, Recombinant DNA, Detection of Nucleic Acids and Proteins, Gene Function in Eukaryotes

**Unit-II**

**Nucleus**: Nuclear envelope and traffic between the nucleus and cytoplasm, internal organization of the nucleus, nucleolus, nucleus during mitosis.

**Protein Sorting and Transport**: Endoplasmic reticulum, Golgi apparatus, and Lysosomes, mechanism of vesicular transport

**Unit-III**

**DNA Replication:**DNA polymerases, replication fork, fidelity of replication, origins and initiation of replication, replication at the ends of chromosomes.

**DNA Repair:**Direct reversal of DNA damage, excision repair, error-prone repair, recombinational repair.

**RNA Synthesis and Processing:**Prokaryotic transcription, Eukaryotic transcription: RNA polymerases and transcription factors, RNA processing and turnover,

**Protein Synthesis, Processing and Regulation:**Translation of mRNA, Protein folding and processing, regulation of protein function, protein degradation

**Unit-IV**

**Cell Signaling**: Signaling molecules and their receptors, functions of cell surface receptors, pathways of intracellular signal transduction, signal transduction and cytoskeleton, signaling in development and differentiation.

**Cell death and cell renewal:**programmed cell death, stem cells and maintenance of adult tissues. Embryonic stem cells and therapeutic cloning.

**Cancer**: Development and causes of cancer, tumor viruses, oncogenes, tumour suppressor genes, application of molecular biology to cancer prevention and treatment

**Recommended Books**

1. The Cell - A Molecular Approach, Cooper, Geoffrey M. Sunderland (MA): Sinauer Associates, Inc. ; c2000

2. Cell and Molecular Biology: Concepts and Experiments, 5th Edition, Gerald Karp : Wiley 2007

3. Essentials of Molecular Biology, David Friefilder, Jones and Barllett Publications.

4. Gene VII (7th Edition) Benjamin Lewin, Oxford University Press, U.K., 2000.

5. Molecular Biology and Biotechnology. A comprehensive desk reference, R.A. Meyers (Ed.) VCH Publishers, Inc., New York, 1995.

6. Molecular Biology LabFax, T.A. Brown (Ed.), Bios scientific Publishers Ltd., Oxford, 1991.

7. Molecular Biology of the Cell (2nd edition) B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, and J.D. Watson. Garland publishing, Inc., New York, 1994.

8. Molecular Biology of the Gene (4th edition), J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A .M. Weiner, The Benjamin/Cummings Publ. Co., Inc., California, 1987.

9. Molecular Biology of the Gene (7th Edition) by [James D. Watson](http://www.amazon.com/James-D.-Watson/e/B001KD83S2/ref=dp_byline_cont_book_1)  [Tania A. Baker](http://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=Tania+A.+Baker&search-alias=books&field-author=Tania+A.+Baker&sort=relevancerank) , [Stephen P. Bell](http://www.amazon.com/Stephen-P.-Bell/e/B00CTTBTKK/ref=dp_byline_cont_book_3) , [Alexander Gann](http://www.amazon.com/Alexander-Gann/e/B00CTUIFJM/ref=dp_byline_cont_book_4)  , [Michael Levine](http://www.amazon.com/s/ref=dp_byline_sr_book_5?ie=UTF8&text=Michael+Levine&search-alias=books&field-author=Michael+Levine&sort=relevancerank) , [Richard Losick](http://www.amazon.com/s/ref=dp_byline_sr_book_6?ie=UTF8&text=Richard+Losick&search-alias=books&field-author=Richard+Losick&sort=relevancerank) **.**Pearson, 2013

10. Molecular Cell Biology(4th edition) by Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. NewYork: W. H. Freeman; 2000.

11. Encyclopaedia of Molecular Biology, J. Kendrew, Blackwell Scientific Publications, Oxford.

**Semester – I**

**Paper BT-104 Biotechniques**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs.**

**Objectives:** The aim of the course is to create broad understanding of principles, applications and instrumentation of analytical techniques used in biotechnology.

**Outcomes:** At the end of the course, the students will have understanding of the techniques and instrumentation used in biotechnology. This is essential because they have to use these tools and methodologies for the better understanding of the basic and applied aspects of biotechnology in forth coming semesters.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit -I**

**Cell Separation, disruption, extraction and concentration techniques:**

Microfiltration, Centrifugation, Ultrasonication, High pressure Homogenisation, Bead Milling, Ultrafiltration, Diafiltration and their applications, reverse osmosis, Lyophilisation.

**Centrifugation Methods:**Principles of Sedimentation, centrifugation techniques and their applications, differential centrifugation, density gradient and ultracentrifugation techniques.

**Unit -II**

**Microscopy:**Light Microscopy – Magnification, Resolving power, Numerical aperture, Limit of Resolution, Principles and applications of bright field, phase contrast, fluorescence, scanning and transmission electron microscopy.

**Spectroscopy:**Principles of biophysical methods used for analysis of biopolymer structure -X-ray diffraction, fluorescence, UV and visible, ORD/CD, NMR and ESR spectroscopy, Atomic absorption and Atomic emission spectroscopy.

**Unit -III**

**Chromatography:**Principles and applications of Paper, Thin layer,Gel-filtration, ion-exchange, Affinity chromatography, Gas liquid chromatography, High pressure liquid chromatography (HPLC); Reversed Phase chromatography ,Hydrophobic interaction chromatography.

**Unit -1V**

**Electrophoresis:**Concept, Factors affecting electrophoresis, Agarose gel electrophoresis, Pulse field gel electrophoresis, PAGE, SDS-PAGE, Isoelectrofoccusing, 2 Dimentional electrophoresis

**Radioisotope Techniques:**Radioactivity, Units of radioactivity, Radioactive decay, Rate of radioactive decay, Measurement of radioactivity- Geiger counter, Liquid scintillation counting, Autoradiography, Effect of radiations on biological system, Cerenkov radiations, Tracer technique-Principle and applications

**Recommended Books:**

1. Molecular Cloning : a Laboratory Manual, J. sambrook, E.F. Fritsch and T.Maniatis, Cold Spring Harbor Laboratory Press, New York, 2000

2. Richard E. Venn (2003), Principal and Practice of Bioanalysis. Taylor and Francis.

3. Walker J. and Wilson K (2010), Principles and Techniques-PracticalBiochemistry, 7th Edition, Cambridge University Press, London.

4. Freifelder D. (1982), Physical Biochemistry – Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman and Company, San Fransisco

5. Slater R.J. (2002), Radioisotopes in Biology-A Practical Approach, Oxford University Press, New York

6. Switzer R.L. and Garrity L.F.(1999), Experimental Biochemistry, W.H. Freeman and Company, New York

7. Sawhney, S.K. and Singh R (2005), Introductory Practical Biochemistry, Alpha Science International.

8. Atlas R.M. (1995), Microbiology – Fundamentals and Applications, Mc Millan Press, New York

9. Upadhayaye, A ; Upadhyaye, K and Nath N. (2002), Biophysical Chemistry : Principles & Techniques, Himalaya Publication House, New Delhi.

10. David Sheehan, Physical Biochemistry; Principles and applications (2000):Wiley Press

11. Simon Roe, Protein purification techniques –A practical approach, Oxford University Press.

**Semester – I**

**Paper BT-105 Lab. Course based on Biomolecules and Biotechniques**

**Marks: 80**

**Internal Assessment: 20**

**Time: Six hours(Two Sessions of Three Hours each)**

1. Safety measures to be taken while handling Biochemicals.

2. Working of Spectrophotometer and verification of Lambert – Beer’s Law.

3. Preparation of various types of solutions – Standard solution, Molal, Molar, Normal, acid solution, Buffers etc.

4. Preparation of Standard Curves for quantitative estimations.

5. Extraction and estimation of sugar from biological materials

6. Titration curve for amino acids

7. Estimation of proteins by Biuret, Lowry and Bradford method.

8. Analysis of fats/oils – iodine number, saponification value, acid value, free fatty acids.

9. Determination of various metabolites in given biological samples.

10. Quantitative estimation of DNA and RNA content in the given sample by colored reaction.

11. Paper and Thin Layer Chromatography

12. Gel Filtration, Ion-exchange and Affinity Chromatography

15. Agarose gel electrophoresis and PAGE

13. Microscopy, Centrifugation

14. Microfiltration, Ultrafiltration, Ultrasonication and Lyophilisation

**Semester – I**

**Paper BT-1 Paper BT-106 Lab. Course based on Molecular Cell Biology & Microbiology**

**Marks: 80**

**Internal Assessment: 20**

**Time: Six hours (Two Sessions of Three Hours each)**

1. Genomic DNA isolation from *E .coli*and blood.

2. RNA isolation from *E. coli*/ blood

3. Plasmid DNA isolation from *E. coli.*

4. Molecular weight determination of the DNA.

5. Spectrophotometric analysis of DNA/ RNA.

6. Determination of Tm value.

7. Plasmid purification using DNA binding membrane

8. Lab rules for biosafety in Microbiology lab.

9. Measurement of the growth of microbial culture.

10. Study of Thermal death point and thermal death time of microbes.

11. Isolation and enumeration of micro-organisms of air, water and soil.

12. Pure culture of micro-organisms.

13. Various staining methods – Gram staining, capsule, spore, fungal staining etc.

14. Micrometry

15. Phage titration studies.

16. Growth curve.

17. Biochemical tests useful in bacterial taxonomy.

18. Parameters for identification of unknown micro-organisms.

19. Antibiotic sensitivity test and MIC value.

20. Evaluation of disinfectants and antiseptics/ antiseptics, evaluation of sterilization methods.

**Semester -II**

**Paper BT-201 Genetic Engineering**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives:** Thiscourse aims to introduce the students to field of Genetic Engineering including introduction, basic principles, milestones, scopes and advances.

**Outcomes:** At the completion of this course, students would understand concept and scopes of Genetic Engineering and central role of recombinant DNA technology in all fields of Biotechnology. They would be acquainted with basic concepts and different methodologies used for isolation, purification and manipulation of nucleic acids, gene cloning, transformation, selection of desired clones, protein-protein interactions, site directed mutagenesis, gene expression and regulation, and nucleic acid sequencing. It is expected that students have understood the concepts and methodology of PCR and its uses in diverse fields of life sciences.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit – I**

**Genetic Engineering**

Introduction and scope of Genetic Engineering, Miles stones in Genetic engineering, Central role of *E.coli*.

**Nucleic Acids**

Purification of total cell DNA, plasmid DNA, phage DNA, Yield Analysis, , Nucleic acid blotting and hybridization

**Manipulation of purified DNA**

DNA modifying enzymes- Terminal deoxynucleotidyl transferase, Polynucleotide kinase, Alkaline phosphatase, Nucleases, Methylases

Restriction Endonucleases- Host controlled restriction and modification, Nomenclature, types, Recognition sequence, blunt and sticky ends, applications.

Ligases- *E. coli*and T4 DNA ligases, Linker, Adaptor, Homopolymer tailing

**Gene Cloning Vectors**

General features, Types of cloning vectors- Plasmid,bacteriophage,phagemid,cosmid,artificial chromosomes (YAC, BAC, PAC)

**Unit – II**

**Transformation of *E. coli***

Concept, Selection of transformed cells, Identification of recombinants (bacteria and phages)

**Cloning of Specific Gene**

Direct selection, identification from a gene library-genomic library, cDNA synthesis and cloning-Properties of cDNA, mRNA enrichment, cDNA library.

**Methods for Clone Identification**

Screening strategies-Colony and plaque hybridization, Abundancy probing, Heterologus probing, Immunological screening, Differential screening, Subtractive hybridization.

**Protein-Protein interactions-**Phage display, Yeast two hybrid system, Yeast three hybrid system.

**Unit – III**

**Nucleic Acid Sequencing**

DNA Sequencing: Rapid DNA sequencing techniques and strategic details of range of methodologies eg. Dideoxyribonucleotide chain termination, Chemical degradation, Automated DNA sequencing, Thermal cycle sequencing, Pyrosequencing.

**Polymerase Chain Reaction**

Concept, Basic PCR reaction, Factors affecting the PCR, Types of PCR ( RT- PCR, Real time PCR, Allele specific PCR, Multiplex PCR) , Applications of PCR

**Site Directed Mutagenesis**

Oligonucleotide directed mutagenesis, PCR amplified oligonucleotide directed mutagenesis, Random mutagenesis with degenerate oligonucleotide primers / nucleotide analogs.

**Unit – IV**

**Gene expression and Regulation studies**

Primer extension, S1 mapping, Gel retardation assay, Deletion analysis, Reporter genes, DNA foot printing, Modification interference assays, HRT, HART

**Manipulation of gene expression in prokaryotes**

Problems with production of recombinant proteins in *E coli*, Optimizing expression of foreign genes in *E.coli*- Strong and regulatory promoters, Codon usage, Fusion proteins, Increasing protein stability and secretion, Translation expression vectors, Protease deficient host strains.

**Heterologous protein production in Eukaryotes**

*Saccharomyces cerevisiae*and *Pistia pastoris*expression systems, Baculovirus Insect cell expression systems, Mammalian cell expression system

**Recommended Books:**

1. Gene cloning and DNA analysis – An Introduction (2015) 7th edition, T.A Brown, Blackwell publisher.

2. Essential genes (2006), Benzamin Lewin, Pearson education international.

3. Genome-3 (2007) T.A Brown. Garland science, Taylor & Francis, NewYork.

4. Principles of gene manipulation and Genomics (2006) 7th edition, S.B Primose and R.M Twyman, Blackwell publishing.

5. Principles of Genetic Engineering (2009), Mousumi Debnath, pointer publisher, Jaipur.

6. Molecular Biotechnology-Principles and Applications of Recombinant DNA (2003) 3rd edition, Bernard R Glick and Jack J pasternak. ASM press, Washington.

7. Human Molecular Genetics (2004) 3rd edition, Tom Strachan & Andrew P Read, Garland science.

8. Molecular Biology of Gene (2008) 6th edition, Watson, Baker,Bell. Gann,Levine and Losick, Pearson education Inc.

9. Biotechnology-Applying the genetic Revolution (2009), Clark and Pazdernik, Academic Press

10. Molecular Cloning : A Laboratory Manual (2000), J. sambrook, E.F. Fritsch and T.Maniatis, Cold Spring Harbor Laboratory Press, New York

11. DNA Cloning : A Practical Approach (1995) , D.M. Glover and B.D. Hames, IRL Press, Oxford,

12. Genetic Engineering. An Introduction to gene analysis and exploitation in eukaryotes (1998), S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford.

**Semester - II**

**Paper BT-202A Animal Cell & Tissue Culture**

**Marks: 40**

**Internal Assessment: 10**

**Time: 3 hrs**

**Objectives**: The objective of this course is to teach students the different aspects of animal cell culture. Also it is desired to make them understand that how a culture is established, propagated and characterized and what are the applications of animal cell cultures.

**Outcomes**: At the end of the course, the students are expected to understand the establishment, maintenance, characterization as well as applications of animal cell cultures. Students will also learn the use of animal cells for production of high value therapeutics as well as for various *in vitro* tests.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit - 1**

**Animal cell and tissues culture**: Historical background, development, advantages and limitations of cell & tissue culture.

**Requirements of cell & tissue culture:**aseptic area, incubation, preparation and sterilization, storage, specialized equipment, consumable items.

**Aseptic techniques:**elements of aseptic environment, sterile handling, laminar flow, standard procedure.

**Culture vessels and substrates:**the substrate, choice of culture vessel, treated surfaces.

**Unit-II**

**Defined media and supplements:**physicochemical properties, balanced salt solutions, complete media, role of serum and supplements, **serum free media**: advantages and disadvantages of serum and serum free media, replacement of serum, development of serum free media.

**Unit-III**

**Primary culture:**types of primary cell culture, isolation of the tissue, primary culture,

**Sub-culturing of animal cells:**Subculture and propagation, Criteria for subculture, Subculture of monolayer cells, growth cycle and split ratio, propagation and subculture in suspension.

**Cloning and selection:**dilution and suspension cloning, scaling up in suspension and monolayer, large scale production of cells using bioreactors, micro-carriers and perfusion techniques.

**Cell line characterization**: need for characterization, authentication, cell morphology, chromosome content, DNA content, RNA and protein expression, enzyme activity, antigen markers.

**Unit-IV**

**Production of high value therapeutics**: enzymes, hormones, monoclonal antibody, cytokines, tissue plasminogen activators**.**

**Applications of animal cell culture:**virology, cancer research, gene therapy, drug development and cytotoxicity, animal cloning, genetic counseling, cryopreservation of cells.

**Recommended Books:**

1. Animal Cell Culture - Practical Approach ( 3rd edition), Ed. John R.W. Masters, Oxford, 2000.

2. Animal Cell Culture Methods In: Methods in Cell Biology, Vol. 57, Ed. Jenni P Mather and David Barnes, Academic Press.

3. Animal Cell Culture Techniques. Ed. Martin Clynes, springer.

4. Biotechnology, Vol. 7b 1993 Rehm. H.J. and Reed, G.(eds) VCH Publications.

5. Cell Culture Lab Fax. Eds. M Butler & M. Dawson, Bios Scientific Publications Ltd. Oxford.

6. Cell Growth and Division: a Practical Approach. Ed. R. Basega, IRL Press.

7. Culture of Animal Cells, (6th edition), R. Ian Freshney. Wiley-Liss, 2010.

**Semester - II**

**Paper BT- 202B - Plant Cell & Tissue Culture**

**Marks: 40**

**Internal Assessment: 10**

**Time: 3 hrs**

**Objectives:**

* + - * To develop trained and skilled manpower in the field of plant tissue culture.
      * To ensure better quality of education by continuous monitoring and review of performance and counseling students.
      * To enhance problem-solving skills of students through applying state-of -art techniques.
* To supplement the academic input of students by way of seminars, conferences, guest lectures and industry oriented projects/ visits.

**Outcomes:** Trained and skill development of students in various aspects of plant tissue culture such as: in aseptic manipulations of plant tissue culture, to micro-propagate crop and medicinal plants for large scale production of propagule material, learn techniques for production of somatic embryos and synthetic seeds, in the field of germplasm preservation, for large scale culture of isolated free plant cells that may be used for various purposes, for production of virus/pathogen free plants and for novel plant varieties development for the improvement of crop plants via somaclonal variations, wide hybridization, haploid plant production, somatic hybrids and cybrids production.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit - I**

Introduction to plant cell tissue culture and historical perspective.

Laboratory organization, aseptic manipulations and, culture media – composition, preparation and development.

Callus culture; Initiation and maintenance of suspension culture- batch and continuous culture, assessment of growth and viability; Static techniques of single cell culture. Organogenesis, somatic embryogenesis and synthetic seeds.

**Unit - II**

Micropropagation – technique, factors affecting *in vitro*culture of plants (physical, chemical, genotypic and others), applications and limitations of micropropagation.

Meristem, shoot tip culture and production of virus free plants.

Somaclonal variations, molecular basis of variation and their significance in plant breeding.

**Unit - III**

*In vitro*production of haploid plants – Androgenesis (anther and pollen culture) and Gynogenesis (ovary and ovule culture). Significance and uses of haploids in agriculture.

Wide hybridization and embryo rescue technique.

**Unit - IV**

Protoplast culture and somatic hybridization – Isolation, culture and fusion of protoplast, selection of fusion products and plant regeneration, assessment of somatic hybrid plants, production of cybrids, applications of protoplast culture and somatic hybridization in the improvement of crop plants.

*In vitro*germplasm conservation and cryopreservation.

**Recommended Books:**

1. Plant tissue culture – Theory and Practice (2005) by Bhojwani S. S. and Razdan M. K., Elsevier publication.

2. Elements of Biotechnology by P. K. Gupta, Rastogi pub.

3. Biotechnology in crop improvement (1998) by H. S. Chawla, International Book distributing company.

4. Plant cell, organ and tissue culture (1995) by Gamborg O.L. and Phillips G.C., Springer Verlag pub. Germany.

5. Plant Tissue Culture – Basic & Applied (2005) by Jha T.B. & Ghosh B., Universities press.

6. Plant cell culture – A practical approach (1994) Dixon R.A., Gonzales R.A. Oxford University press, UK.

7. Bhojwani S.S. (2003), Agrobiotechnology & Plant Tissue Culture

8. Smith R.H. (2000), Plant Tissue Culture, Academic Press

9. Evans D.A. (2003), Plant Cell Culture, Taylor & Francis

**Semester - II**

**Paper BT–203 Bioinformatics**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives**: The aim of this course is to introduce the students to the basics of bioinformatics. This includes teaching the basis of the biological system via information and technology.

**Outcomes**: After completing the course, students will be able to learn various methods of shortlisting, analyzing, interpreting the vast biological data generated in *in vitro* and *in vivo* experiments. They will also learn application of various bioinformatics tools that will help in generating more accurate predictions.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit –I**

**Bioinformatics and Biological Databases**

**Bioinformatics**: Introduction**,**Goal, Scope, Applications, Limitations, and New Themes

**Biological Databases:**Introduction**,**Types of Databases, Biological Databases, Pitfalls of Biological Databases, Information Retrieval from Biological Databases

**Sequence Alignment**

**Pairwise Sequence Alignment:**Evolutionary Basis, Sequence Homology versus Sequence Similarity, Sequence Similarity versus Sequence Identity, Methods, Scoring Matrices, Statistical Significance of Sequence Alignment

**Database Similarity Searching:**Unique Requirements of Database Searching, Heuristic Database Searching, Basic Local Alignment Search Tool (BLAST), FASTA, Comparison of FASTA and BLAST, Database Searching with the Smith– Waterman Method

**Multiple Sequence Alignment:**Scoring Function, Exhaustive Algorithms, Heuristic Algorithms, Practical Issues

**Profiles and Hidden Markov Models:**Position-Specific Scoring Matrices, Profiles, Markov Model and Hidden Markov Model

**Protein Motifs and Domain Prediction:**Identification of Motifs and Domains in Multiple Sequence Alignment, Motif and Domain Databases Using Regular Expressions, Motif and Domain Databases Using Statistical Models, Protein Family Databases, Motif Discovery in Unaligned Sequences, Sequence Logos

**Unit -II**

**Gene and Promoter Prediction**

**Gene Prediction:**Categories of Gene Prediction Programs, Gene Prediction in Prokaryotes, Gene Prediction in Eukaryotes

**Promoter and Regulatory Element Prediction:**Promoter and Regulatory Elements in Prokaryotes, Promoter and Regulatory Elements in Eukaryotes, Prediction Algorithms

**Molecular Phylogenetics**

**Phylogenetics Basics:**Molecular Evolution and Molecular Phylogenetics, Terminology, Gene Phylogeny versus Species Phylogeny, Forms of Tree Representation, Why Finding a True Tree Is Difficult, Procedure

**Phylogenetic Tree Construction Methods and Programs:**Distance-BasedMethods, Character-Based Methods, Phylogenetic Tree Evaluation, Phylogenetic Programs

**Unit -III**

**Structural Bioinformatics**

**Protein Structure Basics:**Amino Acids, Peptide Formation, Dihedral Angles, Hierarchy, Secondary Structures, Tertiary Structures, Determination of Protein Three- Dimensional Structure, Protein Structure Database

**Protein Structure Visualization, Comparison, and Classification:**Protein Structural Visualization, Protein Structure Comparison, Protein Structure Classification

**Protein Secondary Structure Prediction:**Secondary Structure Prediction for Globular Proteins, Secondary Structure Prediction for Transmembrane Proteins, Coiled Coil Prediction

**Protein Tertiary Structure Prediction:**Methods, Homology Modeling, Threading and Fold Recognition, Ab Initio Protein Structural Prediction, CASP

**RNA Structure Prediction:**Introduction, Types of RNA Structures, RNA Secondary Structure Prediction Methods, Ab Initio Approach, Comparative Approach, Performance Evaluation

**Unit -IV**

**Genomics and Proteomics**

**Genome Mapping, Assembly, and Comparison:**Genome Mapping, Genome Sequence Assembly, Genome Annotation, Comparative Genomics

**Functional Genomics:**Sequence-Based Approaches, Microarray-Based Approaches, Comparison of SAGE and DNA Microarrays

**Proteomics:**Technology of Protein Expression Analysis, Posttranslational Modification, Protein Sorting, Protein–Protein Interactions

**Recommended Books:**

1. Bioinformatics for Dummies, Jean-Michel Claverie, Cedric Notredame, 2003, John Wiley & Sons

2. Bioinformatics Computing, Bryan P. Bergeron, 2002, Prentice Hall

3. Introduction to Bioinformatics, Arthur M. Lesk, 2002, Oxford University Press

4.Instant Notes in Bioinformatics, D.R. Westhead, J. H. Parish, R.M. Twyman, 2002, Bios Scientific Pub

5. Fundamental Concepts of Bioinformatics, Dan E. Krane, Michael L. Raymer, Michaeel L. Raymer, Elaine Nicpon Marieb, 2002, Benjamin/Cummings

6. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Second Edition, Andreas D. Baxevanis, B. F. Francis Ouellette, 2001, Wiley- Interscience

7. Introduction to Bioinformatics, Teresa Attwood, David Parry-Smith,2001, Prentice Hall

8.Bioinformatics: A Primer, Charles Staben, 2001, Jones & Bartlett Pub

9. Bioinformatics: Sequence and Genome Analysis, David W. Mount, 2001, Cold Spring Harbor Laboratory Press

10.Bioinformatics: Sequence, Structure and Databanks: A Practical Approach (The Practical Approach Series, 236), Des Higgins (Editor), Willie Taylor (Editor), 2000, Oxford Univ Press

**Semester II**

**Paper BT- 204 Enzyme Technology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives**: This Enzyme-Technology oriented course covers the applications of enzymes in various industries; classification of enzymes on the basis of their structures, functions and their salient features; How enzymes work and their regulation; Strategies being adopted for production, isolation, purification and Characterization of enzymes at laboratory and industrial scale from plant, animal and microbial sources; Strategies for immobilization and engineering of enzymes etc.

**Outcomes**: This foundation course on Enzyme Technology will help the students to understand the nature, structure, function, kinetics, specificity, categories and regulation of enzymes. The students will get acquainted with their role in various sectors and how their structure can be modified to make them industrially suitable.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit-I**

History of enzymology, advantages of enzymes over chemical catalysts, Nomenclature and classification of enzymes; Determination of three dimensional structure of enzyme by X-ray crystallography and NMR spectrometry, importance of3-D structure of an enzyme; Classification of enzyme structures, structures adopted by enzymes, principles that govern the 3-D structure adopted by enzymes; Forces for stability of 3-D structure; Denaturation and renaturation;Isoenzymes, enzyme specificity, monomeric and oligomeric enzymes, multienzyme complex, holoenzyme, apo-enzyme, cofactor, coenzyme, prosthetic group; enzyme activity unit, turn over number and specific activity, Ribozymes and Abzymes – A brief account.

**Unit -II**

Enzyme action; effect of enzyme on the rate and equilibrium of a reaction; principles that explain catalytic power and substrate specificity of enzymes; enzyme substrate complex, factors responsible for catalytic efficiency of enzyme; proximity and orientation effect, acid-base catalysis, covalent catalysis, strain and distortion theory; Nature of active site, identification of functional groups at active sites; regulatory enzymes- covalently modulated enzymes, allosteric enzymes and their mode of action; regulation of enzyme activity in the living system.

**Unit -III**

An introduction to enzyme kinetics and its importance, Methods used for investigating the kinetics of enzyme catalyzed reactions; factors affecting the velocity of enzyme catalysed reaction; Michaelis-Menten equation, Vmax, Km and its significance; Lineweaver Burk plot- its advantages and limitations, Eadie- Hofstee and Hanes plots; enzyme inhibition, types of enzyme inhibitions- competitive, uncompetitive, noncompetitive, mixed type inhibition and determination of Ki, feed- back inhibition; Bisubstrate reactions- brief introduction to sequential and pingpong mechanism with examples.

**Unit -IV**

Strategies used for enzyme production, isolation and purification, method of calculating the purification fold; estimation of enzyme activity; characterization of an enzyme, criteria of enzyme purity, determination of the molecular weight (MW) and the number of sub-units of an enzyme; enzyme immobilization and its importance; protein engineering; enzyme therapy, enzyme inhibitors and drug design; enzymes as biosensors, enzyme reactors; Applications of enzymes in medicine, textile, leather, detergent, paper, bakery, dairy industry, beverage and fruit processing, food processing and preservation, clinical applications of enzyme estimation.

**Recommended Books:**

1. Segal, L.H (1975). Enzyme Kinetics, Wiley Interscience, USA

2. Walsh, C (1979). Enzymatic reaction mechanism, Freeman and Company, USA.

3. Gerhartz, W (1990) Enzyme in Industry, production and application VCH.

4. Shultz, A.R. (1994) Enzyme Kinetics, Cambridge Press.

5. Fresht (1995) Enzyme structure and mechanism, 2nd edition, Freeman and Company.

6.Trevor, P. (1995) Understanding Enzymes, 4th edition, Prentice Hall/Ellis, Harwood, England.

7. Dixon, M and Webb E.C (1997) Enzymes, 3rd edition, Academic Press, New York.

8. Nicholas C. Price and Lewis Stevens (2001) Fundamentals of Enzymology. 3rd edition.

**Semester-II**

**Paper BT-206 Biotechnology and Human Welfare-I**

**Marks: 40**

**Internal Assessment: 10**

**Time: 3 hrs**

**Objectives:** The course will provide a basic knowledge of applications of Biotechnology in industrial and medical fields.

**Outcomes:** After the completion of the course, the students would learn the tools and techniques used in industrial and medical biotechnology. They would learn about basics of fermentation and downstream processing, uses of microbes, Probiotics, industrial application of enzymes and enzyme engineering. They would also learn about basic concepts of molecular diagnostics, vaccines, gene therapy, Stem cell technology, DNA fingerprinting, pharmacogenomics and Nano biotechnology.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with four questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting two questions from each unit.

All questions will carry equal marks

**Unit-I**

**Industrial Biotechnology**

Introduction, Isolation and screening of microbes, strain development, process development, Bioreactors, Fermentation Media, Types of fermentation, Downstream processing

Production of organic compounds, enzymes and antibiotics by microbes, Microbial transformation, SCP, Fermented foods, Probiotics

Enzyme Technology-Introduction, Enzymes vs whole cells, Enzyme immobilization, Ribozyme, Abzyme, Industrial applications of enzymes

Protein and enzyme engineering, Metabolic engineering

**Unit-II**

**Medical Biotechnology**

Molecular Diagnostics- PCR to detect infectious diseases, Monoclonal antibodies, Nucleic acid therapeutic agents-Antisense RNA, Ribozyme, interfering RNA, Protein Therapeutics-Pharmaceuticals

Vaccines*:*live, attenuated, killed, subunit, Recombinant and DNA vaccines

Gene Therapy-Types of gene therapy, Augmentation Gene therapy, Targeted gene therapy, Ethical issues

DNA fingerprinting and forensic analysis, Drug designing, Stem cell technology, Tissue Engineering, Pharmacogenomics, Nanobiotechnology

**Recommended Books**

1. Singh B.D. Biotechnology: Expanding Horizon(2010)3rd edition. Kalyani publishers.
2. Gupta P.K. Biotechnology and Genomics (2013) 1st Edition. Rastogi publishers
3. Clark D.V and Pazdernik,N.J Applying Genetic Revolution(2009) Academic Press
4. Watson J.D.et al. Molecular Biology of Gene (6th Ed.) Publisher Benjamin Cummings, (2007).
5. Ratlege, C. and B. Kristiansen, Basic Biotechnology. Cambridge Univ. Press, London. 2001
6. David S L. Genetics to Gene Therapy – the molecular pathology of human disease (1st Ed.) BIOS scientific publishers, (1994).
7. Prescott, Sc and Dunn, C. Industrial Microbiology, McGraw Hill, New York. 1984
8. Jogdand S N. Medical Biotechnology 2nd Edition Himalaya publishers 2008
9. Niemeyer C.M. and Mirkin C.A, Introduction to Nanobiotechnology, Wiley VCH publishers 2003
10. .Glick B.R, Delovitch,T.L and Patten,C.L. Medical Biotechnology,ASM press, (2014).
11. Palmer T. and Bonner P.L. Enzymes, East-West Press.
12. Price, N.C. and stevens L. Fundamentals of Enzymology, Oxford University Press.
13. Nelson, D.L. and Cox, M.M. Lehninger principles of Biochemistry, W.H. freeman and Company , NY
14. Stansbury P.F. et al., Principles of Fermentation Technology, Pergmon Press Oxford.
15. Glazer and Nikaido ,Microbial Biotechnology By WH Freeman &Company, New York.
16. Cruger and Cruger, Biotechnology – A Textbook of Industrial Microbiology, 2nd Edition, Panima Publishing Corporation, New Delhi.

**Semester-II**

**Paper- BT 207 Lab Course based on Genetic Engineering and Cell and Tissue Culture Technology**

**Marks: 80**

**Internal Assessment: 20**

**Time: Six Hours (Two sessions of three hours each)**

1. Restriction Digestion of DNA
2. Ligation of DNA fragments
3. Preparation of competent cells,Bacterial transformation
4. To perform gene amplification using PCR
5. Gene cloning in plasmid vector
6. Gene expression in *E. coli*and analysis of gene product
7. Components of an animal cell culture lab, aseptic techniques used in animal cell culture
8. Preparation of medium and primary cell culture
9. Staining and counting of animal cells, viability/cytotoxic/Proliferative assays in animal cells
10. Trypsinization/Disaggregation of cells
11. Estimation of lipid peroxides in cytotoxicity induced animal cells
12. Freezing and thawing of cells
13. To study the laboratory organization and aseptic manipulations in PTC lab.
14. Preparation of Murashige and Skoog medium, stocks of macronutrients, micronutrients, vitamins and hormones, autoclaving, filter sterilization of hormones and antibiotics.
15. Surface-sterilization of seeds, establishment of axenic plants, acclimatization of tissue culture plants and establishment in pots.
16. Callus induction using various explants.
17. Regeneration of shoots, root induction, role of hormones in morphogenesis.
18. Anther culture
19. Protoplast isolation and culture
20. Initiation and maintenance of cell suspension cultures of plant cells
21. Development of synthetic seeds
22. To study development of S.E.

**Semester – II**

**Paper BT-208 Lab. Course based on Enzyme Technology and Bioinformatics**

**Marks: 80**

**Internal Assessment: 20**

**Time: Six Hours (Two sessions of three hours each)**

1. To estimate the quantity of protein by UV-absorption method
2. To estimate the activity of amylase enzyme in serum/urine, saliva
3. Assaying of alkaline phosphatase activity
4. Study of enzyme kinetics

* Time course of enzyme catalysed reaction
* Effect of substrate concerntration on the activity of enzyme
* To determine the Km and Vmax of the reaction
* Effect of enzyme concentration
* Temperature optima for the enzyme
* pH optima for the enzyme

5. Partial purification of enzyme by change of pH, temperature, addition of organic solvents and ammonium sulphate fractionation and to determine the specific activity of the enzyme

6. Purification of enzyme by Adsorption/Affinity/Ion exchange/gel-filtration chromatography and to determine the specific activity of the enzyme  
  
7. Immobilization of the enzyme

8. Detailed study of NCBI Homepage.

9. To perform BLAST for Nucleotide Sequence

10. To perform virtual library via NCBI

11. To perform BLAST for a protein sequence

12. To perform multiple sequence alignment via CLUSTAL

13. To perform phylogenetic analysis

13. To display PDB structure using Rasmol

14. Comparative study of the two formats: Gene Bank/ Genepept and FASTA

15. Analysis of Prosite pattern

**Semester - III**

**Paper BT-301 Plant Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives:** Plant biotechnology is the current urgent need for the benefit of humankind and development of our nation. Keeping this in mind the curriculum is designed to develop trained and skilled manpower in the field of Plant Biotechnology and particularly in the field of transgenics, plant metabolites and related IPR issues, this is the current demand in the field of Agriculture/Plant biotechnology

**Outcomes:** Trained and skill development of students in various aspects of plant biotechnology such as: in the field of plant genetic transformation techniques, to develop strategies for introducing biotic and abiotic stress resistance/tolerance in plants, they become able to find out new genes via gene tagging, for molecular characterization of transformants, multiple gene engineering, marker free methodologies, gene silencing, learn strategies for molecular farming/pharming, in production of plant secondary metabolites small and large industrial level, technique of biotransformation of metabolites and generate awareness about Intellectual Property Rights, Biosafety and Ethical Issues

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit - I**

**Plant genetic transformation:**

Organization of plant genome – Nuclear genome, Chloroplast genome and mitochondrial genome. Transposon and T – DNA tagging.

Chloroplast transformation – vector designing, method and advantages *Agrobacterium*mediated transformation – Ti and Ri plasmids, role of virulence genes, mechanism of T-DNA transfer, vectors based on Ti and Ri plasmids – cointegrate and binary vectors, technique and factors affecting *Agrobacterium*mediated transformation of plants.

Direct gene transfer – particle bombardment, PEG-mediated, electroporation, microinjection and alternative methods.

Screenable and selectable markers, molecular characterization of transformants. Marker free methodologies, methods for multiple gene transfer in plants.

Gene silencing in transgenic plants.

**Unit - II**

**Strategies for introducing biotic and abiotic stress resistance/tolerance:**

Viral resistance; Fungal resistance; Insect resistance; Herbicide resistance; Various abiotic stresses (like drought, salinity, temperature and flooding).

**Genetic engineering of plants for molecular farming/pharming:**

Production of medically related proteins in plants, nutritional enhancement of plants (carbohydrates, seed storage proteins, vitamins), manipulation of flower colors and other value addition compounds (like industrial enzymes).

**Unit - III**

**Plant cells as biofactories for the production of secondary metabolites:**

Production of useful secondary metabolites through plant cell cultures;

Strategies used for high yield of product – development and selection of high yielding cell line cultures, optimization of factors affecting yield of plant cells (physical culture conditions, media and other biochemicals), bioreactors and immobilized plant cell culture, biotransformation, permeabilization of cells and removal of secreted products.

**Unit - IV**

**Intellectual Property Rights, Biosafety and Ethical Issues –**Intellectual property rights (IPR); Patents, trade secrets, copyright, trademarks; Plant genetic resources; GATT & TRIPPS; Patenting of biological material; Patenting of transgenic organisms and genes; Plant breeders rights (PBRs) and farmers rights; Concerns about GM crops– environmental, biosafety and ethics**.**

**Recommended Books:**

1. Plant Genetic Engineering Vol. 1 - 6 (2003) Singh R. P and Jaiwal P. K. (Eds.), Sci tech publishing LLC, USA.

2. Elements of Biotechnology by P. K. Gupta, Rastogi pub.

3. Biotechnology in crop improvement (1998) by H. S. Chawla, International Book distributing company.

4. Gene transfer to plants by Potrykus I. and Spangenberg G., Springer Verlag, Germany.

5. Plant tissue culture – Theory and Practice (2005) by Bhojwani S. S. and Razdan M. K., Elsevier publication.

6. Plant biotechnology (2000) by Hammond J, McGarvey P. and Yusibov V. (Eds.) Springer verlag, Germany.

7. Plant gene isolation – Principles and practice (1996) by Foster G.D. and Twell D., John Wiley & Sons, USA.

8. Plant Biotechnology – The genetic manipulation of plants (2003) by Slater A., Scott N. and Fowler M., Oxford pub.

9. Practical application of Plant Molecular Biology (1997) by Henry R.J., Chapman and Hall.

10.Plants, genes and agriculture (1994) by Chrispeels M.J., Sadava D.E, Jones & Bartlett pub., UK.

**Semester - III**

**Paper BT-302 Microbial Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives**: The objective of the course is to create general understanding amongst the students in the subject of Microbial Biotechnology. This course will take an in-depth look at how microbes and their metabolic pathways and products can be used in biotechnology. The objective of the course is to understand them a general overview, concepts and basic principles in the subject of Microbial Biotechnology with emphasis on how to apply the knowledge in bio processing.

**Outcomes**: At the end of the course, it is expected that students understood the basic principles of microbial commercial fermentations, knowledge to solve critical problems. It is expected that they will be more confident to use the Bioprocess knowledge in industrial biotechnological application.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit – I**

Microbial Biotechnology: Scopes application and challenges. Isolation preservation and improvement of industrially important microorganisms. Kinetics of microbial growth and product formation. Fermentation system; batch and continuous system, fed batch system, multistage system. Solid state fermentation. Overproduction of primary and secondary metabolites.

**Unit – II**

Fermentation raw materials: Media for industrial fermentations; criteria used in media formulation. Fermenter/bioreactor design and operation; types of fermentor, stirred tank reactor, bubble column reactor, airlift reactor, packed bed reactor, fluidized bed reactor and trickle bed reactor, agitation and aeration in a reactor, mass transfer. Foam formation and control.

**Unit - III**

Industrial production of alcohol (ethanol, wine and beer) and improvement by genetic engineering. Microbial production of acids (citric, acetic and gluconic acid) solvents (glycerol acetone and butanol) aminoacids (lysine and glutamic acid).Production of antibiotics ; Penicillin and cephalosporin.

**Unit – IV**

Microbial polysaccharides: fermentative production of xanthan gums,. Bacterial bioplastics, genetic engineering of microorganisms for the production of poly-3 hydroxyalkanoates.

Microbial inoculants: Food starter cultures; baker’s yeast, starter cultures for the dairy industry, meat starter cultures

Biomass production: single cell protein (SCP) production; microbial inoculants; Microbial transformation of steroids and sterols.

**Recommended Books :**

1. Stansbury P.F. et al. (1997), Principles of Fermentation Technology, Pergmon Press Oxford.

2. Ward O.P., (1998), Fermentation Biotechnology – Principles, Process and Products. Prentice Hall Publishing, New Jersey.

3.Rehm H.J. Reed G.B. Punler A and Stadler (1993), Biotechnology, Vol.1-8, VCH Publication.

4. Prescolt and Dunn (1992), Industrial Microbiology, 4th Edition CBS Publication, New York.

5. Arnold I. Demain and Julian E. Davies (1999), Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press, Washington D.C.

6. Glazer and Nikaido (1998) Microbial Biotechnology By WH Freeman & Company, New York.

7. Cruger and Cruger (2002), Biotechnology – A Textbook of Industrial Microbiology, 2nd Edition, Panima Publishing Corporation, New Delhi.

**Semester - III**

**Paper BT-303 Molecular Genetics**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives:** The purpose of the course is to teach the students about basics and advanced concepts of Molecular Genetics and ensuring that students acquire an extensive and sound knowledge base for future studies.

**Outcomes:** After the completion of the course, the students would acquire the knowledge of genome structure and organization in eukaryotes, DNA mutability, transcription regulation in prokaryotes and eukaryotes, site specific recombination and its biological role, transposition and its mechanisms. They would learn advanced techniques of genome mapping and sequencing, comparative genomics and transcriptome analysis. They would also be acquainted with methodological concepts and tools needed to acquire top-level skills in the field of molecular genetics

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit – I**

**Eukaryotic Genome Structure and Organization**

Genome sequence and chromosome diversity, variation in chromosome number, Special features of metaphase chromosomes, Chromosome banding, Genome size and complexity, organization and content of human genome, Repetitive DNA, Microsatellites, genome wide repeats, Split genes, overlapping genes, cryptic genes, Retrogenes, Multigene families, Pseudo genes

Nucleosome-Basic Structure, spatial arrangements of histones, chromatosome, Solenoid model, Chromatin domains, Chromatin modifications

**The Mutability of DNA**

An overview of mutation and polymorphism, VNTR polymorphism, DNA damage- spontaneous, Induced (Alkylation, oxidation, radiation), Genotoxicity/ mutagenicity test systems - Ames test, Sister chromatid exchanges, Micronucleus, Comet assay

**Unit – II**

**Transcription Regulation in Prokaryotes**

Positive and negative control of transcription, Repression and activation, Organization and regulation of Lac, Trp and Ara operon in *E. coli.,*Organization of genome in lambda phage, Regulation of lytic cascade, Antitermination, Repressor proteins, Establishment of lysogeny, Balance between lysogeny and lytic cycle.

**Transcription Regulation in Eukaryotes**

Eukaryotic activators, DNA binding domains, Transcriptional repressors, Signal transduction and control of transcriptional regulators, Gene silencing, Epigenetic gene regulation

**Regulatory RNAs**

Riboswitches, Interfering RNA (RNAi) and gene expression, Short interfering RNA ( si RNA) and its fuctions, Micro RNA and its fuctions, Antisense RNA and gene expression

**Unit – III**

**Site-Specific Recombination and Transposition**

Concept, Recombinases and their function, cre-lox recombination, Biological role of site specific recombination, Classes of transposableelements-DNA transposons, Virus like transposons, Non viral retro transposons, Mechanism of DNA and RNA mediated transposition

**Genome Mapping**

Shot gun approach, Clone contig approach, DNA markers for genetic mapping, RFLP, SSP, SNPs, Physical mapping-Restriction mapping, Florescent *in situ*hybridization (FISH), Sequence tagged sites (STS) mapping

**Unit – IV**

**Genome Sequencing**

High throughput sequencing, Clone by clone approach, whole genome shot gun sequencing

**Comparative Genomics**

Concept, Comparative genomics of eukaryotes and its role in evolution.

**Transcriptome Analysis**

Transcriptome, Rapid Amplification of cDNA ends (RACE), SAGE, DNA microarrays

**Recommended Books:**

1. Essential genes (2006), Benzamin Lewin, Pearson education international.

2. Genome-3 (2007), T.A Brown Garland science, Taylor & Francis, NewYork.

3. Principles of gene manipulation and Genomics (2006) 7th edition, S.B Primose and R.M Twyman, Blackwell publishing.

4. Molecular biotechnology-Principles and Applications of Recombinant DNA (2003) 3rd edition, Bernard R Glick and Jack J pasternak, ASM press, Washington.

5. Human Molecular Genetics (2004) 3rd edition, Tom Strachan & Andrew P Read, Garland science.

6. Molecular Biology of Gene (2008,) 6th edition, Watson, Baker *etal*, Levine and Losick, Pearson education Inc.

7. Principles of Genetics (2005), 8th Edition,Gardener *et.al,*John Wiley, New York.

8. Essential Genetics – A Genomic Perspective (2002) 3rd Edition, Hartl & Jones, Jones and Bartlett.

9. Genetics: Conceptual approach (2003), Benjamin A.P, W.H. Freeman & Company, New York.

10. Gene IX (2009) Lewin B, Jones and Bartlett.

11. Biotechnology-Applying the genetic Revolution (2009), Clark and Pazdernik, Academic Press

12. Principles of Genetics (2006), 4th edition, Snustad and Simmons, Wiley

**Semester - III**

**Paper BT-304 Immunology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objective:** The objective of this course is to introduce the students the basics and applied aspects of Immunology which include introduction and overview, fundamentals of the immune system including cells and tissues of the immune system, generation of immune cells and their responses and applications of Immune system in health and disease.

**Outcome:** After the completion of the course, it is expected that the students will be able to conceptualize how the innate and adaptive immune responses coordinate to fight invading pathogens. They would be able to understand and describe antigen, antibodies interactions, generation of immune cells responses, hybridoma technology for the production of monoclonal antibodies, recombinant Antibodies, different types of vaccines, development of diagnostics and immunoprophylactics using biotech and nanotech tools.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit - I**

**Introduction and overview**

Introduction and overview of immunology, cells of immune system, innate and cellular immunity, physical and chemical barriers, cellular defenses, inflammation, receptors involved in innate immune system, cells and organs involved in adaptive immune response, fate of antigen after penetration, interrelationship between innate and acquired immunity.

**Unit – II**

**Antigens, antibodies and their interactions**

Requirements of immunogenicity, primary and secondary responses, major classes of antigens, basic structure of antibodies, antibody classes and biological activity, antigenic determinants on immunoglobulins, immunoglobulin super family, organization and expression of immunoglobulin genes, antigen-antibodyinteractions: immunoprecipitation, agglutination, ELISA, immunofluorescence, flow cytometry

**Unit - III**

**Generation of B- cell and T- cell responses**

Biology of B lymphhocytes*:*introduction, ontogeny, B cell membrane proteins, signal transduction molecules associated with membrane immunoglobulins,biology of T- cells*:*antigen specific T cell receptors, T cell differentiation, thymic selection, role of major histocompatibility complex in immune response, activation and function of T and B cells, cytokines, complement system.

**Unit - IV**

**Immune system in health and disease**

Hybridoma technology: commercial production of antibodies using monoclonal antibodies. Vaccines*:*live attenuated, killed, subunit, conjugate and DNA vaccines. Production of recombinant antibodies and edible vaccines, development of diagnostics and immunoprophylactics using biotech and nanotech tools

**Recommended Books:**

1. Benjamin E. Immunology – A short course 4th Edition, John Wiley, New York
2. Kuby J. Immunology,7th Edition, W.H. Freeman & Co., New York
3. Roitt, I.M. Essential Immunology, 12th Edition, Oxford Black Well Science, London
4. Tizard I.R. Immunology – An introduction, 9th Edition, Philadephia Sauders College press.
5. Gupta P.K. Biotechnology and Genomics, Rastogi Publications Meerut
6. Ommerville et al. Alcamo’s Fundamentals of Microbiology, Jones and Barteett Publishers.

**Semester – III**

**Paper BT-305 Medical Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives:** The purpose of the course is to teach the students about basics and advanced concepts in medical biotechnology and ensuring that students acquire an extensive and sound knowledge base for future studies.

**Outcomes:** After the completion of the course, the students would gain thorough understanding of various chromosomal, gene and mitochondrial disorders, different approaches to detect these disorders, nucleic acid and protein therapeutics, different types of vaccines, gene therapy and DNA fingerprinting. They would also learn advanced techniques such as, nanobiotechnology and pharmacogenomics. It is expected that students would have a broad understanding of the biomedical research for biotechnological applications. The course will provide the students with a springboard to develop their creative thinking and explore their ideas of new vision of medical biotechnology.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit-I**

Chromosomes Anomalies and Disorders - Numerical (polyploidy, aneuploidy, autosomal, sex- chromosomal) & Structural (deletion, duplication, translocation, inversion, isochromosome, ring chromosome).

Single gene disorders – Sickle cell anemia, Hemophila, Cystic Fbrosis,Tay-Sachs disease, Huntington disease- Genetics, Prevalence, Diagnosis and prognosis

Polygenic disorders – Type 1 Diabetes, Breast Cancer, Alzheimer disease -Genetics, Prevalence, Diagnosis and prognosis

Mitochondrial disorders – Mitochondrial Homeostasis and Parkinson disease

**Unit- II**

Immunological approaches to detect protein biomarkers of disease-ELISA, Sandwich ELISA for measuring disease associated proteins, Diagnosing autoimmune diseases by indirect ELISA, Immunoassays for infectious disease, protein arrays to detect polygenic disorder

DNA based approaches to disease diagnosis -Hybridization probes, allele specific hybridization, Oligonucleotide ligation assay, Padlock probes, Allele specific PCR, Real Time PCR to detect infectious disease, Detection of multiple disease associated mutations using Microarrays

Genetic counseling

**Unit- III**

Nucleic Acid Therapeutics -Antisense RNA, Ribozyme, Aptamers, DNAzymes, RNAi, Zinc Finger Nucleases

Protein Therapeutics-Pharmaceuticals (Tumour Necrosis Factor, Human Growth Hormone, Interferon etc), Recombinant Antibodies (Human Monoclonal Antibodies, Hybrid Human-Mouse Monoclonal Antibody, Anticancer Antibodies), Enzymes (DNase, Alginate Lyase, Alpha 1 Antitrypsin, Phenyl Ammonia Lyase, Glycosidases) ; Use of Lactic Acid Bacteria for delivery of therapeutic agents (Interleukin-10,Leptin, An HIV Inhibitor, Insulin)

Vaccines- Peptide, Subunit, Attenuated, DNA and Recombinant vaccines

**Unit- IV**

Gene Therapy-Types of gene therapy, Augmentation Gene therapy, Targeted gene therapy, gene therapy for SCID, Cancer, Neurological disorders, Ethical issues

Nanobiotechnolgy- Introduction, types and synthesis of Nanoparticles, Protein based nanostructures, applications of nanoparticles –Nanobiosensors, drug and gene delivery, disease diagnostics and therapy; risk potential of nanomaterials

Pharmacogenomics-concept, Role of Genetic Variations in different responses of individuals to drugs, Pharmacogenomics and industry, personalized Medicine

DNA fingerprinting in Forensic sciences

**Recommended Books**

1. Glick B.R, Delovitch,T.L and Patten,C.L. Medical Biotechnology,ASM press 2014
2. Judit Pongracz and Mary Keen, Medical Biotechnology 1st Edition, Elsevier publications, 2008
3. Jogdand S N. Medical Biotechnology 2nd Edition Himalaya publishers 2008
4. Clark D.V and Pazdernik,N.J Applying Genetic Revolution(2009) Academic Press
5. Singh B.D. Biotechnology: Expanding Horizon(2010)3rd edition. Kalyani publishers.
6. Gupta P.K. Biotechnology and Genomics (2013) 1st Edition. Rastogi publishers
7. David S L. Genetics to Gene Therapy – the molecular pathology of human disease (1st Ed.) BIOS scientific publishers, 1994.
8. Niemeyer C.M. and Mirkin C.A, Introduction to Nanobiotechnology, Wiley VCH publishers 2003
9. Primose, S.B. and Twyman, R.M. Principles of Gene manipulation and Genomics (7th edition), Blackwell Publisher
10. Strachan Tom and Andrew Read, Human Molecular Genetics 4th Edition (2011). Garland Science, Taylor & Francis Group LLC, USA.
11. Bartram G. Katzung, Basic & Clinical Pharmacology, 9th Edition, Mc Graw Hill Publications, 2004.
12. Devlin TM, Text book of biochemistry with Clinical Correlations (5th edition), 2002

**Semester - III**

**Paper BT-306 Biotechnology and Human Welfare-II**

**Marks: 40**

**Internal Assessment: 10**

**Time: 3 hrs**

**Objectives:** The course will provide a basic knowledge of applications of Biotechnology agricultural and environmental fields.

**Outcomes:** After the completion of the course, it is expected that students have understood the basic concepts of cell and tissue culture and its applications, uses of transgenic plants and animals, cloning IVF and embryo transfer technology. It is also expected that in field of environment, they have learnt about role of biotechnology in waste management and are able to describe various concepts and principles of Bioremediation, Biohydrometallurgy and Biomineralization using microbes and plants.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with four questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting two questions from each unit.

All questions will carry equal marks

**Unit-I**

**Agricultural Biotechnology**

Animal cell culture and hybridoma technology. Cell culture products, Plant tissue culture, micropropagation, virus free plants, Biochemical production from culture plant cells, Biotransformation.

Transgenic plants for enhanced yield, insect and herbicide resistance and quality modifications, Molecular Farming, Biopharmaceuticals, edible vaccines, status of transgenic research, safety regulations for transgenic plants

Transgenic animals- mice, cattle, sheep, pigs, fish etc, Biofarming, pharmaceutical products, IVF and embryo transfer technology for livestock improvement, Animal cloning, Bioethics

**Unit-II**

**Environmental Biotechnology**

Role of Biotechnology in the treatment of waste water, Solid waste management using biotech approaches

Bioremediation: Concept and principles, Bioremediation using microbes and plants,

Biohydrometallurgy, Biomineralization

Bioinsecticides, Biofertilizers, Biofuels, Biosensors,

Biosafety- Introduction, Risk assessment, containment, Biosafety guidelines in India

IPR- Introduction, protection of IPR, Protection of Biotechnological inventions

**Recommended Books**

1. Singh B.D. Biotechnology: Expanding Horizon(2010)3rd edition. Kalyani publishers.
2. Gupta P.K. Biotechnology and Genomics (2013) 1st Edition. Rastogi publishers
3. Clark D.V and Pazdernik,N.J Applying Genetic Revolution(2009) Academic Press
4. .Gistou, P and Klu, H.Hand book of Plant Biotechnology (Vol. I & II).John Publication.2004
5. Halford N.G. Plant biotechnology: current and future applications of genetically modified crops. John Wiely Publishers.2006
6. .Ballinic C.A., Philips J.P and Moo Young M.Animal Biotechnology. Pergamon press, New York. 1989.
7. .Watson J.D.et al. Molecular Biology of Gene (6th Ed.) Publisher Benjamin Cummings.2007.
8. Ratlege, C. and B. Kristiansen, Basic Biotechnology. Cambridge Univ. Press, London. 2001
9. Glazer and Nikaido ,Microbial Biotechnology By WH Freeman &Company, New York.
10. Chawla, H. S. Biotechnology in crop improvement, International Book distributing company.

**Semester -III**

**Paper- BT-307 Lab Course Based on Microbial and Plant Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: Six Hours (Two sessions of three hours each)**

1. Working of fermenter, Fermentation
2. Production of wine, beer, ethanol
3. Isolation of industrially important micro-organisms
4. Screening for lignocellulolytic and pectinolytic micro-organisms
5. .Isolation of protease/lipase/amylase producing micro-organisms
6. Isolation of keratinase producing micro-organisms
7. Production of xylanase/Cellualse/Pectinase by microbes and activity estimation
8. Selection system for transformants
9. Agrobacterium mediated transformation
10. Reporter gene (GUS) assay.
11. Isolation of Plant genomic DNA from the leaves tissue
12. Isolation of plasmid vector from *Agrobacterium*
13. Restriction digestion of plant genomic DNA
14. Transgene detection by amplification
15. Southern blotting of DNA
16. Secondary metabolites isolation from plant tissues**.**

**Semester -III**

**Paper- BT-308 Lab Course Based on Molecular Genetics and Immunology /Medical Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: Six Hours (Two sessions of three hours each)**

1. Spontaneous and induced mutations
2. Lymphocyte culturing for chromosome preparation, chromosome banding techniques.
3. Sister chromatid exchange assay using peripheral blood lymphocytes for genotoxicity studies
4. Single Cell Gel Electrophoresis to detect DNA damage
5. Analysis of Micronucleus as biomarker of genotoxicity using buccal epithelial cells
6. To determine IC50 of a toxic compound
7. To determine TLC and DLC in human blood smear
8. Isolation of Lymphocytes from peripheral blood
9. Serum preparation and serological reactions-Agglutination and Percipitation
10. To perform Enzyme-linked Immunosorbent assay
11. To perform immunodiffusion by Mancini and Ouchterlony method (single or double)
12. To perform immunoelectrophoresis with a given antigen-antibody system
13. To perform DNA fingerprinting analysis
14. PCR-RFFLP for SNP detection

**Semester – IV**

**Paper BT-401 Food Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives:**

* To convey better knowledge among the students about modern day food biotechnology, its associated techniques like packaging etc and Food safety and Quality control.
* To ensure better quality of education by continuous monitoring and review of performance and counseling students.
* To enhance problem-solving skills of students through applying state-of -art techniques.
* To supplement the academic input of students by way of seminars, conferences, guest lectures and industry oriented projects/ visits.

**Outcomes:** Food biotechnology has a great scope at present and in future. As there is increasing popularity and explosive growth, there are plenty of opportunities available in Food Biotechnology field. Students get training and skill development in the field of food biotechnology such as:Biotech foods and supplements as GM foods, food from fungi, algae and bacteria and their large scale production. Get knowledge about different food additives & preservation techniques, various food packaging materials and their functioning, sterilization techniques of food and packaging materials, concepts of food safety and food quality assurance, food adulteration and role of national and international regulatory agencies their standards for food quality and safety.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit – 1**

**Biotech foods and supplements**

Introduction to food biotechnology; transgenic plant foods: carbohydrates, proteins, vitamins nutritional quality improvement of the food crops by genetic engineering, safety of GM food crops. Dietary supplements; Production of food from fungi, algae and bacteria: SCP, mushrooms production technology, large scale production of algae and yeast.

**Unit – II**

**Food additives & preservation techniques**

Food additives- definitions, need for food additives, classification and functions of different additives: thickeners, antioxidants, coloring agents, flavoring agents, sweeteners, emulsifiers, flour improvers; Preservation techniques: techniques like refrigeration & freezing, dehydration, heating etc., antimicrobial agents used in food preservation.

**Unit –III**

**Food Packaging**

Introduction to Food Packaging: definition, factors involved in the evolution and selection of a food package, functions of food packaging. Types of packaging materials and their functioning properties; Aseptic packaging of foods: sterilization techniques of food and packaging material; Advantages and disadvantages associated with packaging of foods.

**Unit –IV**

**Food Safety and Quality Control**

Introduction to concepts of food safety and food quality assurance; Food adulteration, nature of adulterants, methods of evaluation of food adulterants and toxic constituents. Role of national and international regulatory agencies, Bureau of Indian Standards (BIS), AGMARK, Food Safety and Standards Authority of India (FSSAI), USFDA, International organization for standards (ISO) and its standards for food quality and safety (ISO 9000 series, ISO 22000, ISO 15161, ISO 14000).

**Recommended Books:**

1. Sivasankar,B (2002): Food Processing and Preservation, Prentice Hall of India Pvt.Ltd., New Delhi.
2. Khetarpaul N. (2005).Food Processing and Preservation, Dya Publishing House, New Delhi.
3. Robertson, G.L. (2006). Food Packaging: Principles and Practice (2nd ed.), Taylor and Francis
4. Ahvenainen, R. (Ed.) Novel Food Packaging Techniques, CRC Press, (2003).
5. Han, J.H.(Ed.) Innovations in Food Packaging, Elsevier Academic Press, (2005).
6. Food and Agricultural Organization (1980): Manuals of Food Quality Control. 2 Additives Contaminants Techniques, Rome.
7. Gould,W.A. and Gould, R.W. (1998). Total Quality Assurance for the Food Industries, CTI Publications Inc.Baltimore.
8. Dietrich Knorr, Steven R. Tannebaum and Pieter Walstra.Food Biotechnology. Biotechnology group, Department of food and sciences, University of Delaware, New York Delaware.Marcel Dekker Inc. New Yorl and Baset.
9. V.K. Josh (2009).Biotechnology; Food fermentation in Microbiology, Biochemistry and Technology, Vol. 1 and 2.

**Semester – IV**

**Paper BT-402 Environmental Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives:** The proposed course is designed to teach students the scientific and engineering principles of microbiological treatment technologies to clean up contaminated environments and to generate valuable resources for the human society. Also it is desired to make them understand the role of biotechnology in environment for prevention, remediation and monitoring of pollutants.

**Outcomes**: At the end of the course, the students will have sufficient scientific understanding of different types of biotechnological methods to improve environment value and new techniques used in Environmental Biotechnology.

**NOTE:**

Nine questions will be set in all

Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

All questions will carry equal marks.

**Unit – I**

**Environmental Biotechnology:**An overview, concept, scope and market Biological control of air pollution.

Bacterial examination of water for potability.

Testing of water for physiochemical parameters including BOD & COD.

Solid waste: Sources and management (composting, verrmicomposting and methane production).

**Unit – II**

**Waste water :**origin, composition and treatment. Physical, chemical and biological treatment of waste water. Aerobic processes: activated sludge, oxidation ponds, trickling filter towers, and rotating discs. Anaerobic processes: anaerobic digesters, anaerobic filters and up flow sludge blanket reactors. Microbiology and biochemistry of aerobic and anaerobic waste water treatment processes.

**Treatment of industrial effluents:**distillery effluent, paper and pulp mill effluent, tannary effluent, textile dye effluent, removal of heavy metals from waste waters.

**Unit – III**

**Bioremediation :**Bioremediation of fuel oils and lubricants in soil and water. Degradation of sulphur compounds present in coal and petroleum. Microbial degradation of xenobiotics, genetic engineering of biodegradation pathways.

**Environmental Monitoring:**Biosensors for environmental applications, BOD sensor, ammonia sensor, Nitrite sensor and sulphite ion sensor. Indicator organisms: Safety indicators and Quality indicators

**Unit – IV**

**Microbial Insecticides :**Bacteria, fugi and viruses. Use of R-DNA technology to enhance the efficacy microbial insecticides.

Biofertilizers

Microbes in oil recovery and bioleaching.

Biodeterioration of stored plant food materials, leather, wool, metals, textiles, stone & related building. Control of microbial bideterioration.

**Recommended Books:**

1. Environmental Chemistry. A.K. De, Wiley Eastern Ltd., New Delhi.

2. Introduction to Biodeterioration. D. Allsopp and K.J. Seal, ELBS/Edward Arnold.

3. Advanced Environmental Biotechnology by S.K. Agarwal. APH Publishing, New Delhi, (2005).

4. Bioremediation Protocols. David S. (1997), Humana Press, New Jersey.

5. Environmental Science and Technology. Stankey E.M. (1997), Lewis Publishers, New York.

6. Microbial Biotechnology: Fundamentals of Applied Microbiology (2nd edition). Glazer and Nikaido Cambridge University Press, (2007).

7. Biodegradation and Bioremediation: Soil Biology. Singh A. and Ward O.P. (2004), Springer

**Semester – IV**

**Paper BT-403 Animal Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives**: This course is designed to teach students about the different scientific aspects of animal biotechnology to utilize the livestock for welfare. Also it is desired to make them understand the role of biotechnology in production of transgenic animals and animal cloning.

**Outcomes**: At the end of the course, the students will have good understanding of the various aspects of animal biotechnology as well as of different methods available for producing transgenic animals and animal cloning.

**NOTE:**

1. Nine questions will be set in all

2. Question No. 1, which will be short answer type covering the entire syl- labus, will be compulsory. The remaining eight questions will be set unit- wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

3. All questions will carry equal marks.

**Unit -I**

**Animal Biotechnology-**Scope, global perspective and new horizons, Historical per- spective, and economically important livestock breeds, Model animals in animal bi- otechnology and genetic engineering.

**Somatic Cell Genetics:**Production of hybrid cells, Properties of hybrids, Applica- tions hybrid cells,

**Unit -II**

**Gene Transfer into Animal Cells:**DNA transfer techniques into mammalian cells: calcium phosphate precipitation, DEAE-dextran procedure, polycation DMSO, mi-croinjection, electroporation; Selectable markers, viral vectors for gene transfer into mammalian cells: SV40, adenovirus, vaccinia, bovine papiloma virus, baculovirus, retrovirus.

**Transgenic animals:**Transgenic mice: Methodology and applications; Transgenic cattle, Livestock transgenesis- production of drugs using animals

**Unit -III**

**Biotechnology in livestock assisted reproduction, biodiversity and conservation:**

Biotechnology in conservation of livestock diversity, Superovulation, Embryo biotechnology- Embryo collection, evaluation, and transfer, IVF and *in vitro*embryo production, Cryobanking of germplasm, oocytes and sperm, Somatic cell nuclear transfer, Stem cells technology in livestock

**Unit-IV**

**Animal cloning:**Concepts of animal cloning, Principles and techniques of cloning, Applications of animal cloning.

**Animal genomics:**crucial role for health and biomedical sciences. Models used in animal genomics. Functional genomics and livestock traits assessment, Livestock in the post genomic era of biology and medicine

**Recommended Books:**

1. Animal Cell Biotechnology, Vol. 1-6 Spier, R.E. and Griffiths, J.B. (eds), Academic Press.

2. Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, Oxford.

3. Animal Cell Culture Methods In: Methods in Cell Biology, Vol. 57, Ed. Jenni P Mather and David Barnes, Academic Press.

4. Biotechnology, Vol. 7b 1993 Rehm. H.J. and Reed, G.(eds) VCH Publica- tions.

5. Comprehensive Biotechnology. Vol. **I,**Murray Moo-Young (ed.) 1985, Aca- demic Press, USA

6. Culture of Animal Cells:A Manual of Basic Technique and Specialized Applications(6th edition). R. Ian Freshney. Wiley- Blackwell, (2010).

7. Genetic engineering: An introduction to gene analysis and exploitation in euk- aryotes Kingsman, S.M. and Kingsman, AJ. 1988. Blackwell scientific Publ. U.K.

8. Molecular Biotechnology: Principles and Applications of Recombinant DNA 4th Ed. (2009). Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. ASM Press, USA.

9. Molecular Genetics 2 Strachan, Tom and Read, Andrew P. New York and London: Garland Science, (2010).

**Semester – IV**

**Paper BT-404 Genomics, Proteomics and Metabolomics**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objectives:** During the course students would learn about genomics including genetic features of nuclear genomes of prokaryotes and eukaryotes, eukaryotic organelle genomes, genome evolution and molecular phylogenetics.The course also aims to introduce the students to the fields of proteomics and metabolomics.

**Outcome:** After the completion of the course, it is expected that students have understood the concept of genome, proteome and metabolome and their correlation with each other. They would understand genetic organization of nuclear genomes of prokaryotes and eukaryotes, features of eukaryotic organelle genomes, genome evolution and molecular phylogenetics. They would conceptualize concepts and different techniques used for proteomics and metabolomics and apply these for further research studies.

**NOTE:**

1. Nine questions will be set in all

2. Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

3. All questions will carry equal marks.

**Unit-I**

Genetic Features of Eukaryotic Nuclear Genomes -Where are the genes in a nuclear genome?, How are the genes organized in a nuclear genome?, How many genes are there and what are their functions?

Genetic Features of Prokaryotic Genomes-How are the genes organized in a prokaryotic genome? How many genes are there and what are their functions?, Prokaryotic genomes and the species concept

Eukaryotic Organelle Genomes-The origins of organelle genomes, Physical features of organelle genomes, The genetic content of organelle genomes

**Unit-II**

Genome Evolution**-**Genomes: the first ten billion years- the origins of genomes, Acquisition of new genes- by duplication events, from other species,Non coding DNA and genome evolution: Transposable elements and genome evolution, The human Genome: the last five million years

Molecular Phylogenetics -origin of molecular phylogenetic, phonetics and cladistics,key features of DNA based phylogenetic trees, Applications of molecular phylogenetics-Evolutionary relationships between humans & other primates, the origins of AIDS, molecular phylogenetic as a tool in the study of human prehistory.

**Unit - III**

An introduction to Proteomics, Proteome; Areas of Proteomics – Structural proteomics, Functional proteomics, Expression proteomics.

Approaches for study of Proteomics: Separation of proteins by Two dimensional electrophoresis; Mass spectrometry (ESI and MALDI); Amino acid sequencing of protein by Edman method (Traditional approach); Identification of proteins by tandem mass spectrometry; Shot gun proteomics; Protein Sequence databases; Peptide fingerprinting/mapping; Determination of 3D structure of protein by X-ray diffraction and NMR spectroscopy.

Protein expression profiling – 2D differential in–gel electrophoresis, Isotope-coded affinity tag (ICAT) method for quantitative proteome analysis; Various approaches for determining the function of a protein; Protein-protein interaction using two hybrid system, complementation, tandem affinity purification (TAP) tag method; Protein-protein interaction mapping; Protein microarrays – Analytical, reverse phase, functional.

**Unit - IV**

Introduction to metabolism, metabolic pathways, metabolite, metabolomics; Methods/ approaches employed to study metabolism; Inter-relationship between genome, transcriptome , proteome and metabolome; Methods for measurement of metabolites level / concentration.

Metabolic regulation and control – Homeostasis and metabolic control , metabolic flux , metabolic control Analysis , Demand –Supply Analysis , mechanisms of flux control , Regulation of glycolysis in muscle as an example of metabolic regulation.

Metabolic engineering – Transfer of gene/s, partial pathways, entire biosynthetic pathways for creating new products. Metabolic engineering for altering / redirecting metabolite flow. Limitations in Metabolic Engineering.

**Recommended Books:**

1. Brown T. A. Genomes 3 (2007) Garland Science Publishing, New York, USA.
2. Strachan Tom and Andrew Read, Human Molecular Genetics 4th Edition (2011). Garland Science, Taylor & Francis Group LLC, USA.
3. Primose, S.B. and Twyman, R.M. Principles of Gene manipulation and Genomics (7th edition), Blackwell Publisher
4. Voet , D and Voet , J.G. Biochemistry,John wiley and Sons, USA
5. Satyanarayana, U and chakrapani, U. Biochemistry , Books and allied (P) Ltd , India.
6. Nelson, D.L. and Cox, M.M. Lehninger principles of Biochemistry, W.H. freeman and Company , NY
7. Gupta, P.K. Elements of Biotechnology, Rastogi publications , India.
8. Sawhney, S.K. and Singh, R. Introductory Practical Biochemistry , Narosa publishing house Pvt. Ltd. India.
9. Dubey, R.C. A Text book of Biotechnology, S. Chand & company Ltd,India.
10. Price, N.C. and stevens L. Fundamentals of Enzymology, Oxford University Press.
11. Wilson, K. and walker, J. Principles and Techniques of Biochemistry & Molecular Biology, Cambridge University Press.
12. Glick, B.R., Pasternak, J.J. and patten C.L. Molecular Biotechnology, ASM Press. Washington DC.
13. . Devasena, T. Enzymology, Oxford University Press.

**Semester – IV**

**Paper BT-405 Biosafety, Bioethics and IPR Issues**

**Marks: 80**

**Internal Assessment: 20**

**Time: 3 hrs**

**Objective:**

The objective of the course is to make students learn about the legal, safety and public policy issues raised due to the rapid progress in biotechnology and development of new products.

**Outcome:**

At the end of the course, it is expected that students have understood the basic issues of biosafety, bioethics and IPR arising from the commercialization of biotech products. They are now supposed to follow the regulatory framework in their future venture to ensure product safety and benefit the society

**NOTE:**

1. Nine questions will be set in all

2. Question No. 1, which will be short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit.

3. All questions will carry equal marks.

**Unit-I**

Biosafety: Introduction; Historical background; Biosafety in the laboratory; Laboratory associated infections and other hazards;Biosafety management for environmentally safe use of biotechnology; Biosafety guidelines; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Definition of GMOs & LMOs; Good manufacturing practices (GMP) and Good lab practices( GLP); Overview of National Regulations and relevant International Agreements including Cartagena Protocol; Roles of Institutional Biosafety Committee ( IBSC), RCGM, GEAC, MEC, SBCC, DLC and RDAC; Guidelines for research in transgenic sciences and release of GMOs to environment; Bioterrorism and convention on biological weapons

**Unit-II**

Bioethics: Ethical issues related to biotechnology research; Ethical issues associated with consumptions of genetically modified foods and other products, Ethical implications of human genome project, Social and ethical implications of biological weapons, Bioremediations and environmental impacts of using GMOs; Ethics of patenting- and its impact on biodiversity rich developing countries; Use of animals for research and testing and Alternatives for Animals in Research.

**Unit-III**

Social, economical and legal issues related to biotechnology: Public education of the processes of biotechnology involved in generating new forms of life for informed decision making; Testing of drugs on human volunteers; Human cloning and Gene therapy - ethical and social issues; Organ transplantation- ethical and legal implications; Research focus to address the need of the poor and of environment.

Entrepreneurship: Potential entrepreneurship activities in biotechnology, product development, marketing, research and training units. Industrial licensing, venture capital, Biotechnological industries in India and potential job opportunities.

**Unit- IV**

Intellectual Property Rights: Intellectual property rights and IPR protection; Patenting and the procedure involved in the application of patents and granting of a patent; Compulsory licenses; Patent search; Patent Cooperation Treaty(PCT); Examples of patents in biotechnology; Legal implications; Traditional knowledge commercial exploitation; Farmers rights; Plant breeder’s rights; International and National conventions on Biotechnology and related areas- GATT, TRIPS, Biodiversity convention, etc.

**Recommended Books:**

1. Thomas, J.A. and Fuch, R.L. Biotechnology and Safety Assessment. Academic Press. (2002).

2. Fleming, D.A., Hunt, D.L., Biological safety Principles and practices. ASM Press. (2000).

3. Sateesh, M.K. Bioethics & Biosaftey, IK Publishers. (2008).

4. Sassaon A. Biotechnologies and development. UNESCO Publications. (1988).

5. Sasson A. Biotechnologies in developing countries, UNESCO Publishers, (1993).

6. Singh BD. 2007. Biotechnology: Expanding Horizon. Kalyani.

7. Singh K., Intellectual Property Rights on Biotechnology BCIL, New Delhi. (2008).

**Important Links:**

http://www.w3.org/IPR/

http://www.wipo.int/portal/index.html.en

http://www.ipr.co.uk/IP\_conventions/patent\_cooperation\_treaty.html

www.patentoffice.nic.in

www.iprlawindia.org/ - 31k - Cached - Similar page

<http://www.cbd.int/biosafety/background.shtml>

**Semester – IV**

**Paper- BT-406 Lab Course Based on Food and Environmental Biotechnology**

**Marks: 80**

**Internal Assessment: 20**

**Time: Six Hours (Two sessions of three hours each)**

1. Preparation of synthetic medium for yeast culture.
2. To study the production of yeast.
3. To study the production of algae using natural raw/ industrial waste materials and synthetic medium.
4. To study the cultivation of mushrooms.
5. To study the various sterilization and food preservation techniques.
6. Estimation of a) Iodine value, (b) Saponification value (c) acid value of fats and oils.
7. Determination of moisture, total crude fat in a given food sample.
8. Determination of Acidity & pH in food sample/beverages.
9. Determination of total, non-reducing and reducing sugars.
10. Determination of water vapour transmission rate for given packaging materials.
11. To determine TDS, DO, COD, BOD of given water sample.
12. Total bacterial population of given samples of water by standard plate count technique (SPC)
13. To check the potability of given water sample.
14. To check the presence of coliform in given water sample by Multiple- tube fermentation test or most probable number test (Presumptive, confirmed and completed test)
15. To check the presence of coliforms using membrane filter method.
16. To check the presence of faecal and non- faecal coliforms in the given water sample and confirmation of faecal coliforms.
17. To determine the quality of given milk sample.
18. Isolation and immobilization of dye-degrading microbes.