B.Sc. Biotechnology (H) (6 semester duration)

Course Structure

First Semester

Course Code	Course title	Credit Hrs.
BTM -111	Biochemistry-I	3+0
BTM -112	Microbiology-I	3+0
BTM -113	Cell Biology	3+0
BTM -114	Biochemistry lab-I	0+2
BTM -115	Microbiology lab-I	0+2
BTM -116	Cell biology lab-I	0+2
BTM -117	**Cell Metabolism**	**3+0**
BTM -118	**Basic English**	**0+0**

Second Semester

Course Code	Course title	Credit Hrs.
BTM -121	Biochemistry -II	3+0
BTM -122	Genetics	3+0
BTM -123	Microbiology-II	3+0
BTM -124	Biochemistry lab-II	0+2
BTM -125	Microbiology lab-II	0+2
BTM -126	Cytogenetics lab	0+2
BTM -127	**Recombinant DNA Technology**	**3+0**
BTM -128	**Advanced uses of Computer**	**0+0**

Third Semester

Course Code	Course title	Credit Hrs.
BTM -211	Molecular Biology	3+0
BTM -212	Biophysical chemistry	3+0
BTM -213	Instrumentation	3+0
BTM -214	Molecular biology lab	0+2
BTM -215	Biophysical techniques	0+2
BTM -216	Instrumentation lab	0+2
BTM-217	**Plant and Animal Tissue Culture**	**3+0**

Fourth Semester

Course Code	Course title	Credit Hrs.
BTM -221	Genetic engineering	3+0
BBT-222	Developmental biology	3+0
BTM -223	Immunology	3+0
BTM -224	Genetic engineering lab	0+2
BTM -225	Immunology lab	0+2
One month mandatory Industrial summer internship		

Fifth Semester

Course Code	Course title	Credit Hrs.
BBT-311	Plant biotechnology	3+0
BBT-312	Animal Biotechnology	3+0
BBT-313	Biostatistics and Bioinformatics	3+0
BBT-314	Plant and Animal Biotechnology lab	0+2
BBT-315	Biostatistics Computer application and Bioinformatics lab	0+2
BTM- 316	**Basic Fermentation techniques**	**3+0**

Sixth Semester

Course Code	Course title	Credit Hrs.
BBT-321	Food and Industrial Biotechnology	3+0
BBT-322	Environmental biotechnology	3+0
BBT-323	Food and Industrial Biotechnology Lab	0+2
BBT-324	Bioethics, legal issues and patenting	3+0
BBT-325	Project Work	0+6

SEMESTER I

BTM -111: Biochemistry I (3+0)

1. Basic chemistry of biomolecules: Carbohydrates, Lipids, Proteins and Nucleic acids
2. Amino acids: Classification and properties
3. Proteins: Classification based on structure and functions, structural organization of proteins (primary, secondary, tertiary and quaternary structures).
4. Photosynthesis: Structure of photosynthetic apparatus, Light and Dark reactions, C_3 and C_4 cycle
5. Lipids: Structure, properties, classification and functions

BTM -112: Microbiology I (3+0)

1. History of microbiology, Scopes in microbiology, Concept of microbial diversity
2. Microscopy: Fluorescence, Phase contrast, Electron Microscope
3. Introduction to eubacteria, archaea and eukaryotic microorganisms
4. Structural differences between Gram positive, Gram negative and archaea cells
5. Microbial growth: batch, continuous and synchronized cultures
6. Microbial nutrition: phototrophs, chemotrophs, heterotrophs
7. Microbial Media: simple, differential and selective
8. Pure culture technique: Isolation, preservation and maintenance of culture

BTM -113: Cell Biology (3+0)

1. Introduction: the Cell theory, structural organization of a prokaryotic and eukaryotic cell.
2. Plasma membrane: structural organization, function, transport across the membrane.
3. Cellular organelles: structure and functions of rough and smooth endoplasmic reticulum, Golgi complex, **Protein Trafficking**, Lysosome, Peroxisome, Vacuoles, Mitochondria, Chloroplast.
4. Nucleus and nucleolus, chromatin structure and organization
5. Cytoskeleton and extra cellular matrix
6. Cell divisions: Cell cycle and control of cell cycle, cell death (apoptosis and necrosis), cancer.

BTM - 114: Biochemistry lab-I (0+2)

1. Units of Biochemistry
2. Instruments/Equipments and Glass Ware Used in Biochemical Laboratory
3. Concentration of Solution
4. pH and It's determination
5. Buffer and It's uses
6. Qualitative tests of Carbohydrate
7. Estimation of glucose by O-Toluidine method.
8. Qualitative test of Amino acids
9. Qualitative test of Protein.
10. Estimation of Protein by Biuret method.
11. Titration of Mixture of strong and weak acids
12. Paper chromatography

BTM - 115: Microbiology lab-I (0+2)

1. Introduction To The Microbiology Laboratory
2. Microscope And Microscopy
3. How To Use Microscope
4. Control Of Microorganisms
5. Preparation Of Culture Media
6. Pure Culture Techniques
7. Isolation Of Pure Culture
8. Sampling Of Microorganism
9. Preparation Of Bacterial Smear
10. Morphological Characteristics Of Bacteria
11. Cultural Characteristics Of Bacteria
12. Simple Staining
13. Negative Staining Of Bacteria
14. Differential Staining Of Bacteria
15. Special Staining Of Bacteria (Endospore Staining)
16. Special Staining Of Bacteria
17. Motility Test By Hanging Drop Technique
18. Calibration Of Micrometer
19. Measurement Of Microorganism By Using Ocular Micrometer

BTM - 116: Cell biology lab (0+2)

1. Laboratory Safety

2. Osmotic Haemolysis
3. Plasmolysis: Study of plant cell in hypertonic solution
4. Study of plant cell types by cell maceration
5. Pipetting: Using micropipettors
6. Counting and determination of cell viability using haemocytometer
7. Paper chromatography
8. Mitosis in onion root tip cells
9. Meiotic cell Division in flower bud.

BTM – 117: Organic mechanism in biology (3+0)

1. **Common Mechanisms in Biological Chemistry – Overview of Digestion, Absorption, Metabolism (Anabolism & Catabolism), Nutrition, Respiration, Excretion.**
2. **Carbohydrates metabolism: Glycolysis, Kreb's Cycle and Oxidative Phosphorylation, Gluconeogenesis, Pentose phosphate pathway, Glyoxylate cycle.**
3. **Lipid Metabolism – Structures and roles of Fatty acids &Glycerols, beta oxidation of saturated fatty acids, oxidation of unsaturated fatty acids, oxidation of odd chain fatty acids, energy yield, ketone bodies.**
4. **Amino acid Metabolism – Amino acid breakdown (amino acid deamination, Urea cycle, metabolic breakdown of individual amino acids – glucogenic&ketogenic amino acids), amino acids as biosynthetic precursors (haem biosynthesis & degradation, biosynthesis of epinephrine, dopamine, seretonin, GABA, histamin, glutathione); biosynthesis of essential & non-essential amino acids.**

5. **Nucleotide Metabolism – biosynthesis of purine & pyrimidine (de novo & salvage pathway); degradation of purine & pyrimidine.**

BTM – 118: Basic English (0+0)

BOOKS

CELL BIOLOGY

1. Molecular Biology of cell – Bruce Alberts *et al*., Garland Publications
2. Animal Cytology and Evolution – MJD, White Cambridge University Publications
3. Molecular Cell Biology – Daniel, Scientific American Books.
4. Cell Biology – Jack D.Bruke, The William Twilkins Company.
5. Cell Biology – Ambrose and Dorouthy M Hasty, ELBS Publications.
6. Fundamentals of Cytology – Sharp, Mc Graw Hill Company
7. Cytology – Wilson and Morrison, Reinform Publications

MICROBIOLOGY

1. Microbiology – Pelzer, Chan, Krieg, Tata McGraw Hill Publications.
2. Microbiology – Concepts and Application by Paul A.Ketchum, Wiley Publications
3. Fundaments of Microbiology- Frobisher, Sauders and toppan Publications.
4. Microbiology - Ronald M.Atlas
5. Introductory Biotechnology – R.B. Singh C.B.D. India (1990)
6. Industrial Microbiology – Casidal. E.Wiley Eastern Ltd.
7. Fundamentals of Bacteriology – Salley
8. Frontiers in Microbial technology – P.S.Bisen, CBS Publishers
9. General Microbiology- C.B.Powar, H.F. Daginawala, Himalayan Publishing House

BIOCHEMISTRY

1. Principles of Biochemistry- AlbertL. Lehninger CBS Publishers & Distributors
2. Biochemistry – Lubert Stryer Freeman International Edition.
3. Biochemistry – Keshav Trehan Wiley Eastern Publications
4. Fundamental of Biochemistry – Dr. A.C.Deb
5. Biochemistry- L.U. Satyanarayana, Books and Allied Pvt. Ltd.
6. Outlines of Biochemistry- Conn and Stumpf, Wiley Eastern Ltd., New Delhi.
7. Biochemistry-Voet and Voet, John Wiley and Sons.
8. Biochemical Methods- S. Sadasivam and A. Manickam, New Age International Publishers, New-Delhi.
9. Laboratory Manual in Biochemistry- J. Jayaraman, New Age International Publishers, New-Delhi.
10. Text Book of Practical Plant Chemistry- A. Buzarbarua, S. Chand and Co. New Delhi.

SEMESTER II

BTM -121: Biochemistry –II (3+0)

1. Human hormones: protein and steroid hormones, mechanism of hormone action.
2. Plant hormones: auxins, gibberellins, cytokinins, ethylene, abscisic acid
3. Vitamins: water and fat soluble vitamins, dietary source and deficiency syndromes
4. Enzymes: Classification, catalysis, mechanism of enzyme action, factors influencing enzyme activity, immobilization of enzymes, co-enzymes and cofactors, Isozymes.
5. Nitrogen metabolism and fixation of nitrogen in leguminous plants
6. Contractile protein, neurotransmitter

BTM -122: Genetics (3+0)

1. Mendel's laws of inheritance
2. Extension of Mendelism: Incomplete dominance, co-dominance, pleiotropy, multiple allelism, complementation and epistasis,
3. Linkage and crossing over
4. Sex determination and sex linked inheritance
5. Numerical and structural changes in chromosomes
6. Mutation and mutagenesis
7. Extra-nuclear inheritance
8. Population genetics: Hardy-Weinberg equilibrium, maintenance and establishment of the equilibrium

BTM -123: Microbiology II (3+0)

1. Bacterial genetics: conjugation, transformation and transduction
2. Microbial metabolism: photosynthesis, assimilation of inorganic nitrogen, phosphorous and sulphur
3. Viruses: Basic structure, classification, bacteriophages, lytic and lysogenic cycle, Viriods and prions.
4. Plant Microbe interactions
5. Mycoplasmas, Rickettsiae and Chlamydiae
6. Microbes and public health: Enterobacterioceae, Mycobacterium, Gonococci, Candida, Aspergillus, Variola, Varicella-Zoster, etc.
7. Microbes and pharmaceutical industry

BTM - 124: Biochemistry lab II (0+2)

1. Extraction and quantification of total lipids.
2. Estimation of Vitamin C from plant samples.
3. Preparation of starch from Potato and its hydrolysis by salivary amylase. Test of salivary amylase.
4. Estimation of total Protein (Lowry's method).
5. Preparation of acetate and phosphate buffers with different pH.
6. Extraction of casein from milk.
7. Effect of temperature / pH on enzyme activity
8. Assay of alkaline phosphatase.

BTM - 125: Microbiology lab II (0+2)

1. Generation time of bacteria(Growth curve)
2. Most probable number(MPN) of Coliforms in water
3. Isolation of pure culture by streak plate
4. Isolation of pure culture by pour plate method
5. Isolation of pure culture by pour plate method
6. Cultivation of anaerobes
7. Isolation and culture of rhizobium
8. Isolation and identification of *E.coli* from given water sample
9. Detection of extracellular bacterial enzyme production
10. Isolation of slime moulds
11. Antibiotic sensitivity testing
12. Germicidal effect of UV light on bacterial growth

.

BTM - 126: Cytogenetics lab (0+2)

1. Basic sterilization techniques required for Media preparation & Cytological techniques.
2. Media preparation technique.
3. Blood Typing
4. Enumeration of WBC and RBC
5. Mitosis in hordeum vulgare
6. Mitotic aberration
7. Isolation of Lymphocytes
8. Demonstration of banding and Karyotyping with permanent slides.

BTM - 127: Recombinant DNA Technology (3+0)

1. Gene Recombination and Gene transfer : Bacterial Conjugation, Transformation, Transduction, Episomes, Plasmids, Microinjection, Electroporation, Microprojectile, Shot Gun method, Ultrasonication, Liposome fusion, Microlaser.
2. Polymerase chain reaction (PCR), RT-PCR
3. Changing genes: site-directed mutagenesis and Protein engineering: Primer extension is a simple method for site directed mutation, PCR based site directed mutagenesis, Random mutagenesis, Use of Phage display techniques to facilitate the selection of mutant peptides, Gene shuffling, production of chimeric proteins.
4. Molecular Markers – RFLP, RAPD, AFLP
5. Molecular detection techniques - Southern, Northern and Western hybridization.

BTM - 128: Advanced uses of Computer (0+0)

1. **History and Generation of computer:-1st to 4th generation with their characteristics.**
2. **Basic concepts of computer**
3. **Introduction, different components of computer, basic design of computer.**
4. **Computer architects**
5. **Introduction to operating system**
6. **Algorithm and flow chart**

7. **Execution of a Program- spread sheet; data based concepts using MS-EXCEL, MS-POWER POINT and MS-WORD, Networking; LAN,MAN and WAN**
8. **Introduction to OS**
9. **Memory management –Memory allocation rule, Swapping, Overlay, Paging, Demand paging, segmentation, virtual memory.**

BOOKS
GENETICS
1. Principles of Genetics – E.J. Gardener, M.J. Simmons and D.P. Snustad, John Wiley and Sons Publications.
2. Genetics- M.W. Strickberger, Prentice Hall of India Pvt. Ltd., New- Delhi.
3. Fundamentals of Genetics- B.D. Singh

SEMESTER III

BTM -211: Molecular Biology (3+0)

1. Nucleic Acids: Nucleic acid as the genetic material, structure and aggregation of DNA and RNA, DNA double helix, different conformations of double helix, DNA supercoiling, denaturation and renaturation of DNA, C-value paradox, Cot value and curve, chemical complexity
2. DNA replication, DNA damage and DNA repair (SOS and excision repair)
3. Homologous recombination, site specific recombination and transposons
4. Transcription in prokaryotes and eukaryotes
5. Regulation of gene expression in prokaryotes: *lac* and *trp* operons
6. Genetic code
7. Translation in prokaryotes and eukaryotes

BTM -212: Biophysical Chemistry (3+0)

1. pH and Buffers
2. Chemical bonding: Ionic bond, covalent bond, hydrogen bond, peptide bond, Vander-Waals forces
3. Properties of water
4. Thermodynamics- the First law of thermodynamics, concept of internal energy, the Second law of thermodynamics, free energy, enthalpy, entropy, free energy in biochemical reactions, and in transport of non-ionic and ionic substances across the biological membranes.
5. Nucleic Acids: structure and aggregation of DNA and RNA, DNA double helix, different conformations of double helix, DNA supercoiling.
6. Concept of Protein folding: hydrophilic and hydrophobic amino acids

BTM -213: Instrumentation (3+0)

1. Principles of pH meter, dialysis
2. Principles of different types of centrifugation, ultracentrifugation, application of analytical centrifugation and density gradient centrifugation.
3. General principles of chromatography, adsorption chromatography, column, affinity, TLC, partition, ion exchange, gel filtration and permeation chromatography.
4. Principles and application of gel electrophoresis
5. Spectroscopic techniques: principles and applications of spectroscopy,
6. Radioisotope technique: nature of radioactivity, principles of radioisotopes and radiations, units, radioactive decay, detection and measurement of radioactivity.
7. **Thermo cycler and its variants**
8. **Microscopy**

BTM -214: Molecular Biology lab (0+2)

1. Extraction of genomic DNA from animal cell (whole blood)
2. Isolation of Genomic DNA from plant tissue
3. Isolation of genomic DNA from Bacteria
4. Isolation of genomic DNA using teaching kit (whole blood)
5. Quantitative estimation of DNA and RNA
6. Determination of molecular weight of DNA bands based on Agrose gel electrophoresis
7. Southern blotting
8. Isolation of Protein
9. Quantification of Protein.
10. SDS-PAGE

BTM -215: Biophysical Chemistry lab (0+2)

1. To determine the pH of unknown sample
2. To prepare Phosphate, Bicarbonate & Citrate buffer
3. Isolation of Casein protein by Isoelectric precipitation
4. Paper Chromatography of Amino acids
5. SDS PAGE
6. Spectrophotometric quantification of DNA sample

BTM -216: Instrumentation lab (0+2)

1. Calibration of pH meter.
2. Paper chromatography of amino acids/sugars.
3. TLC of sugars/amino acids.
4. Cellular fractionation and separation of cell organelles using centrifuge.
5. Validity of Beer's law for colorimetric estimation of creatinine.
6. Absorption spectrum of NAD & NADH.
7. Rocket immuno-electrophoresis

BTM -217: Plant and Animal Tissue Culture (3+0)

1. Introduction to Techniques - Introductory history, Laboratory organization, Media, Aseptic manipulation.

2. Basic concepts in cell culture - cell culture, Cellular Totipotency, Somatic Embryogenesis.

3. Growth Hormones - Plant cells (Composition of culture media, Growth hormones, Vitamins, Unidentified supplements, selection of media); Animal cells (substrate on which cells grow, Feeder layer on substrate, gas phase for tissue culture, media and supplements).

4. In vitro plant culture : approaches & methodologies - preparation steps for tissue culture, surface sterilization of plant tissue material, basic procedure for aseptic tissue transfer, incubation of culture.

5. Tissue culture methodologies - Plant cells (Callus Culture, Cell Suspension Culture, Organ Micro-culture, plant micro-propagation, Somatic Embryogenesis); Animal cells (Source of tissue, primary culture, differentiation of cells, growth kinetics, animal cell lines and their origin and chracterization).

BOOKS

BIOPHYSICAL CHEMISTRY

1. Narayanan, P (2000) Essentials of Biophysics, New Age Int. Pub. New Delhi.
2. Roy R.N. (1999) A Text Book of Biophysics New Central Book Agency.

MOLECULAR BIOLOGY

1. Glick, B.T and Pasternak J.J (1998) Molecular Biotechnology, Principles and application of recombinant DNA, Washington D.C. ASM press.
2. Howe.C. (1995) Gene Cloning and Manipulations, Cambridge University Press, USA
3. Lewin, B., Gene VI New York, Oxford University Press.
4. Rigby, P.W.J. (1987) Genetic Engineering, Academic Press Inc. Florida, USA.
5. Sambrook et al (2000) Molecular Cloning Volumes I, II, & III Cold spring Harbor Laboratory Press, New York, USA
6. Walker J.M. and Gingold, E.B. (1983) Molecular Biology and Biotechnology (Indian Edition) Royal Society of Chemistry U.K
7. Karp.G (2002) Cell and Molecular Biology, 3rd Edition, John Wiley and Sons; INC
8. Cell and Molecular Biology- P.K. Gupta, Rastogi Publishers, Meerut

SEMESTER IV

BTM - 221: Genetic Engineering (3+0)

1. Introduction to Genetic Engineering: definition, history and scope.
2. Restriction enzymes- definition, characteristics and uses.
3. Cloning and cloning vectors: Plasmid vectors, λ vectors.
4. Construction and screening of Genomic DNA library and c DNA library.
5. DNA finger printing.
6. Nucleic acid sequencing: Di-deoxy and Chemical sequencing methods
7. **Genetic engineering in animals: Production of transgenic mice, ES cells can be used for gene targeting in mice, Applications of gene targeting, Using Yeast to study Eukaryotic gene function, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immunemodulators and vaccines, Transgenic animals, Production of proteins of Pharmaceutical value.**
8. **Genetic engineering in plants: Use of Agrobacterium tumefaciens and Arhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.**

BBT - 222: Developmental Biology (3+0)

1. Introduction to Developmental Biology, Germ cells, Basic concepts in embryology, Genetics and Development.
2. Gametogenesis: Spermatogenesis and Oogenesis; Gametogenesis in angiosperms
3. Fertilization and embryogenesis: overviews in animals and higher plants.
4. **Integrating cells into tissues:- Cell adhesion, cell junctions, extra cellular matrix and connective tissues**
5. Genetic regulation of development
6. **Stem cell Biology**

BTM -223: Immunology (3+0)

1. History and scope of Immunology
2. Types of Immunity: acquired and innate; **Inflammation**, cell mediated and humoral immunity
3. Cells, tissues and organs of the immune system
4. Antigen: antigenicity vs. immunogenicity
5. Immunoglobulin: structure, function and diversity; antigen-antibody reactions, **concept of ELISA, Immuno Assay.**
6. T cell and B cell maturation and activation
7. Cytokines, Interleukins, **T Cell and B Cell defects.**

BTM -224: Genetic Engineering lab (0+2)

1. Isolation of genomic DNA from bacteria, plant and animal tissue.
2. Isolation of plasmid DNA (*E. coli*).
3. Restriction digestion of DNA.
4. Separation of DNA by Gel Electrophoresis.
5. SDS-PAGE for protein profiling.
6. Isolation of chloroplast DNA.
7. Demonstration of Replica plating technique.

8. Identification of Lac+ bacteria by blue white screening using IPTG.
9. Ligation of DNA.
10. Demonstration of Southern blotting.
11. Demonstration of western blotting.

BTM -225: Immunology lab (0+2)

1. Antigen – antibody reaction
2. **ABO-Blood grouping**
3. Ouchterloney immunodiffusion.
4. Radial immunodiffusion.
5. **Differential leukocyte count (DLC)**
6. Blood film preparation.
7. ELISA (Kit).

Books

GENETIC ENGINEERING

1. Glick, B.R and Padternak J.J (1994) Molecular Biotechnology, Principles and Applications of Recombinant DNA, American Society for Microbiology, Washington D.C
2. Christopler, H. (1995) Gene Cloning and Manipulating, Cambridge University Press
3. Nicholl, D.S.T (1994) An Introduction of Genetic Engineering, Cambridge University Press.
4. Old, R.W. and Primrose, S.B. (1986) Principles of Gene manipulation, An introduction to genetic engineering (3rd Edition) Black well Scientific Publications
5. Lewin, B. (1994) Genes VI, New York, Oxford University Press.
6. Gene Cloning- TA. Brown, Blackwell Publisher
7. Molecular Cloning: A Laboratory Manual, Maniatis, Fritch and Samrock.

IMMUNOLOGY

1. William, E. Paul (1989) Fundamental immunology, 2nd Edition Raven Press, New York.
2. William, R. Clark (1991) The Experimental Foundations of Modern Immunology (4th Edition) John Wiley and Sons, New York.
3. Ivan, M, roitt (1994) Clackwell Scientific Publications, London

SEMESTER V

BBT-311: Plant Biotechnology (3+0)
1. Introduction, history and scope of plant cell and tissue culture
2. Sterilization and Plant tissue culture media
3. Micro-propagation technique
4. Callus and suspension culture
5. Organogenesis and somatic embryogenesis – Techniques and applications
6. Protoplast Culture – Isolation, regeneration and viability test, somatic hybridization, methods of protoplast fusion – chemical methods, practical application of somatic hybridization
7. Somaclonal variation and their significance
8. Transgenic plants: Agro bacterium mediated transformation

BBT-312: Animal Biotechnology (3+0)
1. Animal cell culture applications and products: Cell products - antibodies and immuno-regulators, recombinant products, viral vaccines, cell and tissue therapy.
2. Cloning
3. Production of Vaccines in animal Cells.
4. Production and Applications of monoclonal antibodies.
5. Transgenic animals

BBT-313: Biostatistics and Bioinformatics (3+0)
1. Introduction and principles of statistical sampling from a population.
2. Random sampling.
3. Frequency distributions and associated statistical measures.
4. Probability measures and probability distributions and Random variable.
5. Correlation, and regression analysis,
6. Hypothesis testing: T, F, Chi-square distribution and tests.
7. Introduction to bioinformatics.
8. Application of different software in solving biological problems
9. Database management and data analysis – use of different databases e.g. Pubme, TIGR, PDB database, Gene bank.
10. Gene and protein sequence analysis
11. Genomics, transcriptomics and proteomics – computer applications

BBT- 314: Plant and Animal Biotechnology lab (0+2)
1. Tissue culture laboratory general requirement, equipments, common media.
2. Preparation of Plant tissue culture media.
3. In vitro propagation through shoot tip and nodal culture.
4. Production of callus and culture.
5. Sub culture of carrot callus.
6. Hardening of plantlets.
7. Isolation of protoplast from plant leaves.
8. Isolation of lymphocytes.
9. Lymphocytes culture

BBT- 315: Biostatistics and Bioinformatics lab (0+2)
1. Practical work of simple Statistical programmes.
2. Practical on Biostatistics: based on theory papers.

3. Introduction to Computer application.
4. Introduction to software of enzymes, DNA and Proteins.
5. Internet basics.
6. Introduction to NCBI Web sites.
7. Introduction to Data bases.

BTM-316: Basic Fermentation Technique (3+0)

1. Principles of Microbial growth – introduction, the ways of growing microorganisms, ways to increase yield of microbes, Batch, fed-batch and continuous cultures (definition and kinetics).
2. Bioreactor / Fermenter – types & operation of Bioreactors, physico-chemical standards used in bioreactors, limitations of bioreactors, stages of fermentation processes, Media design for fermentation processes, Solid substrate fermentation, Fermenters (Stirred tank, bubble columns, airlift. Bioreactors, Static, Submerged andagitated fermentation), advantages & disadvantages of solid substrate & liquid fermentations.
3. Technology of Microbial cell maintenance – steps to maintain microbial culture in an aseptic & sterile environment (how to inoculate, preserve & maintain), Strain preservation, maintenance and strain improvement.
4. Downstream processing – extraction, separation, concentration, recovery & purification, operations (Insulin, Vitamins, Metabolites), Industrial production of Ethyl alcohol, Acetic Acid (Vinegar), Citric acid, lactic acid, α-amylase, protease penicillin, tetracycline and vitamin B12, with reference to easily available raw materials, Production of herbal drugs.

BOOKS

PLANT BIOTECHNOLOGY

1. Ravishankar G.A and Venkataraman L.V(1997) Biotechnology: Applications of Plant Tissue and Cell Culture. Oxford and IBH Publishing Co., Pvt Ltd.
2. Bhan (1998) Tissue Culture, Mittal Publications, New Delhi.
3. Islan A.C (1996) Plant Tissue Culture, Oxford and IBH Publishing Co., Pvt. Ltd.
4. Lydiane Kyte & John Kelvins (1996) Plants from test tubes. An introduction to Micropropogation (3rd Edition) Timber Press, Partland.
5. Kumar H.D (1991) A Text Book on Biotechnology (2nd Edition). Affiliated East West Press Private Ltd. New Delhi.
6. Chrispeel M.J. and Sdava D.E. (1994) Plants, Genes and Agriculture, Jones and Barlett Publishers, Boston.
7. Reinert J. and Bajaj Y.P.S (1997) Applied and Fundamental Aspects of Plant Cell, Tissue, and Organ Culture, Narosa Publishing House.

ANIMAL BIOTECHNOLOGY

1. Elements of Biotechnology- P.K. Gupta., Rastogi publishers, Meerut.
2. Biotechnology- B.D.Singh, Kalyani Publishers, Ludhiana
3. A Text Book of Biotechnology- R.C. Dubey, S. Chand & Company Ltd.

BIOSTATISTICS

1. Bliss, C.J.K. (1967) Statistics in Biology, Vol. I Mc Graw Hill, New York.
2. Campbell R.C.(1974) Statistics for Biologists, Cambridge Univ. Press, Cambridge.
3. Daniel (1999) Biostatistics (3rd Edition) Panima Publications Corporation.
4. Swardlaw, A.C. (1985) Practical Statistics for Experimental Biologists, John Wiley and sons, Inc, NY
5. Khan (1999) Fundamentals of Biostatistics.

BIOINFROMATICS

1. Introduction to Bioinformatics - T.K. Attwood, D.J.P. Smith and S. Phukan, Pearson Education
2. Bioinformatics of genome regulation and structure - Kolchanov
3. Trends in Bioinformatics – P. Shanmughavel, Scientific Book Center.

SEMESTER VI

BBT-321: Food and Industrial Biotechnology (3+0)

1. Definition and scope for application of biotechnology in food industry.
2. Basic food chemistry and microbiology.
3. Food spoilage and preservation, preservation methods- physical, chemical, biological and irradiation.
4. Application of microorganisms in food fermentation; solid state fermentation (SSF); Types of fermented foods and beverages; traditional fermented foods of the Orient, Advantages of fermented foods. Technologies for production of Sauerkraut, Soya, bamboo shoot, cheese, and grape wine. Concept of starter cultures.
5. Enzymes and their application in food industries.
6. SCP; SCP producing microorganism and substrates used; advantage of using SCP.
7. Fermenters and their types; structure of an ideal Fermenters.
8. Microbes used in industrial fermentation; Industrial production process (Fermentations) for ethanol, vinegar and penicillin. Media for industrial fermentation
9. Microbial enhanced oil recovery.

BBT -322 Environmental biotechnology (3+0)

1. **Overview of the global environmental problems: Climate change, Energy crisis, use and abuse of plastics**
2. **Renewable and Non-Renewable resources of energy**
3. **Biofuels: Scope, source and production process**
4. **Bioremediation: Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents.**
5. **Treatment of municipal and Industrial waste water**
6. **Biofertilizers and Biopesticides- Scope, production and uses.**
7. **Environmental significance of Genetically Modified organisms (GMOs), plants and animals**

BBT-323: Food and Industrial Biotechnology lab (0+3)

1. Isolation of different types (bacteria, mould and yeast) for food.
2. Detection of amylase producing bacteria/ fungi from food sample.
3. Detection of coli forms and E-coli in food.
4. Estimation of BOD.
5. Determination of dissolved oxygen concentration of water sample.
6. Estimation of nitrate in drinking water.
7. Vermiculture and solid waste treatment
8. Testing of chlorine demand of water.
9. Estimation of hardness in drinking water.
10. Estimation of TDS in water
11. Testing of sulfate in water
12. Testing of fluoride in water
13. Testing of iron in water.

.

BBT-324 Bioethics, legal issues and patenting (2+0)

1. **Social, legal and ethical issues – Basic principles of Biosafety and Bioethics .**
2. **IBSC, RCGM**
3. **Institutional animal ethics committee**
4. **GEAC**
5. **CPCSEA**
6. **Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International.**
7. **Intellectual Property Rights – Why IPR is necessary, TRIPS & IPR, IPR – national & international scenario, IPR protection of life forms.**

BBT-325: Project work (0+6)

1. Project report.
2. Seminar and viva –voce on Project work.

BOOKS

FOOD AND INDUSTRIAL BIOTECHNOLOGY

1. Bisen P.S (1994) Frontiers in Microbial Technology, 1st Edition, CBS Publishers.
2. Glaser A.N and Nilaido.H (1995) Microbial Biotechnology, W.H Freeman and Co.
3. Prescott and Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers & Distributors.
4. Prescott and Dunn (2002) Industrial Microbiology, Agrobios (India) Publishers.
5. Crueger W. and Crueger A. (2000) A Text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp.
6. Stanbury P.F, Ehitaker H, Hall S.J (1997) Priciples of Fermentation Technology, Aditya Books (P) Ltd.
7. Food Microbiology – Adams and Moss
8. Food Microbiology – Fraizer and Werthoff
9. Food Fermentation – Microbiology, Biochemistry & Technology, Vol. I & II , Joshi and Pandey.

ENVIRONMENTAL BIOTECHNOLOGY

1. Biosafety and Bioethics – Joshi, R.M.: Eastern Book House.
2. Biotechnology in Environmental Management- Pathade, G.R., Eastern Book House.
3. Biodiversity and Environmental Biotechnology- Dwivedi, P and Kalita, M.C.

B.Sc. Industrial Microbiology (H) (6 semester duration)

Course Structure

First Semester

Course Code	Course title	Credit Hrs.
BTM -111	Biochemistry-I	3+0
BTM -112	Microbiology-I	3+0
BTM -113	Cell Biology	3+0
BTM -114	Biochemistry lab-I	0+2
BTM -115	Microbiology lab-I	0+2
BTM -116	Cell biology lab-I	0+2
BTM -117	Cell metabolism	3+0
BTM -118	Basic English	0+0

Second Semester

Course Code	Course title	Credit Hrs.
BTM -121	Biochemistry -II	3+0
BTM -122	Genetics	3+0
BTM -123	Microbiology-II	3+0
BTM -124	Biochemistry lab-II	0+2
BTM -125	Microbiology lab-II	0+2
BTM -126	Cytogenetics lab	0+2
BTM -127	**Recombinant DNA Technology**	**3+0**
BTM -128	**Advanced uses of Computer**	**0+0**

Third Semester

Course Code	Course title	Credit Hrs.
BTM -211	Molecular Biology	3+0
BTM -212	Biophysical chemistry	3+0
BTM -213	Instrumentation	3+0
BTM -214	Molecular biology lab	0+2
BTM -215	Biophysical techniques	0+2
BTM -216	Instrumentation lab	0+2
BTM-217	**Plant and Animal Tissue Culture**	**3+0**

Fourth Semester

Course Code	Course title	Credit Hrs.
BTM -221	Genetic engineering	3+0
BIM-222	Microbial Physiology & Metabolism	3+0
BTM -223	Immunology	3+0
BTM -224	Genetic engineering lab	0+2
BTM-225	Immunology lab	0+2
BIM -226	Microbial Physiology and metabolism lab	0+2
One month mandatory Industrial summer internship		

Fifth Semester

Course Code	Course title	Credit Hrs.
BIM-311	Medical Microbiology	3+0
BIM-312	Industrial Microbiology	3+0
BIM-313	Biostatistics and Bioinformatics	3+0
BIM-314	Medical Microbiology lab	0+2
BIM-315	Biostatistics, Computer application & Bioinformatics lab	0+2
BTM-316	**Basic Fermentation technique**	**3+0**
BIM-317	Industrial Microbiology lab	0+2

Sixth Semester

Course Code	Course title	Credit Hrs.
BIM-321	Food and dairy microbiology	3+0
BIM-322	**Environmental Biotechnology, Bioethics, Legal Issues and Patenting**	3+0
BIM-323	Microbial Biotechnology	3+0
BIM-324	Food and dairy microbiology/ lab	0+2
BIM-325	Microbial biotechnology lab	0+2
BIM-326	Project work	0+6

SEMESTER I

BTM -111: Biochemistry I (3+0)

1. Basic chemistry of biomolecules: Carbohydrates, Lipids, Proteins and Nucleic acids
2. Amino acids: Classification and properties
3. Proteins: Classification based on structure and functions, structural organization of proteins (primary, secondary, tertiary and quaternary structures).
4. Photosynthesis: Structure of photosynthetic apparatus, Light and Dark reactions, C_3 and C_4 cycle
5. Lipids: Structure, properties, classification and functions

BTM -112: Microbiology I (3+0)

1. History of microbiology, Scopes in microbiology, Concept of microbial diversity
2. Microscopy: Fluorescence, Phase contrast, Electron Microscope
3. Introduction to eubacteria, archaea, **Marine resource and diversity** and eukaryotic microorganisms
4. Structural differences between Gram positive, Gram negative and archaea cells
5. Microbial growth: batch, continuous and synchronized cultures
6. Microbial nutrition: phototrophs, chemotrophs, heterotrophs
7. Microbial Media: simple, differential and selective
8. Pure culture technique: Isolation, preservation and maintenance of culture

BTM -113: Cell Biology (3+0)

1. Introduction: the Cell theory, structural organization of a prokaryotic and eukaryotic cell.
2. Plasma membrane: structural organization, function, transport across the membrane.
3. Cellular organelles: structure and functions of rough and smooth endoplasmic reticulum, Golgi complex, **Protein Trafficking**, Lysosome, Peroxisome, Vacuoles, Mitochondria, Chloroplast.
4. Nucleus and nucleolus, chromatin structure and organization
5. Cytoskeleton and extra cellular matrix
6. Cell divisions: Cell cycle and control of cell cycle, cell death (apoptosis and necrosis), cancer.

BTM - 114: Biochemistry lab-I (0+2)

1. Units of Biochemistry
2. Instruments/Equipments and Glass Ware Used in Biochemical Laboratory
3. Concentration of Solution
4. pH and It's determination
5. Buffer and It's uses
6. Qualitative tests of Carbohydrate
7. Estimation of glucose by O-Toluidine method.
8. Qualitative test of Amino acids
9. Qualitative test of Protein.
10. Estimation of Protein by Biuret method.
11. Titration of Mixture of strong and weak acids
12. Paper chromatography

BTM - 115: Microbiology lab-I (0+2)

1. Introduction To The Microbiology Laboratory
2. Microscope And Microscopy
3. How To Use Microscope
4. Control Of Microorganisms
5. Preparation Of Culture Media
6. Pure Culture Techniques
7. Isolation Of Pure Culture
8. Sampling Of Microorganism
9. Preparation Of Bacterial Smear
10. Morphological Characteristics Of Bacteria
11. Cultural Characteristics Of Bacteria
12. Simple Staining
13. Negative Staining Of Bacteria
14. Differential Staining Of Bacteria
15. Special Staining Of Bacteria (Endospore Staining)
16. Special Staining Of Bacteria
17. Motility Test By Hanging Drop Technique
18. Calibration Of Micrometer
19. Measurement Of Microorganism By Using Ocular Micrometer

BTM - 116: Cell biology lab (0+2)

1. Laboratory Safety

2. Osmotic Haemolysis
3. Plasmolysis: Study of plant cell in hypertonic solution
4. Study of plant cell types by cell maceration
5. Pipetting: Using micropipettors
6. Counting and determination of cell viability using haemocytometer
7. Paper chromatography
8. Mitosis in onion root tip cells
9. Meiotic cell Division in flower bud.

BTM – 117: Organic mechanism in biology (3+0)

6. **Common Mechanisms in Biological Chemistry – Overview of Digestion, Absorption, Metabolism (Anabolism & Catabolism), Nutrition, Respiration, Excretion.**
7. **Carbohydrates metabolism: Glycolysis, Kreb's Cycle and Oxidative Phosphorylation, Gluconeogenesis, Pentose phosphate pathway, Glyoxylate cycle.**
8. **Lipid Metabolism – Structures and roles of Fatty acids &Glycerols, beta oxidation of saturated fatty acids, oxidation of unsaturated fatty acids, oxidation of odd chain fatty acids, energy yield, ketone bodies.**
9. **Amino acid Metabolism – Amino acid breakdown (amino acid deamination, Urea cycle, metabolic breakdown of individual amino acids – glucogenic&ketogenic amino acids), amino acids as biosynthetic precursors (haem biosynthesis & degradation, biosynthesis of epinephrine, dopamine, seretonin, GABA, histamin, glutathione); biosynthesis of essential & non-essential amino acids.**

10. **Nucleotide Metabolism – biosynthesis of purine & pyrimidine (de novo & salvage pathway); degradation of purine & pyrimidine.**

BTM – 118: Basic English (0+0)

BOOKS

CELL BIOLOGY

1. Molecular Biology of cell – Bruce Alberts *et al*., Garland Publications
2. Animal Cytology and Evolution – MJD, White Cambridge University Publications
3. Molecular Cell Biology – Daniel, Scientific American Books.
4. Cell Biology – Jack D.Bruke, The William Twilkins Company.
5. Cell Biology – Ambrose and Dorouthy M Hasty, ELBS Publications.
6. Fundamentals of Cytology – Sharp, Mc Graw Hill Company
7. Cytology – Wilson and Morrison, Reinform Publications

MICROBIOLOGY

1. Microbiology – Pelzer, Chan, Krieg, Tata McGraw Hill Publications.
2. Microbiology – Concepts and Application by Paul A.Ketchum, Wiley Publications
3. Fundaments of Microbiology- Frobisher, Sauders and toppan Publications.
4. Microbiology - Ronald M.Atlas
5. Introductory Biotechnology – R.B. Singh C.B.D. India (1990)
6. Industrial Microbiology – Casidal. E.Wiley Eastern Ltd.
7. Fundamentals of Bacteriology – Salley
8. Frontiers in Microbial technology – P.S.Bisen, CBS Publishers
9. General Microbiology- C.B.Powar, H.F. Daginawala, Himalayan Publishing House

BIOCHEMISTRY

1. Principles of Biochemistry- AlbertL. Lehninger CBS Publishers & Distributors
2. Biochemistry – Lubert Stryer Freeman International Edition.
3. Biochemistry – Keshav Trehan Wiley Eastern Publications
4. Fundamental of Biochemistry – Dr. A.C.Deb
5. Biochemistry- L.U. Satyanarayana, Books and Allied Pvt. Ltd.
6. Outlines of Biochemistry- Conn and Stumpf, Wiley Eastern Ltd., New Delhi.
7. Biochemistry-Voet and Voet, John Wiley and Sons.
8. Biochemical Methods- S. Sadasivam and A. Manickam, New Age International Publishers, New-Delhi.
9. Laboratory Manual in Biochemistry- J. Jayaraman, New Age International Publishers, New-Delhi.
10. Text Book of Practical Plant Chemistry- A. Buzarbarua, S. Chand and Co. New Delhi.

SEMESTER II

BTM -121: Biochemistry –II (3+0)

1. Human hormones: protein and steroid hormones, mechanism of hormone action.
2. Plant hormones: auxins, gibberellins, cytokinins, ethylene, abscisic acid
3. Vitamins: water and fat soluble vitamins, dietary source and deficiency syndromes
4. Enzymes: Classification, catalysis, mechanism of enzyme action, factors influencing enzyme activity, immobilization of enzymes, co-enzymes and cofactors, Isozymes.
5. Nitrogen metabolism and fixation of nitrogen in leguminous plants
6. Contractile protein, neurotransmitter

BTM -122: Genetics (3+0)

1. Mendel's laws of inheritance
2. Extension of Mendelism: Incomplete dominance, co-dominance, pleiotropy, multiple allelism, complementation and epistasis,
3. Linkage and crossing over
4. Sex determination and sex linked inheritance
5. Numerical and structural changes in chromosomes
6. Mutation and mutagenesis
7. Extra-nuclear inheritance
8. Population genetics: Hardy-Weinberg equilibrium, maintenance and establishment of the equilibrium

BTM -123: Microbiology II (3+0)

1. Bacterial genetics: conjugation, transformation and transduction
2. Microbial metabolism: photosynthesis, assimilation of inorganic nitrogen, phosphorous and sulphur
3. Viruses: Basic structure, classification, bacteriophages, lytic and lysogenic cycle, Viriods and prions.
4. Plant Microbe interactions
5. Mycoplasmas, Rickettsiae and Chlamydiae
6. Microbes and public health: Enterobacterioceae, Mycobacterium, Gonococci, Candida, Aspergillus, Variola, Varicella-Zoster, etc.
7. Microbes and pharmaceutical industry

BTM - 124: Biochemistry lab II (0+2)

1. Extraction and quantification of total lipids.
2. Estimation of Vitamin C from plant samples.
3. Preparation of starch from Potato and its hydrolysis by salivary amylase. Test of salivary amylase.
4. Estimation of total Protein (Lowry's method).
5. Preparation of acetate and phosphate buffers with different pH.
6. Extraction of casein from milk.
7. Effect of temperature / pH on enzyme activity
8. Assay of alkaline phosphatase.

BTM - 125: Microbiology lab II (0+2)

1. Generation time of bacteria(Growth curve)
2. Most probable number(MPN) of Coliforms in water
3. Isolation of pure culture by streak plate
4. Isolation of pure culture by pour plate method
5. Isolation of pure culture by pour plate method
6. Cultivation of anaerobes
7. Isolation and culture of rhizobium
8. Isolation and identification of *E.coli* from given water sample
9. Detection of extracellular bacterial enzyme production
10. Isolation of slime moulds
11. Antibiotic sensitivity testing
12. Germicidal effect of UV light on bacterial growth

.

BTM - 126: Cytogenetics lab (0+2)

1. Basic sterilization techniques required for Media preparation & Cytological techniques.
2. Media preparation technique.
3. Blood Typing
4. Enumeration of WBC and RBC
5. Mitosis in hordeum vulgare
6. Mitotic aberration
7. Isolation of Lymphocytes
8. Demonstration of banding and Karyotyping with permanent slides.

BTM - 127: Recombinant DNA Technology (3+0)

1. Gene Recombination and Gene transfer : Bacterial Conjugation, Transformation, Transduction, Episomes, Plasmids, Microinjection, Electroporation, Microprojectile, Shot Gun method, Ultrasonication, Liposome fusion, Microlaser.
2. Polymerase chain reaction (PCR), RT-PCR
3. Changing genes: site-directed mutagenesis and Protein engineering: Primer extension is a simple method for site directed mutation, PCR based site directed mutagenesis, Random mutagenesis, Use of Phage display techniques to facilitate the selection of mutant peptides, Gene shuffling, production of chimeric proteins.
4. Molecular Markers – RFLP, RAPD, AFLP
5. Molecular detection techniques - Southern, Northern and Western hybridization.

BTM - 128: Advanced uses of Computer (0+0)

10. **History and Generation of computer:-1st to 4th generation with their characteristics.**
11. **Basic concepts of computer**
12. **Introduction, different components of computer, basic design of computer.**
13. **Computer architects**
14. **Introduction to operating system**
15. **Algorithm and flow chart**

16. **Execution of a Program- spread sheet; data based concepts using MS-EXCEL, MS-POWER POINT and MS-WORD, Networking; LAN,MAN and WAN**
17. **Introduction to OS**
18. **Memory management –Memory allocation rule, Swapping, Overlay, Paging, Demand paging, segmentation, virtual memory.**

BOOKS

GENETICS

1. Principles of Genetics – E.J. Gardener, M.J. Simmons and D.P. Snustad, John Wiley and Sons Publications.
2. Genetics- M.W. Strickberger, Prentice Hall of India Pvt. Ltd., New- Delhi.
3. Fundamentals of Genetics- B.D. Singh

SEMESTER III

BTM -211: Molecular Biology (3+0)

1. Nucleic Acids: Nucleic acid as the genetic material, structure and aggregation of DNA and RNA, DNA double helix, different conformations of double helix, DNA supercoiling, denaturation and renaturation of DNA, C-value paradox, Cot value and curve, chemical complexity
2. DNA replication, DNA damage and DNA repair (SOS and excision repair)
3. Homologous recombination, site specific recombination and transposons
4. Transcription in prokaryotes and eukaryotes
5. Regulation of gene expression in prokaryotes: *lac* and *trp* operons
6. Genetic code
7. Translation in prokaryotes and eukaryotes

BTM -212: Biophysical Chemistry (3+0)

1. pH and Buffers
2. Chemical bonding: Ionic bond, covalent bond, hydrogen bond, peptide bond, Vander-Waals forces
3. Properties of water
4. Thermodynamics- the First law of thermodynamics, concept of internal energy, the Second law of thermodynamics, free energy, enthalpy, entropy, free energy in biochemical reactions, and in transport of non-ionic and ionic substances across the biological membranes.
5. Nucleic Acids: structure and aggregation of DNA and RNA, DNA double helix, different conformations of double helix, DNA supercoiling.
6. Concept of Protein folding: hydrophilic and hydrophobic amino acids

BTM -213: Instrumentation (3+0)

1. Principles of pH meter, dialysis
2. Principles of different types of centrifugation, ultracentrifugation, application of analytical centrifugation and density gradient centrifugation.
3. General principles of chromatography, adsorption chromatography, column, affinity, TLC, partition, ion exchange, gel filtration and permeation chromatography.
4. Principles and application of gel electrophoresis
5. Spectroscopic techniques: principles and applications of spectroscopy,
6. Radioisotope technique: nature of radioactivity, principles of radioisotopes and radiations, units, radioactive decay, detection and measurement of radioactivity.
7. Thermo cycler and its variants
8. Microscopy

BTM -214: Molecular Biology lab (0+2)

1. Extraction of genomic DNA from animal cell (whole blood)
2. Isolation of Genomic DNA from plant tissue
3. Isolation of genomic DNA from Bacteria
4. Isolation of genomic DNA using teaching kit (whole blood)
5. Quantitative estimation of DNA and RNA
6. Determination of molecular weight of DNA bands based on Agrose gel electrophoresis
7. Southern blotting
8. Isolation of Protein
9. Quantification of Protein.
10. SDS-PAGE

BTM -215: Biophysical Chemistry lab (0+2)

1. To determine the pH of unknown sample
2. To prepare Phosphate, Bicarbonate & Citrate buffer
3. Isolation of Casein protein by Isoelectric precipitation
4. Paper Chromatography of Amino acids
5. SDS PAGE
6. Spectrophotometric quantification of DNA sample

BTM -216: Instrumentation lab (0+2)

1. Calibration of pH meter.
2. Paper chromatography of amino acids/sugars.
3. TLC of sugars/amino acids.
4. Cellular fractionation and separation of cell organelles using centrifuge.
5. Validity of Beer's law for colorimetric estimation of creatinine.
6. Absorption spectrum of NAD & NADH.
7. Rocket immuno-electrophoresis

BTM -217: Plant and Animal Tissue Culture (3+0)

1. Introduction to Techniques - Introductory history, Laboratory organization, Media, Aseptic manipulation.

2. Basic concepts in cell culture - cell culture, Cellular Totipotency, Somatic Embryogenesis.

3. Growth Hormones - Plant cells (Composition of culture media, Growth hormones, Vitamins, Unidentified supplements, selection of media); Animal cells (substrate on which cells grow, Feeder layer on substrate, gas phase for tissue culture, media and supplements).

4. In vitro plant culture : approaches & methodologies - preparation steps for tissue culture, surface sterilization of plant tissue material, basic procedure for aseptic tissue transfer, incubation of culture.

5. Tissue culture methodologies - Plant cells (Callus Culture, Cell Suspension Culture, Organ Micro-culture, plant micro-propagation, Somatic Embryogenesis); Animal cells (Source of tissue, primary culture, differentiation of cells, growth kinetics, animal cell lines and their origin and chracterization).

BOOKS

BIOPHYSICAL CHEMISTRY

1. Narayanan, P (2000) Essentials of Biophysics, New Age Int. Pub. New Delhi.
2. Roy R.N. (1999) A Text Book of Biophysics New Central Book Agency.

MOLECULAR BIOLOGY

1. Glick, B.T and Pasternak J.J (1998) Molecular Biotechnology, Principles and application of recombinant DNA, Washington D.C. ASM press.
2. Howe.C. (1995) Gene Cloning and Manipulations, Cambridge University Press, USA
3. Lewin, B., Gene VI New York, Oxford University Press.
4. Rigby, P.W.J. (1987) Genetic Engineering, Academic Press Inc. Florida, USA.
5. Sambrook et al (2000) Molecular Cloning Volumes I, II, & III Cold spring Harbor Laboratory Press, New York, USA
6. Walker J.M. and Gingold, E.B. (1983) Molecular Biology and Biotechnology (Indian Edition) Royal Society of Chemistry U.K
7. Karp.G (2002) Cell and Molecular Biology, 3rd Edition, John Wiley and Sons; INC
8. Cell and Molecular Biology- P.K. Gupta, Rastogi Publishers, Meerut

SEMESTER IV

BTM - 221: Genetic Engineering (3+0)

1. Introduction to Genetic Engineering: definition, history and scope.
2. Restriction enzymes- definition, characteristics and uses.
3. Cloning and cloning vectors: Plasmid vectors, λ vectors.
4. Construction and screening of Genomic DNA library and c DNA library.
5. DNA finger printing.
6. Nucleic acid sequencing: Di-deoxy and Chemical sequencing methods

7. Genetic engineering in animals: Production of transgenic mice, ES cells can be used for gene targeting in mice, Applications of gene targeting, Using Yeast to study Eukaryotic gene function, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immunemodulators and vaccines, Transgenic animals, Production of proteins of Pharmaceutical value.

8. Genetic engineering in plants: Use of Agrobacterium tumefaciens and Arhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.

BIM - 223: Microbial Physiology and metabolism (3+0)

1. **Metabolite Transport Diffusion: Passive and facilitated, Primary active and secondary active transport,Group translocation (phosphotransferase system), symport, antiport and uniport, electrogenic and electro neutral transport, transport of Iron.**
2. **Microbial Growth: Definition of growth, balanced and unbalanced growth, growth curve, themathematics of growth-generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxie growth curve.**
3. **Measurement of microbial growth: Measurement of cell numbers, cell mass and metabolic activity**
4. **Effect of the environment on microbial growth: Temperature- temperature ranges for microbial growth, classification based ontemperature ranges and adaptations, pH-classification based on pH ranges andadaptations, solutes and water activity, oxygen concentration, radiation and pressure.**
5. **Chemolithotrophic metabolism: Physiological groups of aerobic and anaerobic chemolithotrophs, Hydrogenoxidizingbacteria and methanogens.**
6. **Carbon dioxide fixation : Calvin cycle and reductive TCA cycle.**

BTM -223: Immunology (3+0)

1. History and scope of Immunology
2. Types of Immunity: acquired and innate; **Inflammation**, cell mediated and humoral immunity
3. Cells, tissues and organs of the immune system
4. Antigen: antigenicity vs. immunogenicity
5. Immunoglobulin: structure, function and diversity; antigen-antibody reactions, **concept of ELISA, Immuno Assay.**
6. T cell and B cell maturation and activation
7. Cytokines, Interleukins, **T Cell and B Cell defects.**

BTM -224: Genetic Engineering lab (0+2)

1. Isolation of genomic DNA from bacteria, plant and animal tissue.
2. Isolation of plasmid DNA (*E. coli*).
3. Restriction digestion of DNA.
4. Separation of DNA by Gel Electrophoresis.
5. SDS-PAGE for protein profiling.
6. Isolation of chloroplast DNA.
7. Restriction digestion of DNA.
8. Demonstration of Replica plating technique.
9. Identification of Lac+ bacteria by blue white screening using IPTG.
10. Ligation of DNA.
11. Demonstration of Southern blotting.
12. Demonstration of western blotting.
13. Chemical mutagenesis and production of microbial mutants.

BTM -225: Immunology lab (0+2)

1. Antigen – antibody reaction
2. ABO-Blood grouping
3. Ouchterloney immunodiffusion.
4. Radial immunodiffusion.
5. Differential leukocyte count (DLC)
6. Blood film preparation.
7. ELISA (Kit).

BIM-226: Microbial Physiology and metabolism (0+2)

1. **To study and plot the growth curve of E coli using turbidometric method and to calculate specific growth rate and generation time.**
2. **To study and plot the growth curve of Aspergillus niger by radial growth measurements.**
3. **To study the effect of pH on the growth of E. coli**
4. **To study the effect of temperature of Aspergillus niger by dry weight method.**

Demonstration of the thermal death time and decimal reduction time of E. coli.

Books

GENETIC ENGINEERING

1. Glick, B.R and Padternak J.J (1994) Molecular Biotechnology, Principles and Applications of Recombinant DNA, American Society for Microbiology, Washington D.C
2. Christopler, H. (1995) Gene Cloning and Manipulating, Cambridge University Press
3. Nicholl, D.S.T (1994) An Introduction of Genetic Engineering, Cambridge University Press.
4. Old, R.W. and Primrose, S.B. (1986) Principles of Gene manipulation, An introduction to genetic engineering (3rd Edition) Black well Scientific Publications
5. Lewin, B. (1994) Genes VI, New York, Oxford University Press.
6. Gene Cloning- TA. Brown, Blackwell Publisher
7. Molecular Cloning: A Laboratory Manual, Maniatis, Fritch and Samrock.

IMMUNOLOGY

1. William, E. Paul (1989) Fundamental immunology, 2nd Edition Raven Press, New York.
2. William, R. Clark (1991) The Experimental Foundations of Modern Immunology (4th Edition) John Wiley and Sons, New York.
3. Ivan, M, roitt (1994) Clackwell Scientific Publications, London

SEMESTER V

BIM-311 Medical Microbiology (3+0)

1. **Normal microflora of the human body : Skin, throat, gastrointestinal tract, urogenital tract**
2. **Host-pathogen interaction :Definitions of invasion, pathogen, parasite, pathogenicity, toxigenicity, virulence, carriers and their types, nasocomial infections, opportunistic infections, septicemia, septic shock, transmission and spread of infection.**
3. **Sample collection, transport and diagnosis: Collection, transport and culturing of clinical samples, principles of differentdiagnostic tests (ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes).**
4. **Bacterial diseases (with reference to symptoms, pathogenesis, transmission, prophylaxis and control):** ***Bacillus anthracis, Corynebacteriumdiphtheriae, Streptococcus pyogenes, Escherichia coli, Salmonella typhi and paratyphi, Shigelladysenteriae, Helicobacter pylori, Vibrio cholerae, Haemophilus influenza, Neisseria gonorrhoeae, Mycobacterium tuberculosis, Treponemapallidum.***
5. **Viral diseases (with reference to symptoms, pathogenesis, transmission, prophylaxis and control) Polio, Chicken pox, Herpes, Hepatitis, Rabies, Influenza with brief description ofbird and swine flu, Dengue, AIDS, Viral cancers. An overview of emerging viraldiseases: Japanese Encephalitis, Ebola, Marburg, SARS, Hanta, Nipah, Chandipura,Chikungunya.**
6. **Introduction to protozoan diseases: Malaria, Kala-azar, and Toxoplasmosis.**
7. **Introduction to fungal diseases: Different types of mycoses with particular reference to Dermatomycoses and Opportunistic mycoses.**

8. **Antimicrobial agents and drug resistance: Mechanism of action of important chemotherapeutic agents. Principles of drugresistance in bacteria.**

BIM-312: Industrial Microbiology (3+0)

1. Introduction to industrial microbiology: Brief history and developments in industrial microbiology
2. Fermentation processes : Solid-state and liquid-state (stationary and submerged) fermentations; Batch, fedbatchand continuous fermentations
3. Microbial production of industrial products (micro-organisms involved,media, fermentation conditions, downstream processing and uses)
4. Citric acid, ethanol, penicillin, glutamic acid, riboflavin, enzymes (amylase, lipase, glucose isomerase, glucose oxidase), bioinsecticides (Bt) and Steroid transformations
5. Enzyme immobilization: Methods of immobilization, advantages and applications of immobilization, largescale applications of immobilized enzymes (glucose isomerase and penicillinacylase)

BBT-313: Biostatistics, Computer Application & Bioinformatics (3+0)

1. Introduction and principles of statistical sampling from a population.
2. Random sampling.
3. Frequency distributions and associated statistical measures.
4. Probability measures and probability distributions and Random variable.
5. Correlation, and regression analysis,
8. Hypothesis testing: T, F, Chi-square distribution and tests.
9. Analysis of variance and design of experiment CRD, RBD, LSD and Factorial experiment.
10. Basics about computer (DOS, window operations)
11. Introduction to bioinformatics.
12. Application of different software in solving biological problems
13. Database management and data analysis – use of different databases e.g. Pubme, TIGR, PDB database, Gene bank.
14. Gene and protein sequence analysis
15. Genomics, transcriptomics and proteomics – computer applications

BIM-314 Medical Microbiology (0+2)

1. To identify pathogenic bacteria (any three of *E. coli*, *Salmonella*, *Pseudomonas*, *Staphylococcus, Bacillus*) based on cultural, morphological and biochemicalcharacteristicsCultural characteristics on nutrient agar and in nutrient broth, Gram characteristic,motility, presence of endospore and capsule, IMViC, TSI, sugar fermentation,nitrate reduction, urease production, oxidase and catalase tests.
2. To study composition and use of important differential media for identification of pathogenic bacteria
3. EMB agar, McConkey agar, TCBS agar and Salmonella-Shigella agar (any two)
4. To perform antibacterial testing by Kirby-Bauer method
5. To study symptoms of the diseases with the help of photographs eg. Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis, kaposi's sarcoma), dermatomycoses (ring worms), kala-azar

BBT- 315: Biostatistics and Bioinformatics lab (0+2)

1. Practical work of simple Statistical programmes.
2. Practical on Biostatistics: based on theory papers.
3. Introduction to Computer application.
4. Introduction to software of enzymes, DNA and Proteins.
5. Internet basics.
6. Introduction to NCBI Web sites.
7. Introduction to Data bases.

BTM-316: Basic Fermentation Technique (3+0)

1. Principles of Microbial growth – introduction, the ways of growing microorganisms, ways to increase yield of microbes, Batch, fed-batch and continuous cultures (definition and kinetics).

2. Bioreactor / Fermenter – types & operation of Bioreactors, physico-chemical standards used in bioreactors, limitations of bioreactors, stages of fermentation processes, Media design for fermentation processes, Solid substrate fermentation, Fermenters (Stirred tank, bubble columns, airlift. Bioreactors, Static, Submerged andagitated fermentation), advantages & disadvantages of solid substrate & liquid fermentations.

3. Technology of Microbial cell maintenance – steps to maintain microbial culture in an aseptic & sterile environment (how to inoculate, preserve & maintain), Strain preservation, maintenance and strain improvement by mutation of gene transfer processes

4. Downstream processing – extraction, separation, concentration, recovery & purification, operations (Insulin, Vitamins, Metabolites), Industrial production of Ethyl alcohol, Acetic Acid (Vinegar), Citric acid, lactic acid, α-amylase, protease penicillin, tetracycline and vitamin B12, with reference to easily available raw materials, Production of herbal drugs.

BIM-317 Industrial Microbiology (0+2)

1. Microbial fermentations for the production and estimation (qualitative and quantitative) of:
   (a) Amylase
   (b) Amino acid: Glutamic acid
   (c) Organic acid: Citric acid
   (d) Alcohol: Ethanol
   (e) Antibiotic: Penicillin
2. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations.

BOOKS

PLANT BIOTECHNOLOGY

1. Ravishankar G.A and Venkataraman L.V(1997) Biotechnology: Applications of Plant Tissue and Cell Culture. Oxford and IBH Publishing Co., Pvt Ltd.
2. Bhan (1998) Tissue Culture, Mittal Publications, New Delhi.
3. Islan A.C (1996) Plant Tissue Culture, Oxford and IBH Publishing Co., Pvt. Ltd.

4. Lydiane Kyte & John Kelvins (1996) Plants from test tubes. An introduction to Micropropogation (3rd Edition) Timber Press, Partland.
5. Kumar H.D (1991) A Text Book on Biotechnology (2nd Edition). Affiliated East West Press Private Ltd. New Delhi.
6. Chrispeel M.J. and Sdava D.E. (1994) Plants, Genes and Agriculture, Jones and Barlett Publishers, Boston.
7. Reinert J. and Bajaj Y.P.S (1997) Applied and Fundamental Aspects of Plant Cell, Tissue, and Organ Culture, Narosa Publishing House.

ANIMAL BIOTECHNOLOGY

1. Elements of Biotechnology- P.K. Gupta., Rastogi publishers, Meerut.
2. Biotechnology- B.D.Singh, Kalyani Publishers, Ludhiana
3. A Text Book of Biotechnology- R.C. Dubey, S. Chand & Company Ltd.

BIOSTATISTICS

1. Bliss, C.J.K. (1967) Statistics in Biology, Vol. I Mc Graw Hill, New York.
2. Campbell R.C.(1974) Statistics for Biologists, Cambridge Univ. Press, Cambridge.
3. Daniel (1999) Biostatistics (3rd Edition) Panima Publications Corporation.
4. Swardlaw, A.C. (1985) Practical Statistics for Experimental Biologists, John Wiley and sons, Inc, NY
5. Khan (1999) Fundamentals of Biostatistics.

BIOINFROMATICS

1. Introduction to Bioinformatics - T.K. Attwood, D.J.P. Smith and S. Phukan, Pearson Education
2. Bioinformatics of genome regulation and structure - Kolchanov
3. Trends in Bioinformatics – P. Shanmughavel, Scientific Book Center.

SEMESTER VI

BIM-321 Food and dairy microbiology (3+0)

1. Foods as a substrate for microorganisms: Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general
2. Microbial spoilage of various foods: Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, cannedfoods
3. Principles and methods of food preservation : Principles, physical methods of food preservation: temperature (low, high, canning,drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processingand aseptic packaging, chemical methods of food preservation: salt, sugar, organicacids, SO2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins

4. Fermented foods: Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss,kefir, dahi and cheese, other fermented foods and probiotics.
5. Food borne diseases (causative agents, foods involved, symptoms andpreventive measures) Food intoxications: *Staphylococcus aureus, Clostridium botulinum*and mycotoxins;Food infections: *Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli,*Salmonellosis, Shigellosis, *Yersinia enterocolitica, Listeria monocytogenes*and*Campylobacterjejuni*
6. Food sanitation and control : HACCP, Indices of food sanitary quality and sanitizers
7. Water Potability: Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

BIM-322: **Environmental Biotechnology, Bioethics, Legal Issues and Patenting (3+0)**

1. Overview of the global environmental problems: Climate change, Energy crisis, use and abuse of plastics
2. Renewable and Non-Renewable resources of energy
3. Biofuels: Scope, source and production process
4. Bioremediation: Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents, Marine resources and diversity
5. Treatment of municipal and Industrial waste water
6. Biofertilizers and Biopesticides- Scope, production and uses.
7. Environmental concerns of Genetically Modified Microbes (GMOs), plants and animals
8. Biosafety regulations.
9. Intellectual property rights in biotechnology – patenting of life forms.
10. Moral and ethical issues in biotechnology.

BIM-323 Microbial Biotechnology (3+0)

1. Microbial Products: - Application of microbial biotechnology, production of primary and secondarymetabolites of industrial significance, A brief discussion about production of industrial products such asFuels: Ethanol, Methane;Alcoholic beverages: Beer, Wine.
2. Organic acids: Citric acid, Lactic acid;Antibiotics: Penicillin, Streptomycin;Amino acids: Glutamic acid, Lysine;Enzymes: Protease, Amylase and Lipases
3. Bioconversions: A brief account of steroid biotransformation ;Microbial Foods: Single cell proteins.Sewage waste water treatment: Technique and plants.;Biogas production
4. Biodegradation of xenobiotic compounds;Microbial technology in agriculture- Bioinsecticides, Bioherbicides, Biofungicides. Biotechnology ofmushroom cultivation.

BIM-324 Food and dairy microbiology lab (0+2)

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of any pathogenic bacteria (*Staphylococcus* or *Salmonella*) from foodproducts.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Isolation of spoilage microorganisms from bread.

6. Preparation of Yogurt/Dahi.
7. Determination of potability and faecal contamination of water samples bypresumptive test/MPN test confirmed and completed tests.

BIM-325 Microbial Biotechnology lab (0+2)

1. Fermentation of fruit juices.
2. Demonstration of mushroom production (White button mushroom).
3. Isolation of *Azotobacter*from soil.
4. Isolation of *Rhizobium* from legume root nodules.
5. Preparation of biofertilizer from *Azotobacter*and *Rhizobium* in the laboratory.
6. Demonstration of nodulation ability of rhizobia by inoculation of the legume seeds.
7. Culturing and identification of a yeast (*Saccharomyces cerevisiae*) in the lab.
8. Demonstration of amylolytic and proteolytic activity by a mold/bacterium.
9. Demonstration of antibiotic sensitivity test.
10. Primary screening of amylase producing bacteria from soil

BBT-326: Project (0+6)

1. Project report.
2. Seminar and viva –voce on Project work.

BOOKS

FOOD AND INDUSTRIAL BIOTECHNOLOGY

1. Bisen P.S (1994) Frontiers in Microbial Technology, 1st Edition, CBS Publishers.
2. Glaser A.N and Nilaido.H (1995) Microbial Biotechnology, W.H Freeman and Co.
3. Prescott and Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers & Distributors.
4. Prescott and Dunn (2002) Industrial Microbiology, Agrobios (India) Publishers.
5. Crueger W. and Crueger A. (2000) A Text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp.
6. Stanbury P.F, Ehitaker H, Hall S.J (1997) Priciples of Fermentation Technology, Aditya Books (P) Ltd.
7. Food Microbiology – Adams and Moss
8. Food Microbiology – Fraizer and Werthoff
9. Food Fermentation – Microbiology, Biochemistry & Technology, Vol. I & II , Joshi and Pandey.

ENVIRONMENTAL BIOTECHNOLOGY

1. Biosafety and Bioethics – Joshi, R.M.: Eastern Book House.
2. Biotechnology in Environmental Management- Pathade, G.R., Eastern Book House.
3. Biodiversity and Environmental Biotechnology- Dwivedi, P and Kalita, M.C.

M.Sc. / M.V.Sc. Biotechnology (4 semester duration)

First Semester

Course Code	Course title	Credit Hrs.
BT-611	Molecular Cell Biology	1+1
BT-612	Concepts and Methods in Molecular Biology	1+1
BT-613	Principles of Biochemistry	2+1
BT-614	Principles of Microbiology	2+1
BT-615	Principles of Immunology and Vaccinology	2+1
BT-616	Scientific writing and techniques	1+0
ELECTIVE COURSES		
***BT-617**	Cytogenetic Techniques	1+1
***BT-618**	Enzymology and Enzyme Technology	1+1

Second Semester

Course Code	Course title	Credit Hrs.
BT-621	Molecular Genetics	2+1
BT-622	Bioinformatics	1+1
BT-623	Genetic Engineering & its Applications	2+1
BT-624	Tissue Culture and Hybridoma Technology	2+1
BT-625	Statistical Techniques	1+1
BT-626	Problems and Prospects of Biotechnology	1+0
ELECTIVE COURSES		
***BT-627**	Reproductive Biotechnology	1+1
***BT-628**	Rumen Ecosystem and Manipulation	1+1

Third Semester

Course Code	Course title	Credit Hrs.
BT-631	Seminar	1+0
BT-632	Biodiversity, IPR, Bio safety and Bioethics	2+0
BT-633	Environmental Biotechnology	3+0
ELECTIVE COURSES		
***BT-634**	Animal Genomics	1+1
***BT-635**	Bioprocess Engineering and Food Technology	2+0

Fourth Semester

Course Code	Course title	Credit Hrs.
BT-640	Research Project	0+20

COURSE CONTENT

SEMESTER -1

1. Molecular Cell Biology: (1+1)

Origin and evolution of cells, Prokaryotic and eukaryotic cell architecture, Molecular organization and functions of cell membrane. Organization and functions of the cytoplasm. Cell organelles. Endoplasmic reticulum. Ribosomes. Golgi complex. Mitochondria. Lysosomes. Nucleolus and subnuclear structure. Cell Junction, cytoskeleton, microtubules and microfilaments. Protein secretion and targeting. Intracellular digestion. Oxidative phosphorylation. Pathways of Signal transduction, Cell division, cell cycle, phases of cell cycle. Normal and tumor cell growth and differentiation. Control of proliferation and self regulation. Cell motility. Cell trafficking and signaling. Apoptosis.

Practicals:

- **Laboratory Safety**
- **Microscopy**
- **Osmotic Haemolysis**
- **Plasmolysis: Study of plant cell in hypertonic solution**
- **DNA isolation**
- **Agarose gel electrophoresis**
- **Paper chromatography**
- **Mitosis in onion root tip cells**
- **Meiotic cell Division in flower bud.**
- **Ultra centrifugation technique**
- **Isolation of mitochondria**
- **Blood smear preparation**

2. Concepts and methods in Molecular Biology: (1+1)

Historical development of molecular biology. Chemistry and structure of DNA and RNA. Biosynthesis of purine and pyrimidine. Nucleotides and their regulation. Genome organization in prokaryotes and eukaryotes. Genome diversity, genome complexity, viroids, genomes of viruses. Plasmids, Chloroplast and mitochondrial DNA. Molecular structure and function. Chromatin structure and function. DNA replication. Repetitive and non repetitive DNA. Satellite DNA. Transcription processes in prokaryotes and eukaryotes. RNAediting and RNA processing. Ribosomes- structure and function. Organization ribosomal RNA genes. Organization of mRNA and the initiation of translation and process of polypeptide synthesis. Genetic code. Aminoacyl tRNA synthetases. Translation and post translational modifications. Nucleases and restriction enzymes. DNA sequencing. DNA labeling and blotting techniques.

Practicals:

- **Preparation of buffers and solutions**
- **Isolation of genomic DNA from animal, plant and prokaryotic cells.**
- **Isolation of total RNA,**
- **Qualitative and quantitative estimation of DNA.**
- **Agrose gel electrophoresis of DNA and RNA.**
- **Restriction analysis of DNA.**

- **Isolation of protein.**
- **SDS-PAGE**
- **Western blotting**

3. Principles of Biochemistry: (2+1)

Scope of Biochemistry. Protein, carbohydrates and lipids- structure and properties. Lipid definition, classification and Biological significance. Proteins nature, classification and biological significance. Structure of different types of nucleic acids, biological function and properties of nucleic acidand metabolism. Glycolysis. Pentose phosphate pathway and glycogenasis. Biosynthesis and oxidation of fatty acids. Volatile fatty acids as source of energy in ruminants. Ketogenesis and causes of ketogenesis in ruminants. Structure and functions of biomembranes with special reference to active transport of ions and metabolites. Extra and intracellular communication. Biosynthesis of sterols and phospholipids. Catabolism of amino acids. Transamination and deamination. Urea cycle. Conversion of amino acids into other bioactive compounds. Biosynthesis of nutritionally non essential amino acids. Metabolism of purines and pyrimidines. Disorders of lipid, carbohydrate, nucleic acid and amino acid metabolism. Structure and metabolic functions of water soluble and lipid soluble vitamins. Vitamins as coenzyme and prosthetic group of enzyme Trace elements and their role in biological processes. Deficiencies and nutritional significance of vitamins and trace elements in domestic animals and poultry. General description of nature of hormones, receptors and mechanism of their action. Mechanism of hormone action. Role of cAMP and cGMP. Metabolic functions of different hormones and associated disorders due to hypo or hyper secretions of major endocrine glands viz. pituitary, thyroid, adrenal, pancreas and gonads.

Practicals:

- **Isolation of protein**
- **Quantification of protein**
- **SDS-PAGE**
- **Western blotting**
- **Spot test for carbohydrates.**
- **Estimation of reducing sugars by benedict's method.**
- **Spot test of amino acids.**
- **Saponification.**
- **TLC**
- **Column chromatography**

- **Estimation of enzymes**
- **Estimation of cholesterol**
- **Liver and kidney function test**

4. Principles of Microbiology: (2+1)

History of microbiology, discovery of the microbial world. Isolation, pure culture techniques. Methods of sterilization and enrichment techniques. Bacterial identification. Nomenclature and classification. New approaches to bacterial taxonomy / classification including ribotyping. General structure and features. Brief account of all group of bacteria nd cyanobacteria. Rickettsia. Chlamydia and Mycoplasma. Archaea, Arhcaebacteria and extremophilic microbes – their Biotechnological potentials.The definition of growth, growth curve. Measurement of growth and growth yields. Culture collection and maintenance of cultures.

Different modes of nutrition in bacteria, Sulfate reduction,Nitrogen metabolism – Nitrate reduction, nitrifying and denitrifying bacteria. Nitrogen fixation and Microbes used as biofertlizer.

Viruses: Classification, morphology and composition of viruses in general. Unclassified viruses, viroids, prions. Infectivity assay of viruses; quantal and quantitative assay. Multiplication of virus: steps in viral replication adsorption, penetration, un-coating and eclipse, transcription, synthesis of DNA or RNA, translation, synthesis of viral protein. Bacteriophages : ØX174, cyanophages and retroviruses. Viroids and Prions.

Practicals:

- Sterilization technique with preparation of media.
- Serial dilution method and viable counting of microorganism
- Identification of bacteria through various techniques (by staining: Grams staining. Negative, Positive,
- Acid fast, Nuclear and Flagellar staining: Motility test: by Hanging drop method)
- Cultivation & Enrichment techniques for microorganism (cultural & metabolic characteristic).
- Antibiotic disc diffusion test & MIC (Minimum Inhibitory Concentration).
- Biochemical tests
- Proteins nonproteineous and nitrogenous substances.
- Inoculation and cultivation of virus in embryonated eggs
- Viral nucleic acid isolation

5. Principles of Immunology and Vaccinology: (2+1)

Immune response: innate, acquired and passive. Cells and organs of immune system. Leococyte recirculation. **Inflammation and its mechanism.** Antigen: properties of antigen. Epitope; concept of epitope for B-cell and T-cell response. Haptens and carrier function. Antibody: different types/ classes of immunoglobulins. Antigen super antigens and immunogeneicity. Antigen – Antibody

reaction. Various tests to detect antibody – antigen reaction in –vitro viz. immuno-diffusion, immuno-electrophoresis, ELISA, RIA. Introduction to monoclonal antibody production: concept and applications, recent developments in vaccine technology. Different types of vaccines i.e. sub-unit vaccines, recombinant vaccines, synthetic vaccines, idiotypic based vaccines, DNA vaccines, glycoconjugate vaccines, deletion vaccines. Genetic bases of attenuation. Vaccine vectors. Large-scale production of vaccines and automation. Vaccine delivery system and approaches to enhance immunogenecity, immunomodulators and Immunomodulation adjuvants. Immunological tolerance and auto immunity. Delivery of particulate antigens through liposomes, microspheres. Protein cocheleates. GMPs and quality control of conventional vis-à-vis recombinant vaccines.

Practicals:

- **Basic hematology**
- Isolation of lymphocytes.
- Study of Immunoglobulins, purification of Immunoglobulins & SDS-PAGE (Immunoglobulin – G).
- Immunobloting experiment.
- ELISA, Precipitation tests for antigen – antibody interaction (Gel diffusion and different types of immunoelectrophoresis.
- Complement fixation test.
- Flourescent antibody technique.

6. Scientific writing and techniques: (1+0)

Introduction to scientific thinking, aptitude. Planning and designing of a dissertation project,and Research methodology. Managing with research literatures, use of end note and literature management software. search and understanding. Scientific writing of research paper / articles. Development of winning project proposals.

SEMESTER – 2

1. Molecular Genetics: (2+1)

History and development of genetics. Introduction to cell division. Chromosomal theory of inheritance. Mendelian laws and physical basis of inheritance, dominance and its molecular basis. Model of Genetic system: Lambda, *E.Coli*, Neurospora, Yeast, Drosophila, Arabidopsis and Maize. Principles of inheritance, Qualitative & Quantitative Traits, DNA, a genetic material. Source of genetic variations, Molecular basis of genetic variation. Induced, Mutagenesis: physical, chemical & biological. Site directed mutagenesis: DNA sequences, chromatin & Chromosome structures. DNA & chromosomes replicationrepair and recombination, central dogma. Genetic, physical & molecular maps. Gene transfer in prokaryotes; conjugation, complementation & test of allelism. Changes concept of gene. Prokaryotic & Euryotic genomes, Genome complexity, repetitive vs unique molecular mapping &

tagging of genes, Marker assisted selection; structural organization of genes in prokaryotes & controls. Genetics of antibody diversity, molecular genetics of cell division and ageing. DNA finger printing and biodiversity, functional genomics. **An overview of genomic selection of animals: Useful economic traits, Reference population, Construction of SNP genotyping platforms, Calculation of GEBV.**

Practicals:

- **RFLP,PCR-RFLP**
- **R.E. digestion**
- **Agarose gel electrophoresis**

- **DNA finger printing.**
- **Estimation of genetic diversity and phylogenetic analysis**
- **Numericals on fundamental genetics**
- **Quantification of RNA/DNA**

2. Bioinformatics: (1+1)

Introduction to Bio-informatics: Definition and aims. Information retrieval concepts, fundamentals of Database searching. Computational gene finding – multiple alignment and sequence search. Biomolecules – nucleic acid, protein, carbohydrate, lipid, biological database, Biocomputing languages, bio informatics software, data mining and sequence analysis. Predicting structure and function. Molecular evolution and phylogenetic trees. Biological database, Bioinformtics software: cluster W. Oligopromer analysis software, tree view, linkage analysis data mining software, introduction to international databases NCBI, EBI and DDBJ. Introduction to BLAST and its types, Multiple sequences alignment tools. **Structure prediction software, Rasmol. Submitting sequence to data base. DNA and RNA secondary structure, Analysis of Microarray and NGS data. analysis. Analysis of variance and design of experiment CRD, RBD, LSD and Factorial experiment, Genomics – about the genomics, history, comparative genomics, comparative genomic hybridization, functional genomics, Genome projects – an overview of genome projects of human and other model organisms of Human Genome Project.**

Practicals:

- Biological database.
- Bioinformatics software: cluster W. Oligopromer analysis software, tree view, Alscript; Rasmol, phylip, linkage analysis.
- Data mining software: NCBI, BLAST.
- Multiple sequences alignment: MULTI ALIN, BLOCKS, MOST, PROBE.
- Structure production software: ssPRED, SOPMA
- Primer designing
- Submission of nucleotide sequence to GenBank

3. Genetic Engineering & its applications (2+1)

History of genetic engineering. Restriction endonucleases, Modification methylases and other enzymes needed in genetic engineering. Cloning vectors: Plasmid vectors, Phagemids, cosmids, artificial chromosome vectors (YAC, BAC). Animal virus derived vectors – SV40 and retroviral vectors, Molecular cloning: Recombinant DNA techniques, constructions of genomic DNA and cDNA libraries, screening of recombinants. Expression strategies for heterlogous genes. DNA analysis: labeling of DNA and RNA probes. Southern and Fluorescence in situ hybridization, DNA fingerprinting, chromosome walking, Techniques for gene expression: Northern and Western blotting, gel retardation technique. DNA footprinting, Primer extension. SI mapping, Reporter assays, Sequencing of DNA, Chemical synthesis of oligonucleotides: techniques of in vitro mutagenesis. Site directed mutagenesis, gene replacement and gene targeting. Polymerase chain reaction, principaland its applications in gene assemblies. Application of RT PCR in gene expression. Use of transposones in genetic analysis: Transposon tagging and its use in identification and isolation of genes, Applicationof genetic engineering: Transgenic animal, production of recombinant pharmaceuticals, gene therapy, disease diagnosis.

Practicals:

- **Isolation of Plasmid DNA**
- **DNA cloning in plasmid**

- **Isolation and identification of positive clones.**
- **Replica plating technique**

4. Tissue culture and Hybridoma technology: (2+1)

Good laboratory practices (GLPs), cell culture media, cell cultures- primary secondary, cell lines Animal cell growth requirement, type of animal cell culture. Continuous cell lines. Monolayer culture, Suspension culture, hybridoma techniques. Introduction to the balanced salt solutions and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Development of cell (Tissue) and organ culture techniques, Nutrient requirements of mammalian cells. Media for culturing cells. Growth supplements, primary cultures. Established cell lines. Hybridoma-devlopment of monoclonal antibodies as immunodiagnostic agents, immunotheraputics. Stationary, Roller and suspension culture techniques. Large- scale production of cells using bioreactors, microcarriers and perfusion techniques. Characterization of maintenance of cells, karyotyping, cryopreservation and revival, Detection of contaminants in cell cultures, Isolation and culture of lymphocytes. Application of cell and organ cultures. Micromanipulation of cells. Cell cloning. Cell fusion and somatic cell hybrids. Principles and methods of hybridoma technology. Production and characterization of monoclonal antibodies and their application in animal health and production.

Practicals:

- **Dynamics of animal tissue culture (Primary cell culture, diploid cell culture, cell lines).**
- **Preparation of media culturing and sub culturing**
- **Small scale culture.**
- **Scaling up of animal cell cultures.**

SEMESTER – 3

1. Biodiversity, IPR, Biosafety and Bioethics (2+0)

Definition Historical and geographical causes for diversity. Genetic diversity, Molecular taxonomy. Species and population biodiversity. Quantifying biodiversity. Maintenance of ecological biodiversity, Biodiversity and centres of origins of animals. Biodiversity hot spots in India. Collection and conservationof biodiversity, conservation of animal genetic resources. Assessing analyzing and documenting biodiversity. Morphological and molecular characterization of biodiversity. Vulnerability and extinction of biodiversirty. Introduction to biodiversity database: endangered animals, endemism and Red data books. Global biodiversity information system. Intellectual property rights (IPR). Sanitary and Phytosanitary measures. WTO, GAAT, Voluntary and Mandatory standards for product development for exports. Soveregnity rights, CBD, bioethics and patenting. General agreement on trade and tariffs. Indian sui-generis system for animal variety and farmer's rights protection act.

2. Environmental Biotechnology: (3+0)

Environment: Basic concepts and issues. Environmental pollution: types of pollution, measurement of pollution: Methodology of environmental management – the problem solving approach, its limitations. Limiting factors, energy transfer and biogeochemical cycling in ecological systems; Response of microbes, plant and animals to environmental stresses; Concept of ecosystems and ecosystem management, Environmental problems- ozone depletion, green house effect, water, air and soil pollution, land degradation. Air pollution and its control through Biotechnology. Water pollution and its control: Water as a scarce natural resource: Need for water management, measurement of water pollution, Source of water pollution, Waste water collection, Waste water treatment- physical, chemical and biological treatment processes, Microbiology of the water waste treatment, Aerobic processes:Activated sludge, Oxidation ditches, Trickling filter. Towers. Rotating discs, Rotating drums, Oxidation ponds, Anaerobic processes: Anaerobic digestion,Anaerobic filters, up flow anaerobic sludge blanket reactors: Treatment schemes for wastewaters of dairy, distillery, sugar, antibiotic industries. Degradation of xenobiotic compounds in environment- Decay behavior and degradtive plasmids; Hydrocarbons, Substituted hydrocarbons, oil pollution, Surfactants, Bioremediation of contaminated soils. Biopesticides: their role in pest managements. Sewage and waste water treatment and solid waste management, chemical measure of water pollution, conventional biological treatment, role of microphyte and macrophytes in water treatment; Recent approaches to biological waste water treatment, composting process and techniques, use of composted materials. Food Feed and energy for waste

(Biomass and Agrowaste). Global Environmental problems; Ozone depletion, UV- and greenhouse effect. Acid rain, its impact and biotechnological approaches for management.

3. **Statistical techniques 1+1**Introduction and principles of statistical sampling from a population. Random sampling, Frequency distributions and associated statistical measures, Probability measures and probability distributions and Random variable, Correlation, and regression analysis,Hypothesis testing: T, F, Chi-square distribution and tests.Basic idea of probability. Normal binominal and Poisson distribution. Sampling methods. Statistical design. Measures of central tendency and dispersion: Mean, Median, Mode, Chi square test, exponential and logarithmic function. Student 't' test. Z- test, F-test. Chi- square test. Analysis of variance (ANOVA). Brief description and tabulation of data and its graphical representation. Mann Whitney . Regression analysis, Factor analysis. Correlation . Pearson product-moment correction coefficient. Spearman's rank correction coefficient. Time series analysis.

ELECTIVES

1. **Cytogenetic techniques: (1+1)**

Cell division and cell cycles, lymphocyte cell culture preparation of the metaphase chromosomes, chromososomes structures and organization, cromometry and chromosomes staining – giemsa staining, G bending, C bending, R bending, NOR bending. Fluorescent bending, sister chromatin exchange (SCE), high resolution bending, in situ hybridization and FISH technique.

Genome projects in model organisms: Yeast, C elegans, Arabidopsis and rice genome projects, organization of human genome; Instability of the genome: Mutation-types, chromosomal aberrations, gene mutation, molecular basis of mutation, polymorphism, DNA damage and mechanism of DNA repair; Application of Molecular cytogenetic techniques: Chromosome banding, chromosome FISH and GISH, chromosome painting and CGH- analysis. Detection of chromosomal abnormalities, classification its effects on animal reproduction and production. Applications of cytogenetic techniques in animal breeding, clinical cytogenetics, chromosomes and cancer, gene mapping and somatic cell hybridization.

Practicals:

- **Setting up of lymphocyte culture**
- **Preparation of metaphase chromosomes from blood, bone marrow and cell lines.**
- **Various staining methods**

2. **Reproductive Biotechnology (1+1)**

Induction of super ovulation. Embryo collection and evaluation. Embryo splitting, Embryo sexing, Embryo transfer Embryo Culture & Embryo Rescue. Advantages of embryo

transfer in farm animals**. Ovum pickup technology**, *In vitro* maturation in vivo sperm capacitation in female reproductive tract. Events of *In vitro* fertilization, cleavage and development of embryos. **Stem cell isolation, characterization, culture and propagation.**

Embryo cloning, nuclear transplantation. Sperm and embryo sexing. Production of transgenic animals and gene farming. Identification and transfer of genes influencing production and disease resistance.

Practicals:

- **Collection of oocytes**
- **IVM of oocytes**
- **In vitro capacitation of spermatozoa**
- **Spermatozoa staining for capacitation**
- **Acrosome reaction**
- **Sperm DNA**
- **Sperm mitochondria**

3. Enzymology and Enzyme Technology: (1+1)

Enzymes as biological catalyst, concept of activation energy and transition stage. Classification and nomenclature of enzymes. Isolation. Purification and large scale production of enzymes, Co enzymes and cofactors. Steady state kinetics: Methods for estimation of rate of enzymes catalyzed reactions with special reference to Michaelis – Menton equation. Effects of substrates, temperature, pH and inhibitors on enzyme activity and stability. Mechanism of the enzyme action (active site, chemical modification) and regulation (Zymogens, Isoenzymes). Enzyme engineering. Application of enzymes. Immobilization of enzymes. Catalytically defective enzymes due to genetic mutation. Use of enzymes in the diagnosis and monitoring of myocardial infarction, liver diseases and pancreatic diseases. Normal and abnormal serum values of the enzymes and their significance, acid and alkaline phosphatase, SGOT, SGPT, α-amylase, LDH, creatine kinase, troponin.

Practicals:

- Comparision of the reactions using enzymes & chemical catalysis.
- Enzyme assay, enzyme activity and specific activity determination.
- Study of mechanism of enzyme action.
- Study of allosteric, competitive & non-cometitive inhibition.
- Methods of immobization .
- Kinetics of immobilized enzymes.

4. **Animal Genomics (2+0)**

Organization of genomes, different types of DNA elements in Domestic animals, microsattlite markers, long interspread nucleotide elements, PCR, PCR-RLFP, SSCP etc. Mapping of structural and functional genes, genetic linkage, contig mapping (Physical mapping), QTL mapping, genomic database and genome status in livestock species and poultry. Gene expression and DNA fingerprinting principal, microarray

technique. Expressed sequence Tags (ESTs), Mapping and characterization of genmic region affecting performance of livestock. Chromosomal localization of genes by FISH, Chromosomal organization of genomes, Use of bioinformatics in genome analysis. MHC and its significance in disease resistance and immune response. Application of genome analysis in animal breeding. Somatic cell genetics, Radiation hybrids, gene mapping techniques. Status of gene maps in different species.

5. Rumen Ecosystem and Manipulation: (1+1)

Introduction to rumen bacteria, protozoa, fungi, archaea and bacteriophages. Ruminal digestion, role of microbes, classification, rumen fermentative process by microbes, role of cellulose and cellulolytic methanogenic organisms and control of methane production. Use of new fungal mutants with less cellulose and high ligninase through recombinant DNA technology. Single cell protein in animal feed. Biological detoxification of aflatoxin and other anti-metabolites present in animal feeds. Role of prebiotics and probiotics.

Practicals:

- Collection of rumen liquor-metods advantages and disadvantages of each.
- Direct and indirect counts of rumen microbes.
- Isolation, culture and characteristics of rumen microbes.
- Effect of chemical and biological substance on rumen fermentation.
- Counting of rumen microbes by MPN technique.

6. Bioprocess Engineering and Food Technology: (2+0)

Isolation, Preservation and Maintenance of Industrial Microorganisms. Microbial growth and Death kinetics. Media for Industrial Fermentation. Fungal biotechnology and its application. Air and Media Sterilization. Types of fermentation processes – Analysis of batch, Fed-batch and continuous bioreactors, Stability of microbial reactors, Analysis of mixed microbial populations, specialized bioreactors (pulsed, fluidized, photo bioreactors etc.), Measurement and control of bioprocess parameters. Downstream processing, Whole cell Immbolization and their Industrial Applications, Industrial production of Chemicals – Ethanol, Acids (citric,acetic & glutamic). Solvents (glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin, tetracycline), Semisynthetic antibiotics, Amino acids (lysine, glutamic acid), Single cell protein. Liposome technology and liposome-mediated drug targeting. Use of microbes in mineral beneficiation and oil recovery. Introduction to food technology – Elementary idea of canning and packing. Sterilization and Pastuerization of food products. Technology of typical food / food products.

PhD. BIOTECHNOLOGY (6 semester duration)

COURSE CURRICULUM

Course Number	Course Outline (credit hours) Semester
BT 701	GENE CLONING AND EXPRESSION (1+1) Sem 1
	Theory : UNIT I Gene cloning- General strategy for gene cloning, transformation. Cloning vectors-plasmids, phages, cosmids, BAC, YAC, expression vectors- viral, baculo and yeast vectors, shuttle vectors. UNIT II Restriction, ligation, transformation and recombinant selection methods, construction of genomic and cDNA library, construction of full length cDNA. UNIT III Linkers, adapters and cassettes, screening the library. UNIT IV Expression of genes in bacteria, yeast, mammalian cells and in plants., identification and purification of expressed protein. Practical : i. Preparation of vector ii. Restriction enzyme digestion of vector. iii. Purification of DNA iv. DNA ligation v. Transformation vi. Calculation of transformation efficiency. vii. Preparation of electro competent cells. viii. Screening by PCR ix. Cloning of PCR products in vectors. x. Introduction of expressed protein. xi. PAGE and western blotting
BT 702	FUNCTIONAL GENOMICS & PROTEOMICS (2+1) SemII
	Theory : UNIT I Sequence feature of genes and genome: Promoters, Transcription binding sites, gene prediction, ORFs and cellular location of the protein products (Tools for gene finding and prediction). Transcriptome and different methods to study gene expression, single gene analysis, northern blots, quantitative PCR, SAGE, MPSS and Microarray. UNIT II Introduction to Gene expression and basic microarray technology, principles, types and applications. Design a microarray experiments, Types of microarray, nanoarray, Customized microarray design, Image processing and quantification, Normalization and filtering, Exploratory statistical analysis, gene expression databases. ESTs, SAGE and UNIGENE. UNIT III SAGE and Microbeads, massive parallel signature sequencing, Microbial transcriptome. Role of functional genomics to study cancer and various clinical applications, Development, physiology and behavior, evolutionary and ecology. UNIT IV Proteomics technology, identification and analysis of proteins by 2D analysis, mass spectrophotometery, NMR and X-ray crystallography, MALDI-TOF, Differential display proteomics, Protein interaction, yeast two hybrid system and phage display. Whole genome sequencing and human genome project. Human genome browsers: VISTA, UCSC Genome Browser, Ensembl and NCBI map viewer. Practical : i. Quantitative PCR. ii. DNA microarray, Microarray image processing (Demonstration of these experiments with the help of video and visits to other institutes) iii. Clustering methods to study gene expression. iv. Analytical software related to genomics and proteomics.
BT 703	ADVANCES IN REPRODUCTIVE BIOTECHNOLOGY (2+1) Sem II
	Theory : UNIT I **Animal cloning**, somatic cell nuclear transfer and transgenic animal production, cryopreservation of gametes.

	Super Ovulation. Surgical and non surgical methods of embryo collection. UNIT II Preimplantation genetic diagnosis (PGD), genomic imprinting and assisted reproduction, receptors of different hormones and their estimation. UNIT III Introduction to stem cells, types, identification, characterization and development of stem cells, transfection of gene in embryonic blastomeres. UNIT IV **Sperm and Embryo sexing.** Stem cell therapeutics, social, ethical religious and regulatory issues. Practical : i. Embryo micromanipulation. ii. ii Identification of stages of maturation of embryos iii. Microinjection. iv. Intra-cytoplasmic sperm injection. v. ICSI Embryo Biopsy for PGD and sexing. vi. Culture of embryonic stem cell.Characterization of embryonic stem cells.
BT 704	TRENDS IN VACCINOLOGY (2+0) Sem II
	Theory : UNIT I Molecular approaches for development of vaccines including: recombinant peptide vaccines, vectored vaccines, DNA vaccines, genetically manipulated live vaccines. UNIT II Plant expression system based vaccines, idiotype and synthetic peptide based vaccines, reverse genetic approach and computational vaccinology. Genetic basis of attenuation. UNIT III Vaccine delivery systems and approaches to enhance immunogenicity. Immuno.modulators including cytokines and new adjuvants, Immunomodulation, innovative methods of delivery of immunogens through liposomes, microspheres, ISCOMS, etc. UNIT IV Large scale production technology and quality control, regulatory issues, environmental concerns with the use of recombinant vaccines. GMp and quality control of conventional and recombinant vaccines.
BT 705	ADVANCES ANIMAL CELL CULTURE (2+1) Sem I
	Theory : UNIT I Development of cell lines, characterization of cell lines by morphology, chromosome analysis, DNA content enzyme activity and antigenic markers, differentiation. UNIT II Cultivation requirements of different types of cells, flow cytometry, DNA transfer by calcium phosphate co-precipitation, electroporation. UNIT III Expression of recombinant proteins in mammalian and avian cell lines. Hybridoma development of monoclonal antibodies as immunodiagnostic agent and immunotheraputics. UNIT IV Up-scalling of cells for production of vaccines, diagnostic antigens and other pharmaceutical agents, up-stream and downstream processing, cell culture fomenters. Practical : i. Primary and Secondary mammalian cell culture. ii. Development of transformed cell lines- Demonstration iii. Characterization of cells lines. iv. Transfection of cells with recombinant DNA. v. Expression of recombinant proteins. vi. Scalling – up of cultures.
BT 706	TRANSGENIC TECHNOLOGY (2+0) Sem II
	Theory : UNIT I Concept of transgenics, techniques of gene transfer, microinjection of recombinant DNA into fertilized eggs/stem cells, transfection of DNA totipotent keratocarcinoma cells, electroporation, gene transfer into cultured cells. UNIT II **Transgene construct and their preparation strategies.** Suitable promoters for expression of transgenes, eukaryotic expression vectors, detection of transgenes in the new born. UNIT III

	Principles of cloning, application of transgenic and cloning technologies for improvement of livestock. Transgenic as bioreactors. UNIT IV Problems associated with foreign gene integration and expression, gene silencing; genes of interest; application of transgenic animals, plants and microbes; ethical issues. Social, ethical, religious, environmental and other regulatory issues related to transgenic biotechnology.
BT 632	**Biodiversity IPR, Bio safety and Bioethics (2+0)**
BT 791	DOCTORAL SEMINAR I (1+0)
BT 792	DOCTORAL SEMINAR II (1+0)
BT 799	DOCTORAL RESEARCH 45