Course Structure & Curriculum
For
B. Tech. Programme

In
BIOTECHNOLOGY

Department of Biotechnology
Motilal Nehru National Institute of Technology Allahabad

Curriculum for
Bachelor of Technology in
Biotechnology

3rd Semester (Biotechnology)

Course Code	Course name	L	T	P	Credit
BT-1301	Biochemistry	3	1	-	4
BT-1302	Microbiology	3	1	-	4
BT-1303	Cell and System Biology	3	-	-	3
BT-1304	Genetics	3	1	-	4
AM-1305	Biomaterial Science and Engineering	3	1	-	4
BT-1305	Thermodynamics of Biological system	3	1	-	4
BT-1351	Microbiology (Lab)	-	-	3	2
BT-1352	Genetics (Lab)	-	-	3	2
AM-1355	Biomaterial Science and Engineering (Lab)	-	-	3	2
	Total	18	5	9	29

4thSemester (Biotechnology)

Course Code	Course name	L	T	P	Credit
BT-1401	Biophysics and Structural Biology	3	1	-	4
AM-1406	Applied Computational Methods	3	1	-	4
BT-1402	Instrumentation in Biotechnology	3	1	-	4
BT-1403	Bioprocess Engineering	3	1	-	4
BT-1404	Molecular Biology	3	-	-	3
BT-1451	Biochemistry and Molecular Structural Analysis (Lab)	-	-	3	2
AM-1453	Applied Computational Methods (Lab)	-	-	3	2
BT-1452	Techniques in Biotechnology (Lab)	-	-	3	2
BT-1453	Bioprocess Engineering (Lab)	-	-	3	2
	Total	15	4	12	27

5th Semester (Biotechnology)

Course Code	Course name	L	T	P	Credit
BT-1501	Genetic Engineering	3	1	-	4
BT-1502	Microbial Biotechnology	3	1	-	4
BT-1503	Immunology	3	-	-	3
BT-1504	Molecular and Cellular diagnostics	3	1	-	4
HS-1501	Principles of Management	3	-	-	3
MA-1501	Biostatistics	3	1	-	4
BT-1551	Genetic Engineering (Lab)	-	-	3	2
BT-1552	Microbial Biotechnology (Lab)	-	-	3	2
BT-1553	Immunology (Lab)	-	-	3	2
	Total	18	4	9	28

6thSemester (Biotechnology)

Course Code	Course name	L	T	P	Credit
BT-1601	Bioinformatics	3	1	-	4
BT-1602	Enzyme Technology and Engineering	3	1	-	4
BT-1603	Animal Biotechnology	3	-	-	3
BT-1604	Plant Biotechnology	3	1	-	4
BT-1605	IPR and Biotechnology	3	-	-	3
HS-1601	Communication Skill Workshop	-	2	-	0
BT-1606	Bioreactor and Plant Design	3	1	-	4
BT-1651	Bioinformatics (Lab)	-	-	3	2
BT-1652	Enzyme Technology and Engineering (Lab)	-	-	3	2
BT-1653	Animal Biotechnology (Lab)	-	-	3	2
	Total	18	6	9	28

7thSemester (Biotechnology)

Course Code	Course name	L	T	P	Credit
OE-1781 to 1790	Open Elective-I	3	-	-	3
BT-1731 to 1740	Professional Elective-I	3	-	-	3
BT-1741 to 1750	Professional Elective-II	3	-	-	3
BT-1791	Major Project (Interim Evaluation)	-	6	-	6
BT-1751	Medical Biotechnology and Diagnostic (Lab)	-	-	3	2
BT-1752	Plant Biotechnology (Lab)	-	-	3	2
	Total	9	6	6	19

8th Semester (Biotechnology)

Course Code	Course name	L	T	P	Credit
BT-1801	Bioprocess Control and Economics	3	1	-	4
OE-1881 to 1890	Open Elective-II	3	-	-	3
BT-1831 to 1840	Professional Elective-III	3		-	3
BT-1841 to 1850	Professional Elective-IV	3		-	3
BT-1891	Major Project (Final Evaluation)	-	6	-	6
	Total	12	7	-	19

1st digit; 1: UG, 2nd digit; 2, 3, etc.: Semester

Code	Description
01-30	Theory Courses
31-40	Professional Elective –I
41-50	Professional Elective –II
51-70	Practical Courses
81-90	Open Elective
91-99	Project

BIOCHEMISTRY (BT-1301)

UNIT 1: Introduction to Biochemistry-Introduction to biochemistry, water, carbohydrates, amino acids, fatty acids, lipids and nucleic acids. 2(L)

UNIT 2: Biochemistry of carbohydrates-Carbohydrate metabolism and regulation: glycolysis, citric acid cycle (TCA Cycle) and oxidative phosphorylation, biosynthesis of glucose, glycogen and starch. Pentose phosphate pathway. Regulation of carbohydrate metabolism and disease associated. 8(L)

UNIT 3: Biochemistry of lipids-Lipid Metabolism: catabolism of fatty acids, metabolism of triglycerol and cholesterol, biosynthesis of saturated and unsaturated fatty acids, phospholipids and sphingolipids. Regulation of lipid metabolism. Cofactors, vitamins and disease associated. 8(L)

UNIT 4: Metabolism of amino acids-Biosynthesis of amino acids, catabolism of carbon skeletons of amino Acids - oxidative de-amination and oxidative de-carboxylation, nitrogen excretion and urea cycle. Regulation of amino acids metabolism and disease associated. Cofactors, vitamins and disease associated. 8(L)

UNIT 5: Biochemistry of Nucleic acids-Metabolic pathways - biosynthesis of purines, pyrimidines, nucleotides and nucleic Acids (DNA and RNA), nucleic acid metabolism - degradation of nucleotides and nucleic acids and genetic disorders. Cofactors, vitamins and disease associated. 8(L)

UNIT 6: Biochemistry of Photosynthesis- Light reaction, dark reaction cyclic in C3 and C4 plants 6(L)

Text/Reference Books:

- Principles of Biochemistry (Lehninger) by David. L. Nelson and Michael. M. Cox
- Outlines of Biochemistry by Conn, E.E and StumpfP.K.
- Biochemistry by StryerLubert.
- Harper's review of Biochemistry by Martin D. W, Mayes. P. A and Rodwell. V. M
- Practical of Biochemistry by Wilson and Walker.
- Biochemistry by Champe P.C., Harvey R.A., Ferrier D.R.

MICROBIOLOGY (BT-1302)

UNIT 1: Introduction to Microbiology-Discovery of microorganisms, theory of spontaneous generation, germ theory of diseases, major contribution and events in the field of microbiology, scope and relevance of microbiology. 4(L)

UNIT 2: Classification and Identification of microorganisms-Study of classification systems, numerical taxonomy, polyphasic taxonomy, major characteristics used in taxonomy, identification of microorganisms - a general account, staining techniques. pure culture, preservation methods. 6(L)

UNIT 3: Morphology and Major Groups of Microorganisms-Morphology and fine structure of bacteria: cell wall, structure external and internal to cell wall, spore and cysts, characteristics of archeabacteria and eubacteria, characteristics of important groups of microorganisms. 7(L)

UNIT 4: Microbial Metabolism, Nutrition and Genetics-An overview of microbial metabolism, nutritional Types, uptake of nutrients by cells, simple diffusion, facilitated diffusion, group translocation, active transport, chemiosmotic theory. Microbial genetics: transformation, conjugation, transduction. 8(L)

UNIT 5: Growth and Cultivation of Microorganisms-Growth of microorganisms: growth curve, measurement of microbial growth, continuous growth, chemostat, turbidostat, balanced and unbalanced growth, methods of culturing microorganisms (aerobes and anaerobes), culture media, factors influencing growth, control of microorganisms by physical and chemical agents,evaluation of antimicrobial chemical agents. 9(L)

UNIT 6: Principles of Disease and Epidemiology-Mechanism of bacterial pathogenicity, general characteristics of antimicrobial drugs, antibiotics: classification, mode of action and resistance. 6(L)

Text/ Reference Books:

- Microbiology by Presscort L.M., Harley, J.P and Klein, D.A. McGraw Hill.
- Microbiology by Pelczar, M.J. Chan ECS and Krieg NR, Tala McGraw Hill.
- General Microbiology by Roger Y. Stanier, Macmillan.
- Bergeys Manual of Systematic Bacteriology.
- General Microbiology by Prescott and Dunn.
- Microbiology by T. D. Brocks.

CELL AND SYSTEM BIOLOGY (BT-1303)

UNIT 1: The Cell and Organelles-Introduction, definition and type of cell, cellular compartmentalization and different cell organelles (structure and functions), the nucleus: global structure of chromosomes, chromosomal DNA and its packaging, organization and evolution of the nuclear genome. 5(L)

UNIT 2: Bio-membranes and cytoskeleton-Introduction to bio-memebranes, plasma membrane: organization and transport across the plasma membrane and epithelia, nature of the cytoskeleton, intermediate filaments, extracellular matrix (ECM), cell-cell junctions 5(L)

UNIT 3: Cell Cycle-General strategy of the cell cycle, mechanics of cell division, cell-cycle control, programmed cell death (apoptosis), signals that trigger cell death, growth and proliferation 5(L)

UNIT 4: Signal Transduction-Mechanisms of cell signalling, Intracellular receptor and cell surface receptors, signalling via G-protein linked receptors and enzyme linked receptor signalling pathways. 5(L)

UNIT 5: Systems Biology-Structure and function of epithelial system, muscular system, circulatory system, endocrine system and nervous system 9(L)

UNIT 6: Cancer, Stem Cells and AIDS-Cancer as a microevolutionary process, tumour cells, proto-oncogenes and viral oncogenes, tumour suppressor genes, various types of cancer, stem cells and their application in research, physiology, causes and prevention of AIDS. 5(L)

Text/Reference Books:

- Essential Cell Biology by Alberts.
- The Cell: A molecular Approach by Cooper.
- Developmental Biology by Gilbert Sinauer.
- Cell Biology by Pollard and Earnshaw.
- The Cell: A Problems Approach by Wilson and Hunt.
- Asking about Cells by Tobin and Morcel.

GENETICS (BT-1304)

UNIT 1: Physical Basis of Heredity-Basic law of inheritance, deviations of Mendel's ratios due of gene interaction, concept of alleles, complementation test, multiple factors of inheritance. genes and environment interaction. probability and statistical testing. 6(L)

UNIT 2: Cell division, Linkage, Recombination and Gene Mapping Methods-Mitosis, meiosis, chromosomal inheritance, concept of linkage, crossing over and mapping to genes by recombination frequency , three point test cross, tetrad analysis, mitotic crossing over, sexuality and recombination in bacteria and viruses, molecular mechanism of genetic recombination. 8(L)

UNIT 3: Sex Determination and sex linkage-Mechanism of sex determination in animals and plants, sex linked, sex influence and sex limited traits, sex linked disorders in human beings. 5(L)

UNIT 4: Cytogenetic, Mutation and Extra Chromosomal Inheritance- Chromosome aberrations, polyploidy. Mutation: type, cause and detections, application of mutants. Maternal inheritance: inheritance of mitochondrial and chloroplast genes, Transposable elements, transpositions of transposons in genome. 6(L)

UNIT 5: Molecular and Human Genetics-Identification of genetic materials, the genetic code, gene regulation and gene expression. Pedigree analysis, genetic disorders, inborn errors of metabolism (Phenylketonuria andGalactosemia), neurogenetic disorders (Alzheimer's and Parkinson's), muscle genetic disorders (Muscular Dystrophy), cancer genetics and genetic counselling 9(L)

UNIT 6: Population and Developmental Genetics-The Hardy- Weinberg equilibrium, change in gene frequencies and mating system. Genetics of the evolutionary process and development, genetic basis of evolution and speciation, genetics of development. 6(L)

Text/Reference Books:

- Genetics by Goodenough U, Hold Saunders International.
- Principles of Genetics by Gardner EJ, Simmons M.J., Snustad D.P.
- Principal of Genetics by Tamarin, Macgrahill.
- Genetics by Strickberger, Phi Learning.
- Genetics by B.D.Singh, Kalyani publication.
- Genetics by P.K.Gupta, Rastogi publication.

BIOMATERIAL SCIENCE AND ENGINEERING (AM-1305)

UNIT 1: Introduction-Introduction and overview of biomaterials, structure and property relation in materials and characterization and testing of biomaterials. 4(L)

UNIT 2: Interactions of materials-Interactions of materials with human body, bio-compatibility of materials, metals, alloys, ceramics, polymers and composites as biomaterials. 5(L)

UNIT 3: Biopolymers-Biopolymers, natural materials, material for drug delivery: biodegradable polymers. 4(L)

UNIT 4: Implants-Materials for hard tissue replacement: orthopaedic implants, dental implants. 4(L)

UNIT 5: Materials for soft tissue replacement- dermal and facial prosthesis, cardiovascular implants, ophthalmology, materials for artificial organs transplant and extracorporeal device. 6(L)

UNIT 6: Legal Issues-Recent developments in biomaterials, legal issues related to development of biomaterials. 4(L)

Text/Reference Books:

- Biomaterials: An Introduction by Park J.B. and Lakes R.S., Plenum Press, New York.
- Biomaterials, Medical Devices & Tissue Engineering: An Integrated Approach by Silver F.H., Chapman and Hall publication.
- Biomaterials by BhatSujata V., Narosa Publishing House.
- Biomaterials science: an introduction to materials in medicine by Buddy D. Ratner., Elsevier Academic Press.
- Biomaterials: A Tantalus Experience by Jozef A. Helsen., YannisMissirlis Springer.
- Biomaterials by TemenoffJohnna S., Dorling Kindersley India Pvt Ltd.

THERMODYNAMICS OF BIOLOGICAL SYSTEM (BT-1305)

UNIT 1: Fundamentals and Law of Thermodynamics-Terminologies of thermodynamics, variables and quantities of thermodynamics, Point and path properties, heat and work, reversible and irreversible processes, phase rule, First law and internal energy, statements of first law for the non flow and flow systems, enthalpy and heat capacity limitations of the first law, Statements of the second law of thermodynamics, available and unavailable energies, entropy function, applications of the second law. Zeroth law of thermodynamics. 8(L)

UNIT 2: Thermodynamic Properties of Real Gases-The PVT behavior of fluids, laws of corresponding states and equation of states approaches to the PVT relationships of non ideal gas problems, compressibility factors, generalized equations of state, property estimation via generalized equation of state, fugacity and fugacity coefficients of real gase. 8(L)

UNIT 3: Thermodynamics of Solutions-Ideal and non-ideal solution, Concept of Fugacity and Fugacity coefficient, Fugacity and Activity Coefficient Modes, Solid-liquid equilibrium, solubility of gases in liquids, Liquid-liquid equilibrium. 6(L)

UNIT 4: Chemical Reaction Equilibrium-Heat effects, industrial reactions (NH3 synthesis etc), free energy calculations, Homogeneous and heterogeneous reaction systems, multiple reactions, Work of separation, Evaluation of Properties. Phase Equilibrium, Pure component and mixtures, Latent Heat correlation Van Laar, Margules' equation, Gibbs'-Duhem equation, Maxwell equation, consistency tests, multi-component phase equilibrium, partially miscible and immiscible systems, Azeotropes, retrograde condensation, thermodynamic diagram. 8(L)

UNIT 5: Thermodynamics of Chemical and living system-Gibbs free energy –properties, applications, Thermodynamics of oxidation-reduction reactions, Degree of reduction concepts, available electron balances; yield coefficients, Oxygen consumption and heat evolution in aerobic cultures, Effect of temperature on U, H and entropy (S), Energetic of Metabolic Pathways; Energy Coupling (ATP & NADH), Structure and properties of ATP and other energy currencies. 9(L)

UNIT 6: Compression and Refrigeration Cycle-Thermodynamic aspects of compression process, classification of compression processes, basic equation for change of state of gases, the work expression for different situations, the effect of clearance volume, multistage compression, convergent divergent flow, Ejectors. Definitions of refrigeration, Reverse Carnot cycle, Vapor compression and vapor absorption cycle, Gas refrigeration. 5(L)

Text/Reference Books:

- J. M. Smith and Van Ness, "Introduction to Chemical Engineering Thermodynamics", McGraw Hill, New York.
- Rao. Y.V.C. "Chemical Engineering Thermodynamics", Universities Press.
- S. Sundaram, "Chemical Engineering Thermodynamics", Ahuja Publishers, Delhi.
- B.F. Dodge, "Chemical Engineering Thermodynamics", McGraw Hill, New York.
- S.I. Sandler, "Chemical and Engineering Thermodynamics, Wiley.
- Bioprocess Engineering Principles, . Doaran, P.M, Academic Press.
- Biochemical Engg. Fundamentals, Bailey & Olis, MGH.
- Kinetics and Energetic in Biotechnology, Roels J.A, Elsevier.
- Biological Thermodynamics, Donald T Haynie.

MICROBIOLOGY (LAB) (BT-1351)

Experiment 1: Introduction to the rules, tools and equipments used in microbiology.
Experiment 2: Examination of microorganisms by staining techniques.
Experiment 3: Preparation of media for cultivation of microorganisms.
Experiment 4: Isolation and Enumeration of microorganisms by serial dilution agar plating method.
Experiment 5: To obtain pure culture of microorganisms by pour, spread and streak plate method.
Experiment 6: To measure bacterial growth and determine the effect of various factors on bacterial growth.
Experiment 7: To assess biochemical activities *viz*., catalase, IMViC of given culture of bacteria.
Experiment 8: Assay of an antibiotic by zone-inhibition method using antibiotic impregnated discs.
Experiment 9: Determination of bacterial transformation and conjugation.

GENETICS (LAB) (BT-1352)

Experiment 1: Chi Square Test forMonohybrid and dihybrid crosses
Experiment 2: Probability and Pedigrees analysis.
Experiment 3: Study of chromosome morphology at different stages of cell division.
Experiment 4: Study of multiple alleles inheritance by ABO blood genotyping.
Experiment 5: Study genetic material transfer in two different strain bacteria by conjugation method
Experiment 6: Study of genetic markers in bacteria.
Experiment 7: Study of genetic polymorphism from diverse populations.
Experiment 8: Study Allele Frequency Distributions in Pooled DNA Samples.
Experiment 9: Identification dominant hybrid by DNA based markers

BIOMATERIAL SCIENCE AND ENGINEERING (LAB) (AM-1355)

Experiment 1: Antimicrobial testing of bio-polymers by agar well diffusion methods.
Experiment 2: Mechanical testing of bio-materials by tenso-meter.
Experiment 3: Preparation of scaffolds by lyophilisation techniques.
Experiment 4: Coating on biomaterials by dip-coating.
Experiment 5: Preparation of hydro-gel.
Experiment 6: Preparation of biopolymer films.
Experiment 7: Quantification of biofilm and biomaterials.

BIOPHYSICS AND STRUCTURAL BIOLOGY (BT-1401)

UNIT 1: Different interactions among proteins-Hydrogen bonding, hydrophobic interactions, ionic interactions, disulphide bonds and their role in protein structure. 2(L)

UNIT 2: Different structures of proteins-Proteins: Primary, secondary, super-secondary (motifs, folds) and tertiary structural elements and their conformational study. Protein folding kinetics: helix-coil transition, molten globule and zipper model etc. Three dimensional conformations of proteins, Ramachandran plot, fibrous proteins, membrane proteins and their structures. 12(L)

UNIT 3: Structures of nucleic acids and compositions-Nucleic acid structure and composition: A, B, and Z: forms of DNA, Topology of DNA: supercoiling of DNA. Nucleic acid and protein denaturation and renaturation kinetics. 7(L)

UNIT 4: Methods of structural determination of bio-molecular-Macromolecular structure determination by X-ray diffraction, crystallography, NMR and circular dichroism. 7(L)

UNIT 5: Biomolecularinteractions-Protein-Protein interactions, protein-carbohydrate interactions, Protein-DNA interactions. 6(L)

UNIT 6: Biomechanics and Neurobiophysics-Cell contractility and motility, cytoskeletal Motility, neurobiophysics. 6(L)

Text/ Reference books:

- Principles of Biochemistry by Lehninger
- Principles of Physical Biochemistry by Kensal E van Holde,
- Essentials of Biophysics by R. Narayanan
- Introduction to Bioinformatics by Arther M. Lesk.
- Proteins: structures and Molecular Properties by Thomas E.Creighton.
- Practical Biochemistry Principles and techniques by Wilson and Walker., Cambridge University Press.

APPLIED COMPUTATIONAL METHODS (AM-1406)

UNIT 1: Introduction-Motivation, mathematical modeling, errors in numerical computation, convergence, conditioning and stability. 2(L)

UNIT 2: Interpolation and Curve Fitting-Motivation, polynomial forms, linear interpolation, Lagrangean interpolation, Newton interpolation, Spline interpolation, Chebyshev interpolation, regression analysis, fitting linear equations, least-square method, fitting transcendental equations, polynomial functions, multiple linear regression. 8(L)

UNIT 3: Simultaneous Linear Equations-Motivation, gauss elimination, pivoting, factoring, solution accuracy, iterative methods, Jacobi method, Gauss-Siedel method, relaxation method. 6(L)

UNIT 4: Nonlinear Equations-Motivation, open and bracketing method, bisection, fixed point, Newton's method, secant and false position method, rate of convergence, method for complex root, Muller's method, quotient Difference method, Newton-Raphson method. 8(L)

UNIT 5: Numerical Integration-Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature, singular integrals. 8(L)

UNIT 6: Initial Value Problem-Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods. 6(L)

Text/Reference Books:

- Applied Numerical Analysis by C.F. Gerald and P.O. Wheatley., Addison-Wesley.
- Numerical Mathematics and Computing by W. Cheney and D. Kincaid.
- Applied Numerical Methods by B. Carnahan (John Wiley and Sons).
- Numerical methods by E. Balaguruswamy (TMH).
- Introductory methods of numerical analysis by S.S. Sastry (PHI).
- Introduction to Numerical Methods by V. Rajaraman (TMH).

INSTRUMENTATION IN BIOTECHNOLOGY (BT-1402)

UNIT 1: Microscopy-Principle, working, sample preparation and biological applications of different microscopes – light microscope (bright field and dark field, phase contrast, polarization, differential interference contrast), electron microscope (TEM, SEM), fluorescence microscope (simple and confocal) and Atomic force microscope. 8(L)

UNIT 2: Centrifugation-Principle, construction, working of centrifugation and concept of RCF, types of instruments and rotors used in centrifugation, types of centrifugations- preparative, differential density gradient centrifugation and analytical ultracentrifuge. 5(L)

UNIT 3: Electrophoresis-Principle & Working of zonal and continuous electrophoresis, types of electrophoresis- paper, cellulose acetate, gel and capillary electrophoresis, native and denaturing gels, isoelectric focusing, two dimensional gel electrophoresis, pulse-field gel electrophoresis. 7(L)

UNIT4: Chromatography-Principle, instrumentation and biological applications of paper and thin layer (TLC) chromatography, gel permeation (GPC), ion exchange chromatography, affinity chromatography, gas liquid (GC) and high pressure liquid chromatography. 7(L)

UNIT 5: Spectroscopy-Part I-Basic concepts of spectroscopy, beer lamberts law, principles, instrumentation and applications of UV-Visible spectroscopy, nephelometry, turbidometry, fluorescence spectroscopy, atomic absorption spectrophotometry. 6(L)

UNIT 6: Spectroscopy-Part II-Basic concepts, instrumentation and biological applications of infra red spectroscopy and mass spectroscopy. 7(L)

Text/Reference Books:

- Practical Biochemistry by Wilson and Walker.
- Biophysics by VasanthaPattabhi and N. Gautham.
- Handbook of analytical techniques by Helmut gunzler and Alex Williams
- Bioanalytical chemistry by Susan R Mikkeleson and E. Corton.
- Biophysical chemistry by Alan Cooper.
- Fundamentals of Analytical Biochemistry by Skoog and West.

BIOPROCESS ENGINEERING (BT-1403)

UNIT 1: Introduction to Bioprocesses-An Overview of bioprocess engineering, outline of an integrated bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses, generalized process flow sheets. 3(L)

UNIT 2: Sterilization-Sterilizationmethods,del factor, thermal death kinetics of cells and spores: survival curve-decimal reduction factor, extinction probability-sterilization of culture medium- batch and continuous sterilization- design aspects- air sterilization- design of fibrous type filters. 5(L)

UNIT 3: Microbial Growth Kinetics-Kinetic modelling of cell growth: model structure, structured and un-structured models, Monod chemostat model, models with growth inhibitors, growth models for filamentous organisms-structured kinetic models. Elemental balances- respiratory quotient, degree of reduction-Yield and maintenance coefficients. 9(L)

UNIT 4: Fermentation Process and Product Formation-Type of fermentation: solid state and submerged state, batch, fed-batch and continuous fermentation, kinetic of batch and continuous reactor. Growth associated and non - growth associated product formation kinetics. Leudeking-Piret models, substrate and product inhibition on cell growth. 9(L)

UNIT 5: Introduction To Transport Phenomena: Mass Transfer -Mechanisms of mass transport, molecular and diffusion theory, role of diffusion in mass transfer, film theory, types of mass transfer, mass transfer in bioprocessing systems: gas liquid mass transfer- volumetric oxygen transfer coefficient-correlations. 5(L)

UNIT 6: Aeration and Agitation in Fermentations- Introduction, the oxygen requirement for industrial bioreactors, volumetric oxygen transfer, oxygen transfer mechanism- assessment of KLa and its determination methods, factors affecting KLa, fluid rheology, effect of medium rheology on KLa, fluid flow and mixing in fermentation broths, newtonian and non newtonian fluids, factors affecting agitation in bioreactor. 7(L)

Text/Reference Book:

- Bioprocess engineering by M.L.Shuler and F. Kargi., Prentice Hall of India.
- Biochemical process principles by P.M. Doran., Academic Press.
- Introduction to Biochemical Engineering by D.G. Rao,
- Bioprocess Engineering Fundamentals by G.E Bailey and D.F Ollis, McGraw Hill
- Biochemical engineering by Aiba, Humphrey and Mells, academic press.

MOLECULAR BIOLOGY (BT-1404)

UNIT 1: DNA Structure Replication and Repair-Nucleic acids and their structure, nucleic acid as genetic material, types of DNA, DNA replication in prokaryotes and eukaryotes, model of DNA replication, DNA repair: types and mechanism DNA repair in prokaryotes and eukaryotes 6(L)

UNIT 2: Organization of genetic material- Packaging of DNA as nucleosides in chromosome, repetitive and unique DNA sequences, split genes, overlapping genes and pseudo genes 6(L)

UNIT 3: Transcription in prokaryotes and eukaryotes: Central dogma concept, transcription in prokaryotes: initiation, elongation and termination. Transcription in eukaryotes: RNA polymerase, transcription factors and initiation RNA synthesis, elongation and termination of RNA synthesis. Transcription in mitochondria and chloroplast. 6(L)

UNIT 4: RNA processing-Ribosome- Structural features of prokaryotic and eukaryotic ribosome. Types of RNA, processing of RNA and RNA Splicing, mRNA transport, mRNA synthesis in prokaryotes and eukaryotes. 6(L)

UNIT 5: Translation in prokaryotes and eukaryotes-Initiation and elongation of polypeptide, formation of peptide bond, termination of polypeptide, modification, folding and transport of released polypeptide, protein sorting or protein trafficking, protein folding. 8(L)

UNIT 6: Regulation of Gene Expression-Regulation of gene expression in bacteria- operon concept, inducible and repressible operons (lac and trp), catabolite repression of lac operon in *E.coli*. Control of gene expression in eukaryotes.enhancers, silencers and other upstream controlling elements. DNA methylation.Chromatin remodelling. 8(L)

Text/Reference Books:

- Essential Cell Biology by Alberts, Garland
- Molecular Biology of the Cell by Alberts et al, Garland
- Cell and Molecular Biology by Karp., John Wiley
- Genes IX by Lewin, Pearson
- Molecular Cell Biology by Lodish., Freeman
- Principle of Genetics by Gardner., John Wiley
- Essential Molecular Biology VII by T.A. Brown., AP

BIOCHEMISTRY AND MOLECULAR STRUCTURAL ANALYSIS (LAB) (BT-1451)

Experiment 1: Buffer preparations with the help of pH meter.

Experiment 2: Estimation of carbohydrates: DNS Methods etc.

Experiment 3: Estimation of proteins: Lowry's method, Burette method.

Experiment 4: Extraction of Lipids.

Experiment 5: To study Heat Capacity, Enthalpy and Entropy of biomolecules by DSC/ITC.

Experiment 6: Measurement of thermodynamic parameters of heat denaturation of proteins by micro-DSC.

Experiment 7: Study of re-naturation kinetics of DNA by micro-DSC.

Experiment 8: Measurement of the conformational stability of a protein.

Experiment 9: Calculation of number of particles /unit cells of a cubic crystal system.

APPLIED COMPUTATIONAL METHODS (LAB) (AM-1453)

Experiment 1: Introduction to Programming (C / C++), MATLAB.

Experiment 2: Interpolation with finite divided differences, Lagrange interpolation.

Experiment 3: Poisson distribution random number generator, χ^2 test for goodness of fit, Polynomial regression with plotting.

Experiment 4: Power method and Jacobi method, Gauss –Seidel and Gauss elimination method.

Experiment 5: Bisection and Newton – Raphson method.

Experiment 6: Simpson's rule, Romberg integration, Velocity distribution using Gauss quadrature.

Experiment 7: Euler's method and Fourth order Runge-Kutta method.

TECHNIQUES IN BIOTECHNOLOGY (LAB) (BT-1452)

Experiment 1: Preparation of a slide of given plant or bacterial sample and visualize it under dark field, bright field, and phase contrast microscopy.

Experiment 2: Isolation of chloroplast using differential centrifugation and quantitative estimation of different plant pigments using spectrophotometer.

Experiment 3: Quantitation of given nucleic acid solution and determination of its purity and molarity spectrometrically.

Experiment 4: Separation of biomolecules using paper chromatography.

Experiment 5: Separation of biomolecules using Thin Layer Chromatography.

Experiment 6: Purification and isolation of biomolecules using affinity chromatography/ ion-exchange chromatography.

Experiment 7: To purify a given protein or lipid sample by GPC/HPLC.

Experiment 8: To separate nucleic acid fragments using agarose gel electrophoresis.

Experiment 9: To separate and resolve a given protein mixture using SDS-PAGE electrophoresis.

BIOPROCESS ENGINEERING (LAB) (BT-1453)

Experiment 1: To get familiarized with the Conventional Stirred tank reactor (CSTR).

Experiment 2: To plot Microbial growth curve for shake flask culturing using turbidity method.

Experiment 3: Prepare a standard curve for substrate determination.

Experiment 4: To Estimate the Monod Parameters for microbial growth kinetics.

Experiment 5: Preparation of standard curve of Ethanol.

Experiment 6: Quantitative estimation of ethanol produced during Yeast fermentation.

Experiment 7: To determine the residence time distribution (RTD) in Biochemical reactor.

Experiment 8: To determine Chemical oxygen demand (COD)

Experiment 9: To determine Biological oxygen demand (BOD)

Experiment 10: To Determine the Oxygen transfer coefficient (KLa) in CSTR.

Experiment 11: Advanced Molecular Biology by Twyman., Viva

GENETIC ENGINEERING (BT-1501)

UNIT 1: Recombinant DNA and Gene Cloning-Introduction to various vector, properties of ideal vector and host, development of high capacity vectors. Plasmids: types of plasmids. Construction of Genomic and cDNA libraries, their strategies and advantages. 7(L)

UNIT 2: Restriction Enzymes , DNA finger printing and DNA labeling-Enzymes used in cloning – polymerases, ligases, restriction endonuclease. Types and nomenclature of restriction enzymes. Different blotting techniques: southern, northern, western and hybridization. 7(L)

UNIT 3: Gene amplification through Polymerase Chain Reaction-Principle of PCR, design of primers, PCR methodology: RT-PCR, multiplex PCR, anchored PCR, inverse PCR, site directed mutagenesis, gene sequencing. 6(L)

UNIT 4: Molecular Markers, Micro array and gene silencing-Type of molecular markers, use of RFLP, RAPD, AFLP, STMS, DNA chips, SNPs and micro array, 16s r-ANA typing, gene chip and micro array; applications in disease profiling, RNA silencing. 10(L)

UNIT 5: Expression and purification of recombinant proteins-Strategies of protein expression in bacteria, insects, transgenic plant and animal, purification of recombinant proteins. 5(L)

UNIT 6: Applications of Genetic Engineering-Gene cloning in medicine, agriculture, transgenic animals and plants, molecular farming.Trait modification by genetic engineering – over expression or under expression of heterologous genes. 5(L)

Text/Reference Books

- Genes to clone by T. A. Brown, Blackwill publication.
- Biotechnology and Genetic engineering by S. Mitra
- Principles of Gene Manipulation: An Introduction to Genetic Engineering Old RW and Primrose SB. Blackwell Science Publications.
- Molecular cloning: a laboratory manual: Volume II by Joseph Sambrook and David William Russell.

MICROBIAL BIOTECHNOLOGY (BT-1502)

UNIT 1: Introduction to Industrial Bioprocess-An overview of industrial fermentation process and products. process flow sheeting - a brief survey of microorganisms, processes, products and market economics relating to modern industrial biotechnology, screening, and fermentation media for industrial fermentation. 5(L)

UNIT 2: Production of Primary & Secondary Metabolites- A brief outline of processes for the production of some commercially important organic acids (e.g. citric acid, lactic acid), amino acids (glutamic acid, lysin); alcohols, steroids, vitamin B12. 8(L)

UNIT 3: Study of production process for various classes of low molecular weight secondary metabolites-Antibiotics-beta-lactams (Penicillins), aminoglycosides (streptomycin), macrolids (erythromycin),quinines. 4(L)

UNIT 4: Production of commercially important enzymes-Proteases, amylases lipases, cellulases, pectinases, isomerases and other commercially important enzymes for the food, pharmaceutical and detergent industries. 8(L)

UNIT 5: Production of recombinant proteins, & vaccines-Insulin,interleukin, interferons and their therapeutic and diagnostic applications, production of vaccines. 6(L)

UNIT 6: Production of other commercially important products and strain improvement-Production of natural biopreservatives (nisin), and biopolymers (xanthan gum and PHB), single cell protein, high – fructose com syrup; bioconversion of vegetable oils. strain improvement through physical and chemical mutation and molecular tools. 7(L)

Text/ Reference Books:

- Biotechnology by John E.Smith., Cambridge Low Price Edition.
- Industrial Microbiology by J.E.Casida.
- Industrial Microbiology by A.H.Patel.
- Microbiology by Prescott and Dunn.
- Microbial biotechnology by Glazer, A.N. and Nikaido H., NewYork.

IMMUNOLOGY (BT-1503)

UNIT 1: The Immune system-History and evolution of immune system, Innate and acquired immunity, humoral and cell-mediated immunity, hematopoiesis, cells and organs of immune system, concept of immunogenicity, antigens, epitopes, and haptens, antibodies-structure, classes, functions, monoclonal and polyclonal antibodies, primary and secondary immune response. 9(L)

UNIT 2: Diversity in B and T cell receptors-Molecular basis of antibody diversity: DNA rearrangements, variations arising out of V,D,J joining, somatic hypermutation, class switching, B and T cell generation, maturation, and their receptors;. 7(L)

UNIT 3: MHC and its role in transplantation- MHC: gene organization, types of MHC molecules and their structure, basis and significance of MHC polymorphism, antigen processing and presentation, transplantation immunology- immunologic basis of graft rejection 6(L)

UNIT 4:Cytokines, complement system and hypersensitivity-Cytokines and their role in immune response, Complement system-different complement pahtways, action of complement proteins. Hypersensitivity-types and their mechanism of action, inflammatory response. 6(L)

UNIT 5: Techniques in immunology-Antigen-antibody interactions- agglutination, precipitation, immunodiffusion, rocket immunoelectrophoresis, immunoassay (competitive, sandwich and indirect) ELISA, RIA. vaccines: active and passive immunization, types of vaccines. 4(L)

UNIT 6: Immune response and tolerance-Tolerance-mechanism of developing immune tolerance for T and B lymphocytes; autoimmunity-organ specific and systemic and its various causes. Immunodeficiency- with AIDS as example. 7(L)

Text/Reference books:

- Essential Immunology by Roitt, I.M., Blackwell Scientific, Oxford, UK
- Immunology by Kuby J., Freeman, W.H., Oxford,UK
- Immunology by Weir W.B. Saunders and Co.
- Immunology by K.A. Abbas., W.B. Saunders and Co.

MOLECULAR AND CELLULAR DIAGONSTICS (BT-1504)

UNIT 1: Introduction-Specimen collection (blood, urine, spinal fluid, saliva, synovial fluid and amniotic fluid), preservation, transportation. Biomarkers, markers used in cell and molecule diagnosis such as antibody markers, CD markers, secreted proteins/enzymes, cell specific antigens etc. single cell diagnostics. 5(L)

UNIT 2: General Function Tests-Principle of diagnostic enzymology: liver, cardiac, skeletal enzyme and digestive enzyme. Liver function test, cardiac function test, renal function test, thyroid function test, reproductive endocrine function test. 6(L)

UNIT 3: Techniques used in cell diagnostics-Cytodiagnosis - detection of disease in cells using specialized staining methods and microscopically examining their morphology and internal architecture, flow cytometry, immunohistochemistry, tissue in-situ hybridization, tissue microarrays. 8(L)

UNIT 4: DNA based diagnostics-DNA based diagnostic approaches-PCR and RT-PCR based diagnosis of diseases, fluorescent in-situ hybridization, DNA microarrays, spectral karyotype imaging, aptamers in diagnosis, DNA methylation based diagnosis. 8(L)

UNIT 5: Diagnosis of important disorders/diseases-Cellular and molecular diagnosis of some important diseases caused by bacteria and viruses, Molecular diagnostics in the evaluation of cancer. 6(L)

UNIT 6: Discovery of new biomarkers and their evaluation-Role of genomic, proteomics and bioinformatics tools in biomarker discovery and evaluation. 5(L)

Text/ Reference Books:

- Advanced techniques in diagnostics cellular pathology by Marry Hennon-Fletcher and Perry Maxwell, Wiley-Blackwell.
- Molecular diagnostics: for the clinical laboratorian by William B. Coleman and Gregory J. Tsongalis
- Molecular diagnostics by George P. Patrinos and Wilhelm Ansorge
- Commercial Biosensors by Graham Ramsay., John Wiley and Son, INC.
- Diagnostic microbiology by W. R. Bailey, E. G. Scott and C. V. Mosby.
- Fundamentals of clinical chemistry by W.B. Saunders and Carl A. Burtis.

PRINCIPLES OF MANAGEMENT (HS-1501)

UNIT 1: Concept of business environment-Significance and nature, the interaction matrix of different environment factors, environmental scanning, basic philosophies of capitalism and socialism with their variants. 5(L)

UNIT 2: Politico-legal environment: Relationship between business and Government of India, introduction to some important business laws: competition act, FEMA, SEBI, RBI, consumer protection act, changing dimensions of these laws and their impact on business, Economic environment: philosophy and strategy of planning in India, concept of mixed economy, their changing role, policy with regard to small scale industries. 5(L)

UNIT 3: Technological and socio-cultural environment-Policy for research and development in India, multinationals as source of technology; foreign collaborations and joint ventures, liberalization in India: the new economic Policy; globalisation; FDI policy, reforms in financial Sector. 7(L)

UNIT 4: General Management-Management concepts, theories and practices, functions of management – Planning, Organizing, directing-leadership, motivation, communication and controlling, decision making. 10(L)

UNIT 5: Organisational Behavior-Orgnisational change, conflict management and stress management. 5(L)

UNIT6: Functional management-Human resource management, financial management, marketing management 5(L)

Text/ Reference Books:

- Principles & Practices of Management by L.M. Prasad., Sultan Chand and Sons.
- Management by Harold, Koontz and CyriloDonell., Mc.Graw Hill.
- Business and society by Khan Farocq., S Chand, Delhi .
- Indian Economy Dutt R and Sundharam K.P.M., S .Chand ,Delhi .
- Business Environment by Francis Cherunilam, Himalaya Publishing House, Bombay.

BIOSTATISTICS (MA-1501)

UNIT 1: Presentation of Data-Data type, classification and summarization of data, diagrams and graphs, measures of dispersion, skewness and kurtosis. 4(L)

UNIT 2: Probability and Distribution-Introduction to probability, laws of probability, bayes theorem, binomial distribution, poisson distribution, normal distribution and gaussian distribution, mean and variance, expectation and moments, moment generating functions of these distributions. 8(L)

UNIT 3: Correlation and Regression-Positive and negative correlation, pearson and mathew correlation coefficient, non parametric tests, receiver operating characteristics (ROC) curve, linear and non linear regression, multiple regression. 6(L)

UNIT 4: Sampling-Concept of population and sample, random sample, methods of taking a random sample. 3(L)

UNIT 5: Tests of Significance-Sampling distribution of mean and standard error, large sample tests (test for an assumed means and equality of two population means with known S.D.), small sample tests (t-test for an assumed mean and equality of means of two populations when sample observations are independent, paired and unpaired), t-test for correlation and regression coefficients, t-test for comparison of variances of two populations, chi-square test for independence of attributes, goodness of fit and homogeneity of samples. 8(L)

UNIT 6: Experimental Designs-Principles of experimental designs, completely randomized, randomized block and latin square designs, simple factorial experiments of 22, 23, 24 and 32 types. Confounding in factorial experiments (mathematical derivations not required, analysis of variance (ANOVA) and its use in the analysis of RBD. 6(L)

Text/Reference Books:

- Statistical methods in Biology by Norman T.J. Bailey., Cambridge University Press.
- Statistical methods by George W. and William G., IBH Publication.
- Introduction to Biostatistics by Ipsen J., Harper and Row Publication.
- Statistical methods in Biology by N.T.J. Bailey., English University Press.
- A Text Book of Agricultural Statistics by R. Rangaswami, New Age Intl. Pub.

GENETIC ENGINEERING (LAB) (BT-1551)

Experiment 1: Isolation & purification of Genomic DNA
Experiment 2: Isolation, purifaction and visualization of plasmid DNA.
Experiment 3: Isolation and quantification of RNA
Experiment 4: Restriction digestion of plasmid DNA
Experiment 5: Preparation of competent cells and cloning.
Experiment 6: Screening of transform colony by X gal – IPTG
Experiment 7: Blotting techniques – southern blotting.
Experiment 8: Amplification of DNA fragments by Polymerase chain reaction (PCR) using RAPD primers
Experiment 9: Separation of proteins molecules by SDS-PAGE method

MICROBIAL BIOTECHNOLOGY (LAB) (BT-1552)

Experiment 1: Check the production of antibiotic in Synthetic media.
Experiment 2: Determination of the minimum inhibitory concentration (MIC) antibiotic.
Experiment 3: Demonstration of wine production by using fruit juice and determination of alcohol content.
Experiment 4: Microbial enzyme (lipase/proteinase/pectinase/cellulase) production.
Experiment 5: Production of citric acid in lab.
Experiment 6: Analysis of critical parameters for metabolite production in a fermentor.
Experiment 7: Study of product recovery process using chromatography columns and precipitation techniques.

IMMUNOLOGY (LAB) (BT-1553)

Experiment 1: Purification of lymphocytes from peripheral blood.
Experiment 2: Blood typing and count.
Experiment 3: Haemmaglutination test.
Experiment 4: Isolation of antibody from blood and their quantification using spectrophotometer.
Experiment 5: Purification of antibodies using ammonium sulphate and size exclusion chromatography.
Experiment 6: Immunodiffusion test.
Experiment 7: Rocket electrophoresis.
Experiment 8: Enzyme linked immunosorbent assay (ELISA)-competitive and sandwich.
Experiment 9: Immunoblotting and immunodetection.

BIOINFORMATICS (BT-1601)

UNIT 1: Introduction-Introduction to strings, edit distance strings, string similarity, elementary commands and protocols, Scope of Bioinformatics. 3(L)

UNIT 2: Sequence Databases and Their Use-Introduction to databases, database search, algorithms issues in database search, sequence database search, parametric sequence alignments, sub optimal alignments, dynamic programming global and local alignment gaps, multiple alignment, common multiple alignment methods. FASTA and BLAST. Amino acid substitution matrices PAM and BLOSSOM. 8(L)

UNIT 3: Evolutionary Trees and Phylogeny-Ultrasonic trees, parsimony, ultrametric problem, perfect phylogeny, phylogenetic alignment, connection between multiple alignment and tree constructions. 6(L)

UNIT 4: Protein Classification and Structure Visualization-Overview of the protein structure, protein structure visualization, visualization tools and databases, protein structure alignment, protein classification approaches, tools for plotting protein-ligand interaction. 7(L)

UNIT 5: Protein Structure Prediction-Protein identification and characterization, primary structure analysis and prediction, secondary structure analysis and prediction, *Ab initio* method for protein prediction, protein function prediction 7(L)

UNIT 6: Applications of Bioinformatics- DNA mapping and sequencing, gene predictions, molecular predictions with DNA strings, role of bioinformatics in drug design. 4(L)

Text/ Reference Books:

- Bioinformatics basics, applications in biological science and medicine by Hooman H.
- Bioinformatics: A machine learning approach P. Baladi, S. Brunak
- Algorithms on strings trees and sequences by Dan Gusfield.

ENZYME TECHNOLOGY AND ENGINEERING (BT-1602)

UNIT 1: Introduction to Enzymes-Hitorical aspects, nomenclature and their classification. cost effective production, purification and characterization of enzymes. 8(L)

UNIT 2: Applications of Enzymes-Commercial applications of enzymes in food, pharmaceutical and other industries, enzymes for analytical and diagnostic applications. 6(L)

UNIT 3: Mechanisms and Kinetics of Enzyme Action-Mechanisms of enzyme action, concept of active site and energetics of enzyme substrate complex formation, specificity of enzyme action, kinetics of single substrate reactions, turn over number, estimation of Michaelis-Menten parameters. 8(L)

UNIT 4: Enzymes inhibition and multi-substrate enzyme kinetics-Multi substrate reaction mechanisms and kinetics, types of inhibition, allosteric regulation of enzymes, deactivation kinetics. 4(L)

UNIT 5: Enzyme Immobilistion-Physical and chemical techniques for enzyme immobilization, adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding etc., examples advantages and disadvantages of different immobilization techniques. 6(L)

UNIT 6: Enzyme based bio sensors-Overview of applications of immobilized enzyme systems. Applications of enzymes in analysis, design of enzyme electrodes and their application as biosensors in industry health care and environment. 5(L)

Text/Reference Books:

- Enzymes: Biochemistry Biotechnology by Trevor Palmer and Philip Bonner, Clinical chemistry.
- Enzyme Chemistry: Impact and Application by Colin J. Suckling & Colin L. Gibson., Blackie Academic &Professional.
- Biochemical Engineering by James M. Lee., Prentice Hall.
- Biochemistry by LubertStryer.
- Fundamentals of Enzymology by Nicholas C. Price and Lewis Stevens.
- Enzymes in Food Processing by Gerald Reed, Academic presses.

ANIMAL BIOTECHNOLOGY (BT-1603)

UNIT 1: Introduction of animal cell culture- Basic principles of animal cell culture, biology of cells in culture and their characteristics, basic requirements for setting up of a animal cell laboratory- space, equipments, asptic techniques. Safety, ethical issues, norms and guidelines for handling animal cells. 4(L)

UNIT 2: Cell culture media, nutrition and types-Media for culturing cells and tissues; natural and defined media, effect of their r physicochemical characteristics such as pH, temperature, gases, osmolality, etc on cell culture, balanced salt solutions, serum free and serum based media, advantages and disadvantages of serum free media, primary and secondary cell cultures, steps in establishing primary cell culture, characteristics of continuos cell lines, development and their maintenance of cell lines, scaling-up of cell cultures. 7(L)

UNIT 3: Cryopreservation, Quantitation and cytotoxicity-Need of cryopreservation, cell banks, transporting cells, steps involved in cryopreservation of cell culture, thawing of frozen cell culture. Various methods of cell quantitation- hemocytometer, electronic cell counting, quantitation by measuring total DNA and protein content, cytotoxicity assessment in cell cultures- viability assessment by dye exclusion and dye uptake test, MTT based cytotoxicity assay, clonogenic survival assay. 8(L)

UNIT 4: Micromanipulation of embryos-Introduction, basics and methodology of micromanipulations. Composition of IVF media, steps involved in IVF, fertilization by micro-insemination. 8(L)

UNIT 5: Transgenic animals-Concept of transgene and transgenic animals, gene transfer approaches for producing transgenic animals- pronuclear microinjection method, embryonic stem cell method, retroviral vector method, homologous recombination for producing knock-in and knockout mice, sperm mediated DNA transfer. Importance and applications of transgenic animals, study of model transgenic animals. 7(L)

UNIT 6: Industrial application of animal cell culture: Market existing cell culture product, different medical applications for cell culture including expression system, therapeutics etc. 6(L)

Text/Reference Books:

- Culture of animal cells: a manual of basic technique by R. Ian Freshney., Wiley-Liss.
- Animal Cell Culture by John R.W., Masters Oxford University Press.
- Introduction to Cell and Tissue Culture by Jennie P. Matcher and Penelope E. Roberts., Plenum Press, New York and London.
- Molecular Biotechnology by Primrose.
- Animal Cell Biotechnology by R.E. Spier and J.B. Griffiths, Academic press.
- Animal Biotechnology by Ranga M.M, Agrobios India Limited.

PLANT BIOTECHNOLOGY (BT-1604)

UNIT 1: Plant tissue culture laboratory and media-Introduction to plant cell and tissue culture, historical perspectives, laboratory organization, tissue culture media- composition and preparation. 4(L)

UNIT 2: Cell culture, organogenesis, embryogenesis and production of haploid - Callus formation, organogenesis, protoplast isolation, culture and fusion; selection of hybrid cells and production of somatic hybrid, somatic embryogenesis;somaclonal variation, and application in crop improvement. Production of haploid and homozygous diploid lines through embryo culture, anther and pollen culture. 8(L)

UNIT 3: Regeneration, production, preservation and selection of plant cells-Plant regeneration, production of "synthetic seeds. Cryopreservation for germplasm conservation, clonal and micropropogation.Production of pathogen free plant.Production of plant cell line and its applications. 6(L)

UNIT 4: Genetic engineering in plant-Gene constructs and vector for the production of transgenetic plant. Techniques for plant transformation: *Agrobacterium* mediated transformation, physical methods of gene transfer, production of human protein in plant cell (planti bodies) and pharmaceutically useful proteins in plants. Biosafety regulations relating to transgenic plants. 9(L)

UNIT 5:.Production of transgenetic plant-The genetic manipulation of herbicide tolerance, insect resistance, weedicides resistance plant Genetic modification of plant for biotic and abiotic resistance. Improvement, yield and quality in crop plant. 8(L)

UNIT 6: Chloroplast transformation and production of useful product-

Chloroplast transformation: metabolic engineering and industrial products; production of plant secondary metabolites. Production of edible vaccine, molecular farming and its application. 5(L)

Text/Reference Books:

- Experiments in Plant Tissue Culture by John H. Dodds and Lorin W. Robert.
- Plant tissue Culture: Theory and Practice by S.S. Bhojwani and M.K. Razdan Elsevier, Amsterdam.
- An Introduction to Plant Biotechnology by H C Chawla Oxford and IBH.
- Elements of Biotechnology by P.K. Gupta Rastogi Publications.
- Text Book of Biotechnology by B.D. Singh Kalyani Publishers
- Plant Genomics and Proteomics by C.A. Cullis. John Wiley and Sons, New York.
- Plant Functional Genomics by E. Grotewold. Humana Press, Totowa.

IPR AND BIOTECHNOLOGY (BT-1605)

UNIT 1: Why there is a need to commercialize Biotechnology-Discovery, market needs development process, success rates and costs, current need in different sectors of biotechnology in India. 5(L)

UNIT 2: Technology transfer and R&D-Role of Research & development University-industry technology transfer arrangements, how and why a biotech company can benefit, status of R&D in India, different GLPs, GMPs and other practices. 7(L)

UNIT 3: Intellectual properties and application-Intellectual properties in biotechnology, definitions. Trademarks, copyright and related rights, industrial design, traditional knowledge, patent laws, procedures, precautions, patent infringement. WIPO, international conventions. 10(L)

UNIT 4: Bioethics and related legal issues-Bioethics and current legal issues. Ethics of new technology.Marketing and public perceptions in product development. 8(L)

UNIT 5: Bio-business and finance-Art of negotiation & effective communication. Role of venture capitalism, business plan, ffinancing biotech businesses and project finance. 6(L)

UNIT6: Indian and international scenario of biotechnology based products and future prospects: Indian and foreign prospective of biotechnology and current challenges for the biotechnology based products. 4(L)

Text/Reference Books:

- Positioning by All Rise and Jack Trout, Warner Books.
- Biotechnology: The science and the business by V. Moser and R.E. Cape, Harwood.
- Latest review articles and papers on the subject.

COMMUNICATION SKILL WORKSHOP (HS-1601)

Experiment 1: Art of communication: What is communication, good communication and effective communication, barriers and filters, activity on barriers and filters.

Experiment 2: Body language: verbal and non –verbal behavior interpretation, activity on non-verbal communication.

Experiment 3: Active listening. Active listening quiz.

Experiment 4: Feedback: How to give and receive feedback, Activity on feedback.

Experiment 5: Hidden date of communication: Feelings. Activity on how to handale feelings.

Experiment 6: Practical skills: assertiveness, activity on assertiveness, self-confidence, activity.

Experiment 7: In the world of teams: the team concept, element of teamwork. Team formation, effective team, exercise on team, Team players, activity.

Experiment 8: Discussions, decisions and presentations: Structured and un-structured group discussions. Activity on each.

Experiment 9: Adapting to Corporate life: exercise on grooming and dressing, getting ready for interview.

Experiment 10: Business Etiquette/Dining etiquette.

BIOREACTOR AND PLANT DESIGN (BT-1606)

UNIT 1: Bioreactor Types and operation control- batch reactors, fed-batch reactors, CSTR reactors, various types of bioreactors for microbial, animal , plant cell culture, fluidized bed reactor, bubble column, air lift fermenter, packed bed, trickle bed etc. parallel and series bioreactor. Impellers, stirrer, glands and bearings, packed gland seal, mechanical seal, magnetic drives, baffles, different types of spargers. 7(L)

UNIT 2: Bioreactor Design-Introduction, general design information, design of bioreactors, basic function of a bioreactor design, mass and energy balance, materials of construction for bioprocess plant, mechanical design of process equipment, utilities for biotechnology production plants. 5(L)

UNIT 3: Reactor engineering-Ideal reactors, concept of holding and space time, performance equations for single reactors; multiple reactor systems, design of multiple reactors: kinetics of series and parallel reaction, residence time distributions (RTD), exit age distribution, **r**ecycle reactors, recycle ratio for auto catalytic reactions. 6(L)

UNIT4: Scale Up process-= operation, analysis and scale-up criterion: dimensional analysis, scale-up of stirred tank bioreactors. 4(L)

UNIT 5: Instrumentation and Control-Introduction, measurement of physical and chemical parameters in bioreactors, on-line, in-line and off-line sensors, temperature- pressure measurement and control, foam sensing and control, inlet and exit gas analysis, pH and dissolve oxygen probes. Computer Interfaces and peripheral devices, data logging, data analysis, process control. 9(L)

UNIT 6: Down Stream processing-Overview of bio-separations, strategies to recover and purify products, filtration, centrifugation, cell disruption, liquid-liquid extractions, flocculation, adsorption, precipitation, membrane separation, chromatographic techniques, final steps in purification – crystallization and drying. 9(L)

Perquisite- Knowledge of Bioprocess Engineering.

Text/Reference Books:

- Biochemical engineering by Aiba, Humphrey and Mells, Academic press.
- Bioprocess engineering principles by Pauline M. Doran, Academic Press.
- Biochemical Engineering by H.W. Blanch and D.S. Clark, Marcel Dekker.
- Bioseparations Science and Engineering by Roger. H. Harrison., Oxford University press.
- Applied instrumentation in the Process Industries,VolsI,II,III Andrew W G., Gulf Publishing Company.
- Bioseparations-Downstream processing for Biotechnology by Paul. A. Belter, E.L.Cussler and Wei-Shou Hu., John Wiley and sons.

BIOINFORMATICS (LAB) (BT-1651)

Experiment 1: Retrieval and analysis of sequences (nucleotides/amino acids) from biological databases using BLAST and FASTA.
Experiment 1: Implementation of a selected sequence alignment algorithm.
Experiment 2: Prediction of secondary and tertiary structure of protein from primary structure using homologymodelling.
Experiment 3: Multiple sequence alignment using ClustalW
Experiment 4: Calculation of physio-chemical properties of proteins
Experiment 5: Transmembrane prediction
Experiment 6: Protein targeting prediction
Experiment 7: Coiled coil prediction
Experiment 8: Primer designing

ENZYME TECHNOLOGY AND ENGINEERING (LAB) (BT-1652)

Experiment 1: Determination of enzyme activity: Enzyme assay.
Experiment 2: Production of an enzyme under solid state fermentation.
Experiment 3: Production of an enzyme in submerged fermentation.
Experiment 4: Extraction of an enzyme by salting out.
Experiment 5: Purifiction of an enzyme by size exclusion chromatography.
Experiment 6: Analysis of the isolated microbes for enzymes i.e., protease/cellulase production.
Experiment 7: Enzyme immobilisation either by alginate, agar-agar or cellulose strips.
Experiment 8: Determination of K_m of an enzyme Amylase/Protease/Lipase
Experiment 9: Determination of V_{max} of an enzyme Amylase/Protease/Lipase.
Experiment 10: Determination of K_i for metal inhibitors of amylase Amylase/Protease/Lipase.

ANIMAL BIOTECHNOLOGY (LAB) (BT-1653)

Experiment 1: To study laboratory requirements for animal cell culture.
Experiment 2: To determine the percentage of the viable cells in a suspension by trypan blue exclusion test.
Experiment 3: To study apoptosis by microscopic analysis.
Experiment 4: To establish primary cell culture using fine dissection for disaggregation of tissue & collagenase..
Experiment 5: To perform assay for metabolic activity of cell lines using MTT/XTT dyes.
Experiment 6: Cell proliferation study: measurement of cell growth rate and study of growth kinetics.
Experiment 7: Fluorescence staining and microscopy for cell quantification visualization

PROFESSIONAL ELECTIVE-I

FOOD BIOTECHNOLOGY (BT-1731)

UNIT 1: Introduction-Historical highlights, important genera of food borne microorganisms, factors affecting the growth and survival of microorganisms in food. 5(L)

UNIT 2: Microbiological examination of food-Direct examination, culture techniques, MPN count, dye reduction assay, immunological methods and advance techniques**.** 4(L)

UNIT 3: Food preservation-Principles of food preservation, asepsis, anaerobic conditions, removal of microorganisms, low temperature, high temperature, radiation, drying, chemical preservatives and miscellaneous methods, canning. 8(L)

UNIT 4: Food spoilage- Microbial spoilage of food, common food borne diseases, bacterial agents of food borne illness, non-bacterial agents of food borne illness. 8(L)

UNIT 5: Fermented foods-Fermented milk, cheese, sauerkraut, fermented meat, beer, vinegar, fish products, products of baking, oriental foods. Role of enzymes in different food products (bakery, cheese, beverage production and cereal products) and industries, utilization of food waste for production of valuables. 9(L)

UNIT 6: Quality Control using Microbiological Criteria-Cleaning and disinfection code for good manufacturing practices, microbial and chemical safety of food products, indicator organisms, ISO, hazard analysis and critical control points, sterility testing. 6(L)

Text /Reference Books:

- Modern Food Microbiology by James M. J., CBS Publishers and Publishers.
- Food Microbiology by Freiser.
- Willis Biotechnology, Challenges for the flavour and food industries by Lidsay, Elsevier Applied Science.
- Food Biotechnology by Roger A., Gordan B., and John T.
- Basic Food Microbiology by George J. B., CBS Publishers and Distributors.

PHARMACEUTICAL BIOTECHNOLOGY (BT-1732)

UNIT 1: Introduction-Development of drug and pharmaceutical Industry, therapeutic agents, their use and economics, regulatory aspects. 4(L)

UNIT 2: Drug Metabolism and Pharmacokinetics-Drug metabolism-physico chemical principles, radio activity-pharmacokinetic action of drugs on human bodies. 4(L)

UNIT 3: Manufacturing Principles-Compressed table, wet granulation, dry granulation or slugging, direct compression, tablet presses, coating of tablets, capsules, sustained action dosage forms, parental solution, oral liquids, injections, ointment-topical applications. 4(L)

UNIT 4: Preservation-Preservation, analytical methods and test for various drug and pharmaceuticals, quality management, GMP. 4(L)

UNIT 5: Pharmaceutical Product and their Control- Therapeutic categories such as vitamins, laxatives, analgesics, non-steroidal contraceptives, antibiotics, hormones. 8(L)

UNIT 6: Application-Pharmacological screening models for therapeutic areas such as hypertension, cerebral ischaemia, pain, epilepsy, depression, parkinson's disease, alzheimer's disease, diabetic, leishmania 5(L)

Text / Reference Books:

- Theory and Practice of Industrial Pharmacy by Leon Lachman, Lea and Febiger.
- Remington's Pharmaceutical Science, Mark Publishing and Co.

DRUG DESIGN AND DELIVERY (BT-1733)

UNIT 1: Introduction-Introduction to the drug discovery and development, structural effects on drug action, physico-chemical properties that are related to drug action, role and types of chemical bonding involved in drug-target interactions. 3(L)

UNIT 2: Approaches and Principles to Drug Design-Enzyme Inhibition, molecular recognition, receptor based molecular modelling, molecular docking, QSAR, agonist and antagonist. Computer-aided drug Design: lead optimization and computer-aided drug design, overview of ligand-based and structure-based design, viewing tools and graphics tools. 7(L)

UNIT 3: Preclinical development-Clinical trials, patenting and clearance for application.
5(L)

UNIT 4: Designed Drug in Application-Antihypertensive, antiviral, anticancer and antibiotic, combinatorial library and highthrouput Screening 5(L)

UNIT 5: Drug Delivery Approaches-Pharamacokinetics and its role in drug discovery, vehicles used for drug delivery, drug development and process development, drug absorption, distribution and excretion 5(L)

UNIT 6: Drug Metabolism-Different routes of drug administration, drug absorption, drug transport in biological systems, drug permeation through biological barriers, drug distribution, transcapillary exchange of drugs, perfusion limited and permeability limited distribution of drugs, drug excretion. 8(L)

Text/Reference Books

- Comprehensive Medicinal Chemistry (Vols. I-VI) by C. Hansch
- Design of Enzyme Inhibitors as Drugs by M. Sandler and H. J. Smith.
- Computer Aided Drug Design by T. J. Perun and C. L. Propst., Dekker.
- Molecular Modelling Principles and Applications, Longman by A.R Leach
- Molecular Dynamics Simulation Elementary methods by J.M. Haile, John Wiley.

PROFESSIONAL ELECTIVE-II

ENVIRONMENTAL BIOTECHNOLOGY (BT-1741)

UNIT 1: Introduction to Environment-Ecology and ecosystem, environmental pollution (water, soil and air) noise and thermal pollution, their sources and effects. 4(L)

UNIT 2: Sewage and waste treatments-Anaerobic and aerobic treatment, conventional and advanced treatment technology, methanogenesis, methanogenic, acetogenic, and fermentative bacteria, waste water treatment. Landfills, composting, vermicomposting, recycling and processing of organic residues. 7(L)

UNIT 3: Microbial Interactions and biogeochemical cycles-Microbial interactions, carbon, sulphur and nitrogen cycles, microbial leaching. 4(L)

UNIT 4: Bioremediation-Biodegradation of xenobiotic compounds, organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants and microbial treatment of oil pollution. 7(L)

UNIT 5: Emerging technologies-Use of biomarkers, bioreporters, bioprobes and biosensors for environmental monitoring. 8(L)

UNIT 6: Bioresource Technology, Development and Issues-Microbial leaching and mining, microbial polymer production and bio-plastic technology biofertilizers and microbial inoculants, biofuel, environmental laws and policies. 10(L)

Text/Reference Books:

- Environmental Microbiology by W.D. Grant and P.E. Long., Blakie, Glassgow and London.
- Manual of Environmental Microbiology by Cristian J.Hurst and Ronald L.Crawfold.,
- ASM press.
- Wastewater Engineering, Treatment, Disposal and Reuse by Metcalf and Eddy, Tata Mc Graw Hill.
- Environmental Biotechnology by Foster C.F., John Ware D.A., Ellis Horwood Ltd.
- Environmental Biotechnology by Bruce Rittmann and Perry McCarty
- Biotechnology and Biodegradation, Advances in applied biotechnology series, by Kamely.D., Chakrabarty K and Omen G.S, Gulf publishing company.
- Standard Methods for the Examination of Water and Waste Water. American Public health Association

BIO-NANOTECHNOLOGY (BT-1742)

UNIT 1: Introduction-Concept and definition of bionanotechnology, the nanoscale dimension and paradigm, definitions, history and current practice, overview of current industry application, structural and functional principles of bionanotechnology. 5(L)

UNIT 2: Self assembled biological nanostructures-Artificial transmembrane ion channels such as gated and non gated ion channels, nanostructures based on coiled coil peptides, nanostructures synthesized using bio-derived templates. 6(L)

UNIT 3: DNA based nanostructures-DNA as a polymer and DNA based motors basics of DNA structure, hairpin loops and helices: reciprocal exchange and stability of DNA structure, Base pairing, motifs used in DNA nanotechnology. RNA polymerase and DNA helicase as motors, single molecule mechanics and DNA dynamics. 6(L)

UNIT 4: Biologically inspired nanomaterials for new generation of medicine-Structurally inspired materials like liposomes, virosomes. Polymersomes, peptoids, functionally inspired biomaterials such as mussel-adhesive proteins. 5(L)

UNIT 5: Nanostructures in biological detection-Use of quantum dots and gold nanoparticles in electrochemical detection, surface plasmon resonance based detection, fluorescence detection. 5(L)

UNIT 6: Techniques used for characterization of nanostructures-Particle size determination, zeta potential, electron microscopy, atomic force microscopy. 5(L)

Text/ Reference Books:

- Nanobiotechnology: Concepts, Applications and Perspectives by Christof M. Niemeyer and Chad A. Mirkin, Wiley-VCH.
- Nanotechnology: A gentle introduction to the next big idea by Ratner, M.Ratener, D.
- Bionanotechnology: Lessons from Nature by David S. Goodsell, John Wiley and Sons.
- Introduction to Nanotechnology by Charles P. Poole, Frank J. Owens, John Wiley and Sons, Inc.

STEM CELLS IN HEALTH CARE (BT-1743)

UNIT 1: Introduction- Stem cell biology, fate mapping of stem cells. 4(L)

UNIT 2: Stem Cell Pattern-Differentiated parental DNA chain causes stem cell pattern of cell-type switching in *Schizosaccharomyces pombe on* equivalence groups and the Notch/LIN-12 communication System. 6(L)

UNIT 3: Cell Cycle Control-Checkpoints, and stem cell biology, senescence of dividing somatic cells. 4(L)

UNIT 4: The Drosophila Ovary-An in vivo stem cell System. 4(L)

UNIT 5: Male Germ-line Stem Cells-Primordial germ cells as stem cells, embryonic stem cells, embryonal carcinoma cells as embryonic stem cells, trophoblast stem cells. 7(L)

UNIT 6: Hematopoietic Stem Cells-Repopulating patterns of primitive hematopoietic stem cells, molecular diversification and developmental interrelationships, lymphopoiesis and the problem of commitment versus plasticity, hemangioblast, mesenchymal stem cells of human adult bone marrow, stem cells and neurogenesis. 10(L)

UNIT 7: Epidermal Stem Cells-Liver stem cells, pancreatic stem cells, stem cells in the epithelium of the small intestine and colon. 5(L)

Text/Reference Books:

- Developmental Biology by Scott F. Gilbert.
- Hematology by William J. Williams, Ernest Beutler, Allan JU. Erslev and Marshall A. Lichtman.
- Molecular Biology of the Cell by Bruce Alberts, Dennis Bray, Julian Lewis, Martin Raff, Keith Roberts and James D. Watson.
- Stem Cell Biology by Marshak, Cold Spring Harbour Symposium Publication.

MAJOR PROJECT (INTERIM EVALUATION) (BT-1791)

Exprtiment 1: Plan and complete a significant problem.
Exprtiment 2: Find and document, together with their advantages and disadvantages, possible solutions to the problem.
Exprtiment 3: Select their preferred solution, and document the arguments for their selection.
Exprtiment 4: Understand the advantages and disadvantages of working in a group.
Exprtiment 5: Consider alternative working methods, including method-based and problem-based forms.
Exprtiment 6: Present their work using different techniques.

MEDICAL BIOTECHNOLOGY AND DIAGNOSTIC (LAB) (BT-1751)

Experiment 1: Isolation of various cell subsets like macrophages, T and B cells from human blood using nylon wool.
Experiment 2: Identification of various cell subsets from human blood.
Experiment 3: Counting of CD4+ cells in human blood by immune-fluorescence.
Experiment 4: Determination of blood group
Experiment 5: Demonstration of tumor agglutination test
Experiment 6: Attenuation of bacteria and/or parasite
Experiment 7: Demonstration of in vitro infection of macrophages with bacteria and/ or parasite
Experiment 8: Demonstration of one way/ two way mixed lymphocyte reaction
Experiment 9: Demonstration of Liver function test and Kidney function test.
Experiment 10: Estimation of urea in urine samples
Experiment 11: Determination of cholesterol in blood samples
Experiment 12: Determination of Erythrocyte Sedimentation Rate (ESR)

PLANT BIOTECHNOLOGY (LAB) (BT-1752)

Experiment 1: Selection, preparation and sterilization of explant and laboratory wares.
Experiment 2: Aseptic culture techniques for establishment and maintenance of cultures.
Experiment 3: Preparation of stock solutions of MS (Murashige and Skoog) basal medium and plant growth regulator stocks.
Experiment 4: Production Callus from different tissues of plant.
Experiment 5: Isolation and culture of protoplasts.
Experiment 6: Plant regeneration by embryo/ anther /pollen culture.
Experiment 7: Performance of Agrobacterium mediated gene transformation in plant.
Experiment 8: Performance of gene transfer by physical delivery method.
Experiment 9: Isolation of plant genomic DNA by modified CTAB method.
Experiment 10: Screening of putative transformed plants cell by PCR/ Fluorescent dye test

BIOPROCESS CONTROL AND ECONOMICS (BT-1801)

UNIT 1: Introduction-Introduction, process design development. General design considerations, design-project procedure, feasibility survey, flow diagrams. 4(L)

Unit 2: Process Plants-Batch versus continuous operation, bioprocess plant and equipment start up and shut downs, operations at steady state. Factors effecting investment and production cost, capital investments, estimation of capital investments. 7(L)

UNIT3: Direct Expenses-Manufacturing costs general expenses, estimation of total product of cost direction, direct production cost, fixed charges, plant overhead costs, financing, administration expenses, distribution and marketing expenses. 7(L)

UNIT4: Legal policies- Environmental protection, health and safety factors, materials of construction, plant location, government polices and company polices. 6(L)

UNIT5: Plant Operation and Control-Instrumentation, maintenance, utilities;supply of power,abundance of good water supplies, storage, materials handling 6(L)

UNIT6: Financial statements-Basic relationships in accounting, balance sheet and profit and loss account, factors affecting investment and production costs, price fluctuations, operating time and rate of production, capital investments, fixed-capital Investment, working capital. 8(L)

Text/Reference Book list:

- Plant Design and Economics for Chemical Engineering by M.S. Peters and K.D.Timmerhaus., McGraw Hill.
- Process Engineering Economics by Schweyer.
- Biochemical Engineering by Aiba, Humphry and Millis, Academic press.

PROFESSIONAL ELECTIVE-III

BIOSENSOR TECHNOLOGY (BT-1831)

UNIT 1: Introduction-Introduction to biosensors: concepts and applications, biosensing and biosensor technology. Review of important analytes and biomolecules. 3(L)

UNIT 2: Study of biological sensors-Sensors / receptors in the human body, basic organization of nervous system-neural mechanism and circuit processing. Chemoreceptor: hot and cold receptors, barro receptors, sensors for smell, sound, vision, osmolality and taste. Sensor models in the time and frequency domains. 6(L)

UNIT 3: Transduction principles-Classification of transducers, selecting of transducers, circuit based on transduction. Temperature transducers: thermo-resistive transducers, thermoelectric, p-n junction, chemical thermometry. Pressure transducer, photoelectric transducers, flow transducers, displacement transducers. 7(L)

UNIT 4. Analytical Techniques-Chemical sensing methods, optical sensing mechanisms and tools, eletrochemical sensing mechanisms and tools, mass spectroscopy. 7(L)

UNIT 5: Biochemical Transducers-Biopotential electrodes: microelectrodes, body surface electrodes, needle electrodes. Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, calomel electrodes. Recording electrodes for ECG, EEG, and EMG. Transducers for the measurement of ions and dissolved gases, pH electrode, specific ion electrodes. 8(L)

UNIT 6: Application-Applications of biosensor-based instruments to the bioprocess industry, application of biosensors to environmental samples, introduction to biochips and their application in modern sciences. 5(L)

Text /Reference Books:

- Handbook of Biomedical Instrumentation by R. S. Khandpur, Tata McGraw Hill.
- Transducers for Biomedical Instruments by S.C. Cobbold, Prentice Hall.
- Engineering Principles in Physiology Vol. I by Brown & Gann, Academic Press.
- Introduction to Biomedical Equipment Technology by Carr and Brown Pearson Education, Asia.
- Principles of Medical Electronics & Biomedical Instrumentation by Rao and Guha, University Press, India.

CELL AND TISSUE ENGINEERING (BT-1832)

UNIT 1: Introduction-Basic definition, structural and organization of tissues: epithelial, connective; vascularity and angiogenesis, basic wound healing, cell migration, current scope of development and use in therapeutic and in-vitro testing. Cells and cell injury, extracellular matrix and cell biomaterial interactions. 7(L)

UNIT 2: Cell culture-Different cell types, progenitor cells and cell differentiations, aspect of cell culture: cell expansion, cell transfer, cell storage and cell characterization, bioreactors. 6(L)

UNIT 3: Biocompatability and Testing-Bioresorbable materials, introduction to testing of biomaterials, tissue compatibility and prosthetic devices. Biocompatibility and toxicological test for screening of biomaterials. Role of molecular biology in tissue engineering. 9(L)

UNIT 4: Scaffold and transplant-Engineering biomaterials for tissue engineering, degradable materials (collagen, silk and polylactic acid), porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver. Prosthesis, transplantation biology. 9(L)

UNIT 5: Gene Therapy-Virus, liposome, receptor, $CaPO_4$, electroporation and gene gun-mediated gene transfer into mammalian cells. Computer aided tissue engineering. 4(L)

UNIT 6: Ethical and Legal Issues-Ethical issues in biomaterial science, legal aspects of biomaterials. 4(L)

Text / Reference Books:

- Frontiers in Tissue Engineering by Patrick, Mikos and McIntire, Pergamon Press.
- Principles of Tissue Engineering by Lanza, Labnger and Vacanti, Academic Press.
- Tissue Engineering Methods and Protocols by Morgan and Yarmush, Humana Press.
- Biomaterials Science by Buddy D. Ratner, AS Hoffman, FJ Schoen and Jack E Lemons. Academic Press.
- Principles of tissue engineering by Robert. P.Lanza, Robert Langer and William L. Chick, Academic press.
- The Biomedical Engineering –Handbook by Joseph D. Bronzino., CRC press.
- Introduction to Biomedical Engg. by Endarle, Blanchard and Bronzino., Academic press.
- Tissue Engineering by B. Palsson, J.A. Hubbell, R.Plonsey and J.D. Bronzino, CRC- Taylor and Francis.

AGRO BIOTECHNOLOGY (BT-1833)

UNIT 1: Sustainable Agriculture-An introduction, role of biofertilizers and bio-pesticides in sustainable agriculture. Mass cultivation of microbial inoculants, plant growth promoting rhizobacteria, diazotrophic microorganism, Free living and symbiotic nitrogen fixing microbes, Molecular basis of legume r*hizobium* symbiosis. 8(L)

UNIT 2: Molecular Farming-Molecular farming, use of plants and animals for production of neutraceuticals, organic farming and sustainable use of natural and bioresources, integrated pest management, world food security. 8(L)

UNIT 3: Soil Microbiology-Soil as a habitat for microorganisms, rhizosphere: concept, rhizospheric effect and microorganisms, factors affecting microbial community in soil, organic matter decomposition, carbon assimilation and immobilization. 6(L)

UNIT 4: Agriculture Biotechnology and Laws-Plant variety protection act, TRIPS and WTO, patenting of life forms−plant and products, Plant breeders rights. 6(L)

UNIT 5: Agricultural Biotechnology and Society-Commercial status and public acceptance, bio-safety guidelines for research involving GMO's, benefits and risks, socio-economic impact and ecological considerations of GMO's. 6(L)

UNIT 6: Agribusiness and Entrepreneurship-Types of business organizations, characteristics of small and medium agribusinesses. Setting up of an agribusiness unit and development of a business plan. Marketing strategies for an agribusiness. Entrepreneurship: generation of business ideas and innovation. Clustering. Incubators. 6(L)

Text /Reference Books:

- Agricultural Biotechnology by Arie Altman. Marcel Dekker, Inc.
- Plants, Genes and Crop Biotechnology by Chrispeels, M.J. and Sadava D.E. American Society of Plant Biologists, Jones and Bartlett Publishers, USA.
- Biochemistry and Molecular Biology of Plants by Buchanan B.B.,Gruissem W and Jones RL, American Society of Plant Biologists,USA.
- Soil Microorganisms and Plant Growth by Rao Subba S.M.
- Biotechnology and integrated pest management by Persely, CAB, Wallingford.
- Plant Biotechnology: The genetic manipulation of plants by A. Slater, N. Scott, M. Fowler; Published by Oxford University press, New York.
- Food and Vegetable Biotechnology by V. Valpuseta., CRC Press, New Delhi.

PROFESSIONAL ELECTIVE-IV

MICROBES, HEALTH AND VACCINES (BT-1841)

UNIT 1: Introduction to microflora, disease and clinical handling-Normal flora of human body, principles of disease and epidemiology, collection and transport of clinical specimens for microbiological examinations. 4(L)

UNIT 2: Disease Cycle and Pathogenesis-Disease cycle, mechanism of pathogenesis: entry, adhesion, colonization, invasion, avoidance of host defense mechanisms, role of aggresins, host parasite interactions. 7(L)

UNIT 3: Important Diseases-Important food-borne, water-borne, blood-borne, vector-borne, nosocomial, zoonotic, and STD infections prevalent in the human population. Morphology, culture, biochemical, pathogenicity, lab diagnosis and prevention of these important diseases, nosocomial infections. 13(L)

UNIT 4: Emerging Diseases-Emerging infectious diseases, factors leading to disease emergence, monitoring and intervention strategies. 6(L)

UNIT 5: Bioterrorism-Bioterrorism and bio-weapons: historical perspective, current situation, future threats. 4(L)

UNIT 6: Vaccines and Antibiotics-Vaccines, disease eradication programs, antibiotics and the genetics of antibiotics resistance. 6(L)

Text /Reference Books:

- The Short Text books of Medical Microbiology by Satish Gupte. Jaype Brothers, Medical Publishers (P) Ltd., New Delhi.
- Text Book of Microbiology by Ananthanarayan R and CK Jayaram Paniker. Orient Longman Private Limited.
- Essentials of Medical Microbiology by Rajesh Bhatia and Rattan Lal Ichhpujani. Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
- Text book of Medical Parasitology, Protozoology and Helminthology by Subhash Chandra Parija., All India Publishers & Distributors, Medical Books Publishers, New Delhi.
- Bailey and Scott's – Diagnostic Microbiology by Baron EJ, Peterson LR and Finegold SM Mosby Publications.
- Principles of Bacteriology, Virology and Immunology by Topley and Wilsons., Edward Arnold, London.

BIOENERGY (BT-1842)

UNIT 1: Introduction-Bioenergy, classification and sources of energy, problems relating demand and supply of various energy sources. 3(L)

UNIT 2: Coal-Origin and formation, composition and classification, resources and production, exploration and mining, analysis and testing storage and handling; coal carbonisation, briquette, coal hydrogenation. Wood and wood products. 4(L)

UNIT 3: Petroleum-Origin, occurrence, chemical composition, world reserve, production, refining operations, storage and conveying, testing and analysis different products from petroleum. Combusting methods; and systems, pulverised coal furnaces; cyclone furnaces, oil fired systems, gas fired systems, waste heat boilers 6(L)

UNIT 4: Biogas plant and its design-KVIC plants, process kinetics, digester design, sludge treatment, energy from wastes. Development in energy routes. 5(L)

UNIT 5: Conversion of heat to power-Thermoelectric converters, thermo-electric refrigerators, magneto-hydrodynamics, fuel cells, conversion of chemical energy into electricity, fuel cell performance, co-generation, efficiency improvement, energy conversion in petrochemical industries, polymer industries, natural organic industries, fertilizer industries etc. 6(L)

UNIT 6: Energy conservation-Process modifications, preventing energy loss, waste utilisation, energy audit. 4(L)

Text/Reference Books:

- Conventional Energy Technology - Fuels and chemical Energy by S.B Pandya., TMH .
- Fuels and Combustion by S.P. Sharma and Chander Mohan., TMH.
- Energy resources, demand and conservation with special reference to India by Kash Kori, C., TMH.
- Principles of Energy Conservation by Gulp Jr., MGK.
- Chemtech I - Manual of Chemical Technology, Vol.I., S. Chand and Co., New Delhi.
- Non Conventional energy resources by Pryde P.R., JW.
- Tidel Power by Gray T.J. and Gashos G.K., Plenum Press.
- Fuels and Combustion by Sarkar S, Orient Longmans.

BIODIVERSITY AND BIOPROSPECTING (BT-1843)

UNIT 1: Ecosystems-Major ecosystems and their flora and fauna. Co-evolution, symbiosis and interaction among organisms. 6(L)

UNIT 2: Taxonomy-Nomenclature and classification of flora and fauna. 6(L)

UNIT 3: Biodiversity-Analysis of biodiversity, on farm, *ex situ*, *in situ* and gene bank conservation, geological and human activities endangering biodiversity, domestication and utilization of biodiversity. 8(L)

UNIT 4: Organic Farming-Organic farming and sustainable use of natural and bioresources, organic standards and certification of organic produce and products, biological control, global initiatives on future prospects. 8(L)

UNIT 5: Bioprospecting-Bioprospecting biodiversity for food, feed, health care and other products. Ethnobiology. 8(L)

UNIT 6: Bioprospecting of Extremophiles-Bioprospecting and conservation of extremophile microorganisms. 5(L)

Text/Reference Books:

- Biodiversity: New leads for the pharmaceutical and agrochemical industries by S.K., Hayes M.A., Thomas R, Chrystal E.J.T. and Nicholson L. Royal Society of Chemists., Wrigley.
- Biological and Biotechnological Resources by G Tripathi and Y.C. Tripathi., Campus Books International.

MAJOR PROJECT (FINAL EVALUATION) (BT-1891)