**CENTRE FOR BIOTECHNOLOGY**

**INSTITUTE OF SCIENCE AND TECHNOLOGY**

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**

**KUKATPALLY, HYDERABAD-500 085, TELANGANA STATE. TELE NO.040 23156129**

**Master of Technology**

**in**

**BIOTECHNOLOGY**

 **(Part Time PG)**

**COURSE STRUCTURE**

**&**

**DETAILED SYLLABUS**

**W.E.F. 2015**



**EACH SEMESTER IS APPROXIMATELY 20-21 WEEKS DURATION INCLUDING EXAMINATIONS. EACH PERIOD IS ABOUT 50 MINITUES DURATION. THERE WILL BE NORMALLY FOUR SESSIONS PER DAY EACH OF ABOUT 100 MINITUES DURATION. TWO SESSIONS OF LABORATORY IS EQUIVALENT TO ONE SESSION OF THEORY**

**COURSE STRUCTURE FOR PART TIME P.G. PROGRAMMES**

**M.TECH (Biotechnology)**

**I YEAR**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **I Semester** | **Int. Marks** | **Ext. marks** | **L** | **P** | **C** |
|  | Core Course I | 25 | 75 | 4 | -- | 4 |
|  | Core Elective I | 25 | 75 | 4 | -- | 4 |
|  | Core Elective II | 25 | 75 | 4 | -- | 4 |
|  | Laboratory I | 25 | 75 | -- | 4 | 2 |
|  | **Total Credits** | **12** |  **4** | **14** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **II Semester** | **Int. Marks** | **Ext. marks** | **L** | **P** | **C** |
|  | Core Course II | 25 | 75 | 4 | -- | 4 |
|  | Core Course III | 25 | 75 | 4 | -- | 4 |
|  | Core Elective III | 25 | 75 | 4 | -- | 4 |
|  | Laboratory II | 25 | 75 | -- | 4 | 2 |
|  | Seminar I | 50 | -- | -- | 4 | 2 |
|  | **Total Credits** | **12** | **8** | **14** |

**IIYEAR**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **I Semester** | **Int. Marks** | **Ext. marks** | **L** | **P** | **C** |
|  | Core Course IV | 25 | 75 | 4 | -- | 4 |
|  | Core Course V | 25 | 75 | 4 | -- | 4 |
|  | Open Elective I | 25 | 75 | 4 | -- | 4 |
|  | Laboratory III | 25 | 75 | -- | 4 | 2 |
|  | **Total Credits** | **12** |  **4** | **14** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **II Semester** | **Int. Marks** | **Ext. marks** | **L** | **P** | **C** |
|  | Core Course VI | 25 | 75 | 4 | -- | 4 |
|  | Core Elective IV | 25 | 75 | 4 | -- | 4 |
|  | Open Elective I | 25 | 75 | 4 | -- | 4 |
|  | Laboratory IV | 25 | 75 | -- | 4 | 2 |
|  | Seminar II | 50 | -- | -- | 4 | 2 |
|  | **Total Credits** | **12** | **8** | **14** |

**III YEAR**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **I Semester** | **Int.****Marks** | **Ext.****Marks** | **L** | **P** | **C** |
|  | Comprehensive Viva-Voce | -- | 100 | -- | -- | 4 |
|  | Project Work Review I | 50 | -- | -- | 24 | 12 |
|  | **Total Credits** |  | **24** | **16** |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **II Semester** | **Int.****Marks** | **Ext.****Marks** | **L** | **P** | **C** |
|  | Project Work Review II | 50 | -- | -- | 8 | 4 |
|  | Project Evaluation (Viva-Voce) | -- | 150 | -- | 16 | 12 |
|  | **Total Credits** |  | **24** | **16** |

**FIRST YEAR – I SEMESTER**

|  |  |  |  |
| --- | --- | --- | --- |
| **Core Course I** - Microbial Engineering | 4 | -- | 4 |
| **Core Elective I ( based on the educational background)**1. Basic Engineering Mathematics
2. Industrial Biotechnology
3. Biochemical and Biophysical Techniques
 | 4 | -- | 4 |
| **Core Elective II ( based on the educational background)**1. Process Engineering Principles
2. Biochemistry and Metabolic Regulation
3. Tissue Engineering and Stem Cell Technology
 | 4 | -- | 4 |
| **Laboratory I**Process Engineering Principles Laboratory | -- | 4 | 2 |
| **Total** |  **12** |  **4** |  **14** |

**Note:**

1. Basic Engineering Mathematics and Process Engineering Principles are mandatory for all the students joining with their Masters’ in life Sciences, Chemical Sciences and for B.Pharmacy graduates.
2. Industrial Biotechnology & Biochemistry and Metabolic Regulation are mandatory for students having their B.Tech Degree in Chemical Engineering/ Food Technology/ Dairy Technology.
3. B. Tech (Biotechnology/Biochemical Engineering) students have the freedom to select any two courses of their choice.

**FIRST YEAR – II SEMESTER**

|  |  |  |  |
| --- | --- | --- | --- |
| **Core Course II** Molecular Biology and Genetic Engineering | 4 | -- | 4 |
| **Core Course II**I Enzyme Engineering and Technology | 4 | -- | 4 |
| **Core Elective III** Plant BiotechnologyNanobiotechnology and NanodevicesMicrobes and Infections | 4 | -- | 4 |
| **Laboratory II**Molecular Biology Laboratory | -- | 4 | 2 |
| **Seminar I** | 0 | 4 | 2 |
| **Total** |  **12** |  **8** |  **16** |

**SECOND YEAR – I SEMESTER**

|  |  |  |  |
| --- | --- | --- | --- |
| **Core Course IV** Bioreactor Engineering | 4 | -- | 4 |
| **Core Course V**Immunology and Immunotechnology | 4 | -- | 4 |
| **Open Elective I**Environmental Biotechnology2. Biobusiness Management | 4 | -- | 4 |
| **Laboratory III**Bioprocess Engineering Laboratory | -- | 4 | 2 |
| **Total** |  **12** |  **4** |  **14** |

**SECOND YEAR – II SEMESTER**

|  |  |  |  |
| --- | --- | --- | --- |
| **Core Course VI** Downstream Processing | 4 | -- | 4 |
| **Core Elective IV**Animal Cell Science and TechnologyBiochemical Reaction EngineeringBioinformatics and Systems Biology | 4 | -- | 4 |
| **Open Elective II** Bioethics, Bio-safety and Intellectual Property RightsPharmaceutical Biotechnology | 4 | -- | 4 |
| **Laboratory IV**Cell culture Techniques Laboratory | -- | 4 | 2 |
| **Seminar II** |  | 4 | 2 |
| **Total** |  **12** |  **8** |  **16** |

**THIRD YEAR – I SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **I Semester** | **Int.****Marks** | **Ext.****Marks** | **L** | **P** | **C** |
|  | Comprehensive Viva-Voce | -- | 100 | -- | -- | 4 |
|  | Project Work Review I | 50 | -- | -- | 24 | 12 |
|  | **Total Credits** |  | **24** | **16** |

**THIRD YEAR – II SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **II Semester** | **Int.****Marks** | **Ext.****Marks** | **L** | **P** | **C** |
|  | Project Work Review II | 50 | -- | -- | 8 | 4 |
|  | Project Evaluation (Viva-Voce) | -- | 150 | -- | 16 | 12 |
|  | **Total Credits** |  | **24** | **16** |

**Core Course I**

**MICROBIAL ENGINEERING**

**UNIT-I MATERIAL BALANCES:**

Introduction to engineering Calculations, Thermodynamics preliminaries, Law of conservation of mass, Procedure for Material Balance calculations, Material Balance worked examples, Material Balances with Recycle, Bypass and Purge streams, Stoichiometry of cell growth and product formation.

**UNIT-II ENERGY BALANCES:**

Basic Energy concepts, General Energy Balance Equations, Enthalpy calculation procedures, Enthalpy change in Non reactive processes, procedure or Energy Balance calculations without reaction. Energy Balance worked Examples without reaction, Enthalpy change due to reaction, Heat of reaction for process with biomass production, Energy Balance calculation for cell culture, cell culture Energy Balance worked Examples.

**UNIT-III MEDIA OPTIMIZATION AND STERILIZATION**

**MEDIA OPTIMIZATION:** Optimizationtechniques with special emphasis on statistical techniques, Placket-Burman design, ANOVA, central composite design, response surface methodology.

**STERLIZATION:** Media sterilization, Kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilization, coupling of Arrhenius equation and cell death kinetics, sterilization of air and filter design, Radiation and Chemical sterilization.

**UNIT-IV UNSTRUCTED MODEL FOR MICROBIAL GROWTH:**

The development of different microbial growth kinetics like Malthus, Pearl and reed, Monad Model, Konark Model. The limitation of Monod model and development of other constitutive models of growth. Multi-substrate models, inhibition models for substrate, Product and toxic substances. Development of logistic equation. Maintenance and endogenous metabolism kinetics.

**UNIT-V STRUCTURED MODELS OF MICROBIAL GROWTH:**

Kinetics based on molecular mechanism, Compartmental models, Model of Cellular Energetics and Metabolism, Models of product formation, single cell model, Models of gene expression and regulation, Plasmid Expression and Replication, Model of plasmid stability, parameter estimation, Model validation and bioprocess optimization.

**BOOKS:**

1. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker (1987)
2. Pauline M. Doran: Bioprocess Engineering Principles, Elsevier Publications.

**REFERENCE BOOKS:**

1. Biochemical Engineering Principles and functions by Syed Trnveer Ahmed Inamdar, PHI

Learning Private limited.

1. Wiseman, A: Handbook of Enzyme Biotechnology, 3rd Edition, Ellis Horwood Publication

(1999)

1. Moser, A; Bioprocess technology, kinetics and reactors; Springer Verlag, (1988)
2. Schugerl K: Bellgart K H (Eds); Bioreaction Engineering, Modeling and control; Springer –

verlog, berlin (2000)

1. Introduction to Biochemical Engineering by D G Rao. Tata, Mc Graw Hill, New Delhi.
2. Bailey JE, Ollis DF; Biochemical Engineering fundamentals (1986)

**Core Elective I (Based on the educational background)**

**1. BASIC ENGINEERING MATHEMATICS**

UNIT-I QUADRATIC EQUATION: Roots of quadratic equation of the forms ax2+bx+c=0 and simple properties of the quadratic roots.

THEORY OF EQUATIONS: Polynomial function, polynomial equation, reminder theorem, synthetic division, relation between the roots and coefficients of f(x) = 0, Transformation equations, Partial fractions.

UNIT-II TRIGONOMETRY: Relations related to compound angles, multiple and sub-multiples, transformations, hyperbolic functions

UNIT-III DIFFERENTIATION AND ITS APPLICATION: Concepts of limit, Continuity, Differentiation, Product and quotient rule, differentiation of Trigonometric, inverse trigonometric, logarithmic and exponential functions.

Applications of differentiation – problems on tangent, sub tangent normal, sub normal. Maxima and minima. Introduction to partial differentiation - Euler’s theorem on Homogenous functions, errors and approximations.

UNIT-IV INTEGRATION AND ITS APPLICATION: Integration Basics, Methods of Integration, Methods of substitution, Integration by parts, Definite integrals and their properties, Application of definite integrals – Areas and lengths (Cartesian and Parametic). Trapezoidal rule and simpsons 1/3 rule.

UNIT-V ORDINARY DIFFERENTIAL EQUATIONS: Order and degree of a differential equation. Formation of and ODE by eliminating arbitary contants. Solution of First order and First degree differential equation. Method of variable separables, homogenous exact, linear and Bernoullis Equation. Application of differential Equations – Newton Law of cooling – Growth and decay – Logistics.

TEXTBOOKS:

1. Engineering Mathematics - N.P. Bali.

2. Engineering Mathematics - B.V. Ramana

3. Intermediate Maths Vol. I & II - Krishna Murthy, S. Chand

REFERENCE BOOKS:

1. Differential Calculus - Shanthi Narayana

2. Integral Calculus - Shanthi Narayana

**Core Elective I (Based on the educational background)**

**2. INDUSTRIAL BIOTECHNOLOGY**

**UNIT-I INTRODUCTION AND METHODS IN MICROBIOLOGY:** INTRODUCTION: History, Scope & milestones of microbiology, Ultra-structural organization of prokaryotic and eukaryotic cells.

**MICROBIOLOGICAL METHODS:** Staining Techniques - Stains, simple staining, negative staining, differential staining, staining specific structures (capsular staining, endospore staining, flagellar staining), Pure culture isolation techniques, culture preservation techniques, sterilization techniques, antimicrobials and their mechanism of action.

**UNIT-II MICROBIAL GROWTH AND FORMULATION OF MICROBIOLOGICAL MEDIA: Microbial growth:** Microbial growth curve - mathematical expression of growth, classification of microbes based on physical factors (pH, temperature, O2 requirement).

**Media formulation:** Microbial nutrition and types of microbial culture media, Different components of microbial culture medium and their physiological role in microbial growth, raw materials used in preparation of medium, factors affecting the choice of Carbon & Nitrogen sources, Vitamins, Minerals and Anti-foam agents.

**UNIT-III FERMENTATIONS: Overview of Industrial fermentation processes and products:** Antibiotics - Penicillin, Streptomycin; Organic acids – Citric acid , Lactic acid; Industrial enzymes – Amylases, Proteases, Cellulases; Alcoholic beverages – Ethanol, Beer, Wine.

**Fermentors:** Fermentation equipment and its uses, types of fermentors and different fermentation modes

**UNIT-IV PRODUCTION OF r-DNA BASED PRODUCTS:** Special procedures for production of r-DNA based products – Monoclonal antibodies (mAb’s) and Bio- therapeutics Eg.: Insulin , vaccines. Applications of Bioconversions in r-DNA products.

**UNIT-V FOOD & ALLIED PRODUCTS:** Food industry: Bakers’ yeast and bread making, rennet and other proteolytic enzymes in cheese making, production of different cheeses; other products from diary industry. Single cell protein, Biofertilizers, Bio Fuels, Biopesticides: Methane generation, biological production of hydrogen.

**TEXT BOOKS:**

1. "Principles of fermentation technology" by P F Stanbury and A Whitaker, Pergamon press (1984).
2. Industrial Microbilogy by A.H. Patel, Macmillan India Ltd.
3. Industrial Biotechnology by S.N. Jogdand, First edition, Himalaya Publishing House, (2006).

**REFERENCE BOOKS:**

1. “General Microbiology” 5th Edition Stanier et al.
2. “Enzymes in food processing” by Gerald Reed, Academic press.
3. “Comprehensive Biotechnology” Vols III & IV, Editor M.Moo young.
4. “Industrial Microbiology” by Prescott
5. “Industrial Microbiology” by Casida.

**Core Elective I (Based on the educational background)**

### 3. BIOCHEMICAL AND BIOPHYSICAL TECHNIQUES

**UNIT-I COLLOIDS OF BIOPOLYMERS AND THEIR PROPERTIES:** Colloidal solutions of biopolymers and their electrochemical properties. Hydrodynamic properties: Viscosity, diffusion etc. of biopolymers; Molecular weight determination, osmotic pressure, reverse osmosis, and Donnan effect. Structure of Biomembranes and their electrochemical properties, membrane potential, action potential and propagation of impulses.

**UNIT-II MICROSCOPY:** Introduction to principles and working of light & Electron Microscope, Scanning Tunneling Microcopy, SEM, TEM, AIM, Sample preparation for Electron Microscopy.

**UNIT-III: ELECTROPHORESIS & ADVANCED IMMUNO TECHNIQUES:** Different methods of electrophoresis for protein, nucleic acids, small molecular weight compounds. Peptide mapping and combination of electro focusing and SDS-PAGE, Comet assay, Karyotyping, FISH, Rocket Immunoelectrophoresis, ELISA, RIA, western blot.

**UNIT-IV SPECTROPHOTOMETRY AND RADIO ACTIVITY:** Introduction to principles and applications of (a) spectroscopic methods (UV, Vis, IR, Fluorescence, ORD, CD & PAS) (b) NMR, ESR & Mass spectrometry. Uses of radioactive and stable isotopes and their detection in biological systems.

**UNIT-V SEPARATION AND SEQUENCING TECHNIQUES:** Automatic analyzer for amino acids, HPLC, UPLC (Reverse phase, ion exchange, size exclusion), cell sorters and their applications.

**TEXT BOOKS:**

1. Introduction to Biophysics by Pranab Kumar Banerjee, S Chand and company, 2008.
2. Instrumental methods of chemical analysis by G. R Chatwal and S .K Anand, Himalaya publishing house, 2008.

**REFERENCE BOOKS:**

1. Biotechnology Procedures and Experiments handbook by S. Harisha, Infinity Science Press LIC, 2008.

**Core Elective II (Based on the educational background)**

**1. PROCESS ENGINEERING PRINCIPLES**

**UNIT-I Process Calculations & Thermodynamics:** Overview of Chemical Engineering, Concepts of Unit operations & Unit processes with examples, Units & Dimensions, Stoichiometric principles, Law of conservation of mass.

**Thermodynamics:** Scope of Thermodynamics, Force, Temperature, Volume, Pressure, Work, Energy, Heat, Heat capacities, Enthalpy, Law of thermodynamics.

**UNIT-II Unit Operation & Fluid Mechanics:** Introduction, Characterization of solid particles, Screen analysis, Size reduction – law of crushing, various types of size reduction equipment.

**Fluid Mechanics:** Fluid Flow, Newton’s law of viscosity, Classification of Fluids, Hydrostatic Pressure, Manometers, Continuity equation, Bernoulli’s equation & Its applications, Metering & Transportation of fluids using orifice meter, venture meter & Rota meter.

**UNIT-III Heat Transfer:** Modes of heat transfer with examples, Conduction – Fourier’s law, one dimensional conduction through plane wall, composite wall, cylinder and spherical system.

**Convection:** Introduction, natural and forced convection, Concept of heat transfer coefficient, relationship between Individual and overall heat transfer coefficient.

**UNIT-IV Radiation & Heat Transfer Equipment:**

**Radiation:** Introduction, Black body, Laws of black body radiation; Kirchoff’s law, Stefan-Boltzmann law, Wein’s displacement law.

**Heat Transfer Equipment:** Overview of heat exchangers-types and temperature area graphs, Concept of LMTD. Concepts of Boiling & evaporation-types of boiling & its mechanism, types of evaporators.

**UNIT-V Mass Transfer:** Introduction, Molecular diffusion, Fick’s law of diffusion, diffusivities of gases and liquids, Theories of mass transfer, Concept of mass transfer coefficients, Principles of Absorption, Adsorption, extraction, Distillation and Drying.

**TEXT BOOKS:**

1. Unit operations of Chemical Engineering, by W.L. McCabe, J.C. Simth and Harriott, McGraw Hill publishers.

**REFERENCE BOOKS:**

1. Bioprocess Engineering principles By Pauline M Doran, Academic Press.
2. Unit Operations-1, K. A. Gavhane, Nirali Prakashan Publication.
3. Introduction to Biochemical Engineering, Second edition, By D.G. Rao, Tata McGraw Hill Publications.

**Core Elective II (Based on the educational background)**

**2. BIOCHEMISTRY AND METABOLIC REGULATION**

**UNIT-I FUNDAMENTALS OF BIOCHEMISTRY AND BIOENERGETICS: Fundamentals:**  Water, pH, pK, buffers, covalent bond, non-covalent interactions. **Bioenergetics:** free energy, enthalpy, entropy, laws of thermodynamics, high energy compounds.

**UNIT-II BIOMOLECULES:** Classification, physical and chemical properties of carbohydrates, lipids, amino acids and proteins; protein structural hierarchy, Ramachandran plot; nucleotides and nucleic acids; Pigments and storage materials.

**UNIT-III** **METABOLISM: Catabolism of biomolecules:**  Carbohydrate metabolism - (GLYCOLYSIS, TCA cycle, Pentose phosphate pathway, HMP shunt, glycogen metabolism). Lipids - Fatty acid oxidation – saturated and unsaturated, fatty acids with even and odd no of carbon atoms. Proteins - deamination, transamination of amino acids – eg; L-Aspargine, L-valine, L-phenyl alanine.

**Anabolism of biomolecules:** Gluconeogenesis, Biosynthesis of lipids, Biosynthesis of amino acids – Glutamate, Tyrosine, Proline. Regulation of important metabolic pathways, role of key enzymes in metabolic control.

**UNIT-IV membrane transport and SIGNAL TRANSDUCTION: PLASMA MEMBRANE:** Structure of plasma membranes. Transportation of molecules across plasma membrane.

**SIGNAL TRANSDUCTION:** Modes of cell signalling, Types of receptors used for cell signalling, pathway of intracellular signal transduction using secondary messengers.

**UNIT-V** **STRATEGIES FOR METABOLIC CONTROL: Metabolic control:** Need for control, control of enzyme activities, allosteric control and control by phosphorylation. Hormonal control of metabolism.

**TEXT BOOKS:**

1. Principles of Biochemistry A. Lehninger
2. Biochemistry and Molecular Biology, Third Edition by William H. Elliott and Daphne C. Elliott, Oxford University press.
3. Biochemistry L. Stryer Third Edition

**REFERENCE BOOKS:**

1. Biochemistry White, Handler and R.B. Smith 7th Ed.
2. Fundamentals of Biochemistry by J.L. Jain, Sunjay Jain AND Nitin Jain, S. Chand and Company Ltd.

**Core Elective II (Based on the educational background)**

**3. TISSUE ENGINEERING AND STEM CELL TECHNOLOGY**

**UNIT-I STEM CELLS & TISSUE ENGINEERING:** Introduction to Tissue Engineering, Cell sources

and stem cells. Embryonic and adult stem cells, Cell isolation and selection; Tissue preservation.

**UNIT-II STRUCTURE AND ORGANIZATION OF TISSUES:** Extracellular matrices; Cell-matrix

interactions. Cell synthetics surface interactions and the ensuing effects on cell growth, cell adhesion,

cell migration, and cell-cell communication.

**UNIT-III PROPERTIES OF BIOLOGICAL TISSUES:** Cell and Tissue Culture, Cell characterization,

cell separations, Mechanical properties of biological tissues. Transport properties of biological

tissues.

**UNIT-IV CELL BIOMATERIAL INTERACTIONS & TRANSPLANTATION:** Cell-Biomaterial Interactions and Host Integration. Biomaterial processing for TE. Scaffolds and Tissue Engineering. Transplantation of engineered cells and tissues. Immunomodulation and Immunoisolation.

**UNIT-V THE DESIGN OF BIOMIMETIC ENVIRONMENTS:** Introduction, Scale Up/Reactor Design. Artificial skin. Artificial blood vessels, vascular grafts, and cardiac prostheses. Bone repair. Repair of cartilage, tendon and ligaments. Artificial liver. Nerve regeneration.

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**TEXT BOOKS**:

1. Bioengineering of the Skin: Methods and Instrumentation, Volume III [Hardcover] enzo Berardesca (Editor), Peter Elsner (Editor), Klaus P. Wihelm (Editor), Howard I. Maibach (Editor).
2. Composite Tissue Transplantation (Tissue Engineering Intelligence Unit-II) [Hardcover] Charles W. Hewitt (Editor), Kirby S. Black (Editor).
3. “”Future Strategies for Tissue and Organ Replacement” edited by Julia M Polak (Imperial College School of Medicine Hammersmith Hospital, UK) Larry L Hence (Imperial College, UK) & P Kemp (Intercytex, Etherley Dene House, UK).
4. Principles of Tissue Engineering by Robert P. Lanza (Editor), Robert Langer (Editor), William L. Chick (Editor).
5. Tissue Engineering Methods and Protocols (Methods in Molecular Medicine, 18) by Jeffrey Robert Morgan (Editor), Martin L. Yarmush (Editor),
6. Tissue Engineering [Hardcover] Bernhard O. Palsson (Author), Sangeeta N. Bhatia (Author).
7. Tissue Engineering (Academic Press Series in Biomedical Engineering) by Clemens van Blitterswijk, Peter Thomsen, Jeffrey Hubbell and Ranieri Cancedda (Apr 8, 2008)
8. Tissue Engineering: Engineering Principles for the Design of Replacement organs and Tissues by W. Mark Saltzman (Jul 15, 2004).
9. Tissue Engineering by John P. Fisher, Antonios G. Mikos and Joseph D. Bronzino (May 30, 2007).

LABORATORY I

**PROCESS ENGINEERING PRINCIPLES LABORATORY**

**LIST OF EXPERIMENTS:**

**PART-A**

**Fluid Mechanics**

1. Reynold’s apparatus (Demo)
2. Bernouli’s Theorem (Verification)
3. Determination of friction factor of Pipeline
4. Determination of Coefficient of Discharge by venturimeter, orifice meter and notch
5. Flow measurement with Rotameter

**Heat Transfer**

1. Thermal Conductivity of insulating material
	1. Searles’ apparatus
	2. Concentric sphere
	3. Lee’s disc apparatus
	4. Lagged pipe
2. Heat Transfer coefficient from a vertical tube and free convection

**FIRST YEAR - SEMESTER II**

**Core Course II**

**MOLECULAR BIOLOGY AND GENETIC ENGINEERING**

**UNIT-I BASICS OF MOLECULAR BIOLOGY:** DNA replication and Regulation, Gene expression (Transcription, Translation) and Regulation (operons, post-transcriptional), Repair mechanisms. RNA:Different classes of RNA and their functions.

**REGULATION OF GENE EXPRESSION**: RNA synthesis and other post transcriptional modifications, Regulation of gene expression in prokaryotes (Lac. Ara and His operons). Transcriptional controls in Eukaryotes (Complexity of genome organization, Regulatory elements, Motifs of protein secondary structure/Transacting elements); Post transcriptional and post-translational modifications.

**TRANSLATION:** Protein synthesis and translational modifications, translational controls and inhibitors of polypeptide synthesis, transport mechanisms (exportins & importins).

**UNIT-II: INTRODUCTION TO GENETIC ENGINEERING:** MOLECULAR TOOLS IN GENETIC ENGINEERING - Restriction enzymes and DNA Modifying enzymes (Polymerases, Reverse Transcriptase, Ligases, Alkaline phosphatase, Recombinases, Terminal deoxy-ribo nucleotide transferases, Nucleases - S1 nucleases etc.).

**PLASMIDS & TRANSPOSONS:** Plasmids, Types of plasmids, Ecological advantage, applications as vectors in gene therapy and genetic transformations.

Mobile elements in bacteria, Drosophila, yeast, maize and human. DNA transposons and Retrotransposons. Features and Transposition of TY elements.

Nucleic Acid Isolation and Purification, Yield analysis, Gel electrophoresis, DNA and RNA markers. Restriction mapping of DNA fragments and Map construction, Nucleic acid Amplification (PCR analysis) and its applications.

**UNIT-III GENE CLONING:** Gene Cloning vectors (Plasmids, bacteriophages, cosmids, phagemids, Artificial chromosomes), Gene Cloning strategies, Transformation and selection of recombinants; Construction of DNA libraries (Genomic library and cDNA library preparations –mRNA enrichment, reverse transcription, use of linkers and adaptors); and their screening; Alternative strategies of Gene cloning; RACE-PCR technique, Map based cloning, Cloning of differentially expressed genes.

**UNIT-IV GENE EXPRESSION AND PROTEIN ENGINEERING:** GENE EXPRESSION:Study of introduced Gene expression – Hybridization techniques, Northern blot analysis, Real-time PCR analysis, Primer extension, S1 mapping, Rnase protection assays, Reporter assays, Nucleic acid microarrays.

Gene expression in bacteria and Yeast, expression in insects and insect cells, expression in mammalian cells, expression in plants – characterization of recombinant proteins, stabilization of proteins; Phage display, Yeast Two- and three Hybrid system.

**PROTEIN ENGINEERING** Site-directed Mutagenesis and Protein Engineering.

**UNIT-V TRANSGENICS, ANTISENSE AND RIBOZYMES:** TRANSGENIC TECHNOLOGY:Gene tagging (T-DNA tagging and Transposon tagging) in gene analysis (identification and isolation of gene), Transgenic and Gene Knockouts and Gene knock down Technologies - Targeted gene replacement, Chromosome engineering, Gene Therapy, Strategies of gene delivery, gene replacement/ augmentation, gene correction, gene editing and silencing.

**ANTISENSE TECHNOLOGY:** Comparisons of different antisense strategies (antisense oligo nucleotides, ribozymes and siRNAs). Molecular mechanisms of antisense molecules. RNA interference induced by siRNA molecules. Applications and challenges of antisense strategies (antisense oligo nucleotides, ribozyme technologies and RNAi) in gene silencing, mi RNAs.

**RIBOZYMES:** Biochemistry of ribozymes – hammer-head, hairpin and other ribozymes,

**TEXT BOOKS:**

1. “Molecular Biology of the gene” by Waston et al 4th edition.
2. “Genes VII” by Benjamin Lewis
3. Biochemistry and Molecular biology, William H. Elliott and Daphne C. Elliott, Third Edition, Indian edition, Oxford University press, 2005.
4. Molecular Cloning: a Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York, 2000.
5. DNA Cloning: a Practical Approach, .M. Glover and B.D. Hames, IRL Press, Oxford, 1995.
6. Principles of Gene manipulation, Introduction to Genetic Engineering : R W Old, S B Primrose

**REFERENCE BOOKS:**

1. “Genetics” by Ursula Goodenough
2. “Cytogenetics” by lGarl P. Swanson, Mertz & Young
3. “General Virology” by Luria & Darnell
4. “Biochemistry” by Stryer.
5. Molecular and Cellular Methods in Biology and Medicine, P.B. Kaufman, W. Wu. D. Kim and L.J; Cseke, CRC Press, Florida, 1995.
6. Route Maps in Gene Technology, M.R. Walker and R. Rapley, Blackwell Science Ltd., Oxford, 1997.
7. Methods in Enzymology vol. 152, Guide to Molecular Cloning Techniques, S.L. Berger and A.R. Kimmel, Academic Press, Inc. San Diego, 1998
8. Methods in Enzymology Vol 185, Gene Expression Technology, D.V. Goeddel, Academic Press, Inc., San Diego, 1990
9. DNA Science. A First Course in Recombinant Technology, D, A. Mickloss and G.A. Froyer. Cold Spring Harbor Laboratory Press, New YorK, 1990.
10. Molecular Biotechnology (2nd Edn.), S.B. Primrose. Blackwell Scientific Publishers, Oxford, 1994
11. Milestones in Biotechnology. Classic papers on Genetic Engineering, J.A. Davies and W.S. Reznikoff, Butterworth-Heinemann, Boston, 1992.

**Core Course III**

**ENZYME ENGINEERING AND TECHNOLOGY**

**UNIT-I INTRODUCTION TO ENZYMES:** INTRODUCTION: Introduction,Nomenclature and Classification of enzymes. Applications in Industrial, Medical, Analytical, Chemical, Pharmaceutical and Food Sectors. Enzyme isolation and purification.

**SPECIFICITY OF ENZYME CATALYZED REACTIONS:** Type of specificity, Active sites, Principles of catalysis- Collision theory, Activation energy and Transition state theory.

**UNIT-II ENZYME KINETICS:** KINETICS:Kinetics of single-substrate enzyme catalyzed reactions, Michaelis - Menten equations, Brigg’s Haldane equation & estimation of constants using graphical techniques, Turnover number (kcat). Kinetics for reversible reactions, Enzyme inhibition kinetics: reversible and irreversible inhibition, substrate, product and toxic substances inhibition.

**UNIT-III PRE-STEADY–STATE AND MULTI-SUBSTRATE ENZYME KINETICS:** PRE-STEADY–STATE KINETICS: Rapid mixing, Stopped flow and Relaxation techniques, Determination of the number of active sites of enzyme and determination of rate constants. Enzyme kinetics at limiting conditions: Dilute substrates, solid substrates and enzyme activity at interfaces.

 **KINETICS OF MULTI-SUBSTRATE REACTIONS:** Mechanism for two substrates reactions, compulsory order, random order reactions and Ping-Pong mechanism. Kinetics of biphasic liquid systems, stabilization of biphasic aqueous-organic systems and equilibrium in biphasic aqueous-organic systems

**UNIT-IV FACTORS AFFECTING ENZYME ACTIVITY & ACTIVE SITE STUDIES:** FACTORS AFFECTING ENZYME ACTIVITY: Temperature and pH effects, thermal deactivation of enzymes. pH dependence: Ionization of Acids and Bases.

**ACTIVE SITE STUDIES:** The identification of binding sites and catalytic sites, Trapping the enzyme substrate complex, The use of Substrate analogues, Enzyme modification by chemical procedures affecting amino acids side chains, the enzyme modification by treatment with proteases and site-directed mutagenesis.

**UNIT-V ENZYME IMMOBILIZATION & KINETICS OF IMMOBILIZATION:** ENZYME IMMOBILIZATION & KINETICS OF IMMOBILIZATION: Immobilization of Biocatalysts an Introduction,Electrostatic effect, Effect of charged and uncharged support, Effect of external and internal mass transfer, Effect of Intra-particle diffusion with uncharged supports, Simultaneous external and internal mass transfer resistances and partitioning effects. Dam Kohler number and effectiveness factor.

**TEXT BOOKS:**

1. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker 1987.
2. Enzymes ,Biochemistry , Biotechnology Clinical Chemistry : Trevor Palmer.2001

**REFERENCE BOOKS:**

1. Bailey JE, Ollis, DF: Biochemical Engineering Fundamentals, Prace and Stevens,
2. Handbook of Enzyme Biotechnlogy, 3rd Edition, Ellis Horwood Publication
3. Moser, A: Bioprocess technology, kinetics and reactors: Springer Verlag
4. Biochemical Engineering Principles and functions by Syed Trnveer Ahmed Inamdar, PHI Learning Private limited.

**Core Elective III**

1. **PLANT BIOTECHNOLOGY**

**UNIT-I PLANT TISSUE CULTURE & TOTIPOTENCY:** Totipotency, Biotechnological applications of plant tissue culture, Establishment of aseptic cultures, Initiation of callus and suspension cultures, Nutritional components of tissue culture media.

**UNIT-II TISSUE CULTURE TECHNIQUES-I:** Regeneration of plants, Organogenesis, Micropropagation with shoot apex cultures (Clonal Propagation), Somatic Embryogenesis. Anther and Pollen culture, Production of haploids and their application, Storage of plant genetic resources (Cryopreservation), Somaclonal variation, Commercial production of plants – Automation. Selection of callus, cell lines – Utilization of artificial, neural networks.

**UNIT-III TISSUE CULTURE TECHNIQUES-II:** Isolation and culture of protoplasts, protoplast fusion and somatic hybridization, Selection systems for somatic hybrids / Cybrids and their characterization, Production of Secondary metabolites by plant cell cultures, commercial production of secondary metabolites, Technology for yield enhancement and bioreactor system and models for mass cultivation of plant cells. Biotransformations using plant cell cultures, Elicitation, permeabilization, immobilization and in situ product recovery.

**UNIT-IV TRANSGENIC TECHNOLOGY-I:** Genetic Transformation methods for production of transgenic plants (Direct, Indirect), In planta genetic transformation, Direct Gene Transfer (DGT) methods, Agrobacterium mediated genetic transformation (Indirect), Chloroplast transformation and production of transplastomics.

**UNIT-V TRANSGENIC TECHNOLOGY-II:** Production of genetically modified plants/crops for agronomic traits, transgenic plants for biotic and abiotic stress tolerance, transgenic plants for quality traits, Industrial enzymes, Molecular farming for therapeutic protein (Plantibodies, Plantigens, Edible Vaccines).

**TEXT BOOKS:**

1. “Plant Cell, Tissue, and Organ culture” by J Reinert and Y P S Bajaj.

2. Plant Tissue Culture Theory and Applications Bhojwani SS and Razdan ,Elsevier

 Publication.

**REFERENCE BOOKS:**

1. Plant Biotechnology New Products and Applications. Hammond PM and Yusibov V. Springer

 International Edition.

2. “Plant Tissue Culture” Thorpe, T.A. (Ed.).

3. “Handbook of Plant Cell Culture” Eds. Sharp et al.

4. “Plant Biotechnology” Eds. Mantell & Smith

**Core Elective III**

**2. NANO BIOTECHNOLOGY AND NANO DEVICES**

**UNIT-I INTRODUCTION TO NANO-BIOTECHNOLOGY:** Nanotechnology definition and concepts; Cellular Nanostructures; Nanopores; Biomolecular motors; Criteria for suitability of nanostructures for biological applications.

**UNIT-II: BASIC CHARACTERIZATION TECHNIQUES**; Electron microscopy; Atomic force: microscopy; Photon correlation Spectroscopy.

**UNIT-III NANO STRUCTURES:** Thin films; Colloidal nanostructures; Nanovesicles; Nanospheres; Nanocapsules.

**UNIT-IV NANOSTRUCTURES FOR DRUG DELIVERY:** Concepts, targeting, routes of delivery and advantages.

**UNIT-V APPLICATIONS OF NANO STRUCTURES:** Nanostructures for diagnostics and biosensors; Nanoparticles for diagnostics and imaging; Nanodevices for sensor development.

**TEXT / REFERENCE BOOKS:**

1. Multilayer Thin Films, Editor(s): Gero Decher, Joseph B. Schlenoff Publisher: Wiley-VCH

 Verlag GmbH & Co. KGaA ISBN: 3527304401

2. Bionanotechnology: Lessons from Nature Author: David S. Goodsell Publisher: Wiley-Liss

 ISBN: 047141719X

3. Biomedical Nanotechnology Editor: Neelina H. Malsch Publisher: CRC Press

 ISBN: 0-8247-2579-4.

**Core Elective III**

**3. MICROBES AND INFECTION**

**UNIT I: EPIDEMIOLOGY AND SPREAD:** Why to study epidemiology? Case of cholera in London, Incidence, Prevalence, Out breaks (Sporadic, epidemic, pandemic, endemic), Spread – fecal/oral (food/water). Air-borne, vector-borne.

**UNIT II: BACTERIAL DISEASES:** Exotoxic and endotoxic bacteria, intracellular and extracellular bacteria, Bacterial diseases of man and animals (Cholera, T.B, Typhoid, Anthrax, Brucellosis), Antibiotics – classes, antibiotic resistance and mechanisms.

**UNIT III: VIRAL DISEASES:** Virus classification and replication, viral diseases of man and animals (Hepatitis B, measles, influenza, rabies, foot and mouth disease, blue tongue, Japanese encephalitis, dengue, HIV), Control of viral diseases – antivirals, vaccines.

**UNIT IV: VECTOR-BORNE DISEASES AND ZOONOSES:** Vector-borne bacteria (Lyme disease), Viruses (JE, Dengue, Chickungunya) and Protozoa (Malaria, trypanosomes), Mechanical and amplifying vectors, zoonoses (Anthrax, Brucellosis, Japanese encephalitis, Influenza, Ebola).

**UNIT V: EXPERIMENTAL MODELS AND PATHOGENESIS:** In vitro models to study pathogenesis (cellular changes – apoptosis, necrosis, changes in cellular function), Animal models of disease – lab animals, transgenic animals, humanized animals, In vivo pathogenesis – host and cell tropism, physiological dysfunction.

**TEXT BOOKS:**

1. Bacterial pathogenesis, Abigail A Salyers
2. Bacterial Pathogenesis: A Molecular Approach, Abigail A
3. Revenge of the Microbes: How Bacterial Resistance is Undermining the
4. Antibiotic Miracle, Abigail A Salyers, Dixie D. Whitt
5. Viral Pathogenesis 1st Edition, Neal M. Nathanson , Nathanson

LABORATORY II

**MOLECULAR BIOLOGY LABORATORY**

**LIST OF EXPERIMENTS**

1. Isolation of Chromosomal DNA from E.coli
2. Isolation and analysis of Plasmid DNA
3. Restriction digestion
4. Ligation
5. Preparation of competent cells
6. Transformation & checking for transformants
7. Electrophoresis of nucleic acid DNA
8. Isolation of Auxotrophic mutants by replica plate methods.

**SECOND YEAR SEMESTER I**

**Core Course IV**

**BIOREACTOR ENGINEERING**

**UNIT-I: BIOREACTORS:** Different types of Bioreactor, Different modes of operation,Main components of the bioreactor and their functions. Bioreactor design: Batch reactor, cell death in batch reactor, chemostat, endogenous metabolism, maintenance, product & substrate inhibition on chemostat, multiple steady state analysis, enzyme catalysis in CSTR, cascade reactor, plug flow reactor, fed batch reactor, Chemostat with cell recycle and feed forward control.

**UNIT-II: MASS TRANSPORT IN BIOREACTORS:** Introduction of mass transfers, Gas-liquid mass transfer in cellular systems, basics mass transfer concepts, solubility of gases (O2, CO2) in biological media, Mass balance for two-phase bioreactor. Bubble column, bubble generation at an orifice, bubble coalescence and breakup, Gas holdup, interfacial area, Immobile and mobile gas liquid interface, Regimes of bubbles, Design of bubble columns. Experiment determination of kLa, static method, dynamic method and chemical method. Oxygen uptake by cell cultures.

**UNIT-III: MOMENTUM TRANSPORT IN BIOREACTORS**: Rheology of Fermentation Broths: Rheology Properties, Factors affecting broth viscosity, mixing equipment, Flow patterns in agitated tanks, Mechanism of Mixing, Assessing Mixing effectiveness Power requirement for mixing: Ungassed Newtonian fluids, Ungassed Non-Newtonian fluids.

**Momentum transport in Stirred tank Bioreator:** Agitator Design & Operation- Radial flow impellers, Axial flow impellers, Agitator design for low Viscous and High Viscous fluids. Laminar and turbulent flow in stirred tank bioreactors, Kolmogorov eddy size, preventing vortex formation, off centre impellers, baffles. Oxygen delivery systems: Sparger design, Effect of impeller speed.

**UNIT-IV :CASE STUDIES:** Introduction, Design of Packed Bed Bioreactor: Design of a packed bed reactor for a bio-film growth on support system, Specific design, Design of packed bed bioreactor packed with immobilized whole cell catalysts; Airlift Bioreactors: Classification, Type of analysis and parameters to measure; Hollow Fiber Bioreactor (HFBR), Plant Cell Bioreactor: Classes and Design of Bioreactor, Design of Bioreactors for Solid State Fermentaion (SSF), Mammalian Cell Bioreactor Design: Fermentor balancing for semi-continuous multi-tank mammalian cell culture process.

**UNIT-V NON IDEAL REACTORS AND SCALE UP & SCALE DOWN OF BIOREACTORS:** Introduction, Non ideal parameters, Residence Time Distribution, E(t) or F(t) and the bioreactor design, Models for Non ideal flow, Application of RTD based models to Non ideal bioreactors.

**SCALE-UP & DOWN OF BIOREACTOR AND CONTROL OF BIOREACTOR:** Scaling up and down of bioreactors, based on rules-of-thumbviz., constant (P/V), KLa etc., Control of bioreactor, Sensor used in the bioreactor, pH, O2, CO2 electode. Online sensors for cell properties, Direct regulatory control and cascade control mechanisms.

**TEXT BOOKS:**

1) Blanch HW and Clark DS: Biochemical Engineering Marcel Decker Year of Publication 1987

2) Bioreactors Analysis and Design: Tapobrata Panda, Tata McGraw Hill Year of publication 2011

**REFERENCE BOOKS:**

1) Bailey JE, Ollis DF; Biochemical Engineering fundamentals Year of Publication 1986

2) Pauline M. Doran: Bioprocess Engineering Principles, Elsevier Publications.

**Core course V**

**IMMUNOLOGY AND IMMUNOTECHNOLOGY**

**UNIT-I INTRODUCTION** : **Immune system and organs of the immune system:** Phylogeny of Immune System - Innate and acquired immunity - Clonal nature of immune response, antigens, immunogens, super antigens. **Lymphoid organs:** Lymphoid follicle, Thymus, Lymph node, Spleen, MALT, GALT, SALT. **Cells of the immune system:** Hematopoiesis and differentiation, Macrophages, Dendritic cells, Natural killer and Lymphokine activated killer cells, Eosinophils, Neutrophils and Mast-Cells.

**UNIT-II:** **HUMORAL IMMUNITY AND APPLICATIONS:**

B cell types, B cell receptors and activation, Immunoglobulin diversity, Antibody structure and function, Antigen- antibody interactions(including ADCC), antibodies in diagnosis, Hybridoma technology, B cell memory.

**UNIT-III: T CELLS AND CELL MEDIATED IMMUNITY:**

MHC restriction, Antigen presentation, T cell subsets and functions of each, T cell activation and regulation, Cell mediated immune functions- cytotoxicity, interferon; T cell memory - Central and peripheral.

**UNIT-IV: AUTOIMMUNITY AND TRANSPLANTATION IMMUNOLOGY:**

**Autoimmune disorders:** Rheumatoid arthritis, Insulin dependent Diabetes Mellitus

**Transplantation:** Transplantation

**UNIT V: IMMUNOTHERAPY, VACCINES AND ADJUVANTS:**

Immune response to infectious diseases (humoral, cell-mediated, examples), Vaccines – Types , technologies, Adjuvants – Function, mechanism of action, new generation adjuvants, Immunotherapy – antibodies (polyclonal, monoclonal), cytokines, cell therapy, diseases (HIV, HCV).

**TEXT BOOKS:**

1. Kuby Immunology (Kindt, Kuby Immunology) - Thomas J. Kindt, Barbara A. Osborne, Richard A. Goldsby, publisher: W. H. Freeman, 2006
2. Immunology- David Male, Jonathan Brostoff, David Roth, Ivan Roitt, publisher: Mosby, 2006

**REFERENCE BOOKS:**

1. Fundamental Immunology- William E Paul, publisher: Lippincott Williams & Wilkins, 2008

# Immunology, Infection, and Immunity - Gerald B. Pier, Jeffrey B. Lyczak, Lee M. Wetzler, publisher: ASM Press, 2004

1. Lecture Notes: Immunology, 5th Edition- Ian Todd, Gavin Spickett, publisher: Wiley-Blackwell, 2005
2. Immunology: A Short Course- Richard Coico, Geoffrey Sunshine, publisher: Wiley-Blackwell, 2009
3. Cellular and Molecular Immunology- Abul K. Abbas MBBS, Andrew H. Lichtman MD PhD, Shiv Pillai MD, publisher: Saunders, 2007
4. Roitt's Essential Immunology (Essentials) - Peter Delves, Seamus Martin, Dennis Burton, Ivan Roitt, publisher: Wiley-Blackwell, 2006
5. Schaum's Outline of Immunology- George Pinchuk, publisher: McGraw-Hill, 2001.

Open Elective I:

* 1. ENVIRONMENTAL BIOTECHNOLOGY

**UNIT-I INTRODUCTION TO AIR POLLUTION:** Introduction to Environmental pollution, Air, water and soil pollution-common effects and control measures and monitoring of pollutants.

**AIR POLLUTION TREATMENT:** Treatment technologies, Biofilters and Bioscrubbers for treatment of industrial waste:

**UNIT-II WASTE WATER TREATMENT:** WATER: Water Pollution and treatment technologies (clean technology). Waste water types, major contaminants in waste water. Physical, chemical and biological methods of waste water treatment.

**AEROBIC:** Activated Sludge Process, Trickling Filters, Biological Filters, Rotating Biological Contractors, Fluidized Bed Reactor.

**ANAEROBIC:** Contact Digesters, Packed Column Reactors, UASB biological treatment process

**UNIT-III WASTE MANAGEMENT:** Management of Contaminated land**,** lake sediments and Solid Waste, Anaerobic digestion, Biostimulation, Bioaugmentation, Phytoremediation, Natural attenuation, Vermicomposting

**UNIT-IV** **BIOREMEDIATION:**  Bioremediation Technologies: Definition, constraints and priorities of bioremediation, Types of bioremediation, *In-situ* and *Ex-situ* bioremediation techniques, Factors affecting bioremediation. Bioremediation of Hydrocarbons and lignocellulosic Compounds.

**UNIT-V** **BIOENERGY & BIOMINING:** BIO ENERGY: Energy and Biomass Production from wastes, biofuels, bio hydrogen and biomass.

**BIOMINING:** Bioleaching, microbial enhanced oil recovery, microbial fuel cells.

**TEXT BOOKS:**

1. Wastewater Engineering - Treatment, Disposal, and Resuse, Metcalf and Eddy, Inc., Tata McGraw Hill, New Delhi.
2. Industrial Pollution Control Engineering- AVN Swamy., Galgotia Publication, (2006).
3. Environmental Biotechnology - Allan Stagg.

**Open Elective I**

**2. BIOBUSINESS MANAGEMENT**

**UNIT I: INTRODUCTION TO BIOBUSINESS:** Principles of business management and concept of Biobusiness, SWOT analysis of Indian Biobusiness. **Project formulation** Project formulation and selection based on size, technological assessment, technical report, feasibility and commercial viability of project.

**UNIT II: PROJECT COST AND MARKET POTENTIAL:** Total product cost, capital investment and profitability, manufacturing costestimation, capital investment estimation, Risk capital and working capital,manufacturing cost estimation for an intracellular protein, using cost analysis for R& D decision making.

**UNIT III: LEGAL PROTECTION IN BIOTECHNOLOGY:** Regulatory and IPR issues in Biotechnology, Intellectual Property Protection (IPP), Trade secret protection, licensing of bio-product, procedure for obtaining US patent, characteristics of the disclosure for a biotechnology invention, marketing a biotechnology invention, trade regulations.

**UNIT IV: BIO-SAFETY:** General guidelines (GLP, GMP), containment facilities, types of containment, guidelines for recombinant DNA research, release of genetically modified

organisms (GMOs), ISO Series, GATT.

**UNIT V: INDUSTRIAL SICKNESS:** Symptoms, Control and rehabilitation and sick units. **Ethics in Biotechnology:** Statutory requirements of social responsibility and entrepreneurial discipline.

**BOOKS:**

1. Patent Law - P. Narayan
2. Economic reforms and Indian markets - S. L Rao
3. Manual of Industrial Microbiology and Biotechnology - A. L. Demain and N.A.

Solomon

LABORATORY III

**BIOPROCESS ENGINEERING LABORATORY**

**LIST OF EXPERIMENTS:**

**PART-A**

1. Growth kinetics in Batch culture.
2. Study of Enzyme kinetics of INVERTASE.
3. Determination of Enzyme activity for CELLULASE.
4. Effect of pH on Enzyme kinetics.
5. Enzyme inhibition.
6. Enzyme immobilization by different methods.
7. Medium Design – a) PLACKETT – BUKMAN design for media.

 b) Response surface methodology for media design

1. Sodium sulphite oxidation method for determination of Mass Transfer coefficient.
2. Dynamic gassing method for determination of Mass Transfer coefficient.
3. Ethanol production from ***Saccharomyces cerevesiae.***
4. Pre-treatment technique for ligno – cellulosic biomass for ETHANOL PRODUCTION.

**SECOND YEAR- SEMESTER II**

**Core Course VI**

**DOWNSTREAM PROCESSING**

**UNIT-I: SCOPE OF DOWNSTREAM PROCESSING:** Importance of Down Stream Processing (DSP) inBiotechnology, characteristics of products, criteria for selection of bio-separation techniques. Role of DSP methods in bioprocess economics. **Cell Disruption Methods:** Various cell disruption methods, need for cell disruption for intracellular products (Homogenizer, French press & Dynomill), cell disruption equipment. Applications in bio-processing. **Flocculation:** Principles of flocculation, various flocculating agents, applications in bio-processing. **Coagulation:** Principles of coagulations and its applications in bio-processing.

**UNIT-II SOLID- LIQUID SEPARATION:**

**Filtration:** Principles, filter aids, Types of filtrations, constant and continuous (TFF), depth filtration, constant volume filtration, constant pressure filtration, specific cake resistance, equivalent cake thickness, filtration equipments viz; plate and frame filter press, vacuum filters, leaf filters. **Sedimentation:** Principles of particle settling, batchsedimentation equipment viz., thickener. **Centrifugation:** Principles of centrifugation, centrifuge effect, g-number, sigma factor, various centrifuges viz., basket centrifuge, tabular centrifuge, disc-bowl centrifuge, scale –up of centrifuges.

**UNIT-III: ADSORPTION:** adsorption equilibria and isotherms, principles of adsorption, adsorption equipment, applications. **Precipitation:** Principles of precipitation, precipitation equipment, applications in bio-processing. **Foaming:** Principles of foaming, various foaming agents and their interaction with the products, applications in bioprocess.

**Liquid-liquid Extraction;** Extraction process and principles, phase equilibrium and distribution, batch and continuous extraction, co-current and counter current extraction processes, L-L-E equipment. Applications in bio-technology.

**UNIT-IV: SEPARATION AND PURIFICATION PROCESSES:** Basic principles of membrane separation, membrane characteristics, different types of membranes, criteria for selection of membranes.

**Chromatographic and Electrophoresis Methods:** Principles of chromatographic separation methods, different types of chromatographic methods, viz., adsorption chromatography, ion – exchange chromatography, gel chromatography, affinity chromatography etc. with applications in bio-processing.

Principles of electrophoresis, SDS- PAGE, Hydrophobic chromatography, 2D gel electrophoresis, capillary electrophoresis.

**UNIT-V: SCALE-UP AND SCALE DOWN OF DOWNSTREAM UNIT OPERATIONS:**

**Crystallization**: Principles of crystallization, crystallization equipment. Applications in bio-processing. **Drying:** Various types of drying methods, principles of drying, EMC-RH data, drying curves, various types of industrial dryers and their criteria for choice. Freeze drying technique and its advantages over other methods. Applications in bio-processing. Overview.

**TEXT BOOKS:**

1. Genekopolis, Transport phenomena and Unit Process.
2. Bailey and Ollis, Biochemical Engineering Principles
3. Blanch, Biochemical Engineering
4. Mc Cabe and Smith, Unit Operations in chemical Engineering
5. Principles of Fermentation Technology by Peter F Stan bury, Allan Whitaker and Stephen J Hall, Pergamon Publications.

**REFERENCE BOOKS:**

1. Separation Process in Biotechnology edited by Juan A. Asenjo, Taylor & Francis Group
2. Comprehensive Biotechnology Vol.2 Edition, M. Moo –young (1985).
3. Product Recovery in Bioprocess technology, BIOTOL series, Butterworth –Heinemann**.**

**Core Elective IV**

1. **ANIMAL CELL SCIENCE AND TECHNOLOGY**

**UNIT-I BASICS OF ANIMAL CELL AND ITS CULTURING:** Structure and organization of an animal cell, Types of animal cell culture – cell culture, organ/tissue culture, organotypic culture and histotypic culture, Equipments and materials needed for animal cell culture technology.

**UNIT-II ANIMAL CELL CULTURE MEDIUM AND ITS COMPONENTS AND THEIR SIGNIFICANCE:** Introduction to the balanced salt solutions and growth medium, Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, Role of carbon-di-oxide and role of serum and its supplements in maintaining cells in culture medium, Serum and protein free defined media and their application

**UNIT-III BASIC TECHNIQUES OF MAMMALIAN CELL CULTURE *in vitro*:** Primary and established cell lines, Biology and characterization of the cultured cells, measuring parameters of growth. Maintenance of cell culture, Cell separation, Cell transformation, Cell synchronization, Measurement of viability and cytotoxicity, Apoptosis – characteristic features and molecular mechanisms, Measurement of cell death.

**UNIT-IV ENGINEERING ANIMAL CELLS:** Somatic cell genetics, Cell culture based vaccines, Genetic engineering of mammalian cells in culture, Scaling up of animal cell culture, Stem cell cultures – embryonic and adult stem cells and their applications.

**UNIT-V APPLICATIONS OF ANIMAL CELL CULTURE:** Three dimensional culture and tissue engineering, Applications of animal cell culture technology (heterologous, Primary culture/CEF culturing, Protein Expression).

**BOOKS:**

1. Culture of Animal Cells, (3rd Edition), Fl. !an Froshney. Wiley-Liss.
2. Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD,
3. Cell Growth and Division: A Practical Approach. Ed. R. Basega, IRL Press.
4. Cell Culture Lab Fax. Eds. M Butler & M. Dawson, Bios Scientific Publications Ltd..Oxford.
5. Animal Cell Culture Techniques. Ed. Martin Clynes, Springer.
6. Methods in Cell Biology, Vol. 57, Animal Cell Culture Methods. Ed. Jenni P Mather and David Barnes. Academic Press.

**Core Elective IV**

1. **BIOCHEMICAL REACTION ENGINEERING**

**UNIT-I** **OVERVIEW OF CHEMICAL REACTION ENGINEERING:** Classification of reactions, variables affecting the rate of reaction, concept of order, molecularity of a reaction, definition of reaction rate, concentration dependent term of rate equation, Temperature dependent term of rate equation.

**UNIT-II INTERPRETATION OF BATCH REACTOR DATA:** Introduction, Interpretation of Batch Reactor Data - Constant volume batch reactor, Integral and differential method of analysis of data.

Variable volume reactor – Integral & Differential method of analysis of data.

**UNIT-III: INTRODUCTION TO REACTOR DESIGN:** Single ideal reactors – Ideal batch reactor, steady state mixed flow reactor, plug flow reactor.

**UNIT-IV DESIGN FOR SINGLE AND MULTIPLE REACTIONS:** Size comparisons of single reactors, mixed versus Plug flow reactors, 1st and 2nd order reactions multiple reactor system – Plug flow reactors in series and parallel, equal size mixed reactors in series.

**Design for Multiple Reactors:** Reactions in Parallel and series.

**UNIT-V NON ISOTHERMAL REACTIONS & NON-IDEAL REACTORS:** Heat of reaction, equilibrium constants from thermodynamics, equilibrium conversion, optimum temperature progression, heat effects, adiabatic operations, non-adiabatic operations.

Concepts of residence time distribution, micro and macro mixing, reasons for non-ideality, concept of RTD analysis (E-C-F functions), diagnosing the ills of non-ideal bioreactors.

**TEXT BOOKS:**

1. Octave Levenspiel, “Chemical Reaction Engineering” Second Edition, Wiley Publishers.

**REFERENCE BOOKS:**

1. K.A. Gavhane, “Chemical Reaction Engineering-I” Nirali Prakashan Publishers.

2. Introduction to Biochemical Engineering by D G Rao, Tata Mc Graw Hill, New Delhi.

**Core Elective IV:**

**3. BIOINFORMATICS AND SYSTEMS BIOLOGY**

UNIT-I Introduction to Bioinformatics & Sequencing alignment CONCEPTS:

Need of Computers in Biotechnology Research; File Transfer Protocol (FTP), TELNET,HTTP; Bioinformatics- Introduction, Scope, Applications; Strings, Edit distance, Pair wise Alignment-Local, Global alignment; Gap- Gap penalty; Comparison of Pair wise and Multiple alignment.

 UNIT-II biological Databases and datamining: Biological Information on the web, Introduction to databases; Classification of Biological databases; Information retrieval from Databases; Sequence database search- FASTA, BLAST; Amino acid substitution matrices- PAM and BLOSUM; Data Mining and Visualization (RASMOL). Phylogenetic analysis and prediction: Understanding Evolutionary process; Origins of Molecular Phylogenetics; Common Multiple Sequence alignment methods; Phylogenetic analysis: Methods, Tools & Problems (Clustal W).

 UNIT-III: genOME MAPPINg and prediction: Genome sequencing; Genome Mapping; Comparative Sequence Analysis; Gene Prediction Methods &Tools, Gene Annotation; Human Genome Mapping (HGP). RNA SEQUENCE AND STRUCTURE ANALYSIS - si-RNA design and development, micro RNA identification strategies, RNA secondary structure, RNA structure Prediction Methods.

 **UNIT-IV PROTEIN STRUCTURE PREDICTION METHODS:** Basics of Protein biology (Classification, Structural Organization, Domains & Motifs); Protein Structure Prediction Concepts : Secondary & Tertiary Structure Predictions (Chou-Fasman Method, GOR Method, Neural Network method, Homology Modeling, Abintio method, Threading methods).

**UNIT V: INTRODUCTION TO SYSTEMS AND SYNTHETIC BIOLOGY:** Genomics, transcriptomics, proteomics and metabolomics as a foundation for Systems Biology, Objectives of Systems Biology – holistic approach to solve biological problems, Strategies relating to *in silico* modeling of biological processes, Gene, protein and metabolic networks, Signal transduction pathways, Gene expression patterns, Synthetic Biology – Introduction and Artificial synthesis of DNA, peptides and chromosomes – Applications.

**TEXT BOOKS:**

1. Bioinformatics: Methods and Applications- SC Rastogi, N Mendiratta & P Rastogi.
2. Bioinformatics Basics, Applications in Biological Science and Medicine- Hooman
3. Bioinformatics: Genome and sequence analysis by David W Mount.
4. Bioinformatics: A practical guide to analysis of genes and proteins by Baxevanis, Andreas D Wiley – Interscience publishers.
5. Principles of biological Databases by P. B. Kavi kishor and L.N. Chavali.

**REFERENCE BOOKS:**

* 1. Computational Molecular Biology – An Introduction by Peter Clote, Rolf Backofen, John Wiley & Sons.
	2. Essential Bioinformatics: by Jin Xiong, Cambridge University Press
	3. Bioinformatics Principles & Applicatrions by Zhumur Ghosh, Oxford University Press

**Open Elective II**

* + 1. **BIO ETHICS , BIOSAFETY & INTELLECTUAL PROPERTY RIGHTS**

**UNIT I:** **BIOETHICS: PRINCIPLES OF BIOETHICS, ETHICS IN CLINICAL RESEARCH:** History structure regulation impact of Ethics in all aspects of health care, historical cases, negligence, informed consent, mental competence, Bioethics in Microbial (Bioterrorism), Plant (GMO) & Animal (Stem Cells, Cloning, human embryos and IVF), shared responsibilities for decisions and the understanding of the risk.

**UNIT II: BIOSAFETY CONCEPTS & REGULATIONS:** Definition of Biosafety, Biosafety for human health and environment, Assessment of Biological hazard, Levels of biosafety for microbes, plants & animals, Cartagena protocol, Use of genetically modified organisms and their release in to the environment.Special procedures for r-DNA based products. International dimensions in Biosafety. Biotechnology and food safety. Case study – Bt Cotton, Bt Brinjal

**UNIT III: INTRODUCTION TO IPR & PATENTS:** Discovery, Creativity, Innovation, Invention, Need for IPR, Types of IPR, Genesis & development of IPR in India, Definition, Scope, Protection, Patentability Criteria, Types of Patents (Process, Product & Utility Models), Software Patenting. Types of searching, public & private searching Databases. Drafting & Filing of Patent applications, Patent Cooperation Treaty (PCT). Patent infringement.

**UNIT IV: OTHER TYPES OF IPR:** Copyrights – Definition, granting, infringement, searching & filing, distinction between copy rights and related rights; Trade Marks - role in commerce, importance, protection, registration, domain names; Trade Secrets, Unfair competition; Industrial Designs – Scope, protection, filing, infringement; Semiconductors, Integrated Circuits & Layout design; Geographical Indications & Appellations of Origin; Case Studies.

**UNIT V: IPRS AND BIOTECHNOLOGY:** Plant variety Protection, Farmers & Breeders Rights, Indian Biodiversity Act, Protection of Traditional Knowledge, Biopiracy & Bioprospecting, ITPGRFA, Budapest Treaty & IDA, Biotechnology Patenting issues, Gene Patenting, Case studies (Diamond vs Chakravarthy, Dimminaco AG vs. Controller of Patents, Basmati Rice, Turmeric, Neem, Harvard Oncomouse, Transgenic Plant Patents)

**TEXT BOOKS:**

1. Bioethics – Shaleesha A Stanley, Wisdom Educational Service, Chennai, 2008
2. V Sree Krishna. Bioethics & Biosafety in Biotechnology. New age International Publications, 2007.
3. Deborah E. Bouchoux, Intellectual Property for Paralegals – The law of Trademarks, Copyrights,
4. Patents & Trade secrets, 3rd Edition, Cengage learning, 2012
5. N.S. Gopalakrishnan & T.G. Agitha, Principles of Intellectual Property, Eastern Book Company, Lucknow, 2009.

**REFERENCES:**

1. Singer, Peter A.; Viens, A.M. (2008), Cambridge Textbook of Bioethics, Cambridge: Cambridge University Press, ISBN 978-0-521-69443-8
2. Anitha Rao R & Bhanoji Rao “Intellectual Property Rights – A Primer”, Eastern Book Company, 2008.
3. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and Safety Assessment (3rd Ed). Academic Press.
4. M. M. S. Karki , Intellectual Property Rights: Basic Concepts, Atlantic Publishers, 2009
5. Neeraj Pandey & Khushdeep Dharni, Intellectual Property Rights, Phi Learning Pvt. Ltd
6. Ajit Parulekar and Sarita D’ Souza, Indian Patents Law – Legal & Business Implications; Macmillan India ltd, 2006.
7. B. L. Wadehra. Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000.
8. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010

**Open Elective II**

**2. PHARMACEUTICAL BIOTECHNOLOGY**

**UNIT I: PROKARYOTIC AND EUKARYOTIC CELLS IN BIOTECH PRODUCTION**: Actinomycetes in BiotechProduction, *Saccharomyces cerevisiae* and Other Fungi in Biotech Production, Plants in BiotechProduction, Transgenic Plants as Functional Foods or Neutraceuticals Transgenic Plants andPlant Cell Culture as Bioreactors of Secondary Metabolites, Transgenic Plants as Bioreactors ofRecombinant Protein.

**UNIT II: DRUG MODIFICATIONS:** Pharmacodynamics of protein therapeutics; Chemical modificationof proteins/ therapeutics; Immuno suppressor in antibody therapy; PharmacoGenomics.**,**Molecular modification of lead compounds; Assay systems and models (e.g., KnockoutMice). Antisense technology as cell based therapeutics.

**UNIT III: PHARMACEUTICALS PRODUCTION IN PLANTS:** Drugs derived from plants, , Antitumor agent -Etoposide, Colchicine, Taxol, Vinblastine, Vincristine. Cardiotonic – Convallatoxin,Acetyldigoxin, Adoniside, Antiinflammatory – Aescin, Bromelain, Choleretic – Curcumin,Biopharmaceuticals Expressed in Plants Alternative Expression Systems, Three PromisingExamples: Tobacco (Rhizosecretion, Transfection) and Moss (Glycosylation).

**UNIT IV: DNA VACCINES AND ANTIBODY DRUG:** DNA Vaccine Construction and Immunology DNAVaccine Expression Plasmids Delivery of DNA Vaccines. Peptide vaccine, Gene Pharming,Cytokines as biopharmaceuticals, Rituximab, therapeutic enzymes.

**UNIT V: BIOGENERIC DRUGS RECOMBINANT THERAPEUTIC PROTEINS:** Erythropoietin (EPO), ColonystimulatingFactors (CSFs), Human Growth Hormone (hGH), Insulins, Hepatitis B Vaccine,Factor VIII (FVIII), Interferons (IFN) **.**Therapeutic hormone- insulin production throughrecombinant DNA technology.

**BOOKS:**

1. Pharmaceutical Biotechnology; Oliver Kayser, Rainer H. Müller, Wiley Publishers, 2005.
2. Drug Discovery and Clinical Applications; Heinrich Klefenz, 2002.
3. Industrial Pharmaceutical Biotechnology, WILEY-VCH Publication, Germany. Daan Crommelin, Robert D Sindelar, 2002.
4. Pharmaceutical Biotechnology; Tailor and Francis Publications, Newyork. Jay P Rho, Stan G Louie, 2003, Hand.

LABORATORY IV

**CELL CULTURE TECHNIQUES LABORATORY**

**LIST OF EXPERIMENTS**

1. Preparation of medium.
2. Surface sterilization.
3. Organ culture.
4. Cell suspension cultures.
5. Growth and production kinetics for secondary metabolite production and quantification.
6. Genetic transformation studies using ***Agrobacterium***.
7. Preparation of Culture medium (Animal Cell Culture).
8. Cell counting and Cell viability.
9. Trypsinization of Monolayer and Subculturing.
10. Cryopreservation and Thawing.

**III YEAR- I SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **I Semester** | **Int.****Marks** | **Ext.****Marks** | **L** | **P** | **C** |
|  | Comprehensive Viva-Voce | -- | 100 | -- | -- | 4 |
|  | Project Work Review I | 50 | -- | -- | 24 | 12 |
|  | **Total Credits** |  | **24** | **16** |

**III YEAR- II SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **II Semester** | **Int.****Marks** | **Ext.****Marks** | **L** | **P** | **C** |
|  | Project Work Review II | 50 | -- | -- | 8 | 4 |
|  | Project Evaluation (Viva-Voce) | -- | 150 | -- | 16 | 12 |
|  | **Total Credits** |  | **24** | **16** |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **I Semester** | **Int.****Marks** | **Ext.****Marks** | **L** | **P** | **C** |
|  | Comprehensive Viva-Voce | -- | 100 | -- | -- | 4 |
|  | Project Work Review I | 50 | -- | -- | 24 | 12 |
|  | **Total Credits** |  | **24** | **16** |

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| --- | --- | --- | --- | --- | --- | --- |
|  | **II Semester** | **Int.****Marks** | **Ext.****Marks** | **L** | **P** | **C** |
|  | Project Work Review II | 50 | -- | -- | 8 | 4 |
|  | Project Evaluation (Viva-Voce) | -- | 150 | -- | 16 | 12 |
|  | **Total Credits** |  | **24** | **16** |