**SYLLABUS**

**FOR**

**TWO-YEAR M. TECH. PROGRAMME**

**IN**

**BIOTECHNOLOGY**



|  |
| --- |
| **NAAC – A Grade** |

**DEPARTMENT OF BIOTECHNOLOGY**

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(An Autonomous and Constituent College of BPUT, Odisha)**

**Techno Campus, Mahalaxmi Vihar, Ghatikia,**

**Bhubaneswar-751029, Odisha, INDIA**

[**www.cet.edu.in**](http://www.cet.edu.in)

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**COURSE: M. Tech. (BT - Biotechnology), Duration: 2 years (Four Semesters)**

**Abbreviations Used: U= UG, I= Integrated, P= PG**

**PC= Professional Core PE= Professional Elective OE= Open Elective**

**LC= Lab Course MC= Mandatory Course AC= Audit Course**

**L= Lectures P= Practical/Laboratory IA\*= Internal Assessment**

**T= Tutorial PA= Practical Assessment EA=End-Semester Assessment**

**\*Internal Assessment Max. Mark (30 marks) consists of Mid Semester (20 marks) and Quiz+Assignment (10 marks)**

**Subject Code Format:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Prog (U/I/P)** | **Type (PC/PE/OE/LC/MC/AC)** | **Department (CE/EE/IE/ME/…)** | **Semester (1/2/…/0)** | **Serial No. (1/2/3/…/99)** |

**1st SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 1 | PPCBT101 | Advanced Bioprocess Engineering | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 2 | PPCBT102 | Bioinstrumentation and Biostatistics | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 1(Any One) | PPEBT101 | Computation methods and Technique | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEBT102 | Cell culture and Metabolic regulations |
| 4 | ProfessionalElective 2(Any One) | PPEBT103 | Internet of Things | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEBT104 | Applied Bioinformatics |
| 5 | Mandatory  | PMCMH101 | Research Methodology & IPR | 2 | 0 | 0 | 2 | 30 | 70 | - | 100 |
| 6 | Lab 1 | PLCBT101 | Bioprocess Engineering Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 2 | PLCBT102 | Biostatistics & Bioinformatics Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | **14** | **0** | **8** | **18** | **150** | **350** | **200** | **700** |
| 8 | Audit 1 | Any one subject from Appendix-I | 100 |
| **Grand Total** | **800** |

**2nd SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 3 | PPCBT201 | Gene manipulation & Vector Technology | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 4 | PPCBT202 | Current trends in Translational Biotechnology | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | ProfessionalElective 3(Any One) | PPEBT201 | Advanced microbiology and immunology | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEBT202 | Advanced drug delivery systems |
| PPEBT203 | Nano-biotechnology |
| 4 | ProfessionalElective 4(Any One) | PPEBT204 | Environmental Biotechnology | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEBT205 | Cancer biology |
| PPEBT206 | Chemistry of nucleic acids and proteins |
| 5 | Practical 1 | PPRBT201 | Mini Project with seminar | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 6 | Lab 3 | PLCBT201 | Genetic Engineering Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 4 | PLCBT202 | Current trends in Translational Biotechnology Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | **12** | **0** | **12** | **18** | **120** | **280** | **300** | **700** |
| 8 | Audit 2 | Any one subject from Appendix-II | 100 |
| **Grand Total** | **800** |

**3rd SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | ProfessionalElective 5(Any One) | PPEBT301 | Advanced Plant Biotechnology | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEBT302 | Molecular modelling and drug designing |
| PPEBT303 | Animal Biotechnology |
| 2 | Open Elective  | Any one subject from Appendix-III | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Project 1 | PPRBT301 | Phase-I Dissertation | 0 | 0 | 20 | 10 | - | - | 100 | 100 |
| **Total** | **6** | **0** | **20** | **16** | **60** | **140** | **100** | **300** |

**4th SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Project 2 | PPRBT401 | Phase-II Dissertation | 0 | 0 | 32 | 16 | - | - | 100 | 100 |
|  |  |  | **Total** | **0** | **0** | **32** | **16** | **-** | **-** | **100** | **100** |

**Abstract of Credit and Marks Distribution**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Semester** | **Maximum Credits** | **Maximum Marks** |
| 1 | 1st Semester | 18 | 800 |
| 2 | 2nd Semester | 18 | 800 |
| 3 | 3rd Semester | 16 | 300 |
| 4 | 4th Semester | 16 | 100 |
| **Total** | **68** | **2000** |

**NB:**

* **Any one of the Courses in Appendix-I is to be Decided by the Concerned Department for Audit-1 (1st Sem)**
* **Any one of the Courses in Appendix-II is to be Decided by the Concerned Department for Audit-2 (2nd Sem)**
* **Any one of the Courses in Appendix-III is to be Decided by the Concerned Department for Open Elective (3rd Sem)**

**Semester-1**

**Core 1: Advanced Bioprocess Engineering (PPCBT101)**

**Module-I**

Isolation, screening and maintenance of industrially important microbes: Growth Kinetics: Batch growth quantifying cell concentration, growth profiles and kinetics in batch culture, fed batch growth, continuous growth and their grow the kinetic quantification; death kinetics (an example from each group); yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

**Module-II**

Bioreactors: Introduction to bioreactors, Types of reactors: Batch and Fed-batch bioreactors, Continuous bioreactors; concept of ideal and non-ideal reactor, Air lift, Packed bed, Bubble column, Fluidized bed, Tower Bioreactor, Photo bioreactor, Unconventional bioreactors (Hollow fibre reactor, membrane reactor, perfusion reactor). Criteria for selection of bioreactors;

Instrumentation: Agitation and aeration: types of impellors and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (kLa), measurement of kLa, power requirement for agitation in gaseous and non-gaseous systems,

**Module-III**

Downstream process engineering: Basic concepts of downstream Process, Characteristics of bio-products,

Filtration: Filtration at constant pressure and at constant rate, numerical examples; Centrifugation: basic principles, design characteristics; ultracentrifuges: principles and applications; Cell disruption techniques (mechanical, chemical, enzymatic), Solvent extraction of bio-processes (liquid-liquid extraction, aqueous two-phase extraction), Precipitation (organic solvent, salting out method), Chromatographic separation (Affinity based, IMAC, ion exchange chromatography, size exclusion etc.); Membrane based separation: Micro-filtration, Reverse osmosis, Ultra filtration.

**Reference Books**

1. Principle of Fermentation Technology. By P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth and Heinemann., Elsevier
2. Bioprocess Engineering Principles (2nd Edition), By by Pauline M Doran, Academic Press.
3. Introduction to Biochemical Engineering. By D.G. Rao, Tata McGraw-Hill Education.
4. Fundamentals of Biochemical Engineering. By Rajiv Dutta, Ane Books India, Springer.
5. Bioprocess Engineering Basic Concepts. By Michael L. Shuler and FikretKargi. Prentice Hall PTR
6. Biochemical Engineering and Biotechnology. By GHASEM D. NAJAFPOUR, Elsevier.
7. Bioprocess Engineering. Kinetics, Biosystems, Sustainability, and Reactor Design. By SHIJIE LIU. Elsevier.

**Core 2: Bioinstrumentation and Biostatistics (PPCBT102)**

**Module-I**

Microscopy Techniques: Bright field microscope, Phase contrast microscope, Differential interface contrast microscope,

Principles & applications of UV-Vis spectroscopy (Beer-Lambert’s law, limitations); Fluorescence: Molecular fluorescence, influencing factors, basic instruments, standardization, quantitative methods and applications.

Calorimeters: Bomb calorimeters, DSC (Differential Scanning Calorimeters), Isothermal titration calorimeters, Calvet type calorimeters.

Principles and applications of FT-IR, NMR, Circular dichroism (CD), Mass-spectroscopy, Optical rotatory dispersion (ORD).

**Module-II**

Introduction and definition of Biostatistics: Mean, Median and Mode, Errors of mean, distribution of means and standard deviation

Probability: Concept of probability, population, sample, parameters.

Distributions: Binomial, Poisson and Normal Distributions and their equations.

Statistical analysis: maximum-likelihood method, t-distribution, confidence levels and test of significance. Chi-square and F-statistics.

**Module-III**

Regression and Correlation: Estimation of simple regression models and hypothesis concerning regression coefficients, Estimation of correlation coefficient, hypothesis concerning correlation coefficient.

Analysis of variance: General principles, completely randomized designs, Randomized block diagram, Latin square designs, Analysis of covariance. One-way ANOVA, Two-way ANOVA Principal component analysis (PCA)

**Recommended 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
3. Wayne Daniel: Biostatistics: Foundation for Analysis in the Health Sciences, 5th Ed., John Wiley & Sons, New York, 2009. 9th Edition.
4. Biostatistics: Rao KS, Himalaya Publishing House.
5. Introduction to Biostatistics & Research Methods: Sundar Rao PSS & Richard J, PHI learning Pvt. Ltd

**PE 1: Computation Methods and Techniques (PPEBT101)**

**Module-I**

Neural Networks: Artificial Neural Network and Introduction, Learning Rules, Knowledge Representation and Acquisition, Different Methods of Learning. Algorithms of Neural Network: Feed-forward Error Back Propagation, Hopfield Model, Kohonen’sFeatrure Map, K-Means Clustering, ART Networks, RBFN, Application of Neural Network to the relevant field.

Fuzzy Logic: Basic Concepts of Fuzzy Logic, Fuzzy vs Crisp Set, Linguistic variables, Membership Functions, Operations of Fuzzy Sets, Fuzzy If-Then Rules, Variable Inference Techniques, Defuzzification, Basic Fuzzy Inference Algorithm, Fuzzy System Design, FKBC and PID Control, Antilock Breaking System (ABS), Industrial Applications.

**Module-II**

Optimization Fundamentals: Definition, Classification of Optimization Problems, Unconstrained and Constrained Optimization, Optimality Conditions.

LINEAR Programming: Simplex Method, Duality, Sensitivity Methods. NON-LINEAR Programming: Newton’s Method, GRG Method, Penalty Function Method, Augmented Langrange Multiplier Method, Dynamic Programming and Integer Programming, Interior Point Methods, Karmakar’s Algorithm, Dual Affine, Primal Affine.

**Module-III**

Genetic Algorithm: GA and Genetic Engineering, Finite Element based Optimization, PSO,BFO, Hybridization of Optimization Technique, Application of Optimization Technique for Solving Projects(Project solutions). Implementation of Branch Relevant Industrial Applications by Matlab Code.

**Recommended Books:**

1. Neural Networks- by Simon Haykin
2. Fuzzy Logic with Engineering Application- by ROSS J.T (Tata Mc)
3. Neural Networks and Fuzzy Logic – by Bart Kosko
4. An introduction Fuzzy Control – by D.Driankor, H. Hellendorn, M.Reinfrank (Narosa Pub)
5. Fuzzy Neural Control – by Junhong NIE & Derek Linkers (PHI)
6. Fuzzy System Design Principles, Building Fuzzy IF-THEN Rule Bases by Riza C. Berikiu and Trubatch, IEEE Press
7. Ashok D. Begundu&chandrapatla T.R “Optimization concept and application in engineering”,Prentice Hall,1999
8. Rao S.S “Engineering Optimization”
9. Gill,Murray and Wright ,”Practical Optimization”
10. James A.Memoh. “Electric Power System Application Of Optimization”.
11. Song Y.,”Modern Optimization Techniques In Power System”
12. Optimization Research; PrabhakarPai,Oxford University Press.

**PE 1: Cell Culture and Metabolic Regulations (PPEBT102)**

**Module- I**

Animal cell culture: Basic concepts animal cell culture; Cell culture media and reagents; Animal cell, tissue and organ cultures; Primary culture, secondary culture; Continuous cell lines; Suspension cultures; Somatic cell cloning and hybridization; Transfection and transformation of cells; Commercial scale production of animal cells; Stem cells and their application; Application of animal cell culture for in vitro testing of drugs; Testing of toxicity of environmental pollutants in cell culture; Application of cell culture technology in production of human and animal vaccines and pharmaceutical proteins.

**Module-II**

Carbohydrate metabolism: Glycolysis, Krebs cycle, ETS, Energetics and regulation of these pathways, HMP pathway and its importance, Gluconeogenesis, Mechanism of Oxidative Phosphorylation.

Lipid metabolism: Fatty acid oxidation and their metabolic routes of carbon.

Glycogen metabolism: Protein metabolism: Oxidative deamination, decarboxylation, and transamination reactions, Urea cycle.

**Module-III**

Integration of metabolism and concept of metabolic regulation: Elucidation of metabolic pathways; Major pathway and strategies of energy metabolism, entry/ exit of various biomolecules from central pathways; Principles of metabolic regulation; Regulatory steps; Signals and second messengers.

Coordination of metabolic reactions: Feedback inhibition, Energy charge, Multigene networks. Transcriptome, Proteome, Metabolome, Fluxome. Metabolic design: Gene amplification, Gene-disruption, Randomized and targeted strain development.

Metabolic flux analysis: Overdetermined and undetermined systems, Sensitivity analysis. Metabolic control analysis (MCA): Determination of Flux control coefficients, MCA of Linear and Branched pathways.

**Recommended Books:**

1. Animal Cell Culture and Technology. By Michael Butler. Taylor & Francis.
2. Culture of Animal Cells. By Ian Freshney. John Wiley & Sons, Inc.
3. Metabolic Regulation: A Human Perspective by Keith N. Frayn. Wiley-Blackwell.
4. Metabolic Regulation: Metabolic Pathways. Henry J. Vogel.
5. Metabolic Regulation in Mammals. By David Gibson, Robert A. Harris. CRC Press

**PE 2: Internet of Things (IoT) (PPEBT103)**

**Module I**

Introduction to Internet of Things: Definition & Characteristics of IoT, Physical Design of IoT:

Things in IoT, IoT Protocols, Logical Design of IoT: IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies: Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication Protocols, Embedded Systems, IoT Levels & Deployment Templates.

**Module II**

Domain Specific IoTs: Home Automation: Smart Lighting, Smart Appliances, Intrusion Detection, Smoke/Gas Detectors, Cities-Smart Parking, Smart Lighting, Smart Roads, Structural Health Monitoring, Surveillance, Emergency Response, Environment-Weather Monitoring, Air Pollution Monitoring, Noise Pollution Monitoring, Forest Fire Detection , River Floods Detection , Energy- Smart Grids , Renewable Energy Systems , Prognostics, Retail-Inventory Management, Smart Payments, Smart Vending Machines, Logistics-Route Generation & Scheduling , Fleet Tracking , Shipment Monitoring , Remote Vehicle Diagnostics, Agriculture-Smart Irrigation ,Green House Control, Industry -Machine Diagnosis & Prognosis Indoor Air Quality Monitoring, Health & Lifestyle -Health & Fitness Monitoring, Wearable Electronics, IoT and M2M Introduction, M2M-Difference between IoT and M2M, SDN and NFV for IoT Software Defined Networking, Network Function Virtualization

**Module III**

IoT Platforms Design Methodology: IoT Design Methodology-Purpose & Requirements Specification ,Process Specification, Domain Model Specification, Information Model Specification , Service Specifications , IoT Level Specification, Functional View Specification, Operational View Specification , Device & Component Integration , Application Development, Case Study on IoT System for Weather Monitoring, Motivation for Using Python IoT Physical Devices & Endpoints, What is an IoT Device-Basic building blocks of an IoT Device, Exemplary Device: Raspberry Pi, About the Board, Linux on Raspberry Pi , Raspberry Pi Interfaces – Serial, SPI , I2C , Programming Raspberry Pi with Python-Controlling LED with Raspberry Pi , Interfacing an LED and Switch with Raspberry Pi ,Interfacing a Light Sensor (LDR) with Raspberry Pi , Other IoT Devices- pcDuino, Beagle Bone Black, Cubieboard

IoT & Beyond: Use of Big Data and Visualization in IoT, Industry 4.0 Concepts. Overview of RFID, Low-power design (Bluetooth Low Energy), range extension techniques (data mining and mesh networking), and dataintensive IoT for continuous recognition applications. Overview of Android / IOS App Development tools & Internet of Everything.

**Recommended Books:**

1. Internet of Things, A Hand Approach, by ArshdeepBahga& Vijay audisetti, University Press.
2. The Internet of Things, by Michael Millen, Pearson

**PE 2: Applied Bioinformatics (PPEBT104)**

**Module-I**

Introduction: Algorithms and Complexity, Biological algorithms versus computer algorithms, The ‘Change problem’, Recursive Algorithms, Iterative versus Recursive Algorithms, Big-O Notations, Algorithm design techniques and the different types of algorithms. Dynamic Programming: DNA Sequence comparison, Manhattan Tourist Problem, Edit Distance and Alignments, Longest commons Subsequences, Global Sequence Alignment, Scoring Alignment: Local Sequence Alignment, Alignment with Gap Penalties, Multiple Alignment.

**Module-II**

Tools for analysis of human genome: Alternative splicing models, Probing with ESTs, Exon Microarray, Implications in Cancer genetics, SNPs, Pharmacogenomics, DNA microarrays, Basics of designing a microarray, Image analysis, Normalization Variability and replication, Clustering, Microarray Databases

**Module-III**

Clustering and trees: Gene expression analysis, Hierarchical clustering-k-means clustering, Clustering and corrupted Cliques - Evolutionary Trees, Distance-based tree reconstruction, Reconstruction trees from additive matrices - Evolutionary trees and hierarchical, clustering, Character-based tree reconstruction, Small and large Parsimony, Hidden Markov Models; Protein Structure prediction; Secondary structure prediction methods and algorithms; Tertiary structure prediction methods and algorithms

**Recommended Books**

1. Bioinformatics: Sequence and Genome Analysis. Mount DW, Spring Harbor Press
2. Introduction to Bioinformatics, Arthur Lesk, Oxford University Press.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Baxevanis AS and Ouellette BF, Wiley International Science.
4. Bioinformatics computing, Bryan Bergeron, Prentice Hall Inc
5. Introduction to computational biology: an evolutionary approach Bernhard houbold, ThomasWiehe, Blkhauserverlag press.

**MC: Research Methodology & IPR (PMCMH101)**

**Module I: (10 Hours)**

Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

Types of Data: Primary data Secondary data, Design of questionnaire; Sampling fundamentals ad sample designs, Methods of data collection, Measurements and Scaling Techniques, Validity & Reliability Test.

**Module II: (10 Hours)**

Data Processing and Data Analysis-I, Data editing, Coding, Classification and Tabulation, Descriptive and Inferential Analysis, Hypothesis Testing- Parametric Test (z test, t test, F test) and non-parametric test (Chi square Test, sign test, Run test, Krushall-wallis test).

**Module III: (10 Hours)**

Data Analysis II: Multivariate Analysis- Factor Analysis, Multiple Regression Analysis. Discriminant Analysis, Use of Statistical Packages.

**Reference Books:**

1. Research Methodology, Chawla and Sondhi, Vikas

2. Research Methodology, Paneerselvam, PHI

**Course Outcomes:**

**CO1:** Understood the Meaning of research problem, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**CO2:** Got the knowledge of How to get new ideas (Criticizing a paper) through the Literature Survey (i.e. Gap Analysis).

**CO3:** Understood the Filing patent applications- processes, Patent Search, Various tools of IPR, Copyright, Trademarks.

**CO4:** Understood How to apply for Research grants and Significance of Report Writing, Steps in Report Writing, Mechanics and Precautions of Report Writing, Layout of Research Report.

**CO5:** Got the knowledge of How to write scientific paper & Research Proposal - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper:

**Lab 1: Bioprocess Engineering Laboratory (PLCBT101)**

**List of Experiments:**

1. Conceptual design of reactors, Bioreactor design, Bioreactor Design parameters
2. Monod Kinetics in batch culture
3. Media Sterilization in the Bioreactor and Thermal deactivation kinetics
4. Continuous culture
5. Enzyme kinetic study
6. Enzyme inhibition kinetics
7. Precipitation of protein
8. Protein separation by chromatography e.g. Gel chromatography
9. Membrane filtration
10. Extraction techniques (like liquid-liquid and Aqueous two phase extraction)

**Lab 2: Biostatistics and Bioinformatics Laboratory (PLCBT102)**

**List of Experiments:**

1. Law of large numbers and Central limit theorem
2. Calculating Mean, median and mode, SEM, SD etc.
3. One- way and two-way classifications analysis of variance (ANOVA) in biology
4. Conducting correlation and linear regression
5. Student T-test and Chi-square test
6. Alignment of multiple sequences
7. Construction of a phylogenetic trees of aligned sequences
8. Statistical analysis of sequence alignments.
9. Protein structure prediction.
10. Mining genomic data to identify genomic features: codon usage, repeats, Homologous sequences etc.

**Audit-1**

**[To be decided by the Department]: Refer Appendix-I**

**Semester-2**

**Core 3: Gene Manipulation & Vector Technology (PPCBT201)**

**Module-I**

Basic concept of gene manipulation: Enzymology of Genetic manipulation, Restriction enzymes (types, pattern of cleavage), Enzymes in modification: Methylases and phosphatises, ligase (blunt and cohesive end ligation). Vectors in recombinant DNA technology: Salient features of Vectors, Plasmids, Phages, Cosmids, Fosmids, Phagemids, and Artificial chromosomes, Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), cDNA, Construction of cDNA library, Construction of Genomic library, Basic concept of gene cloning and screening, TOPO cloning

**Module-II**

Nucleic acid amplification and its applications: Variations in PCR and their applications, Methods of nucleic acid hybridization, Reverse transcriptase, selection and screening (Introduction to marker and reporter genes, positive and negative selection. Gene transfer techniques: biological methods, chemical methods, Nucleic acid sequencing: strategies and methodologies, Nucleic acid micro arrays and DNA Chips, DNA Finger printing and Foot printing. SI mapping, RNase protection assay, Reporter assays and Phage display, Vector engineering and codon optimization, Cassette construction, host-engineering, In vitro transcription and translation, two hybrid and three hybrid assay,

**Module-III**

Processing recombinant proteins: Purification and refolding, characterization of recombinant proteins, stabilization of proteins. Site directed mutagenesis: PCR based methods. Gene therapy: Vector engineering, Strategies of gene delivery, gene replacement/augmentation, gene correction. Gene silencing-RNA interference. Expression strategies for Heterologous genes. In vitro transcription and translation, expression in bacteria, expression in yeast, expression in mammalian cells, expression in plants. T-DNA and transposon tagging, Gene knockout technologies: Targeted gene replacement, chromosome engineering.

**Recommended Books**

1. Gene cloning and DNA analysis: an introduction. TA Brown. John Wiley & Sons.
2. Principles of gene manipulation and genomics. Primrose, S. B., & Twyman, R. Wiley. com.
3. Molecular Cloning: A Laboratory Manual J. Sambrook, MR. Green. Cold Spring Harbor.
4. An Introduction to Molecular Biotechnology: M. Wink. Wiley, ed. 2, 2011
5. Principles and Techniques of Biochemistry and Molecular Biology K. Wilson, J. Walker. Cambridge University Press.

**Core 4: Current Trends in Translational Biotechnology (PPCBT202)**

**Module-I**

Introduction to Translational Biotechnology: Characterization of biochemical activities of gene products in mammalian cells, investigation of gene function in model genetic organisms and manipulations of genetic materials via cloning, mutagenesis and transgenesis.

Cancer Cell culture, 3D culture, Stem Cell based Tissue engineering, Stem cell based future Translational Therapy

**Module-II**

Chemical and Biological Therapeutic Modalities: Therapeutic proteins, monoclonal antibodies, engineered multi-specific antibodies, cell-based immunotherapies, stem cell applications, viral therapy and microbiome-based therapeutics.

Pathway and Target Discovery: Molecular basis of human diseases (Cancer, Alzheimer’s disease, Severe asthma, myocardial infarction, muscular dystrophy etc.), novel therapeutic approaches, new targets and pathways for novel biologics and therapeutic treatments

**Module-III**

Biotechnological product development including biopharmaceuticals, diagnostic test materials: enzymes, antibodies, and other protein products; transgenic plants and animals; tissue and cellular products, and biomedical implants and devices.

**Recommended Books**

1. Translational Medicine: The Future of Therapy? By James Mittra , Christopher-Paul Milne. Pan Stanford.
2. Translational Medicine and Drug Discovery. Bruce H. Littman, Rajesh Krishna. Cambridge University Press.
3. Translational Regenerative Medicine. Anthony Atala, Julie Allickson. Academic Press.
4. Clinical and Translational Science: Principles of Human Research, DavidRobertson, Gordon H. Williams. Academic Press

**PE 3: Advanced Microbiology and Immunology (PPEBT201)**

**Module-I**

Microbial Diversity and Systematics: Classical and modern methods and concepts on classification of microorganisms. Criteria for classification. Classification of Bacteria according to Bergey’s manual. Molecular methods as Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Ribosomal Intergenic Spacer Analysis (RISA)/Automated Ribosomal Intergenic Spacer Analysis (ARISA), Amplified rDNA Restriction Analysis (ARDRA) and Terminal Restriction Fragment Length Polymorphism (T-RFLP) in assessing microbial diversity. 16s rDNA sequencing and Ribosomal Database Project.

**Module-II**

Microbial processes and its optimization: Microbial growth, Models of growth and its kinetics; Microbial processes-production, optimization, screening, strain improvement, factors involving downstream processing and recovery of ethanol, organic acids, antibiotics etc. Enzyme Technology- production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease, penicillin acylase, glucose isomerise and other secondary metabolites; Immobilized Enzyme and Cell based biotransformation of steroids, antibiotics, alkaloids, Enzyme based and cell based biosensor.

**Module-III**

Advanced Immunology: Fundamental concepts of Immune system; components of innate and acquired immunity, phagocytosis; complement system; MHC – structure, genetic organization; HLA typing; graft versus host reaction; Antigens: immunogens, hapten, adjuvant, carrier. Molecular basis of immune responses: Primary and secondary immune response; kinetics of immune response; Immunoglobulins – class, subclass and structure.

Ig superfamily: affinity, avidity, allotype, isotype, idiotype; Antibody genes and antibody diversity.

Immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, Memory Lymphocyte Immunostimulation Assay (MELISA).

**Recommended Books**

1. Prescott’s Microbiology- Willey, Sherwood, Woolverton
2. Microbial Genetics- S.R. Maloy, J.E. Cronan, Jr., D. Freifelder
3. Microbiology An Introduction: Tortora, Funke and Case
4. Kuby Immunology- Owen, Punt, Stranford
5. Roitt’s essential Immunology- P.J. Delves, S. J. Martin, D.R. Burton, I.M. Roitt

**PE 3: Advanced Drug Delivery System (PPEBT202)**

**Module-I**

Fundamentals of drug delivery, including physiology, pharmacokinetics, drug diffusion and permeation through biological barriers, Various types of drug and gene delivery routes including oral, transdermal, implantable, targeted and pulmonary.

**Module-II**

Controlled drug delivery, biomaterials used in drug delivery, particle targeting via receptor-ligand interactions, intracellular transport of collodial particles, protein and peptide delivery, synthetic gene delivery vectors.

Targeted drug delivery systems: active and passive targeting, Enhanced permeation and Retention (EPR) effect, receptor mediated endocytosis, prodrug based drug targeting, brain targeting, tumour targeting. Examples and Case Studies.

**Module-III**

Design and Fabrication of Microencapsulation, Liposomes, Niosomes; Biodegradable polymers in drug delivery: Polymeric drug delivery systems; Transdermal drug delivery: Ocular, Vaginal and Uterine controlled release.

Nanoparticles for drug delivery: NanoSized carriers for drug delivery and drug carrier systems, Protein and peptide nanoparticles, DNA based nanoparticles, Lipid matrix nanoparticles for drug delivery

**Recommended Books**

1. Engineering Principles for Drug Therapy. By Saltzman WM, Oxford University Press (2001).
2. Drug delivery principles and applications By Wang B, Siahaan T, Soltero R, Wiley Interscience (2005).
3. Nanobiotechnology: Concepts, Applications and Perspectives. By Niemeyer, C.M. and Mirkin, C.A. Wiley- VCH, 2006.
4. Nanobiotechnology: Bioinspired Devices and Materials of the Future. By Shoseyov, O. and Levy I., Humana Press, 2008.

**PE 3: Nanobiotechnology (PPEBT203)**

**Module-I**

Course Introduction: The Science of Nano, Nanoscale Properties (Electrical, Optical, Chemical), Size effect of Nanomaterials: size, shape, density, melting point, and specific surface area comparision of Biotechnology to Nanobiotechnology, Principles of nanobiotechnology: Approaches, Energetics, gravity and intertia, water environment, Protein nanotechnology (Protein Interactions & Nanomaterial-Cell interactions) DNA nanotechnology, Overview of natural Bionanomachines. Thymidylate synthetase, ATP synthetase, Actin and myosin, opsin

**Module-II**

Functional principles of Nanobiotechnology: Information driven nanoassembly, Energetics, Role of enzymes in chemical transformation, Nanotechnology by self-assembly (Bottom-Up approach) & self organisation. Nanoscale visualization techniques: Electron Microscopy, Scanning probe Microscopy (AFM, STM, XRD). Carbon nanomaterials- fullerenes, nanotubes, nanowires, Quantum Dots and Metal-based nanoparticles. Nanoporous materials (metalic, zeolite). Micro-fabrication methods (photolithography, etching). Synthesis of Nanomaterials-Sol-Gel synthesis; Microemulsions synthesis, Sonochemical assisted synthesis, Biomolecular motors: ATP Synthetase and flagellar motors, Traffic across membranes: Bionics, Bioelectrical phenomenon in mammals, Potassium channels, ABC Transporters and Bactreriorhodapsin,

**Module-III**

Miniaturized devices in nanobiotechnology- Microfluidics, Lab-on-a-chip devices, Bio-MEMs. Nanoanalysis and nanobiosensors: different classes, molecular recognition elements, transducing elements. Bionics & Plant Nanobionics typical Examples, Drug and gene delivery by polymeric-, metallic- and peptide/DNA based nanoparticles, Nanobiotechnological applications in health, Food and environment, Hybrid materials, Nanomedicine. Nanoparticles Cytotoxicity

**Recommended Books**

1. Bionanotechnology, David S Goodsell , John Wiley & Sons,.
2. Nanoscale Technology in Biological Systems, Greco Ralph S,CRC Press
3. Generic Methodologies for Nanotechnology: Classification and Fabrication. In NanoscaleScience and Technology, Brydson, R. M.; Hammond, C., John Wiley & Sons, Ltd: 2005
4. Chemistry of Nanomaterials: Synthesis, properties and applications, CNR Rao et. al.
5. Fundamental Properties of Nanostructured Materials, Ed. D. Fiorani (World Scientific, Singapore
6. Nanostructured Materials and Nanotechnology -II, S. Mathur and Mrityunjay Singh, Willey

**PE 4: Environmental Biotechnology (PPEBT204)**

**Module- I**

Introduction: Environment, Basic concepts, Resources, Eco system: plants, animals, microbes. Ecosystem management: Renewable resources, Sustainability, Microbiology of degradation and decay, Role of Biotech in environmental protection, Control and management of biological processes. Alternate source of energy: Biomass as source of energy, Bioreactors: Rural biotechnology, Bio composting, Bio fertilizers, Vermiculture: Organic farming, Bio mineralization, Biofuels: Bioethanol and bio hydrogen. Energy management and safety.

**Module-II**

Pollution: Environmental pollution, Source of pollution, Hydrocarbons, substituted hydro carbons, Oil pollution, Surfactants, Pesticides, Measurement of pollution, Water pollution, Biofilm, Soil pollution, Radioactive pollution, Radiation, Ozone depletion, Greenhouse effect, Impact of pollutants, Measurement techniques, Pollution of milk and aquatic animals Pollution Control, remediation and management: Waste water collection, control and management, Waste water treatment, Sewage treatment through chemical.

Bioremediation of organic pollutants and odorous compounds: Use of bacteria, fungi, plants, enzymes, and GE organisms, Plasmid borne metabolic treatment, Bio augmentation, Bioremediation of contaminated soils and waste land, Bioremediation of contaminated ground water, Macrophysics in water treatment, Phytoremediation of soil metals, Treatment for waste water from dairy, distillery, tannery, sugar and antibiotic industries, Solid waste management.

**Module-III**

Environment and health in respect to genetics: Gene and environment, Effect of carbon and other nanoparticles upon health, Gene mutation, Genetic testing, Genetic sensors, Environmental pollution and children, Human biomonitoring Metagenomics, environmental genomics. Bioprospecting, Bio microelectronics and Nano-biotechnology. Metabolic pathways for biodegradation of hydrocarbon compounds and other organic pollutants. Microbial interaction with metals and radionuclides, mechanisms. Nitrate and phosphate removal

**Recommended Books**

1. Environmental Biology, Agarwal, K.C. 2001. Nidi Publ. Ltd. Bikaner.
2. Environmental Studies, R. Rajagopalan, Oxford University Press.
3. Environmental Management, Ajith Sankar, Oxford University Press.
4. Hazardous Waste Incineration, Brunner R.C., 1989, McGraw Hill Inc.

**PE 4: Cancer Biology (PPEBT205)**

**Module-I**

Characteristics of cancer cells, difference between normal and cancer cells, types of cancer, various stages in carcinogenesis, Cell proliferation and malignancy, Cancer microenvironment and angiogenesis, Invasion and metastasis, Carcinogens and its different types, stem cells and cancer stem cells.

**Module-II**

Molecular basis of Cancer: Regulation of gene expression in normal cell, Cellular genes involved in cancer – Oncogenes, Cellular metabolic pathways and Regulation of cell proliferation/growth, DNA repair pathways, Cancer cell metabolic alterations- cause or consequence, Aberrant signalling in cancer, Tumor suppressors, Cell cycle and its regulation, Apoptosis and Immortalization

**Module-III**

Screening and Early Detection of cancer: Therapeutic resistance in cancer, Therapeutics in Cancer, Tumor immunology and cancer immunotherapies, Contemporary chemotherapy, hormone therapy, radiation, surgery, Emerging therapies: Targeted delivery & Synthetic lethal approaches, Future of cancer research.

**Recommended Books**

1. Principle of Bio-Chemistry – Lehinger, Nelson and Cox
2. Principles of Cancer Biology. By Lewis J. Kleinsmith. PEARSON
3. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics. By Lauren Pecorino. Oxford Press
4. Cancer Biology. By R. J. B. King. Prentice Hall

**PE 4: Chemistry of Nucleic Acids and Proteins (PPEBT206)**

**Module-I**

Nucleic acids: Structure and stability of Nucleic acids (DNA and RNA), topological structure, fine structure of DNA and its organization in genome. Genome structural and functional annotation, Genome assembly, De novo and reference based assembly, Genome finishing – Gaps Gene families: Types, Pseudogenes, Origin of gene families

Structure and organization of prokaryotic and eukaryotic genomes

**Module-II**

DNA: Cruciform structure in DNA, formation and stability of cruciforms, Polarity of strands. Parallel duplex. Pyrimidine-purine pyrimidine and pyrimidine- purine-purine triplexes. Quadruplexes miscellaneous alternative conformation of DNA. DNA Intercalators, Biosynthesis of DNA

RNA: Different types of RNA, RNA world hypothesis, Secondary and tertiary structure of RNA, RNA folding problems, Ribozymes, RNA interference, Non sense mRNA mediated decay, RNA editing, Catalytic RNA, siRNA, micro RNA, Biosynthesis of RNA, RNA splicing, RNA catalysis, translation, and selection-amplification methods.

**Module-III**

Proteins: Primary structure - determination of amino acid sequence of proteins. The peptide bond: Protein backbone conformation: Ramachandran plot, random coil, chain dynamics. Secondary structure - weak interactions involved - alpha helix and beta sheet and beta turns structure. Amphipathic character of alpha helix and beta sheets, Hydrophobicity and Hydropathy plots. Pro isomerization / Secondary structure, Helix propensity/fibrous proteins, Turns, super-secondary structure motifs.

Protein folding: factors that determine it. Molecular chaperones. Protein structure prediction.

Quaternary structure. Denaturation and renaturation of proteins.

**Recommended Books**

1. Principle of Bio-Chemistry – Lehinger, Nelson and Cox
2. Biochemistry by L. Stryer
3. Fundamentals of Biochemistry – Voet&Voet
4. Biochemistry by Zubay.
5. Biochemistry, Rastogi, Tata McGraw Hill.
6. Introduction to Genomics - Arthur M Lesk, Oxford University Press, 2007

**Mini Project with Seminar (PPRBT201)**

**[To be decided by the Department]**

**Lab 3: Genetic Engineering Laboratory (PLCBT201)**

**List of Experiments:**

1. Cloning of Gene and screening of recombinants
2. Cloning of PCR products (T-A cloning)
3. Cloning in expression vector
4. Induction and expression of recombinant protein
5. Purification of recombinant protein using His tag
6. Quantitative expression analysis using real time PCR
7. Site directed mutagenesis
8. Fluorescent in situ hybridization (FISH)
9. Genetic transformation by Agrobacterium based and Biolistic based techniques.
10. Analysis of transgenic using molecular markers

**Lab 4: Current trends in Translational Biotechnology Laboratory (PLCBT202)**

**List of Experiments:**

1. Preparation of cell culture media and maintenance of aseptic condition
2. Different steps in the development of primary cell culture.
3. Cell passage, Enumeration of cell number
4. Cell viability study by MTT assay method, Trypan blue dye exclusion assay etc.
5. Cell proliferation assays.
6. Expression of recombinant proteins in cells.
7. Toxicological evaluation of products in suitable model system (In vitro, in vivo)
8. Diagnosis of diseases by biochemical methods
9. Immunoprecipitation reactions
10. Protein –protein interaction study

**Audit-2**

**[To be decided by the Department]: Refer Appendix-II**

**Semester-3**

**PE 5: Advanced Plant Biotechnology (PPEBT301)**

**Module-I**

Plant Genomics and Molecular Mapping: Introduction Genome mapping, Identification of candidate genes using genetic information (positional cloning), biochemical and expression analysis (microarray analysis, proteomics, metabolomics), Characterization and functional analysis of candidate genes using: transformation, mutant populations, knockout systems, Heterologous expression systems. Structural and Functional genomics, application of sequence based and structure based approaches to assignment of gene function.

**Module-II**

Gene transfer Techniques: Overview of different gene transfer methods, plant vectors for transformation, transgene analysis and expression. Indirect Gene transfer Methods: structural features of Ti plasmid, mechanism of gene transfer to plants Integration of T-DNA into plant genome, Molecular events in Agrobacterium mediated gene transfer. Direct gene transfer methods: Particle bombardment mediated transformation, Mechanism, Particle gun design, parameter for effective transformation, silicon carbide fiber mediated transformation and alternative methods.

**Module- III**

Genetic Engineering for Herbicide resistance: Genetic Engineering for Biotic and Abiotic Stress Resistance/Tolerance.

Applications in Agro-industry: Microbes in agriculture, Production and utilization of essential amino-acids, chemicals from micro-algae. Agro-waste utilization.

**Recommended Books**

1. Plant Molecular Biology, Grierson D. and Covey, S.N. 2nd ed., Blackie, 1988
2. Plant Biotechnology: The Genetic Manipulation of Plants, Slater A Oxford University Press, 2003
3. Plant Tissue & Organ Culture: Fundamental Methods. Gam burg O.L., Philips G.C. Nervosa, 1995.
4. Plant Biochemistry & Molecular Biology, Held, Hans-Walter,Oxford University Press, 1997
5. Advanced Plant Physiology, Wilkins M.B. ELBS, Longman, 1987.

**PE 5: Molecular Modelling and Drug Designing (PPEBT302)**

**Module-I**

Basic concepts of molecular structure (bond length, bond angle, torsion angle and non-covalent interactions: Molecular structure and internal energy: Energy minimization of small molecules, Empirical representation of molecular energies: Use of force fields and the molecular mechanics method –Discussion of global energy minimum: Molecular visualization. Molecular Dynamics and Monte Carlo simulation.

**Module-II**

Macromolecular modeling: Identification and mapping of active sites, Design of ligands for known macromolocular target sites. Drug-receptor interactions.Protein flexibility and Protein Docking, Classical SAR/QSAR studies and their Implications to the 3-D modeler. 2-D and 3-D database searching: pharmocophore identification and novel drug design.

**Module-III**

Enzyme background – Theories of enzyme inhibition - Enzyme inhibition as a tool for drug development – Structured-based drug design – structural bioinformatics in drug discovery - Examples.

**Recommended Books**

1. Molecular Modelling: Principles and Applications Andrew Leach, (2nd Edition), Addison Wesley Longman, Essex, England, 1996.
2. Modelling Molecular Structures, Alan Hinchliffe, 2nd Edition, John-Wiley, 2000.
3. Molecular Modelling for Beginners, Alan Hinchliffe, John-Wiley, 2003.
4. Guide Book on Molecular Modeling in Drug Design, N. Cohen (Ed.), Academic Press, San Diego, 1996.
5. Understanding Molecular Simulations. From Algorithms to Applications, D. Frenkel and B. Smith, Academic Press, San Diego, California, 1996.
6. X-ray crystallography and drug design, C. Rauter and K. Horn, Elsevier, 1984.
7. Whitlock, Monte Carlo Methods. M. Kalos and P. A. John Wiley & Sons, New York, 1986.
8. Harvey.Dynamics of Proteins and Nucleic Acids. J.A. McCammon and S.C. Cambridge University Press, Cambridge, 1987.
9. The Art of Molecular Dynamics Simulation. D.C. Rapaport. Cambridge University Press, Cambridge, England., 1995

**PE 5: Animal Biotechnology (PPEBT303)**

**Module-I**

Introduction to animal genomics: Different methods for characterization of animal genomes, SNP, STR, QTLS, RFLP, RAPD, proteomics, metobolomics.

DNA Forensics: Immunological and nucleic acid based methods for identification of animal species, Detection of food/feed adulteration with animal protein, Identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts confiscated by anti-poaching agencies.

**Module-II**

Artificial insemination, Super ovulation, in vitro fertilization, Culture of embryos, Cryopreservation of embryos, Embryo transfer, Embryo-splitting, Embryo sexing, Micromanipulation of animal embryos, Transgenic animal technology and its different applications, Ethical, social and moral issues related to cloning.

**Module-III**

Animal health Biotechnology: Introduction to the concept of vaccines, Conventional methods of vaccine production, Recombinant approaches to vaccine production, Hybridoma technology, Phage display technology for production of antibodies.

Animal disease diagnostic kits: Antigen-antibody based diagnostic assays including radioimmunoassay and enzyme immunoassays, Immunoblotting, Nucleic acid based diagnostic methods including nucleic acid probe hybridization, Restriction endonuclease analysis, PCR, Real time PCR, Nucleic acid sequencing, Commercial scale production of diagnostic antigens and antisera.

**Recommended Books**

1. Culture of Animal Cells. R. Ian Freshney. 3rd Edition, Wiley-Liss publication
2. Animal Cell culture Techniques. Martin Clynes, (Eds). Springer Publication
3. Concepts in Biotechnology. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), University Press, 1996.
4. A Text Book of Biotechnology. R. C. Dubey, S Chand Publication

**Open Elective**

**[To be decided by the Department]: Refer Appendix-III**

**Project 1: (PPRBT301)**

**[To be decided by the Department]: Dissertation (Phase-I)**

**Semester-4**

**Project 2: (PPRBT401)**

**[To be decided by the Department]: Dissertation (Phase-II)**