Biju Patnaik University of Technology, Orissa

Syllabus

for

M.Tech

in

Biotechnology

From 2010 -2011 Academic Session

Biju Patnaik University of Technology, Orissa

M.Tech in Biotechnology

Code	Title	Hours	Credit
Semester-I			
BTPC101	Biomolecules and Metabolic regulations	4-0-0	4
BTPC102	Bioprocess and Bioseparation Technology	4-0-0	4
BTPC103	Genetic Engineering	4-0-0	4
BTPE101	Plant Biotechnology	3-0-0	3
BTPE102	Animal Biotechnology		
BTPE103	Environmental Biotechnology		
BTPE104	Advanced Microbiology & Immunology	3-0-0	3
BTPE105	Food Process Biotechnology		
BTPE106	Pharmaceutical Biotechnology		
BTPR101	Techniques in Genetic Engineering	0-0-3	2
BTPR102	Microbial Biotechnology & Immunotechniques	0-0-3	2
BTPT101	On Research Paper & Pre Thesis review		2
			24
Semester-II			
BTPC201	Advanced Biochemical Engineering	4-0-0	4
BTPC202	Applied Bioinformatics	4-0-0	4
BTPE201	Genomics & Proteomics	3-0-0	3
BTPE202	Computational Biology		
BTPE203	Process control and Instrumentation		
BTPE204	Nanobiotechnology	3-0-0	3
BTPE205	Bioreactor design and optimization		
BTPE206	Metabolic engineering & metabolomics		
BTPE207	Protein Engineering	3-0-0	3
BTPE208	Molecular Modelling and Drug Designing		
BTPE209	IPR, Bioethics and Biosafety		
BTPR201	Bioinformatics	0-0-3	2
BTPR202	Bioreactor design and operations	0-0-3	2
BTPT201	Pre Thesis work		2
BTCV201	Comprehensive viva voce		2
			25

Semester-III			
Project	Thesis Part-I		14
Open elective (anyOne)	Data mining and Data ware housing	3-0-0	3
	Research Methodology		
	Human Resource management		
	Enterprise Resource Planning		
			17
Semester-IV			
BTPT401	Submission of Completed project		20
BTCV401	Presentation of the project		2
BTCV402	Evaluation of the Project		2
			24
			90

Total Credit = 90

Biomolecules and Metabolic regulations

Module-I

Macromolecular structure and dynamics: Configurations and conformations of macromolecules; interaction of biological macromolecules with water and non-aqueous environments; non-covalent (weak) forces that stabilize protein and nucleic acid structure; simulation of the structure of biological macromolecules including energy minimization, molecular dynamics and free energy methods.

Statistical thermodynamics of biological macromolecules: Partition functions, structural transitions in polypeptides and proteins including coil helix transitions, Structural transitions in polynucleic acids and DNA including melting and annealing of polynucleotide duplexes, helical transitions of double stranded DNA, prediction of helical structures in genomic DNA.

Biophysical techniques for analysis of biomolecules – Chromatography, X-ray crystallography, NMR, Mass spectrophotometry and UV spectrometry.

Module-II

Carbohydrate and lipid metabolism-Glycolysis, Krebs cycle, ETS, Energetics and regulation of these pathways, HMP pathway and its importance, Gluconeogenesis, Mechanism of Oxidative Phosphorylation, Fatty acid oxidation and their metabolic routes of carbon, biosynthesis of lipids (fatty acids and sterols), Glycogen metabolism.

Protein metabolism: Oxidative deamination, decarboxylation,and transamination reactions, Urea cycle, Aminoacid synthesis by microorganisms. Central role of Glutamine. Synthesis of Nucleotides, and salvage pathways.

Module-III

Integration of metabolism and concept of metabolic regulation: Elucidation of metabolic pathways; Logic and integration of central metabolism; 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.Organ (Brain, Muscle, Liver) specialization, Metabolic adaptation, Metabolic changes associated with plant development and senescence and its regulation.

Bioprocess and Bioseparation Technology

Module-I

Concepts of Bioprocess and its parameters: Introduction to bioprocess, Instrumentation and operation of bioreactor; Culture-specific design aspects: Plant/Mammalian cell culture reactors. Biomass clarification and disruption; Membrane-based techniques; Extraction; Adsorption and Chromatography

Kinetic models: Stoichiometric analysis; Unstructured Models of growth, substrate utilization and product formation, Transient growth Kinetics, Structured kinetic Models of growth and product formation.

Measurement and control of Bioprocess: On and off-line sensors for a modern bioreactor, Analysis of cell and medium composition,

Module-II

Bioreactor Design, Analysis and Applications: Ideal and Non-Ideal reactors, mixing and residence time distribution studies in a bioreactor. Packed Bed, Bubble columns, fluidized bed and trickle bed bioreactors, Immobilized cell based bioreactor; Bioreactor design for animal cell culture, Bioreactor design for waste treatment.

Bioseparation-I: Theory, Numericals and Applications of Separation of cells and other insolubles from fermented broth. Microfiltration, Ultrafiltration and Nanofiltration, Centrifugation (batch, continuous).

Module-III

Bioseparation-II: Theory, Numericals and Applications of

1. Chromatography: Adsorption chromatography, Ion- exchange, gel-filtration, affinity, high pressure / performance liquid chromatography (HPLC), hydrophobic interaction chromatography. Reverse phase (RP) and thin layer chromatography (TLC).

2. Separation of soluble bio-products: Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption.

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Genetic Engineering

Module-I

Restriction enzymes, modification enzymes, DNA and RNA markers, Linker, adapter, MCS and its application in r-DNA technology, Gene cloning vectors- Plasmids, Bacteriophages, Phagemids, Cosmids, Artificial chromosomes (BAC, PAC, YAC). cDNA synthesis and cloning-mRNA entrapping and reverse transcription, , c-DNA Library construction and screening. Genomic DNA library- construction and screening. Alternative strategies of Gene cloning- Cloning interacting genes, Two and three hybrid systems. Cloning differentially expressed genes.

Module-II

Nucleic acid purification, yield analysis, Nucleic acid amplification and its applications, Restriction mapping of DNA fragments and Map construction, Nucleic acid sequencing- strategies and methodologies, Nucleic acid micro arrays and DNA Chips, DNA Finger printing and Footprinting. Gene regulation analysis-DNA transfection, Northern blot, Primer extension, SI mapping, RNase protection assay, Reporter assays and Phage display

Module-III

Protein Engineering- strategies and applications, Processing recombinant proteins-purification and refolding, characterization of recombinant proteins, stabilization of proteins. Site-directed mutagenesis, Expression strategies for Heterologous genes-Vector engineering and codon optimization, Cassette construction, host-engineering, in vitro transcription and translation, expression in bacteria, expression in yeast, expression in insects and insect cells, expression in mammalian cells, expression in plants. T-DNA and transposon tagging, Gene knockout technologies- Targeted gene replacement, chromosome engineering. Gene therapy-Vector engineering, Strategies of gene delivery, gene replacement/augmentation, gene correction, gene editing, gene regulation and silencing.

Professional Electives:

Plant Biotechnology

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. Molecular marker and its type (RFLP, RAPD, AFLP, SSR, STS, EST, SNP); Constructing molecular maps; Molecular tagging and mapping of genes/traits; Marker assisted selection of qualitative and quantitative traits. Construction of genetic and physical map; Gene mapping and cloning; QTL mapping and cloning; Nucleic acid and Protein arrays: basic principles, instrumentation and applications in plant genomics, Identification of disease genes.

Module-II

The Gene transfer Techniques for the production of Transgenic: 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. Reporter genes, Selectable and scorable markers, Binary and Co-integrative vectors, Removal of marker genes, Applications and limitations of Agrobacterium gene transfer, Concept of marker free transgenic plants. Plastid engineering: Introduction, importance, scope and technique.

Module-III

Crop Improvement and Agro-industrial biotechnology: Genetic Engineering for Herbicide resistance; Genetic Engineering for Biotic and Abiotic Stress Resistance/Tolerance; Genetic engineering for Improvement of crop yield and quality: Protein, lipids, carbohydrates, vitamins & mineral nutrients; Applications in Agro-industry: Microbes in agriculture , Production and utilization of essential amino-acids, chemicals from micro-algae. Agro-waste utilization; Mycorrhiza in agriculture and forestry.

Animal Biotechnology

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

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; 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; Animal disease diagnostic kits; Probiotics.

Structure of sperms and ovum; Cryopreservation of sperms and ova of livestock; 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 genomics: Introduction to different breeds of cattle, buffalo, sheep, goats, pigs, camels, horses, canines and poultry; Genetic characterization of livestock breeds; Marker assisted breeding of livestock and poultry; Introduction to animal genomics; Different methods for characterization of animal genomes, SNP, STR, QTLS, RFLP, RAPD, proteomics, metobolomics; Genetic basis for disease resistance; Gene knock out technology and animal models for human genetic disorders.

DNA Forensics: Immunological and nucleic acid based methods for identification of animal species; Detection of adulteration in meat using DNA based methods; 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; Human forensics; Microbial forensics; Bioterror agents; Biocrimes and Bioterrorism.

Environmental Biotechnology

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; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-mineralization; Biofuels; Bioethanol and biohydrogen; Energy management and safety

Module-II

Pollution: Enviromental 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; Green house 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, microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria, fungi, plants, enzymes, and GE organisms; Plasmid borne metabolic treatment; Bioaugmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Macrophytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy, distillery, tannery, sugar and antibioticindustries; 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, Biomicroelectronics 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.

Advanced Microbiology and Immunology

Module-I

Microbial Diversity & Systematics: Classical and modern methods and concepts; Domain and Kingdom concepts in classification of microorganisms; Criteria for classification; Classification of Bacteria according to Bergey's manual; Molecular methods such as Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Amplified rDNA Restriction Analysis 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 and its kinetics, Models of growth kinetics; Microbial processes-production, optimization, screening, strain improvement, factors affecting down stream processing and recovery; Representative examples of ethanol, organic acids, antibiotics etc.

Enzyme Technology-production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease, penicillin acylase, glucose isomerase; Immobilised Enzyme and Cell based biotransformations 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, Immunoflourescence, flow cytometry and immunoelectron microscopy, lymphoprofileration assay, mixed lymphocyte reaction, cell cytotoxicity assays, microarrays, transgenic mice, gene knock outs.

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Food Process Biotechnology

Module – I

Biotechnology for food production: History; Developments and current status of transgenic crops for: Crop improvement & enhanced agronomic performance; Food products with enhanced shelf-life; Processing and functional quality; Nutritional enhancement-macro and micro-nutrients; Plant vaccines and antibodies

Applications of enzymes in food processing: Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; HFCS; Interesterified fat, hydrolyzed protein etc. and their downstreamprocessing; Baking by amylases; Deoxygenation and desugaring by glucoses oxidase; Beer mashing and chill proofing; Cheese making by proteases and various other enzyme catalytic actions in food processing.

Module –II

Applications of Microbes in food process operations and production: Fermented foods and beverages; Food ingredients and additives prepared by fermentation and theirpurification; Fermentation as a method of preparing and preserving foods; Microbes and their use in pickling; Producing colours and flavours, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.

Bioprocessing of food for nutraceuticals –Lipid based nutraceuticals , polar lipid, PUFA, protein.Polysaccharide,nucleotide, other small molecular weight compounds Functional Food production - Dietary fibre, Food Gum, Emulsifier & Surfactant, Artificial Butter, Favoring agent , Alternative Sweetener , Antioxidant , Preservatives.

Module –III

Biotechnology applications in the production of additives / ingredients: Enzymes, carotenoids, amino acids, organic acids, vitamins, antibiotics, colouring, flavours and nutraceuticals; Biotechnology applications in the production of new protein foods- Single cell proteins (SCP) mushroom, food yeasts, algal proteins

Safety assessment of genetically modified (GM) foods: International and National guidelines; Regulations & safety issues related to production, consumption, import/export and labeling of GM foods.

Pharmaceutical Biotechnology

Module- I

Introduction History of pharmacy; The pharmaceutical industry & development of drugs; Economics and regulatory aspects; Quality management; GMP.

Drug kinetics and biopharmaceutics Mechanism of drug absorption, distribution, metabolism and excretion – factors affecting the ADME process; Bioequivalence; Pharmacokinetics.

Module- II

Principles of drug manufacture Liquid dosage forms – solutions, suspensions and emulsions; Topical applications – ointments, creams, suppositories; Solid dosage forms – powders, granules, capsules, tablets, coating of tablets; Aerosols; Preservation; Packing techniques.

Advances in drug delivery Advanced drug delivery systems – controlled release; Transdermals, Liposomes and drug targeting.

Module-III

Biopharmaceuticals Understanding principles of pharmacology, pharmacodynamics; Study of a few classes of therapeutics like Recombinant therapeutics, Monoclonal Antibodies, Vaccines, Gene therapy, Antibiotics and Hormones.

Immunogenicity of biopharmaceuticals: Immunogenicity; Factors contributing to immunogenicity (product related factors, host- related factors), Consequence of immunogenicity to biopharmaceuticals; Measurement of immunogenicity. Case studies: Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocyte-macrophage-CSF, DNase, Factor VIIa, Factor IX, Factor VIII, Activated protein C, Tissue plasminogen activator, Monoclonal antibodies etc.

Techniques in Genetic Engineering Lab

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. Demonstration of microarray technique and instrumentation
9. FISH
10. Agrobacterium based genetic transformation
11. Biolistic based genetic transformation
12. Analysis of transgenic using molecular markers

Microbial Bioechnology & Immunotechniques Lab

1. Microbial strain development, identification and screening
2. Ribotyping of microbial strains
3. Marker based genotyping of microbial strains
4. Production and optimization of ethanol using different strains
5. Production and optimization of citric acid using difeerent strains of Aspergillus
6. Antibody production
7. 2-D GE based characterization of immunoglobulins
8. ELISA
9. Flow Cytometry
10. Counter Current Immunoelectrophoresis

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Advanced Biochemical Engineering (BTPC 201)

Module-I

Concept of ideal reactors based on flow characteristics, design of ideal reactors using material and energy balance equations. Single reactors, with ideal flow condition, comparison of volumes of plug flow reactor and chemostat. Multiple reactors-methods to show how total volume is affected in multiple reactors.Searching for mechanism – Arrhenius equation – Batch reactor analysis for kinetics (synchronous growth and its application in product production).

Module-II

Growth Kinetics: Batch growth quantifying cell concentration, growth profiles and kinetics in batch culture, fed batch growth, continuous growth and their growth kinetic quantification, chemostat growth, semi-continuous / exponential feeding strategy. Maximizing the yield of intermediate product in series reactions Design principles – Non isothermal reactions and pressure effects; Non-ideal flow in bioreactors-reasons for non-ideality, concept of RTD studies, characterization of non-ideality using RTD studies, various distribution functions, conversions using tracer studies. Diagnosing the ills of non ideal bioreactors, various models of non ideal flow.

Module-III

Design and analysis of bioreactors-stability and analysis of bioreactors, biomass production and effect of dilution rate. Design and operation of various bioreactors, viz CSTF, fed batch systems, air-liftbioreactors, fluidized bed bioreactors. Scale up of bioreactors. Criteria for selection of bioreactors.

Applied Bioinformatics (BTPC 202)

Sequence-alignment methodologies: Sequence databases; Similarity matrices; Pairwise alignment: Features of dynamic Programming, alignment by Bayesian Statistical Methods, multiple sequence alignment: local multiple sequence alignment: MEME, PSSM, HMM(algorithms and applications) Progressive methods for global multiple sequence alignment: CLUSTALW, PILEUP, T-COFFEE; Statistical significance of alignment results;

Pattern analysis in sequences and Phylogenetic tree construction methods: Motif representation, Markov models; .Distance Based methods: clustering based methods,optimality based methods: Fitsch -Margoliash and Minimum evolution methods, Neighbor joining and related neighbor methods Character Based methods: Maximum parsimony methods, Maximum likely hood method, genetic algorithm, Phylogenetic tree evaluation: Boot strap analysis; dendrogram and applications

Structure-Prediction of Biomolecules with applications in Bioinformatics: Structure classification of proteins (SCOP, CATH); Secondary structure prediction of various protein categories (e.g transmembrane proteins and helical proteins), RNA secondary structure prediction methods. Patterns, motifs and Profiles in sequences: Derivation and search methods; Derived Databases of patterns, motifs and profiles e.g Prosite, Blocks, Prints-S, Pfam; Overview of tertiary structure prediction methods; algorithms for modeling protein folding; algorithms for 3D structure prediction with representative examples Protein structure prediction by comparative modelling approaches (homology modeling and fold recognition); ab initio structure prediction methods

Genomics & Proteomics (BTPE 201)

Unit I Introduction

Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNAmitochondrial, chloroplast; DNA sequencingprinciples and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

Unit II Genome sequencing projects

Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, EST's and SNP's.

Unit III Proteomics

Protein analysis (includes measurement of concentration, aminoacid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDITOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

Unit IV Pharmacogenetics

High throughput screening in genome for drug discoveryidentification of gene targets, Pharmacogenetics and drug development

Unit V Functional genomics and proteomics

Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein *in situ* arrays; Structural proteomics

Texts/References:

1. Voet D, Voet JG & Pratt CW, Fundamentals of Biochemistry, 2nd Edition. Wiley 2006
2. Brown TA, Genomes, 3rd Edition. Garland Science 2006
3. Campbell AM & Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings 2007
4. Primrose S & Twyman R, Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 2006.
5. Glick BR & Pasternak JJ, Molecular Biotechnology, 3rd Edition, ASM Press, 1998.

Computational Biology (BTPE 202)

Module- I

Biological Databases: Primary and Secondary Databases; GenBank, EMBL, DDBJ, Swissprot, MIPS, PIR, TIGR, Hovergen, TAIR, PlasmoDB, ECDC, Protein and Nucleic Acid Sequences databases.

Search Algorithms*:* Scoring Matrices and their use; Computational complexities; Analysis of Merits and demerits; Sequence pattern; Pattern databases; PROSITE, PRINTS, Markov chains and Markov models; Viterbi algorithm; Baum- Welch algorithm; FASTA and BLAST Algorithm; Needleman-Wusch & Smith-Waterman algorithms

Module- II

Structure and Analysis: Representation of molecular structures; External and internal co-ordinates; Concept of free energy of molecules; Introduction to various force fields; Molecular energy minimization techniques; Monte Carlo and Molecular Dynamics simulation

Molecular structure Determination: Principle of X-ray crystallography and NMR spectroscopy; 2D Protein Data bank and Nucleic Acid Data bank; Storage and Dissemination of molecular structures

Module- III

Modeling & Drug design: Homology modeling; Threading; Structure prediction; Structure-structure comparison of macromolecules; Simulated docking; Drug design; molecular dynamics simulation, Docking methods, Drug design Process, drug like Property of a molecule, target identification, Drug design process for a known and unknown target. 2D and 3D QSAR; Ligand databases

PROCESS CONTROL & INSTRUMENTATION (BTPE 203)

- Mercuty thermomoter, step function, impulse function, sunusoidal function, step response, impulse response, sinusoidal response, liquid level system, mixing process, RC circuit, Linearization, non-interacting & interacting systems, High order & second order systems. Transportations lag.
- The control system – basics, development of block diagram, control valve, controller, P-control, PI – control, PD – control, PID control. Overall transfer function for single loop systems, for change in set point, for change in load. Overall transfer function for multiloop control systems. Concept of stability, stability criterion. Routh test for stability.
- The Bode stability criterion, ziegler-Nicholas controller settings, Cascade control, Feed forward control. Ratio control, Smith predictor. Internal model control, controller tuning, Ziegler – Nicholas rules, Cohen and Coon rules, process identification, control valve, vlve sizing, valve characteristics, valve positioner.

TEXT BOOKS:

1. 'Process Systems analysis and Control', D.R. Coughanour, McGraw-Hill, 2nd Edition, 1991.
2. 'Process Dynamics and Control', D.E. Seborg, T.F. Edger, and D.A. Millichamp, John Wiley and Sons, 2nd Edition, 2004.

REFERENCES:

1. 'Principle and Practice of Automatic Process Control', C.A. Smith and A.B. Corripio, 3rd ed., John Wiley and Sons, 2005.
2. 'Process Modelling Simulation and Control for Chemical Engineers', W.L .Luyben, McGraw Hill, 2nd Edition, 1990.
3. 'Chemical Process Control – Theory and Practice', Stephanopoulous, Prentice Hall of India Ltd.,.1984.

NANOBIOTECHNOLOGY (BTPE 204)

- Introduction and scope of NanoBiotechnology, comparision of Biotechnology to Nanobiotechnology

- Nanobiomacines: Negligible gravity and intertia, atomic granularity, thermal motion, water environment and theri importance in nanobiomachines. The role of proteins, amino acis, nucleic acids, lipids and polysaccharides in modern biomaterials. Overview of natural Bionanomachines; Thymidylate synthetase, ATP synthetase, Actin and myosin, opsin, Antibodies and collagen.

- Synthesis of Biomolecules: Recombinant Technology, Site-directed mutagenesis, Fusion Proteins. Quantum Dot structures and their integration with biological structures. Tools of Analysis: X-Ray crystallography, NMR spectroscopy, Electron microscopy and Atomic force microscopy. Molecular modeling tools: Graphic visualization, structure and functional prediction, Protein folding prediction and the homology modeling, Docking simulation and Computer assisted molecular design.

- Structural principles of Nanobiotechnology raw matertials: Factors governing biomolecular structure and stability, Protein folding; Self assembly, Self-organization, Molecular recognition and Flexibility of biomaterials.

- Functional principles of Nanobiotechnology: Information driven nanoassembly, Energetics, Role of enzymes in chemical transformation, allosteric motion and covalent modification in protein activity regulation, Structure and functional properties of Biomaterials, Bimolecular motors: ATP Synthetase and flagellar motors, Traffic across membranes: Potassium channels, ABC Transporters and Bactreriorhodapsin, Bimolecular sensing, Self replication, Machine-Phase Bionanotechnology.

- Fields of Application: Designer proteins, Peptide nucleic acids, Nanomedicine, Drug delivery, DNA computing, Molecular design using biological selection, Harnessing molecular motors, Artificial life, Hybrid materials, Biosensors, Future of Bionanotechnology.

Text books:

1. David S Goodsell , Bionanotechnology, John Wiley & Sons, 2004.
2. Greco Ralph S , Nanoscale Technology in Biological Systems, CRC Press, 2005.

Bioreactor Design and Optimization (BTPE 205)

Module- I: Principles and concepts

Recapitulation of the principles of Kinetics for chemical and Bio-chemical Reactions. Fundamentals of homogeneous reactions for batch / semi-batch, plug low reactor (PFR), continuous stirred rank reactors (CSTR), fluidized bed reactor bubble column, air lift fermenter etc, stirred tank/mixed reactors., adiabatic and programmed reactors.

Unconventional bioreactors: Hollow fiber reactor, membrance reactor, perfusion reactor for animal and plant cell culture.

Module- II: Bioreactor Analysis

Analysis of ideal bioreactors: Fed-Batch reactors, Enzyme catalyzed reactions in CSTRs, CSTR reactors with Recycle and Wall growth, Ideal Plug- Flow Tubular reactor.

Analysis of Non-ideal Reactor Analysis: Concept of ideal and non-ideal reactor; residence time distribution; models of non-ideal reactors – plug flow reactor for microbial processes; Mass transfer in biochemical processes; Multiphase bioreactors – packed bed with immobilized enzymes or microbial cells; three – phase fuidized bed trickling bed reactor; Design and analysis of the above reactor systems; Gas liquid reactors, Reactor stability.

Module- III: Bioreactor Design

Design considerations: oxygen transfer, heat transfer, rheology, mixing. Scale up and scale down concepts.Bioprocess control and computer coupled bioreactors; Growth and product formation by recombinant cells. Mechanical fittings in a bioreactor: vessel, agitation system materials, welds, finish, valves, piping and valves for biotechnology, special requirements of utilities and cleaning of production plants.

Instrumentation and control of bioprocesses: Physical and chemical sensors, online sensors for cell properties, off-line analytical methods; Biosensors. Bioreactor design calculations

Books

1. Levenspiel, O., Chemical Reaction Engineering, Wiley Eastern Ltd.
2. Bailey & Olis, Biochemical Engg. Fudamentals, MGH.,1990
3. Atkinson, B.,Biological Reactors, pion Ltd., London,1974.

Coulson, Richardson, Sinnott, An introduction to chemical engineering design, Pergamon Press. Lydersen, D'Elia, Nelson, Bioprocess engineering: Systems and equipment.

METABOLIC ENGINEERING AND METABOLOMICS (BTPE 206)

- Overview of Molecular biology and cellular metabolism. Metabolic regulations network at enzyme level and whole cell level.
- Basic concepts of Metabolic Engineering: Identification of metabolic regulation- a key point in metabolic engineering. Overview of cellular metabolism, Different models for cellular reactions, induction – Jacob Monod model and its regulation, Differential regulation by Isozymes, Feed back regulation.
- Modeling of metabolic networks: Stoichiometry, kinetics, mass balances for the steady state, mass balances for the transient case.
- Metabolic flux analysis: Linear programming, Cell capability analysis, Genome scale Isotope labeling, Integration of anabolism and catabolism. Experimental determination method of flux distriction. Metabolic flux analysis and its applications, Thermodynamics of cellular processes.
- Metabolic control analysis: Nonlinear programming, synthesis and design of metabolic networks – inter programming, mixed integer nonlinear programming case studies – ethanol production, amino acid biosynthesis, metabolism in bacteria and yeast.
- Metabolic engineering with bioinformatics: Metabolic pathway modeling, Analysis of metabolic control and the structure, metabolic networks, Metabolic pathway synthesis algorithms.
- Applications of Metabolic Engineering: Application in Pharmaceuticals, Chemical bioprocess, food technology, agriculture, environmental bioremediation and biomass conversion.

Text and References:

1. Metabolic Engineering: Principles and Methodoligies; G. Stephanopoulos, A.A. Aristidou, J.S. Neilson (1998) Academic Press
2. Metabolic Engineering; S.Y. Lee & e.T. Papoutsakis (1999) Marcel Dekker
3. Biochemistry by J.M. Berg, J.L. Tymoczko nd Lubert Stryer (2002) W.H. Freeman, New York
4. Understanding the Control of Metabolism by David Fell (1997) Portland Press, London.
5. Metabolism at a Glance by J.G. Salway (1994) Blackwell Scientific Publications
6. Systems Biology; Properties of Reconstructed Networks. B.O.Palsson, Cambridge Univ. Press, 2006.
7. Modeling Metabolism with Methematica,P.J.Mulquiney & P.w.Kuchel,CRC Press,2003
8. Pathway Analysis and Optimization in Metabolic Engineering, N.V. Torres and E.O. Vit, Cambridge Univ Press, 2002.
9. Flux balance analysis: Current Opinion in Biotechnology (2003) 14:491 – 496, Nature Reviews Microbiology (2004) 2: 886 - 897

PROTEIN ENGINEERING (BTPE 207)

- Protein – General introduction, structural hierarchy in proteins, forces that determine protein structure and physicochemical properties. Mechanism of protein folding, characterization of folding pathways.
- Determination of Protein structure: various spectroscopic techniques for protein structure determination. Background and basic principles, absorption and fluorescence, circular dichroism, FR-Raman, FT – IR, NMR, X-ray crytallography, MALLS.
- Synthetic and semisynthetic peptides and proteins, Chemical modification of proteins, chimeragenesis of proteins for understanding enzyme mechanism, chemical methods for mimicking post-translational modifications, protein modification as result of technological processes: thermal, physical, pressure, solvents, interactions.
- Site directed mutagnesis for specific protein function, basic concepts for design of a new protein molecule, specific examples of enzyme engineering

Text & Reference Books:

1. Yada R.Y; Jackman, R.L.; Smith J.L; Protein structure-Function Relationships, Blakie Academic and Professional, London
2. Clark R.J. H. And Hester R.E.; Spectroscopy of Biological systems, John Wiley and Sons, New York
3. Caroline Kohrer, Uttam L. RajBhandary; Protein Engineering, Springer

MOLECULAR MODELING & DRUG DESIGN (BTPE 208)

- Quantum chemistry for Modling of small molecules: Variation method and Time independent Perturbation theory, Ab initio methods for molecules; Hartree-Fock SCF method. Introduction to UHF, electron correlation, CI and density functional theory. Introduction to semi-emperical methods: Huckel molecular orbital theroy, Pariser – Parr – Pople method. CNDO, AM1 and PM3.
- Force fields for molecular modeling, Free energy calculations. Potentials of mean force, molecular surface area and solvent accessible surface area. Solvation models, explicit water models, continuum models. Structure functions studies of the G-protein coupled receptors with emphasis on adrenergic receptor.
- Conformational Analysis: Geometry optimization using steepest descent and conjugate gradients. Distance geometry, Monte-carlo simulation. Molecular dynamics and simulated annealing. Prediction of transmembrane segments in membrane proteins. Protein 3D structure prediction: Comparative modeling, Threading and fold prediction. Methods based on minimization of energy.
- Ligand based drug design: SAR, QSAR and 3D-QSAR, Partial least squares and Molecular field analysis (COMFA). 3D-Pharmacophores, Deriving 3D pharmacophores (Constrained systematic search, Ensemble distance geometry, Ensemble molecular dynamics, genetic algorithms, clique detection, maximum likelihood).
- Receptor based drug design: computational methods for identification of plausible binding sites. Molecular docking (rigid body and flexible docking). Receptor based de novo lignad design.

Text Books and References:

1. Molecular modeling, Principles and Applications – Andrew R. Leach, 2nd Ed(2007) Prentice Hall.
2. Structural Bioinformatics. Ed. P.E. Bourne and H. Weissing (2003) Wiley-Liss
3. Molecular quantum mechanics. P. Atkins and R. Friedman. 4th Ed (2005) Oxford University Press
4. Textbook of drug design and discovery, Poul Krogsgaard – Larsen et an (2002) Taylor and Francis publishers.

BTPE 209 **BIOETHICS, BIOSAFETY AND IPR**

BIOTECHNOLOGY AND SOCIETY: Introduction to science, technology and society, issues of access-Case studies/experiences from developing and developed countries. Ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, biological spots, environmental sustainability, Food and agricultural organization, biotechnology in international relations, globalization and development divide. Public acceptance issues for biotechnology: Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries.

BIOETHICS

Principles of bioethics: Legality, morality and ethics, autonomy, human rights, beneficence,privacy, justice, equity etc. The expanding scope of ethics from biomedical practice to biotechnology, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and other global biotech issues.

BIOSAFETY CONCEPTS AND ISSUES

Ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, Biotechnology and biosafety concerns at the level of individuals, institutions, society, region,

BIOSAFETY IN THE LABORATORY

Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution. Experimental protocol approvals, levels of containment.

REGULATIONS

Biosafety assessment procedures in India and abroad. International dimensions in biosafety, HACCP, bioterrorism and convention on biological weapons. Social and ethical implications of biological weapons. Biosafety regulations and national and international guidelines with regard to

recombinant DNA technology. Guidelines for research in transgenic plants. Good manufacturing practice and Good lab practices (GMP and GLP). National and international regulations for food and pharma products. 08 Hours

ECOLOGICAL & FOOD SAFETY

The GM-food debate and biosafety assessment procedures for biotech foods & related products,including transgenic food crops, case studies of relevance. Ecofriendly case studies.

AGRI & PHARMA SECTOR

Plant breeder's rights. Legal implications, Biodiversity and farmers rights. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc. Biosafety issues in Clinical Trials.

Texts/References:

1. BAREACT, Indian Patent ACT 1970 Acts & Rules, Universal Law Publishing Co.Pvt Ltd., 2007.
2. Kankanala C., Gentic patent Law and Strategy, 1st Edition, Manupatra Information Solution Pvt Ltd. 2007.
3. Important Links
   www.w3.org/IPR
   www.wipo.int/portal/index.html.en
   www.ipr.co.uk/IP_conventions/ptent_cooperation_treaty.html
   www.patentoffice.nic.in
   www.iprlawindia.org/-31k-Cached – Similar page
   www.cbd.int/biosafety/background.shtml

- **BIOINFOR LAB (BTPR 201)**

  As per the theory syllabus

- **BIOREACTOR DESIGN AND OPERATION LAB (BTPR 202)**

  As per the theory syllabus