BASAVESHWAR ENGINEERING COLLEGE, BAGALKOTE
DEPARTMENT OF BIOTECHNOLOGY

B. E. V SEMESTER

Sl. No	Category	Subject Code	Subject Title	Credits	Hours/ Week			Examination Marks		
					L	T	P	CIE	SEE	TOTAL
1.	PCC	21UBT501C	Bioinformatics	03	3	0	0	50	50	100
2.	IPCC	21UBT502C	Genetic Engineering & Applications + lab	04	3	0	2	50	50	100
3.	PEC	21UBT5XXE	Elective –I	03	3	0	0	50	50	100
4.	OEC	21UXX5XXN	Open Elective-I	03	3	0	0	50	50	100
5.	PCCL	21UBT503L	Bioinformatics Lab	01	0	0	2	50	50	100
6.	AEC	21UHS521C	Quantitative Aptitude and Professional Skills	02	2	0	0	50	50	100
7.	INT	21UBT504I	Summer Internship – II	03	0	0	4	100	-	100
8.	HSMC	21UBT523C	Environmental Studies	01	1	0	0	50	50	100
			Total	**20**	**15**	**0**	**08**	**450**	**350**	**800**

Elective-I

21UBT511E: Environmental BT
21UBT512E: Nutraceuticals
21UBT513E: Computational Biology
21UBT514E: Protein Engineering and Drug Design
21UBT515E: Environmental BT

Open Elective-I

21UBT532N: Biofuels Technology

21UBT501C	BIOINFORMATICS	Credits: 3
L: T: P – 3-0-0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	12 Hrs.
Introduction to Bioinformatics and Biological Database Introduction to bioinformatics, Components of bioinformatics and interdisciplinary nature of bioinformatics, Classification of biological databases; Primary database: NCBI, GenBank, DDBJ and EMBL, PIR, Uniprot; Secondary databases: PROSITE, PRINTS, BLOCKS and Pfam; Structure databases: Protein Data Bank (PDB), MMDB, CATH, SCOP; Specialized databases: PubMed, OMIM, Metabolic Pathway-KEGG;ExPasy and PubChem databases, File format: GenBank flat file, PDB flat file. Tutorials: Practices on other primary and secondary databases	
UNIT–II	**10 Hrs.**
Sequence alignment and database searches: Introduction, Types of sequence alignment, Comparison between global and local alignment, Pairwise sequence alignment: Dot matrix analysis, Dynamic programming, Global alignment-Needleman-Wunch algorithm, Local Alignment-Smith & Waterman algorithm, Substitution matrix- BLOSUM and PAM; GAP Penalty; Low complexity regions;Word/k-tuple method- BLAST, FASTA. Multiple Sequence Alignment:Introduction, applications of MSA; Types of MSA: Progressive method of MSA-Clustal W; Iterative method of MSA; Motifs and Patterns; Statistical models of MSA-Position Specific Scoring Matrix (PSSM) and Profiles. Tutorials: Solving problems on pairwise sequence alignment	
UNIT–III	**10 Hrs.**
Phylogenetic analysis and predictive methods using sequences Introduction, concepts of trees, types of evolutionary trees, Rooted and unrooted trees, Steps in constructing phylogenetic trees,Tree building methods - Distance based methods: Neighbor Joining (NJ) method, Fitch-Margoliash (FM) method; Character based method: Maximum parsimony; Tree Evaluation methods, Phylogenetic Softwares. Predictive Methods using sequences: Structure of Prokaryote and Eukaryote genes; Algorithms for Prokaryotic and Eukaryotic gene prediction, Web based tools for gene prediction (ORF finder, GenScan).Protein Secondary Structure Prediction, Tertiary Structure Predictions: Homology modelling. Tutorials: Practices on prediction of phylogenetic trees	

UNIT–IV	10 Hrs.

Plasmid mapping and primer designing &molecular modelling techniques

Restriction mapping, Web based tools: Restriction Mapper and REBASE. Utilities of Mac Vector and Vector NTI; Basics of Primer designing, Primer design softwares (PRIME3). Rational Approaches in Drug Design, molecular docking, deriving the Pharmacophoric Pattern, quantitative structure-activity relationship (QSAR), deriving bioactive conformations, Calculation of Molecular Properties,Dockingsoftwares (AUTODOCK, HEX)

Tutorials: Solving problems related to Restriction mapping and Primer designing

REFERENCE BOOKS *

1. Introduction to Bioinformatics – Arthur Lesk, Oxford, 2nd Edition,2006.
2. Bioinformatics – Stuart M Brown, NYU Medical Center, NY USA. 2000.
3. Fundamental Concepts of Bioinformatics – D E Krane & M L Raymer, Pearson, 2006.
4. Computational methods for macromolecular sequence analysis – R F Doolittle. Academic Press, 1996.

COURSE OUTCOMES**

After completion of the course student will be able to

1. Importance of databases involved in bioinformatics along with their file formats
2. Will have idea on searching similar sequences in databases and find similarity between given set of sequences
3. Derive evolutionary relationship between genes and proteins by phylo-genetic analysis
4. Explain various statistical tools involved in predicting the structure of genes and proteins
5. The principle behind restriction mapping and primer designing
6. Different approaches involved in silico drug design

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO 1	3	2	-	-	2	1	2	2				3	2	2	3
CO 2	3	2	2	2	2	1	2	-				3	2	2	3
CO 3	3	2	-	1	-	-	2	-				3	2	2	3
CO 4	2	2	-	1	-	2	-	-				3	1	-	2
CO 5	2	2	2	1	-	2	-	2				1	2	-	2
CO 6	2	1	2	2	2	2	1	1				1	1	1	1

21UBT502C	GENETIC ENGINEERING & APPLICATIONS	Credits: (4: 0: 0)
L: T: P – 3-0-2		CIE Marks: 50
Total Hours/Week: 5		SEE Marks: 50

UNIT-I	10 Hrs.

Introduction

Tools of genetic engineering- vectors in recombinant DNA technology, biology and salient features of vectors, Types of vectors - plasmids, cosmids, bacteriophage lambda vectors.

Enzymes in genetic engineering:

Introduction- Restriction Endonucleases-classification, mode of action, applications. Enzymes used in nucleic acid modification – Alkaline phosphatase, polynucleotide Kinase, Ligases, terminal deoxy nucleotidyl transferase

UNIT–II	10Hrs.

Nucleic acid hybridization and amplification

Methods of nucleic acid detection, Fluorescent In situ hybridization (FISH), colony hybridization, polymerase chain reaction (PCR), its types and applications, methods of nucleic acid hybridization, Southern, Western and Northern hybridization techniques.

Construction of cDNA libraries:

Construction of Complementary DNA (cDNA), genomic DNA libraries and cDNA libraries.

UNIT–III	10 Hrs.

Gene transfer techniques

Gene transfer techniques in plants, animals and microbes –Transformation, microinjection, electroporation, microprojectile system, and liposome mediated transfer, embryonic stem cell method. Agrobacterium-mediated gene transfer in plants – Ti & Ri Plasmid: structure and functions, Ti based vectors- Binary vectors and Cointegrate vectors.

Transgenic science and genetic improvement:

Transgenic science in plant improvement, Antisense RNA technology (Flavr savr tomatoes). Application of plant transformation for productivity and performance – Herbicide resistance - glyphosate. insect resistance - Bt genes(*Bacillus thuringiensis* and its mode of action), Cry proteins – mechanism of action.

UNIT–IV	10 Hrs.

Gene therapy

Introduction, Methods of Gene therapy-gene targeting, gene augmentation, assisted killing, prodrug therapy and gene silencing. Gene therapy in the treatment of cancer, SCID, muscular dystrophy. Use of thrombolytic agents in blood clotting. Challenges in gene therapy.

Applications:

Engineering microbes for the production of Insulin, growth hormones, monoclonal antibodies.

REFERENCE BOOKS

1. Molecular Biotechnology, Principles and applications of Recombinant DNA by Bernard R Glick and Jack J Pasternak, second edition, CBS Publishers, 2012.
2. Recombinant DNA by Watson, et al., second edition, Freeman Publishers 2010.
3. Principles of gene manipulation, Primrose S.B., Blackwell Scientific Publications, 2010.
4. From Genetics to Gene Therapy – the molecular pathology of human disease by David S Latchman, BIOS scientific publishers, 2010.
5. Biotechnology Expanding Horizon, B.D.Singh, 3rd revised edition, Kalyani Publishers,2010
6. https://onlinecourses.swayam2.ac.in/cec19_bt02/preview

LAB

1. Transformation
2. Blue white colony screening
3. Thermal denaturation of DNA
4. Restriction Digestion
5. Ligation Experiment.
6. Southern Blotting – Agarose Gel Electrophoresis
7. Electroblotting and analysis
8. Lyophilization of biologic samples (fluids, microbial samples)
9. SOP for UV-Spectrophotometer
10. SOP for PCR

    PCR (Amplification with specific primers)

COURSE OUTCOMES

1. Apply the knowledge of various tools used in genetic engineering experiments.
2. Select and apply the knowledge of methods of nucleic acid detection, hybridization and amplification and library construction in research.
3. Identify different methods of various gene transfer techniques in plants, animals and microbes
4. Use knowledge of various strategies of Gene therapy in therapeutics and engineer microbes for the production of biopharmaceuticals

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO 1	-	1	-	2	3	-	2	-	-	-	-	2	1	3	1
CO 2	-	1	-	-	3	-	1	-	-	-	-	2	2	3	1
CO 3	-	1	-	2	3	1	1	-	-	-	-	2	3	3	1
CO 4	-	1	-	2	3	2	1	-	-	-	-	2	3	3	1

22UBT511E	ENVIRONMENTAL BT	Credits: 3
L: T: P – 3-0-0		CIE Marks: 50
Total Hours/Week: 3		SEE Marks: 50

UNIT-I	10 Hrs.

Microorganisms

Issues and scope of Environmental BT. Characteristics of soil, microbial flora of soil, interactions among soil microorganisms, biogeochemical role of soil microorganisms.

Bioaccumulation of Toxicants

Characteristics of Xenobiotics, Relationship of Bioaccumulation with Chemical Structure, Ecophysiology of Bioaccumulation, Process of toxicants uptake, Factors affecting bioaccumulation, measurement of bioaccumulation.

UNIT–II	12Hrs.

Biological Treatment of Wastewater

Waste water characteristics BOD, COD, Primary & Secondary treatment, nano-filtration, ulta-filration and microfiltration. Microbial removal of phosphorous and Nitrogen, Nutrient removal by Biomass production Wastewater treatment of food processing industries like sugar factories, vegetable oil industries, potato processing industries, dairy industries, beverages industries, and distilleries.

Solid Waste Management

Basic aspects, general composition of urban solid wastes, aerobic treatment, anaerobic treatment, biogas generation; Solid waste management through Biotechnological processes involving Hazardous wastes, Biomedical wastes, MoEF rules

UNIT–III	10 Hrs.

Bioleaching & Biomining

Microbes in Bioleaching- types, methods of bioleaching, Microbial recovery of metal, phosphate, petroleum.

Bioremediation

Major contaminants of air, water and soil, Biomonitors of environment (Bioindicators), Bioremediation using microbes, Phytoremediation, Biofilms its applications. Bio-stimulation of Naturally occurring microbial activities, Bio-augmentation.

UNIT–IV	10 Hrs.

Biotechnology in Biodiversity Conservation

Value of biodiversity, threats to biodiversity, Biosphere reserves and Ecosystem Conservation, Approaches to Bioresource conservation programme, Biotechnological processes for bioresource assessment, BT in ex situ conservation of Biodiversity, BT and its role in utilization of Biodiversity, International initiatives for biodiversity management.

REFERENCE BOOKS*

1. Environmental Biotechnology by Pradipta Kumar Mahopatra.
2. Text book of microbiology by R C Dubey and D K Maheshwari
3. Environmental Biotechnology by Foster C.F., John ware D.A., Ellis Horwood Limited,1987.
4. Bioprocess Technology- fundamentals and applications, S O Enfors & L Hagstrom (1992), RIT,.
5. Comprehensive Biotechnology Vol. 1- 4 : M.Y. Young (Eds.), Pergamon Press.
6. Industrial Microbiology : L.E. Casida, Willey Eastern Ltd., 1989.
7. Industrial Microbiology : Prescott & Dunn, CBS Publishers, 1987.
8. Biotechnology, Economic & Social Aspects : E.J. Dasilva, C Ratledge & A Sasson, Cambridge

Univ. Press, Cambridge.

COURSE OUTCOMES**

1. Understand issues and scope of Environmental BT and concepts of Bioaccumulation.
2. Develop different treatment methods for waste water by using BT approach.
3. Develop different treatment methods for solid waste by using BT approach.
4. Apply the knowledge of bioleaching for metal recovery and bioremediation processes to remove environmental contaminants.
5. Understand the Value of biodiversity and threats to biodiversity.
6. Apply the knowledge of BT in biodiversity conservation.

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO 1	2	3	2	2				2		3		1	2	3	1
CO 2	2	3	2	1				1	2				3	3	1
CO 3	2	3	2	1				1	2				3	3	1
CO 4	1	3	2	3				2	2	3			2	3	
CO 5								2		3		3			
CO 6	1	3	2	2					2	2			1	3	

22UBT512E	NUTRACEUTICALS	Credits: 3
L: T: P – 3-0-0		CIE Marks: 50
Total Hours/Week: 3		SEE Marks: 50

UNIT-I	10 Hrs.

Introduction to Nutraceutical and dietetics

Organizational elements, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutraceuticals. Scope involved in the industry, Indian and global scenario. Recommended dietary intake (RDA), acceptable dietary intake, nitrogen balance, protein efficiency ratio, net protein utilisation. Basics of energy balance - Basal Metabolic Rate (BMR), Body Mass Index (BMI) and Standard Dynamic Action (SDA) with special reference to nutraceutical industry.

UNIT–II	10Hrs.

Nutrition related diseases and disorders

Carbohydrates, Protein, amino acids, Fat, vitamins and minerals - Excess and deficiency, symptoms, prevention and management.Role of nutraceuticals with special reference to diabetes mellitus, hypertension, hypercholesterolemia, cancer, glands in the prevention and treatment. Concept of antioxidants - use of antioxidants as dietary supplements in prevention and treatment of cancer, obesity and stress.Role of nutraceuticals and functional foods in pediatrics, geriatrics, sports, pregnancy and lactation.

UNIT–III	10 Hrs.

Nutraceuticals of microbial, plant and animal origin

Concept of prebiotics and probiotics - principle, mechanism, production and technology involved, applications - examples of bacteria used as probiotics, use of prebiotics in maintaining the useful microflora - extraction from plant sources. Synbiotics for maintaining good health.Algae as source of omega - 3 fatty acids, antioxidants and minerals - extraction and enrichment. Plant secondary metabolites, classification and sub-classification - Alkaloids, phenols, Terpenoids. Animal metabolites - Sources and extraction of nutraceuticals of animal origin. Examples: chitin, chitosan, glucosamine, chondroitin sulphate and other polysaccharides

UNIT–IV	10 Hrs.

Biotechnology in Phytonutraceuticals

Role of medicinal and aromatic plants in nutraceutical industry – propagation - conventional and tissue culture, cultivation, post harvest technology and strategies for crop improvement, development of high yielding lines and yield enhancement, plant genomics and metabolomics. Biofortification and nutritional enhancement.GM foods with enhanced nutraceutical properties.Golden rice, GM Tomatoes

REFERENCE BOOKS*

1. Israel Goldberg (Ed.) (1999) Functional foods, designer foods, pharma foods, Nutraceuticals, Aspen publishers Inc., USA.
2. L. Rapport and B. Lockwood,Nutraceuticals, Pharmaceutical Press.,2nd Edition,2002.
3. M. Maffei ,Dietary Supplements of Plant Origin, Taylor & Francis,1 st Edition,2003.
4. Shahidi and Weerasinghe, Nutraceutical beverages Chemistry, Nutrition and health Effects, American Chemical Society,1 st Edition, 2004.
5. Richard Neeser& J. Bruce German (2004) Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals, Jean, Marcel Dekker, Inc.
6. TimothtS. Tracy, Richard L. Kingston, Herbal Products 2nd Edition, 2007.

COURSE OUTCOMES**

1. To be aware of basic concepts of nutraceuticals and nutrition.
2. To have a general idea of scope of nutraceuticals and functional foods.
3. To have brief idea about nutrition related health disorders and the role of Nutraceuticals.
4. To classify nutraceuticals and the role of nutraceuticals among different age groups.
5. To learn about the basic aspects of nutraceuticals derived from microbial, plant and animal origin.
6. To know about the role of biotechnology in production of plant secondary metabolites

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO 1	3	2	-	-	2	1	2	2				3	2	2	3
CO 2	3	2	2	2	2	1	2	-				3	2	2	3
CO 3	3	2	-	1	-	-	2	-				3	2	2	3
CO 4	2	2	-	1	-	2	-	-				3	1	-	2
CO 5	2	2	2	1	-	2	-	2				1	2	-	2
CO 6	2	1	2	2	2	2	1	1				1	1	1	1

21UBT513E	COMPUTATIONAL BIOLOGY	03 - Credits (3 : 0 : 0)
Hours / Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – 1	12 Hrs

Nature and scope of Computational Biology: Basic algorithms in Computational Biology, Biological and Computer algorithm, Fibonacci problem, Dynamic Programming, Time and space complexity of algorithms, Laplace's Rule. Search Algorithms: Random walk, Hill climbing, simulated annealing. Combinatorial Pattern Matching: Hash Tables, Repeat Finding, Exact Pattern Matching; Genetic Algorithm: Basic Concepts, Reproduction, Cross over, Mutation, Fitness Value, Optimization using GAs; Applications of GA in bioinformatics.

UNIT – 2	8 Hrs

Combinatorial Pattern Matching: Hash Tables, Repeat Finding, Exact Pattern Matching; Genetic Algorithm: Basic Concepts, Reproduction, Cross over, Mutation, Fitness Value, Optimization using GAs; Applications of GA in bioinformatics.

UNIT – 3	10 Hrs

Hidden Markov Model: Markov processes and Markov Models, Hidden Markov Models. Forward and Backward Algorithms, Most probable state path: Viterbi algorithm, Parameter Estimation for HMMs:- Baum-Welch Algorithm, Applications of profile HMMs for multiple alignment of proteins and for finding genes in the DNA.

UNIT – 4	10 Hrs

Insilico Drug Design and Biopython applications in Computational Biology

Insilico Drug Design: Basic Concepts, importance and application, Molecular force fields and energy minimization, Molecular Dynamics Simulation methods, Methods of Insilico Drug Design: structure and ligand based drug design approach, structure based drug design: Molecular docking. Biopython: Introduction, important features and application of biopython in computational biology, Create a simple sequence in Biopython for DNA, RNA and Protein Alphabets, Sequence Alignment Tools in Biopython, PDB Module of Biopython,

REFERENCE BOOKS

- Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith,1999,Pearson Education.
- Arthur M.Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
- Higgins and W.Taylor (Eds), Bioinformatics-Sequence, Structure and databanks, Oxford University Press, New Delhi, 2000
- An introduction to bioinformatics algorithms by Neil C. Jones, Pavel Pevzner. MIT Press.2004 2.
- Biological sequence analysis: Probabilistic models of proteins and nucleic acids by Richard Durbin, Eddy, Anders Krogh, 1998

Algorithms for Molecular Biology by Ron Shamir Lecture, Fall Semester, 20014.

1. Bioinformatics- a practical guide to the analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellellette, B.F., 1998, John Wiley & Sons, UK.
2. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith, 1999,Pearson Education.
3. Arthur M.Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
4. D.Higgins and W.Taylor (Eds), Bioinformatics-Sequence, Structure and databanks, Oxford University Press, New Delhi, 2000.
5. Bioinformatics: the machine learning approach by Pierre Baldi, Søren Brunak. MIT Press.2001 2.
6. Bioinformatics: Sequence and Genome Analysis: by David Mount, University of Arizona,Tucson

COURSE OUTCOMES

After completion of the course student will be able to

1) Understand the nature, scope of computational biology and biological and computer algorithms.
2) Know about the Combinatorial Pattern Matching, Genetic algorithms and their applications.
3) Analyze various Markov processes and Markov Models.
4) **Learn about the Insilico Drug Design and Biopython applications in Computational Biology**

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO 1	3	3	3									2	2	1	
CO 2	2	3	3									2	2	1	
CO 3	3	3	3									1	2	1	
CO 4	3	3	3									1	2	1	

21UBT514E	PROTEIN ENGINEERING AND DRUG DESIGN	Credits: 03
L:T:P – 3:0:0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	10 Hours

Structure of proteins

Overview of protein structure, PDB, structure based classification, databases, visualization tools, structure alignment, domain architecture databases, protein-ligand interactions.

Protein structure prediction

Primary structure and its determination, secondary structure prediction and determination of motifs, profiles, patterns, fingerprints, super secondary structures, protein folding pathways, tertiary structure, quaternary structure, methods to determine tertiary and quaternary structure, post translational modification.

Protein engineering and design

Methods of protein isolation, purification and quantitation; large scale synthesis of proteins, design and synthesis of peptides, use of peptides in biology, methods of detection and analysis of proteins. Protein database analysis, methods to alter primary structure of proteins, examples of engineered proteins, protein design, principles and examples.

UNIT–II	10 Hrs.

Molecular modeling

Constructing an Initial Model, Refining the Model, Manipulating the Model, Visualization. Structure Generation or Retrieval, Structure Visualization, Conformation Generation, Deriving Bioactive Conformations, Molecule Superposition and Alignment, Deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Molecular Interactions: Docking, Calculation of Molecular Properties, Energy Calculations (no derivation), Examples of Small Molecular Modeling Work, Nicotinic Ligands, Sigma Ligands, Antimalarial Agents.

UNIT–III	10 Hrs.

Insilico drug design

Generation of Rational Approaches in Drug Design, Molecular Modeling: The Second Generation, Conceptual Frame and Methodology of Molecular Modeling, The Field Currently Covered, Importance of the "Bioactive Conformation", Molecular Mimicry and Structural Similarities, Molecular Mimicry, Structural Similarities and Superimposition Techniques, Rational Drug Design and Chemical Intuition, An Important Key and the Role of the Molecular Model, Limitations of Chemical Intuition Major Milestones and Future Perspectives.

Computer assisted new lead design

Introduction, Basic Concepts, Molecular Recognition by Receptor and Ligand Design, Active Conformation, Approaches to Discover New Functions, Approaches to the Cases with known and unknown receptor structure.

UNIT–IV	10 Hrs.

Docking methods

Program GREEN Grid: Three -Dimensional Description of Binding Site Environment and Energy Calculation, Automatic Docking Method, Three-Dimensional Database Search Approaches, Automated Structure Construction Methods, Structure Construction Methods with known Three-Dimensional Structure of the Receptor, Structure Construction in the case of Unknown Receptor Structure. Scope and Limitations, Points for Consideration in Structure, Construction Methods, Handling of X-Ray Structures of Proteins, Future Perspectives, Types of programs available for molecular modeling-scope and limitations-interpretation of results.

Computer - assisted drug discovery

The Drug Development Process, Introduction, The Discovery and Development Process, New Lead Discovery Strategies, Composition of Drug Discovery Teams, The Practice of Computer-Assisted Drug Discovery (CADD), Current Practice of CADD in the pharmaceutical Industry, Management Structures of

CADD Groups, Contributions and Achievements of CADD Groups, Limitations of CADD Support, Inherent Limitations of CADD Support, State of Current Computational Models, Software and Hardware Constraints.

REFERENCE BOOKS *

1. Bioinformatics Methods & Applications: Genomics, Proteomics & Drug Discovery, S C Rastogi, Mendiratta & P Rastogi, PHI,4th Edition, 2013
2. Moody P.C.E. and A.J. Wilkinson Protein Engineering, IRL Press, Oxford, 3rd Edition,2010.
3. Creighton T.E. Proteins, Freeman W.H. Second Edn,1993.
4. Branden C. and Tooze R. Introduction of protein structure, Garland,1993.
5. The molecular modeling perspective in drug design by N Claude Cohen, 2008, Academic Press.

COURSE OUTCOMES**

1. Ability to study protein structure prediction and protein engineering and design
2. Able to understand molecular modeling
3. Able to know computer assisted new lead design
4. Able to study docking methods and computer - assisted drug discovery

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	-	2	-	1	1	2	2	-	-	-	1	2	1	1
CO2	1	-	2	-	-	2	2	3	-	-	-	1	2	1	2
CO3	-	-	1	1	2	-	2	2	-	-	-	1	2	1	-
CO4	2	-	2	-	-	1	2	2	-	-	-	1	2	1	-

21UBT532N	BIOFUELS TECHNOLOGY	Credits: 3
L: T: P – 3-0-0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	10 Hrs.

Biochemistry of biofuels and energy resources

Basic principle of light energy conversion to chemical energy &carbon fixation. Biochemistry involved in conversion of sugars to alcohols. Renewable and non-renewable resources.

Biofuels

Introduction to Biofuels - definition, advantages and disadvantages. Biofuel life cycle. Biomass as an energy core and its different mode of utilization. Conventional fuels and their environmental impacts. Modern fuels and their environmental impacts. Biofuel energy content. World scenario of biofuel production and use.

UNIT–II	12Hrs.

Biofuel feed stocks

Starch feed stocks-cereal grains, tubers & roots; Sugars feed stocks-sugarcane & sugarbeet; cellulosic feed stocks - forest residues, agricultural residues, Agricultural processing by-products, dedicated energy crops, municipal solid waste and paper waste. Lipid feed stocks :-Oilseed crops with examples, Algae, Waste oil, Animal fats. Next generation feed stocks. Environmental impacts of feed stocks.

Types of biofuels

First generation biofuels-vegetable oil biodisel, bioalcohols, bioethers, biogas syngas, solid biofuels. Second generation biofuels and third generation biofuels.

UNIT–III	10 Hrs.

Technologies for biofuels

Historical background. Biochemical platform – bioethanol production, standardization, emissions and properties of bioethanol. Thermochemical platforms - biodiesel production, standardization, properties and emissions of biodiesel. BtL fuels -production, properties and emissions. Biohydrogen processing and uses. Converting solid wastes to pipeline gas. Biomethanation, Microbial fuel cells. Blending of biofuels

UNIT–IV	10 Hrs.

Biofuels in perspective

Integrated refining concepts with reference to ethanol production. Economic feasibility of producing biodisel, Issues with biofuel production & use. Impact of biofuel in global climate change & food production. 1st versus 2nd generation biofuels.. Strategies for new vehicle technologies. Current research on biofuel production. Market barriers of biofuels.

REFERENCE BOOKS*

1. Foster C. F., John ware D.A.Environmental Biotechnology by, Ellis Horwood Limited, 1987.
2. Larry Anderson and David A Fuels from Waste by Tillman. Academic Press, 1977.
3. Biotechnology, Economic & Social Aspects: E.J. Dasilva, C Ratledge & A Sasson, Cambridge Univ. Press, Cambridge, 2000
4. Environmental Biotechnology by Pradipta Kumar Mahopatra, 2007.

COURSE OUTCOMES**

After completion of the course student will be able to

1. Ability to understand the basic principle involved in bioconversion process in energy and to differentiate the conventional fuels with biofuels .
2. Able to diagnose the types of feed stocks used for biofuels.
3. Able to produce the biofuels (biodiesel, bioalcohol biogas and biohydrogen) using current technologies and innovations involved
4. Able to understand and recall current issues related with production and use of biofuels, Research opportunities, economic feasibility of the biofuels

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	-	-	2		1	-	-	-	-	1	3	2	-
CO 2	3	3	-	3			2	-	-	-	-	1	2	-	-
CO 3	3	3	-	3	3		2	-	-	-	-	3	-	2	-
CO 4	3	3	-	3			2	-	-	-	-	3	-	1	-

21**UBT503L**	**BIOINFORMATICS LAB**	**Credits: 1**
L: T: P – 0-0- 2		CIE Marks: 50
Total Hours/Week: 2		SEE Marks: 50

LIST OF EXPERIMENTS

1. Bibliographic search from PUBMED, SCIRUS and MEDMINER
2. Sequence retrieval from Nucleic acid and Protein databases.
3. Sequence searches using BLAST – Retrieval of homologs, paralogs, orthologs, and Xenologs
4. Pair wise comparison of sequences – Analysis of parameters affecting alignment.
5. Multiple alignments of sequences and pattern determination using PROSITE
6. Evolutionary studies / Phylogenetic analysis – Analysis of parameters affecting trees.
7. Identification of functional sites in Genes / Genomes.
8. Secondary structure prediction of proteins and comparison with PDB.
9. Restriction mapping: Analysis of maps for suitable molecular biology experiment.
10. Primer Design: Factors affecting primer design.
11. PDB structure retrieval and visualization: Analysis of homologous structures.
12. Determination of ligand-protein interactions using SPDBV/ LIGPLOT
13. Superposition of structures – Calculation of RMSD.
14. Docking studies – Analysis of substrate / ligand binding using homologous structures.

REFEENCE BOOKS*

1. Bioinformatics – Andreas D Boxevanis. Wiley Interscience, 1998.
2. Bioinformatics – David W Mount, cold spring harbor, 2001.
3. Bioinformatics – A biologists guide to biocomputing and the internet. Stuart M brown,
4. Fundamental Concepts of Bioinformatics – D E Krane & M L Raymer, Pearson, 2006.
5. Computational methods in Molecular Biology – S.L.Salzberg, D B Searls, S Kasif, Elsevier, 1998.
6. Bioinformatics – methods and applications: Genomics, proteomics and drug Discovery – s c Rastogi, N. mendiratta & prastogi, phi, 2006.

COURSE OUTCOMES**

1. Ability to Search literature and sequence databases
2. Ability to retrieve and search sequences from databases
3. Ability to align pair wise and multiple sequences
4. Ability to identify evolutionary and relationships and functional sites in genomes
5. Ability to evaluate primer designing and restriction mapping
6. Ability to docking and superimpose the structures

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	PSO1	PSO2	PSO3
CO 1	**3**	**3**	**3**	**-**	**3**	**1**	**-**	**3**				**3**	3	**3**	**1**
CO 2	**3**	**3**	**3**	**-**	**3**	**1**	**-**	**-**				**3**	2	3	1
CO 3	**3**	**3**	**2**	**2**	**3**	**1**	**1**	**-**				**3**	**3**	**3**	1
CO 4	**3**	**3**	**2**	**-**	**3**	**-**	**1**	**-**				**3**	**2**	**3**	**2**
CO 5	**3**	**3**	**2**	**1**	**3**	**1**	**-**	**2**				**3**	**3**	**3**	**2**
CO 6	**3**	**3**	**3**	**2**	**3**	**1**	**-**	**1**				**3**	**2**	**3**	**1**

21UBT523C/21UBT623C	ENVIRONMENTAL STUDIES	01 - Credits (1: 0 : 0)
Hours / Week : 01		CIE Marks : 50
Total Hours : 15		SEE Marks : 50

UNIT – 1	04 Hrs.

Natural Resources:

Human activities and their impacts. EIA, **Renewable Energy**: Solar energy, Wind energy, Hydropower, Tidal energy, Ocean thermal energy, Geo thermal energy, Biomass energy, Biogas, Biodiesel, Bioethanol, Hydrogen as fuel.

Non renewable Energy: Coal, Petroleum, Natural gas, Nuclear energy.

UNIT – 2	04 Hrs.

Environmental Pollution:

Water pollution, water quality standards, water borne diseases, Fluoride problem, Air pollution, Noise pollution. Effect of electromagnetic waves.

Sustainable future: Concept of sustainable development, threats to sustainability, strategies for sustainable development. Environment economics – concept of green building, Circular Economy.

UNIT – 3	03 Hrs.

Current Environmental Issues of concern:

Greenhouse Effect- Greenhouse gases and Global Warming, Climate change, ozone layer depletion, Acid rain, Eutrophication

Environmental policy legislation rules & regulations

UNIT – 4	04Hrs.

Fundamentals of Waste management:

Solid waste management: Sources, classification, characteristics, collection & transportation, disposal, and processing methods. Hazardous waste management and handling.

Concept of waste water treatment, Bioremediation.

Industrial waste management (Case studies: Cement, plastic, chemical, E–waste, food & construction industry waste management).

REFERENCES

1. Benny Joseph “Environmental Studies” Tata McGraw Hill, 2005
2. Dr. D. L. Manjunath, “Environmental Studies” Pearson Education, 2006
3. Koushik and Koushik “Environmental Science & Engineering” New Age International Publishers, New Delhi, 2006
4. Meenakshi “Environmental Science & Engineering” Pranticce Hall of India, 2006

COURSE OUTCOMES

After completion of the course the students shall be able to,

- Ability to recognize natural resources and its uses.
- Able to understand pollution and its effects on environment and to implement sustainable future in the work place.
- Ability to understand current environmental issues.
- Able to apply the waste management techniques in various fields

Course Outcomes	Program Outcomes												Program Specified Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	-	**1**	-	-	-	**2**	**3**	-	-	-	-	**3**	**1**	-	-
CO 2	**2**	-	-	-	-	-	**3**	-	-	-	-	**3**	**1**	-	-
CO 3	-	**2**	-	-	-	**2**	**2**	-	-	-	-	**3**	**1**	-	-
CO 4	-	-	-	**1**	-	**2**	**2**	**1**	-		-	**3**	**1**	-	**1**

Question Paper Pattern for SEE:

Question is of Objective type
Duration of exam is 1 hour 30 mins
50 questions covering all the four units. Each question carries one mark

B. E. VI SEMESTER

Sl. No	Category	Subject Code	Subject Title	Credits	Hours/ Week			Examination Marks		
					L	T	P	CIE	SEE	TOTAL
1.	BSC	21UBT601C	Bioprocess and Bioreaction Engineering	03	3	0	0	50	50	100
2.	PCC	21UBT602C	Upstream Processing Technology	03	3	0	0	50	50	100
3.	PCC	21UBT603C	Biotransformation and Enzyme Technology	03	3	0	0	50	50	100
4.	PEC	21UBT6XXE	Elective-II	03	3	0	0	50	50	100
5.	OEC	21UXX6XXN	Open Elective –II	03	3	0	0	50	50	100
6.	OEC	21UXX6XXN	Open Elective –III	03	3	0	0	50	50	100
7.	PCCL	21UBT604L	Biokinetics & Enzyme Technology Lab	01	0	0	2	50	50	100
8.	MP	21UBT605P	Mini Project	02	0	0	4	50	50	100
Total				**21**	**18**	**0**	**6**	**400**	**400**	**800**

Elective-II

21UBT621E: Biofuels Technology
21UBT622E: Food Biotechnology
21UBT623E: Biopython
21UBT624E: Genomics & Proteomics
21UBT625E: Bioreactor Design

Open Electives –II

21UBT632N: Environmental Technology

Open Electives –III

21UBT633N: Industrial Safety

21UBT601C	BIOPROCESS AND BIOREACTION ENGINEERING	Credits: 03
L:T:P – 3:0:0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	10 Hrs.

Kinetics of Homogeneous reactions:

Basic Concepts of Bioreaction and bioprocess engineering, Concentration dependent term of a rate equation, Rate Constant. Representation of elementary reaction and non-elementary reactions, Kinetic Models of Non elementary Reactions, Testing Kinetic Models. Temperature-dependent term of a rate equation: Temperature dependency from Arrhenius law, Collision theory, Transition state theory, Thermodynamic approach, Activation Energy.

UNIT–II	10 Hrs.

Interpretation of Batch Bioreactor Data:

Constant volume batch reactor, Integral method of analysis of data -first order, second order, zero order reactions, fractional life, homogenous catalysed reactions, irreversible reaction in series, irreversible reactions in parallel, reactions of shifting order, autocatalytic reactions, reversible reactions, differential method of analysis of data.

UNIT–III	10 Hrs.

Ideal Bioreactor and bioprocess models:

Ideal Batch Reactor, General features of reactors, Basic design equation, relation between Concentration and conversion, Batch cycle time, Space-Time and Space-Velocity, Mixed flow reactor, Plug flow Reactor, Holding time and space time for flow reactors

Design for Single Reactions: Size comparison of single reactors. Growth kinetics quantification Unstructured models for microbial growth- Substrate limited growth-models with growth inhibitors, product formation kinetics. Monod kinetics

UNIT–IV	10 Hrs.

Analysis of Bioreactors:

Various types of reactors for immobilised cell and enzyme systems, Multiple reactors like CSTR in series /CSTR in Parallel; MFR in series/ MFR in Parallel, PFR in series/ PFR in parallel, Reactors of different types in series, Challenges and issues in bioprocess industries- mixing, interphase mass and heat transfer, Bioreactor instrumentation and control, bioreactor considerations for animal cell cultures and plant cell cultures.

Reference Books *

1. Scott Fogler, H (2016) Elements of Chemical Reaction Engineering, 6th edn., Prentice Hall India Pvt. Ltd.
2. Levenspiel O (2006) Chemical Reaction Engineering, Wiley Eastern, 3rd edn, New Delhi.
3. Kargi and Shuler (2015) Bioprocess Engineering. 3nd edn., Prentice Hall PTR.

4. Bailey J E and Ollis DF (2010) Biochemical Engineering Fundamentals, 2nd edn. Mc Graw- Hill.
5. Charles D. Holland (1990) Fundamentals of Chemical Reaction Engineering, John Wiley and Sons.
6. Pauline M Doran., Bioprocess Engineering Principles, 2nd Edition, Academic Press, USA, 2013.
7. Tapobrata Panda., Bioreactors: Analysis and Design, 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2011.
8. Indian Standards Institution, Code for Unfired Pressure Vessels, IS – 2825.
9. Bhattacharya, B.C, Introduction to Chemical Equipment Design, CBS Publications, 1985.
10. Perry's Chemical Engineers Handbook. 7th Edition Mc Graw Hill Publications

Course Outcomes**

After completion of the course student will be able to

1. Understand the basic concept of reaction engineering to solve bioprocess problems
2. Predict the order and rate of the different reactions.
3. Analyze the batch bioreactor data for different reactions.
4. Apply the suitable bioreactor for different biochemical reactions.

*** Books to be listed as per the format with decreasing level of coverage of syllabus**
**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	3	3	2	2							2	2		
CO2	2	3	2	3	1							2	2		
CO3	2	3	3	2	2							2	2		
CO4	2	3	3	3	1							2	2		

21UBT602C	UPSTREAM PROCESSING TECHNOLOGY	Credits: 3
L: T: P – 3-0-0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	10 Hrs.

Fermentation process

Range of fermentation processes, chronological development of fermentation industry, component of the fermentation process. Basic functions of a fermenter for microbial, plant and animal cell culture. Body parts of fermentor, aseptic operation and containment. Sterilization of fermentors. Classification of Fermentation Systems: Batch, fed batch and continuous process and their applications, Types of Fermentors.

Scale Up: Process engineering concepts, engineering considerations, mechanical considerations, energy considerations. Process GMP considerations of scale up, operations and quality.

UNIT–II	10Hrs.

Raw materials and media

Media requirement for typical fermentation process, selection of typical raw materials, types of fermentation media. Preparation and handling of fermentation media, sterilization and its practical limits, Batch sterilization, Continuous sterilization and Filter sterilization. Different methods for optimization (Plackett-Burman Design, RSM) of industrial media, microbio

UNIT–III	10 Hrs.

Microbial system

Isolation of industrially important microorganisms, Strain development methods, Preservation of industrially important microorganisms. Development of inoculum from laboratory scale to pilot scale and large scale fermentation (for bacterial, yeast, mycelial processes). Criteria for the transfer of inoculum. Aseptic transfer of inoculum to the fermentor. Trouble shooting during fermentation process (microbial contamination).

Secondary metabolite production: secondary metabolite production in bacteria, yeast and fungi. Production of lactic acid, butanol, antibiotics and enzymes.

UNIT–IV	10 Hrs.

Plant Cell system

Isolation and culture of single cells, Bioprocess using plant cell cultures. Bioreactors for suspension cultures, immobilized cells and organized tissues. Secondary metabolite enhancement techniques (alkaloids, steroids, phenolics).

Animal Cell system :

Scale up in suspension (stirred and static), monolayer (roller bottles, nunc cell factory microcarriers culture) and Perfusion culture (fixed and fluidized bed reactors).

Factors affecting cell culture,

Growth monitoring.

Genetically engineered cells for bioprocessing; process, selection of host vectors, process constraints- genetic instability, mass transfer and others.

Large scale production of insulin by mammalian cell culture.

Cellbank preparation & cell reviving techniques

Monoclonal antibody production: SUDBRCS (Single use disposable bioreactor configuration, types of production (perfusion culture, submerged culture, suspended adhered culture).

REFERENCE BOOKS

1. Principles of fermentation Technology by P.F. Stanbury and A. Whitaker, Aditya books (P) Ltd. New Delhi 1997.
2. Bioprocess Engineering by Michael L. Shuler, 2nd Edition Shuler & Kargi, Fikret Kargi, Academic Internet Publishers, 2006
3. Introduction to plant Biotechnology by H.S. Chawla, Second edition, Oxford & IBH Publisher
4. Plant tissue Culture : Theory and Practice by S.S. Bhojwani and M.K. Razdan (1996). Elsevier
5. Culture of animal cells by Ian Freshney IVth Edition. John Willey & Sons Publ.
6. Animal Biotechnology by Murray Moo-Young (1989), Pergamon Press, Oxford

COURSE OUTCOMES

1. Understand and identify the component parts of fermentor and fermentation system
2. Select the raw material , prepare and sterilize the media and also to optimize the industrial media using Design of experiments
3. Develop/design the industrially important microbes for industrial scale processes
4. Operate the reactors for Plant, Animal and GMOs

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	1											1	3	
CO 2	-	3												3	3
CO 3	2	2	3	1	1					2		1	3	3	
CO 4	2									3		1		3	

21UBT603C	BIOTRANSFORMATION AND ENZYME TECHNOLOGY	Credits: 3
L:T:P - **3-0-0**		CIE Marks: 50
Total Hours/Week: 3		SEE Marks: 50

UNIT-I	10 Hrs.

Enzyme action:

Mechanism of enzyme action. Derivations of Km value (Michaelis-Menton constant), Lineweaver-Burk plot., Enzyme inhibition and kinetics

Multi-Substrate Reactions:

Introduction to enzyme catalyzed reaction Ping-pong mechanism, Sequential mechanism (ordered and random), Enzyme models - Host guest complexation chemistry

UNIT–II	10 Hrs.

Enzymatic Techniques:

Strategies of purification of enzymes: choice of source, methods of homogenization, Criteria of purity: tests for purity, tests for catalytic activity, active site titrations, Molecular weight determination and characterization of enzymes.

Immobilization of enzymes:

Techniques of enzyme immobilization; design and configuration of immobilized enzyme reactions,Kinetics of immobilized enzymes**,** immobilized enzymes in bioconversion processes(uses). The design and construction of novel enzymes

UNIT–III	10 Hrs.

Enzymes of biological importance:

Enzyme pattern in diseases like in Myocardial infarctions (SGOT, SGPT, & LDH) Acetylcholinesterase, angiotensin converting enzyme (ACE), 5'- nucleotidase (5NT), glucose-6-phosphate dehydrogenase (GPD). Use of isozymes as markers in cancer.

UNIT–IV	10 Hrs.

Industrial uses of enzymes:

Enzymes used in detergents, use of proteases, leather and wool industries; methods involved in production of glucose syrup from starch (using starch hydrolyzing enzymes).Uses of lactase in dairy industry, glucose oxidase and catalase in food industry. Uses of proteases in food industries.

Reference Books *

1. Trevor Palmer (2008). Enzymes: Biochemistry , Biotechnology, Clinical Chemistry. Horwood Publishing Ltd, East-West Press,5th Edition.
2. David L. Nelson and Michael Cox (2017). "Lehninger Principles of Biochemistry" –7th Edition.
3. Nicholas C. Price and Lewis Stevens (2009).Fundamentals of Enzymology, Oxford university Press, 3rd edition.
4. James R Hanson (2017). "An Introduction to Biotransformation in Organic Chemistry" 5th edition , Oxford university Press,
5. Daniel L. Purich, Melvin I. Simon, John N. Abelson (2009). Contemporary Enzyme Kinetics and Mechanism" Academic press, 3rd edition.
6. K. Faber (2018). Biotransformations in Organic: Springer- Verlag.4th Edition,.
7. Bailey and Ollis (2017). "Biochemical Engineering Fundamentals", Mcgraw Hill 2nd Ed.

Course Outcomes**

After completion of the course student will have the ability

1. To understand mechanism of enzyme and its reactions.

2. To know enzymatic techniques to characterize the enzymes and apply the techniques of immobilization of enzymes.
3. To understand the importance of enzymes in diagnostics.
4. To apply knowledge of using enzymes in detergent, wool, leather and food industries.

*** Books to be listed as per the format with decreasing level of coverage of syllabus**

**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	**Programme Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	1	3	1	-	2		-	-	-	-	1	3	2	-
CO2	3	3	2	2	-	3	2	-	-	-	-	-	3	1	-
CO3	3	2	-	2	-	2	-	-	-	-	-	-	3	3	-
CO4	2	3	1	1	-	2	4	-	-	-	-	-	3	1	-

21UBT621E	BIOFUELS TECHNOLOGY	Credits: 3
L: T: P – 3-0-0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	10 Hrs.

Biochemistry of biofuels and energy resources

Basic principle of light energy conversion to chemical energy &carbon fixation. Biochemistry involved in conversion of sugars to alcohols. Renewable and non-renewable resources.

Biofuels

Introduction to Biofuels - definition, advantages and disadvantages. Biofuel life cycle. Biomass as an energy core and its different mode of utilization. Conventional fuels and their environmental impacts. Modern fuels and their environmental impacts. Biofuel energy content. World scenario of biofuel production and use.

UNIT–II	12Hrs.

Biofuel feed stocks

Starch feed stocks-cereal grains, tubers & roots; Sugars feed stocks-sugarcane & sugarbeet; cellulosic feed stocks - forest residues, agricultural residues, Agricultural processing by-products, dedicated energy crops, municipal solid waste and paper waste. Lipid feed stocks :-Oilseed crops with examples, Algae, Waste oil, Animal fats. Next generation feed stocks. Environmental impacts of feed stocks.

Types of biofuels

First generation biofuels-vegetable oil biodisel, bioalcohols, bioethers, biogas syngas, solid biofuels. Second generation biofuels and third generation biofuels.

UNIT–III	10 Hrs.

Technologies for biofuels

Historical background. Biochemical platform – bioethanol production, standardization, emissions and properties of bioethanol. Thermochemical platforms - biodiesel production, standardization, properties and emissions of biodiesel. BtL fuels -production, properties and emissions. Biohydrogen processing and uses. Converting solid wastes to pipeline gas. Biomethanation, Microbial fuel cells. Blending of biofuels

UNIT–IV	10 Hrs.

Biofuels in perspective

Integrated refining concepts with reference to ethanol production. Economic feasibility of producing biodisel, Issues with biofuel production & use. Impact of biofuel in global climate change & food production. 1st versus 2nd generation biofuels.. Strategies for new vehicle technologies. Current research on biofuel production. Market barriers of biofuels.

REFERENCE BOOKS*

1. Foster C. F., John ware D.A.Environmental Biotechnology by, Ellis Horwood Limited, 1987.
2. Larry Anderson and David A Fuels from Waste by Tillman. Academic Press, 1977.
3. Biotechnology, Economic & Social Aspects: E.J. Dasilva, C Ratledge & A Sasson, Cambridge Univ. Press, Cambridge, 2000
4. Environmental Biotechnology by Pradipta Kumar Mahopatra, 2007.

COURSE OUTCOMES**

After completion of the course student will be able to

1. Ability to understand the basic principle involved in bioconversion process in energy and to differentiate the conventional fuels with biofuels .
2. Able to diagnose the types of feed stocks used for biofuels.
3. Able to produce the biofuels (biodiesel, bioalcohol biogas and biohydrogen) using current technologies and innovations involved
4. Able to understand and recall current issues related with production and use of biofuels, Research opportunities, economic feasibility of the biofuels

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	-	-	2		1	-	-	-	-	1	3	2	-
CO 2	3	3	-	3			2	-	-	-	-	1	2	-	-
CO 3	3	3	-	3	3		2	-	-	-	-	3	-	2	-
CO 4	3	3	-	3			2	-	-	-	-	3	-	1	-

21UBT622E	FOOD BIOTECHNOLOGY	Credits: 03
L:T:P – 3:0:0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	10 Hours

Introduction

Hunger, Technology and World food needs-nutritional problems, approaches to combat world hunger, roles of technology. Recent Developments in food biotechnology, introduction to molecular food biotechnology.

Novel bioprocessing

Biosensors for food quality assessment, cold active enzymes in food processing, biotransformation in food industries.

Nutrigenomics

Definition of Nutriomics, Nutrigenetics, and its applications, Nutritional genomics and applications in brief. Nutrigenetics and cancer.

UNIT–II	10 Hrs.

Microbial biotechnology of food

Metabolic engineering of bacteria for food ingredients (Amino acids, organic acids, vitamins). Introduction to technologies for microbial production of food ingredients. Solid-state fermentation for food applications (enzymes, pigments). Biotechnology of microbial polysaccharides- natural occurrence of microbial polysaccharides in foods, additives (xanthan) and its future, Microbial biotechnology of food flavor, oils and fats. Food applications of algae-nutritional value, source of neutraceuticals and industrial production processes (chlorella, spirulina, Agar, alginate). Genetics of Dairy starter cultures.

UNIT–III	10 Hrs.

Plant food applications

Genomic basics for food improvement, molecular design of soybean proteins for enhanced food quality, Genetic modifications of plant starches, plant oils, for food applications. Bioprocessing of starch using enzyme technology. Molecular biotechnology for neutraceutical enrichment of food crops, Biotechnology of nonnutritive sweeteners, metabolic redesign of vitamin -E biosynthesis, production of new metabolites, Engineering of provitamin- A ,biosynthetic pathway into rice(Golden rice), Engineering of carotenoid biosynthesis for antioxidants, approaches to improve nutritional quality and shelf life of fruits and vegetables.

UNIT–IV	10 Hrs.

Enhancement of leaf quality protein for ruminant animals. Methods of chloroplast transformation, markers for transformation, engineering chloroplast for the production of edible vaccine, Transplastomic maize- a case study.

Animal food applications: Genetic modification of production traits in farm animals, Foods made from GM animals, applications of transgenic fish technology in sea food production, enzymatic synthesis of oligosaccharides-progress and recent trends.

Food safety: international aspects of the quality and safety, genetically modified food controversies. Regulation of the release of genetic modified organisms,patenting inventions in food biotechnology.

REFERENCE BOOKS *

1. Kalidas s, Gopinadhan P, Anthony P and Robert E.Levin- " Food Biotechnology"- second edition, CRC press, 2006
2. Gustavo F.G and Gustavo V.B,-" Food Science and Food Biotechnology"- CRC press, 2003
3. Mahesh S.-" Plant Molecular Biotechnology"- first edition, New age international publishers, , 2008

4. Norman N.Potter and Joseph H. Hotchkiss- Food Science- fifth edition- CBS publishers and distributors, 2007

COURSE OUTCOMES**

1. Students will be able to know the importance and current status of food biotechnology
2. Students will acquire the knowledge on novel food bioprocessing, nutrigenomics in brief.
3. Explore the applications of microbes in food biotechnology, new sources of food from microbes etc
4. Will be able to learn about plant food biotechnology and transplastomic technology
5. Will get the knowledge on applications of Animal food biotechnology and food safety and its regulation
6. Able to have an overview recent trends in GMOs and food biotechnology

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	1	2	-	2	1	-	-	-	-	-	1	2	1	1
CO2	2	-	2	-	3	2	-	-	-	-	-	1	2	1	1
CO3	1	1	1	-	2	2	-	-	-	-	-	1	2	1	2
CO4	2	-	2	-	2	1	-	-	-	-	-	1	2	1	1
CO5	2	1	1	-	3	1	-	-	-	-	-	1	2	1	2
CO6	1	-	1	-	2	2	-	-	-	-	-	2	2	1	1

21UBT623E	Biopython	Credits: 03
L:T:P - 3 : 0: 0		CIEMarks:50
Total Hours/Week: 03		SEEMarks:50

UNIT-I	16 Hrs.
Introduction and brief history of Biopython, Biopython modules, Tools and GNU/Linux, Nucleic Acid Bioinformatics, Sequences, Strings, and the Genetic Code, Sequences File Formats, Introduction to Biological Sequence Database, Sequence Motifs, Introduction to Motifs, String Matching, Consensus Sequences, Motif Finding, Promoters, De novo Motif Finding.	
UNIT–II	**12 Hrs.**
Sequence Alignments, Alignment Algorithms and Dynamic Programming, Alignment Software, Alignment Statistics, Short Read Mapping Multiple Sequence Alignments, Molecular Evolution, and Phylogenetics, Multiple Sequence Alignment, Phylogenetic Trees, Models of mutations, Practices Lab 4: Using BLAST on the command line, Lab 5: Phylogenetics	
UNIT–III	**12 Hrs.**
Genomics, The Three Fundamental "Gotchas" of Genomics, Genomic Data and File Formats, Genome Browsers, Transcriptomics, High-throughout Sequencing (HTS), RNA Deep Sequencing, Small RNA sequencing, Long RNA sequencing, Single-Cell Transcriptomics, Transcription Initiation, Transcription, Elongation, RNA Seq, Noncoding RNAs, Small Noncoding RNAs (srcRNAs), Long Noncoding RNAs, RNA Structure Prediction, Destabilizing energies. Practices: Lab 6: Genome Annotation Data, Lab 7: RNA-seq, Lab 8: RNA Structure, Lab 9: Proteins.	
UNIT–IV	**12 Hrs.**
Protein Alignment, Functional Annotation of Proteins, Secondary Structure prediction, Gene Ontology, Gene Regulation, Transcription Factors and ChIP-seq, MicroRNA regulation and Small RNA-seq, Regulatory Networks. Practices: Lab 8: RNA Structure, Lab 9: Proteins, Lab 10: ChIP-seq	

Reference Books *

Reference Books:

1) Prof. David A. Hendrix
2) Deep Learning with Python, Francois Chollet

Reference Books/Protocols: Tutorials Point (Simply easy learning).

Course Outcomes**

After completion of the course student will be able to

1,Obtain knowledge on the biopython-GNU/Linux, modules, tools, commands and Motifs.

2.Acquire the skills of Sequence Alignments using the Softwares, Statistics, Short Read Mapping, Multiple Sequence Alignments, Molecular Evolution,

3.Understand and Analyze the Phylogenetics, Phylogenetic Trees, and Models of mutations.

4.Utilize the biopython in analysis of the Genomic and transcriptomics data.

5. Conduct the Protein Alignment, Functional Annotation, Secondary Structure prediction, Gene Ontology, Gene Regulation.

21UBT624E	GENOMICS AND PROTEOMICS	Credits: 3
L:T:P – 3-0-0		CIE Marks: 50
Total Hours/Week: 3		SEE Marks: 50

UNIT-I	10 Hrs.

Introduction

Genes and Proteins, Polymorphisms – types of polymorphism, commercializing the Genome - Revenue opportunities: a) genome sequences and database subscriptions, b) prediction of new genes and their function by databases. c) prediction of new genes and their function by databases, d) potential revenue in the area diagnostic and biomedical applications, e) biosimilars market and implications.

Sequencing & genome projects: Early sequencing efforts. Methods of preparing genomic DNA for sequencing, DNA sequence analysis methods, Sanger Dideoxy method, Fluorescence method, shotgun approach. Next generation sequencing Genome projects on *E.coli*., Arabidopsis and rice; Human genome project.

UNIT–II	10 Hrs.

Functional Genomics

Gene variation and Single Nucleotide Polymorphisms (SNPs) genotyping tools -DNA Chips, comparative genomics. Functional genomic studies with model systems such as Drosophila, Yeast or C. elegans. Applications in Functional genomics, medicine and Gene Knockdown. Metagenomics-definition & concept. C-Value and paradox of genomes, Repetitive and coding sequences, Genetic and physical maps, chromosome walking Methods of molecular mapping, Marker assisted selection, map based cloning, Bioinformatics analysis- clustering methods. Approaches to physical mapping

UNIT 3	10 Hrs.

Structure of Proteins

Conformational analysis and forces that determine protein structures, geometries, phi, psi, omega angles, Ramachandran diagram, allowed chi angles of side chains in proteins, hydrogen bonding, disulphide bonds, Vanderwaal's force , salt bridges hydrophobic interactions, alpha helices, beta sheets, helix to coil transition, general features and thermodynamic aspects of protein folding, folding kinetics, protein-ligand interactions (Examples of bio-molecular interactions), fibrous proteins (structure of collagen, keratin) and Quaternary structures.

UNIT–IV	10 Hrs.

Proteomics

Introduction to proteomics, Sample preparation, protein extraction Denovo protein synthesis, LCMS/MS, M/Z ratio, sequencing and identification, Predictive Methods using Protein sequences: Protein Identity based on composition, Related web based software (JPRED, PROSEC, NNPREDICT and SOPMA) Proteome analysis "Protein Chip" - interactions and detection techniques, two dimensional PAGE for proteome analysis, Applications of proteome analysis to drug development and toxicology. Crisper-cas. Challenges in proteomics.

REFERENCE BOOKS *

1. Genetic Analysis – Principles, Scope and Objectives by JRS Finchman, Blackwell Science, 1st Edition,1994.
2. A M Campbell & L J Heyer Discovering Genomics, Proteomics & Bioinformatics –, Pearson Education, 2nd Edition, 2006.
3. Albala J S & I Humprey-Smith Protein Arrays, Biochips and Proteomics, CRC Press,1st Edition, 2003.
4. Sabesan, Genomics & Proteomics –Ane Books, 2007. 5. Pennington S. R. and M J Dunn Proteomics.

COURSE OUTCOMES**

After completion of the course student will be able to

1. To know about genes, brief history, polymorphism, prediction methods, Biosimilars, business opportunities in diagnostic and medicine
2. Understand about the Human genome project, tools in DNA sequencing methods and other advanced techniques, Comparative genomics using model organisms, functional genomics of different organisms and molecular markers, gene and physical mapping techniques
3. To know about Protein structure analysis and molecular interactions
4. Analysis of proteins, quantification, sequencing, identification, protein predictive methods and proteomics in medicine

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO 1	**3**	**3**	**2**	**-**	**-**	**2**	**2**	**-**				**1**	-	**2**	**3**
CO 2	**3**	**3**	**1**	**-**	**-**	**2**		**-**				**2**	1	-	3
CO 3	**3**	**2**	**2**	**1**	**2**	**-**		**-**				**1**	**1**	**2**	2
CO 4	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**				**1**	**1**	**2**	**2**

21UBT625E	BIOREACTOR DESIGN	03 - Credits (3 : 0 : 0)
Hours / Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT-I	10 Hrs.

BASICS OF BIOREACTORS

Overview of bioreactions, Elements in bioreactor design, Rate expression in biological systems, Basic concept of material and energy balances, Development and significance of bioreactors, Bioreactor configurations, Classification of bioreactors, Bioreactors for solid-state fermentation, plant and animal cell cultures

UNIT–II	10 Hrs.

BIOREACTOR OPERATION

Common operations of bioreactor, Identification of common factors for smooth operation of bioreactors, Spectrum of basic bioreactor operations, Bioreactor operation for immobilized systems, plant and animal cell cultures

UNIT–III	10 Hrs.

BATCH, SEMICONTINUOUS AND CONTINUOUS BIOREACTORS DESIGN

Overview of bioreactor design, Batch and semi continuous bioreactors for submerged fermentation of microbes, Continuous flow stirred tank and plug flow tubular bioreactors for submerged fermentation of microbes, Recycle bioreactors, Multistage bioreactors, Bioreactors for enzyme reactions and immobilized systems

UNIT–IV	10 Hrs.

CASE STUDIES AND SCALE-UP

Design of packed bed, fluidized bed, airlift, hollow fibre, plant cell, mammalian cell bioreactors for various applications, Scale=up – Criteria, Similarity criteria, Methods, Generalized approaches.

Reference Books *

1. Levenspiel, O., Chemical Reaction Engineering, Wiley Eastern Ltd.
2. Atkinson, B., Biological Reactors, pion Ltd., London,1974.
3. Coulson, Richardson, Sinnott, An introduction to chemical engineering design, Pergamon
4. Alba S., Humphrey E and Milli N.R., “Bio Chemical Engineering” Academic Press, 1973.
5. Scragg. A.H “Bioreactors in Biotechnology”- A Practical approach
6. Tapobrata Panda. “Bioreactors: Analysis and Design”, Latest Edition, New Delhi: Tata McGraw Hill Education Private Limited. 2011
7. Moser, Anton. “Bioprocess Technology: Kinetics and Reactors”, Latest Edition, New York: Springer Verlag. 1988
8. Lydersen, D’ Elia, Nelson, Bioprocess engineering: Systems and equipment.
9. Rawlings, J. B. and Ekerdt, J. G. “Chemical Reactor Analysis and Design Fundamentals”, Latest Edition, San Francisco: Nob Hill Publisher. 2002

Course Outcomes**

After completion of the course student will be able to

1. State and Describe basic concepts of bioreactors
2. Apply the knowledge and Execute bioreactor operations for various applications
3. Design bioreactors for various biochemical applications

4. Apply the knowledge of scale up process to design bioreactors from Research to Industrial level

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO 1	2	2	2	2	1							1	2		
CO 2	3	2	3	3	2							2	2		
CO 3	2	3	2	2	1							1	2		
CO 4	3	2	1	1	1							1	2		

21UBT632N	ENVIRONMENTAL TECHNOLOGY	Credits: 3
L:T:P – 3:0:0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	10 Hours

Introduction:

Current Environmental Issues and scope of Environmental science and technology biogeochemical role of soil microorganisms, Bioconcrete, Environment Impact Assessment

Bioaccumulation of toxicants

Characteristics of Xenobiotics, Relationship of Bioaccumulation with Chemical Structure, Ecophysiology of Bioaccumulation Process of toxicants uptake, Factors affecting bioaccumulation, measurement of bioaccumulation

Sustainable future: Green building concept, Carbon foot print, crediting, trading and its calculation, Water foot print Rain water harvesting .

UNIT–II	10 Hrs.

Waste water treatment:

Waste water characteristics BOD, COD, Primary & Secondary treatment, nanofiltration. ultrafiltration and microfiltration Microbial removal of phosphorous and Nitrogen Wastewater treatment of industries like sugar factories, food industries, beverages industries, and distilleries.

Solid waste management

Basic aspects, general composition of municipal solid wastes, aerobic treatment, anaerobic treatment biogas generation Solid waste management. Hazardous wastes, Biomedical Wastes E waste management, MoEF rules.

UNIT–III	10 Hrs.

Bioleaching & Biomining:

Microbes in Bioleaching- types, methods of bioleaching, Microbial recovery of phosphate, petroleum.

Bioremediation:

Major contaminants of air, water and soil, Biomonitors of environment (Bioindicators), Bioremediation using microbes, Phytoremediation, Biofilms its applications Bio-stimulation of Naturally occurring microbial activities, Bio-augmentation

UNIT–IV	10Hrs.

Biofuels:

Definition, Renewable and nonrenewable resources Advantages and disadvantages of biofuels Biofuel feed stocks-sugar starch, cellulose, lipid Types of biofuel- first, second and third generation Technologies for bio-fuel production-transesterification, gasification 2G technology, Biomethanation, Issues of biofuel production and its use. Microbial fuel cells.

Biodiversity: Value of biodiversity, threats to biodiversity approaches of biodiversity conservation.

REFERENCE BOOKS *

1. Pradipta Kum Mahopatra, 2006, Text Book of Environmental Biotechnology, I K Publishers.
2. R C Dubey and D K Maheshwari,2013 Text book of Microbiology,
3. M Y Young ,2004 ,Comprehensive Biotechnology Vol 1-4 (Eds). Pergamon Press
4. EJ Dasilva, C Ratledge & A Sasson, 2003, Biotechnology, Economic & Social Aspects Cambridge Univ Press.
5. Indu Shekhar Thakur,2012,Environmental Biotechnology Basic concepts and applications, Second Edition, I K international Publishing House, Pvt, Ltd.

COURSE OUTCOMES**

1. Able to analyse the current environmental issues, scope of environmental Technology and understand the various sustainable future concepts.
2. Able to analyse the methods used in treatment of waste water and solid waste.
3. Able to understand the concept of bioleaching process and biomining activity
4. Able to analyse the types and methods used in cleaning of the environment by bioremediation.
5. Able to define the sources of biofuels and produce various biofuels
6. Able to analyse the need of conservation of biodiversity

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2				2	1								1	1
CO2	2	3	1		1								2	2	2
CO3	3	2			1								2	3	2
CO4	2	2	1				1						2	3	1
CO5	2	1					3					2	2	2	2
CO6	2		1		2		1					2	2	3	2

21UBT633N	INDUSTRIAL SAFETY	Credits: 03
L:T:P – 3:0:0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	12 Hrs.

Industrial safety

Need for safety, importance of occupational health and safety, Health and safety programs, unsafe conditions, factors contributing to unsafe conditions, Good Lab Practices (GLP).

Accidents:

Accident preventive measure, Measurement and control of safety performance, 5E's for accident prevention- Engineering, Education, Enthusiasm, Enforcement and Evaluation. Hierarchy of Controls, Safety policy.

Chemical Hazards:

Types of hazards, Classification of chemicals based on their nature, routes to exposure of chemicals, Health effects of harmful chemicals in the work environment, Control of chemical hazards.

UNIT–II	10 Hrs.

Electrical Hazards and Control measures

Electrical hazards, protection against voltage fluctuations, effects of shock on human body. Fire- Fire formation, Fire extinguishing agents. Evacuation procedures for workers during emergency conditions.

Physical Hazards and Control measures:

Noise, noise exposure regulation, properties of sound, Workers exposure to electromagnetic field, Ionizing radiation and non-ionizing radiations, effects of radiations, Classification of dangerous materials with pictorial symbols, Safety in transportation of dangerous materials by road, rail, ships and pipelines.

UNIT–III	10 Hrs.

Biological and Construction Hazards and their control measures

Classification of Bio hazardous agents –bacterial agents, rickettsial and chlamydial agents, viral agents, fungal, parasitic agents, infectious diseases –Hazardous material used in labs, Instructions followed for hazardous waste disposal, Biohazard control program, Biological safety cabinets.

Construction Hazards:

Hazards in construction and safety measures, Good Manufacturing Practices (GMP).

UNIT–IV	10 Hrs.

Occupational Health and Toxicology

Classification of Occupational hazards, occupational related diseases- silicosis, asbestosis, pneumoconiosis, etc. lead, nickel, chromium and manganese toxicity, effects and prevention Industrial toxicology, local, systemic and chronic effects, temporary and cumulative effects. Industrial Hygiene. Various types of Company policies.

REFERENCE BOOKS *

1. Mark Friend and James Kohn, (2007), Fundamentals of Occupational Safety and Health The Scarecrow Press, Inc.
2. Phil Hughes and Ed Ferret, (2011), Introduction to Health and Safety at work, (5th edition), Elsevier Ltd.

COURSE OUTCOMES**

After completion of the course student will be able to

1. Apply the basic knowledge of Industrial hazards and safety.
2. Interpret & analyze the various types of accidents and chemical hazards.

3. Identify physical hazards and apply control measures in work place.
4. Acquire knowledge of electrical hazards and apply control measures in work place.
5. Identify various types of biological hazards and apply control measures.
6. Identify control measures and apply the knowledge in industrial toxicology and hygiene, occupational diseases in work place.

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	-	1	1	1	1	1	1	-	-	-	-	-	3	2	1
CO2	-	1	1	3	1	1	1	-	-	-	-	-	3	2	1
CO3	-	1	3	3	3	2	1	-	-	-	-	-	3	2	1
CO4	-	1	3	2	3	2	1	-	-	-	-	-	3	2	1
CO5	-	1	3	3	3	2	1	-	-	-	-	-	3	2	3
CO6	-	1	3	3	3	3	1	-	-	-	-	-	3	2	3

21UBT604L	BIOKINETICS & ENZYME TECHNOLOGY LAB	Credits: 01
L: T: P - 0: 0:2		CIE Marks: 50
Total Hours/Week: 2		SEE Marks: 50

LIST OF EXPERIMENTS

1. Isolation of alpha-amylase from sweet potato or saliva
2. Maltose calibration curve by DNS method
3. Determination of activity of Salivary alpha-amylase
4. Determination of Specific activity of an enzyme
5. Effect of pH and temperature on enzyme activity
6. Determination of Kinetics constants (Km & Vmax)
7. Urea calibration curve
8. Determine the activity of enzyme Urease
9. Effect of inhibitors on enzyme activity
10. Immobilization of enzyme and determination of immobilized enzyme activity
11. Prediction of % error, standard deviation need to be calculated from expt. no 5 and 6)

12 Hrs.

REFERENCE BOOKS*

1. Pattabiraman 2017. Laboratory manual of Biochemistry, 4th Edition, International Book Publishers, India,.
2. Sadasivam and Manickam, 2017, Biochemical methods, 2nd Edition, New age International Publishers.

COURSE OUTCOMES**

After completion of the course student will have the ability

1. To to isolate enzymes and plot calibration curves for estimation the enzyme activity and specific activity.
2. To evaluate the optimum pH and temperature required for enzyme activity and analyze the effect of inhibitors for enzyme activity.
3. To apply knowledge of Km & Vmax for enzyme activity.
4. To immobilize enzymes and find the activity of enzymes.

*** Books to be listed as per the format with decreasing level of coverage of syllabus**

**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	Programme Outcomes												Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO 1	1	2	3	2			3	3				3	2	3	1
CO 2	2	3	3	2			2	3				3	2	3	1
CO 3	2	3	3	3		3	2	2				2	2	1	2
CO 4	3	3	3	2		2	2	2				2	3	1	1