Basaveshwar Engineering College, Bagalkote
Department of Biotechnology
Schemes of Teaching and Examination
2025-26
B. E. V SEMESTER

Sl. No	Category	Subject Code	Subject Title	Credits	Hours/ Week			SAAE/Sem		Examination Marks				Contact hour per sem
					L	T	P	Study Hours	Assignment/ Quiz/ MCQs	Duration in hours	CIE	SEE	TOTAL	
1.	PCC	22UBT501C	Bioinformatics	03	3	0	0	42	6	3	50	50	100	90
2.	PCC	22UBT506C	Cell Culture Techniques	02	2	0	0	28	4	3	50	50	100	60
3.	PEC	22UBT5XXE	Elective –I	03	3	0	0	42	6	3	50	50	100	90
4.	OEC	22UXX5XXN	Open Elective-I	03	3	0	0	42	6	3	50	50	100	90
5.	PCC	22UBT507C	Bioethics, Biosafety and Regulatory affairs	03	3	0	0	42	6	3	50	50	100	90
6.	PCCL	22UBT508L	Bioinformatics Lab	01	0	0	2	0	2	2	50	50	100	30
7.	HSMS/MC	22UBT523C	EVS	01	1	0	0	14	2	2	50	50	100	30
8.	PP	22UBT504P	Mini project	02	0	0	4	-	-	3	50	50	100	56
9.	AEC	22UHS522C	Quantitative Aptitude and Professional Skills	02	2	0	0	28	4	3	50	50	100	60
10.	MC	22UHS001M 22UHS002M 22UHS003M	Yoga NSS PE	00	0	0	2	-	-	-	25	-	25	-
Total				**20**	**17**	**0**	**08**				**475**	**450**	**925**	

Elective-I

22UBT511E: Environmental BT
22UBT512E: Nutraceuticals
22UBT513E: Computational Biology
22UBT514E: Protein Engineering and Drug Design

Open Elective

22UBT532N: Biofuels Technology

Course Code: 22UBT501C	BIOINFORMATICS	Credits:3
Hours/ Week: L:T:P –3-0-0		CIE Marks:50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	12Hrs.

INTRODUCTION TO BIOINFORMATICS AND BIOLOGICAL DATABASE

Introduction to bioinformatics, Components of bioinformatics and interdisciplinary nature of bioinformatics, Classification of biological databases; Primary database: NCBI, Gen Bank, DDBJ and EMBL, PIR, Uniprot; Secondary databases: PROSITE, PRINTS, BLOCKS and Pfam; Structure data bases: Protein Data Bank (PDB), MMDB, CATH, SCOP; Specialized databases: Pub Med, OMIM, Metabolic Pathway-KEGG; ExPasy and Pub Chemdata bases, File format: Gen Bank flat file, PDB flat file. Tutorials:

Practices on other primary and secondary databases.

UNIT–II	10Hrs.

SEQUENCE ALIGNMENT AND DATABASE SEARCHES:

Introduction, Types of sequence alignment, Comparison between global and local alignment, Pair wise 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 pair wise sequence alignment

UNIT–III	10Hrs.

PHYLOGENETIC ANALYSIS AND PREDICTIVE METHODS USING SEQUENCES

Introduction, concepts of trees, typesof evolutionary trees, Rooted and un rooted 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 (ORFfinder, GenScan). Protein Secondary Structure Prediction, Tertiary Structure Predictions: Homology modeling.

Tutorials: Practices on prediction of phylogenetic trees

UNIT–IV	10Hrs.

PLASMID MAPPING AND PRIMER DESIGNING & MOLECULAR MODELING TECHNIQUES

Restriction mapping, Web based tools: Restriction Mapper and REBASE. Utilities of Mac Vector andVector 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, Docking softwares (AUTO DOCK, HEX), genome assembly and annotation:

Databases: Specialized databases like KEGG, WIT, and COGs can function as annotation tools, Tools for domain identification: CDD and SMART, BUSCO

Tutorials:Solving problemsrelatedtoRestrictionmappingandPrimerdesigning

REFERENCEBOOKS

1. Introduction to Bioinformatics–Arthur Lesk, Oxford, 2nd Edition, 2006.
2. Bioinformatics–Stuart M Brown, NYU Medical Center, NYUSA. 2000.
3. Fundamental Concepts of Bioinformatics–DE Krane & ML Raymer, Pearson, 2006.
4. Computational methods for macromolecular sequence analysis–RF Doo little. Academic Press, 1996.

COURSEOUTCOMES

After completion of the course student will be able to:

1. Analyze the data bases involved in bioinformatics along with their file formats.
2. Identify similar sequences in data bases 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. Apply restriction mapping and primer designing, approaches involved insilico drug design and genome assembly.

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	-	-	2	1	2	2			3	2	2	3
CO2	3	2	2	2	2	1	2	-			3	2	2	3
CO3	3	2	-	1	-	-	2	-			3	2	2	3
CO4	2	2	-	1	-	2	-	-			3	1	-	2
CO5	2	2	2	1	-	2	-	2			1	2	-	2

Course Code: 22UBT506C	CELL CULTURE TECHNIQUES	Credits: 02
Hours/ Week: L: T: P - 2: 0: 0		CIE Marks: 50
Total Hours/Week: 2		SEE Marks: 50

UNIT – I	8 Hrs.

PLANT CELL CULTURE

History and introduction, requirements, lab organization, media constituents, choice of media sterilization of media, explants selection, sterilization and preparation for inoculation, role of growth hormones in cell culture. Cellular totipotency, cyto differentition, organogenic differentiation, somatic embryogenesis. Plant growth hormones - auxins, gibberlins, cytokinins. Stoichometry of cell growth and product formation.

UNIT – II	6 Hrs.

CULTURE TECHNIQUES AND APPLICATIONS

Protoplast culture, somatic hybridization, haploid production, micro propagation, somaclonal variation, crop improvement, hairy root culture, synthetic seeds. Regeneration of plantlets-shooting, rooting and hardening.

UNIT – III	8 Hrs.

ANIMAL CELL CULTURE TECHNIQUES

History and development of mammalian cell culture. Lab layout and equipments, cell culture media (Natural and Artificial) - components of the medium, functions of media components. Role of antibiotics in media. Types of primary culture, establishment of primary culture, cell lines – mechanical and enzymatic mode of desegregation. Subculture - passage number, split ratio, seeding efficiency, criteria for subculture.

UNIT – IV	6 Hrs.

CELL LINE CHARACTERIZATION AND MAINTENANCE

Measurement of Cell viability-Dye exclusion and inclusion tests and Cytotoxicity assay –MTT, clonogenic assay. Preservation of cell lines. Characterization of cell lines. Cell line contaminations, detection and control. Stem cells & their applications.

REFERENCES BOOKS

1. Culture of Animal cells-3rdEdition-R. Ian Freshney. Wiley Less, 2010.
2. Introduction to Plant biotechnology by H. S. Chawla, 2nd Edition, Oxford and IBH Publishers, 2010.
3. Biotech Expanding Horizons-B. D. Singh, Kalyani Publishers, 2010.
4. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter Molecular biology of The Cell, GS publishers, 2002.

COURSE OUTCOMES

After completion of the course student will be able to

1. Apply the fundamental principles, laboratory setup, media components, sterilization techniques, and the role of plant growth regulators in plant cell culture.
2. Applyvarious plant tissue culture techniques for crop improvement.
3. Demonstrate animal cell culture techniques including cell line establishment, sub culturing, and media formulation, and *analyze* the use of antibiotics and enzymes in cell culture.
4. Evaluatecell viability, cytotoxicity, and contamination in cultured cells using appropriate assays in animal cell culture research.

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

Course Code: 22UBT507C	BIOETHICS, BIOSAFETY AND REGULATORY AFFAIRS	Credits:3
Hours/ Week: L:T:P–3-0-0		CIEMarks:50
Total Hours/Week:3		SEEMarks:50

UNIT-I	10 Hrs.

SAFETY:

Need for safety, importance of occupational safety, 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. Conflict resolution techniques.

FIRE: Classification of fire**,** Methods of Fire extinction, fire extinguishing agents, Evacuation procedure for workers during emergency.

CHEMICAL 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. Classification of Occupational health hazards.

UNIT–II	12 Hrs.

INTRODUCTION TO BIOSAFETY AND BIOSAFETY REGULATION GUIDELINES:

Definition and scope of biosafety need for biosafety, Biosafety guidelines- national guidelines, Recombinant DNA Advisory Committee (RDAC), Institutional Biosafety committee (IBC), Review Committee on Genetic Modification (RCGM), Genetic Engineering Approval Committee (GEAC), Biosafety assessment procedures for biotech foods. Cartagena Protocol on Biosafety. HAACP system, Riskgroups, Biosafety levels for microorganism BL1, BL2, BL3, BL4) plants (BL1-P, BL2-P, BL3-P, BL4-P) animals (BL1-N, BL2-N, BL3-N, BL4-N).. Laboratory associated infections and otherhazards. Riska ssessment during laboratory research.

UNIT–III	10 Hrs.

INTRODUCTION TO BIOETHICS & LEGAL ISSUES:

Scope of bioethics. Legal and Socio-Economic impacts of Biotechnology. Ethical issues associated with the consumption of genetically modified foods, Organ transplantation- ethical and legal issues. Bioterrorism-classification of biological agents with examples-social and ethical implications of biological weapons, Use of animals for research and testing and alternatives for animals in research. Recombinant organisms and transgenic crops with examples. Genetically modified organisms and their release in environment, Containments; Physical and Biological. Field trial methods using transgenic Plants.

UNIT–IV	10 Hrs.

REGULATORY AFFAIRS:

The Fundamentals of Regulatory Compliance with respect to Good Clinical Practice (GCP) & Good Manufacturing Practice (GMP) FDA, FAO, CDER. ICH guidelines- Storage conditions, Photo stability testing.

VALIDATION:

Introduction to the Basic Concepts of Process Validation & how it Differs from Design Qualification (DQ),Installation Qualification (IQ),Operation Qualification (OQ),Performance Qualification (PQ) Procedures. A Review of Prospective, Concurrent, Retrospective Validation & Revalidation.

REFERENCE BOOKS

1. Sateesh M.K.(2012), Bioethics and Biosafety, I. K. International Publication
2. Singh B.D.(2010), Biotechnology Expanding Horizon (3rd revised edition), Kalyani Publishers.
3. Goel D and Parashar S (2010), IPR-Biosafety and Bioethics (2nd edition), Pearson Education India.

COURSE OUTCOMES

After completion of the course student will be able to

1. Apply the knowledge of occupational safety, unsafe conditions, and laboratory practices to ensure a safe work environment/ Industry.
2. Apply the basics of Bioethics & Legal Issues in the field of Biotechnology and analyze ethical issues and dilemmas arising in biotechnology and life sciences research.
3. Apply the knowledge of Biosafety and Biosafety regulation guidelines for the research pertaining to applications in Biotechnology and apply relevant biosafety protocols and ethical principles to ensure responsible conduct in research.
4. Analyse the requirements of regulatory documents and compliance protocols used in laboratory and clinical practices.

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

Course Code: 22UBT511E	ENVIRONMENTAL BT	Credits: 03
Hours/ Week: L:T:P - 3_L : 0_T: 0_P		CIE Marks: 50
Total Hour/Week: 3		SEE Marks: 50

UNIT-I	10 Hrs.

INTRODUCTION

Issues and scope of Environmental BT. 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	12 Hrs.

BIOLOGICAL TREATMENT OF WASTE WATER

Waste water characteristics BOD, COD, Primary & Secondary treatment, nanofiltration, ultafilration 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. Mahopatra P K (2006), Textbook of Environmental Biotechnology, I K International Publishing House Pvt. Ltd
2. Dubey R C and Maheshwari D K (2022), Text book of microbiology (5th edition), S Chand and Company Ltd.
3. Forster C F, Wase D A J (1987), Environmental Biotechnology, United Kingdom: Ellis Horwood.

COURSE OUTCOMES

After completion of the course student will be able to

1. Analyze the scope of Environmental BT and concepts of Bioaccumulation.
2. Develop different treatment methods for waste water and solid waste by using BT approach.
3. Apply bioleaching process for metal recovery and bioremediation processes to remove environmental contaminants.
4. Identify and apply BT approach for biodiversity conservation.

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

Course Code: 22UBT512E	NUTRACEUTICALS	Credits: 3
Hours/ Week: 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	12 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, 1st Edition, 2003.
4. Shahidi and Weerasinghe, Nutraceutical beverages Chemistry, Nutrition and health Effects, American Chemical Society, 1st 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

After completion of the course student will be able to:

1. Analyze the basic concepts of nutraceuticals and nutrition.
2. Analyse the scope of nutraceuticals and functional foods.
3. Identify the nutrition related health disorders and the role of Nutraceuticals.
4. Classify nutraceuticals and the role of nutraceuticals among different age groups.
5. Explain about the basic aspects of nutraceuticals derived from microbial, plant and animal origin.
6. 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**	**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

Course Code: 22UBT513E	COMPUTATIONAL BIOLOGY	Credits -03
Hours/ Week: L:P:T- 3:0:0		CIE Marks : 50
Total Hours/Week : 3		SEE Marks : 50

UNIT – I	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 – II	10 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 – III	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 – IV	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

1. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith,1999, Pearson Education.
2. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
3. Higgins and W. Taylor (Eds), Bioinformatics-Sequence, Structure and databanks, Oxford University Press, New Delhi, 2000
4. An introduction to bioinformatics algorithms by Neil C. Jones, Pavel Pevzner. MIT Press.2004
5. Biological sequence analysis: Probabilistic models of proteins and nucleic acids by Richard Durbin, Eddy, Anders Krogh, 1998
6. Algorithms for Molecular Biology by Ron Shamir Lecture, Fall Semester, 20014.
7. 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.
8. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith, 1999,Pearson Education.
9. Arthur M.Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
10. D. Higgins and W. Taylor (Eds), Bioinformatics-Sequence, Structure and databanks, Oxford University Press, New Delhi, 2000.
11. Bioinformatics: the machine learning approach by Pierre Baldi, SørenBrunak. MIT Press.2001
12. 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**	**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	

Course Code: 22UBT514E	PROTEIN ENGINEERING AND DRUG DESIGN	Credits: 03
Hours/ Week: L:T:P – 3:0:0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	12 Hrs

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

After completion of the course student will be able to

1. Perform protein structure prediction and protein engineering and design.
2. Understand molecular modeling.
3. Know computer assisted new lead design.
4. Identify 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	PSO1	PSO2	PSO3
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	-

Course Code: 22UBT532N	BIOFUELS TECHNOLOGY	Credits: 3
Hours/ Week: 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. Benefits of biofuels for developing country (social, environment & economic). 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	10 Hrs.

BIOFUEL FEED STOCKS

Carbohydrate 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 as a source of energy.

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. Blending of biofuels

UNIT–III	12 Hrs.

TECHNOLOGIES FOR BIOFUELS

Historical background. Biochemical platform – bioethanol production with sugar, starch & cellulose based raw materials, properties of bioethanol & Innovations in bioethanol production. Thermochemical platform - biodiesel production both chemical and enzymatic process, properties of biodiesel & Innovations in biodiesel production. Biohydrogen processing and uses. Biomethanation - design of the digester, scrubbing of the gas, properties of the biogas & Innovations in biogas production. Microbial fuel cells. Biomass to bioeneregy

UNIT–IV	10 Hrs.

BIOFUELS IN PERSPECTIVE

Integrated refining concepts with reference to ethanol production. Economic feasibility of producing biodiesel. 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. Biofuel policy. Government initiatives.

REFERENCE BOOKS

1. Hand book of Biofuels edited by Sanjay Sahay Academic Press, 2022
2. Biofuel Technology Handbook by DominikRutz& Rainer Janssen, WIP renewable energies, Germany, 2008
3. Bioenergy development by Elizabeth Cushion, Adrian Whiteman & Gerhard Dieterle, World Bank Publications, 2011
4. Third generation biofuels by PratimaBajpai, Springer , 2019

COURSE OUTCOMES**

After completion of the course student will be able to

1. Apply the basic principle involved in bioconversion process in bioenergy and differentiate the conventional fuels with biofuels .
2. Diagnose the types of feed stocks used for biofuels.
3. Produce the biofuels (biodiesel, bioalcohol biogas and biohydrogen) using current technologies and innovations involved
4. Assess current issues related to biofuel production and use, research opportunities, economic feasibility of the biofuels, market strategies etc,

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

Course Code: 22UBT523C	ENVIRONMENTAL STUDIES	Credits -01
Hours/ Week: L:P:T 1:0:0		CIE Marks : 50
Total Hours/Week : 1		SEE Marks : 50

UNIT – 1	03 Hrs.

Natural Resources:
Human activities and their impacts. Environmental Impact Assessment, **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 BOOKS

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,
1. Identify natural resources and its uses.
2. Understand pollution and its effects on environment and to implement sustainable future in the work place.
3. Analyze current environmental issues.
4. 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	PSO1	PSO2	PSO3
CO 1	2		2			3					3	3		3
CO 2	2		2			3					3	3		3
CO 3	2		2			3					3	3		3
CO 4	2		2			3					3	3		3
CO 5	3		1			3					3	3		1

Course Code: 22UBT508L	BIOINFORMATICS LAB	Credits: 1
Hours/ Week: 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 Inter science, 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

After completion of the course student will be able to:

1. Search literature and sequence databases.
2. Retrieve and search sequences from databases.
3. Align pair wise and multiple sequences.
4. Identify evolutionary and relationships and functional sites in genomes.
5. Evaluate primer designing and restriction mapping.
6. Perform Docking and superimpose the structures.

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	PSO1	PSO2	PSO3
CO1	3	3	3	-	3	1	-	3				3	3	1
CO2	3	3	3	-	3	1	-	-				2	3	1
CO3	3	3	2	2	3	1	1	-				3	3	1
CO4	3	3	2	-	3	-	1	-				2	3	2
CO5	3	3	2	1	3	1	-	2				3	3	2
CO6	3	3	3	2	3	1	-	1				2	3	1

B. E. VI SEMESTER

2025-26

Sl. No	Category	Subject Code	Subject Title	Credits	Hours/ Week			SAAE/Sem		Examination Marks				Contact hour per sem
					L	T	P	Study Hours	Assignment/Quiz/MCQs	Duration in hours	CIE	SEE	TOTAL	
1.	PCC	22UBT601C	Bioprocess and Bioreaction Engineering	03	3	0	0	42	6	3	50	50	100	90
2.	PCC	22UBT602C	Upstream Processing Technology	03	3	0	0	42	6	3	50	50	100	90
3.	IPCC	22UBT606C	Biotransformation and Enzyme technology	04	3	0	2	42	8	3	50	50	100	120
4.	PCC	22UBT604C	Genomics & Proteomics	03	3	0	0	42	6	3	50	50	100	90
5.	AEC	22UHS600C	Indian Knowledge System	01	1	0	0	14	2	3	50	50	100	30
6.	PEC	22UBT6XXE	Elective-II	03	3	0	0	42	6	3	50	50	100	90
7.	OEC	22UXX6XXE	Open Elective –II	03	3	0	0	42	6	3	50	50	100	90
8.	MC	22UHS001M 22UHS002M 22UHS003M	Yoga NSS PE	00	0	0	2	-	-	-	25	-	25	-
Total				**20**	**19**	**0**	**4**				**325**	**350**	**725**	

Elective-II

22UBT621E: Biofuels Technology

22UBT622E: Food Biotechnology

22UBT623E: Biopython

22UBT624E: Bioreactor Design

Open Elective

22UBT632N : Environmental Technology

Course Code: 22UBT601C	BIOPROCESS AND BIOREACTION ENGINEERING	Credits: 03
Hours/ Week: 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	12 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. 3rd edn., Prentice Hall PTR.
4. Bailey J E and Ollis DF (2010) Biochemical Engineering Fundamentals, 2nd edn. McGraw- 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 McGraw 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.

Course Outcomes	Programme Outcomes (POs)											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**PSO1**	**PSO2**	**PSO3**
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		

Course Code: 22UBT602C	UPSTREAM PROCESSING TECHNOLOGY	Credits: 3
Hours/ Week: 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)

UNIT–III	10 Hrs.

MICROBIAL SYSTEM

Isolation of industrially important microorganisms, Strain development methods, Preservation of industrially important microorganisms. Development of inoculumfrom 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	12 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).

ANIMALCELL 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.

Cell bank 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 4th Edition. John Willey & Sons Publ.
6. Animal Biotechnology by Murray Moo-Young (1989), Pergamon Press, Oxford

COURSE OUTCOMES

After completion of the course student will be able to

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**	**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	

Course Code: 22UBT606C	BIOTRANSFORMATION AND ENZYME TECHNOLOGY	Credits: 4
Hours/ Week: L:T:P - 3-0-2		CIE Marks: 50
Total Hours/Week: 5		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	12 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) Acetyl cholinesterase, 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.

LIST OF EXPERIMENTS

1. Maltose calibration curve by DNS method
2. Determination of Alpha-amylase activity.
3. Determination of Specific activity of an enzyme.
4. Determination of effect of pH on alpha amylase enzyme activity
5. Determination of effect of temperature on alpha amylase 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.

12 Hrs.

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). Fundamental 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. K. Faber (2018). Biotransformations in Organic: Springer- Verlag.4th Edition.
6. Bailey and Ollis (2017). "Biochemical Engineering Fundamentals", Mcgraw Hill 2nd Ed.
7. Pattabiraman 2017. Laboratory manual of Biochemistry, 4th Edition, International Book Publishers, India.
8. Sadasivam and Manickam, 2017, Biochemical methods, 2nd Edition, New age International Publishers.

COURSE OUTCOMES

After completion of the course student will be able to

1. Explain mechanism of enzyme catalyzed reactions and isolate enzymes and plot calibration curves for estimation the enzyme activity and specific activity.
2. Analyze enzymatic techniques to characterize and immobilize the enzymes for industrial application. And also evaluate the optimum pH and temperature required for enzyme activity
3. Interpret the importance of enzymes for disease diagnosis and the role of inhibitors.
4. Apply their knowledge of using enzymes in detergent, wool, leather and food industries by estimating the Km and Vmax values.

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

Course Code: 22UBT604C	GENOMICS AND PROTEOMICS	Credits: 3
Hours/ Week: L:T:P – 3-0-0		CIE Marks: 50
Total Hours/Week: 3		SEE Marks: 50

UNIT-I	12 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 newgenesandtheirfunctionbydatabases, 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-III	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. 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**	**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

Course Code: 22UBT621E	BIOFUELS TECHNOLOGY	Credits: 3
Hours/ Week: 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	12 Hrs.

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 biodiesel, 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 wareD. 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. Understand the basic principle involved in bioconversion process in energy and to differentiate the conventional fuels with biofuels .
2. Diagnose the types of feed stocks used for biofuels.
3. Produce the biofuels (biodiesel, bioalcohol biogas and biohydrogen) using current technologies and innovations involved
4. Identify 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**	**PSO1**	**PSO2**	**PSO3**
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	-

Course Code: 22UBT622E	FOOD BIOTECHNOLOGY	Credits: 03
Hours/ Week: 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	12 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

After completion of the course student will be able to:

1. Analyze the importance and current status of food biotechnology.
2. 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. Apply plant food biotechnology and transplastomic technology.
5. Identify the applications of Animal food biotechnology and food safety and its regulation.
6. Analyze the 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**	**PSO1**	**PSO2**	**PSO3**
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

Course Code: 22UBT623E	BIOPYTHON	Credits: 03
Hours/ Week: L:T:P - 3 : 0: 0		CIEMarks:50
Total Hours/ Week: 03		SEEMarks:50

UNIT-I	10 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	**10 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	**10 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

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

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.

Course Outcomes	Programme Outcomes (POs)											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	PSO1	PSO2	PSO3
CO1	2	2	2	-	3	-	-	-	-	-	1	2	1	1
CO2	2	2	3	-	3	-	-	-	-	-	1	2	1	1
CO3	1	3	3	-	3	-	-	-	-	-	1	2	1	2
CO4	2	2	2	-	3	-	-	-	-	-	1	2	1	1
CO5	2	2	3	-	3	-	-	-	-	-	1	2	1	2

Course Code: 22UBT624E	BIOREACTOR DESIGN	Credits -03
Hours/ Week: L:P:T 3 : 0 : 0		CIE Marks : 50
Total Hours/Week : 3		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	12 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	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		

Course Code: 22UBT632N	ENVIRONMENTAL TECHNOLOGY	Credits: 3
Hours/ Week: L:T:P – 3:0:0		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	12 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	10 Hrs.

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. PradiptaKumMahopatra, 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. InduShekhar Thakur,2012,Environmental Biotechnology Basic concepts and applications, Second Edition, I K international Publishing House, Pvt. Ltd.

COURSE OUTCOMES

After completion of the course student will be able to:

1. Analyse the current environmental issues, scope of environmental Technology and understand the various sustainable future concepts.

2. Analyse the methods used in treatment of waste water and solid waste.
3. Understand the concept of bioleaching process and biomining activity
4. Analyse the types and methods used in cleaning of the environment by bioremediation.
5. Define the sources of biofuels and produce various biofuels
6. 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**	**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