	Code : BBTA501C	**Bioinformatics**		Semester :	5
	LTP : 3:0:0			Course Type :	PCC
Hours/Sem.	Teaching : 42Hrs.			CIE Marks :	50
	Learning (TW+SL) : 42Hrs.			SEE Marks :	50
	Exam : 6Hrs.			Total Marks :	100
	Total Hrs. : 90Hrs.			Credits :	03

Professional Competency:

Combining biology, statistics, and computer science to analyze complex biological data. This skillset is in high demand for drug discovery, clinical diagnostics,
and precision medicine, offering a competitive edge for both industry and academic roles

Course Outcomes:

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 and they understand how to utilize programming for BIG Data management
3. Construct phylo-genetic tree and analysis and use of statistical tools in predicting the structure of genes and proteins.
4. Apply restriction mapping and primer designing, approaches involved insilico drug design and genome assembly.

UNIT-I **10 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, 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 **10 Hrs.**

PROGRAMMING FOR BIG DATA MANAGEMENT AND DATABASE SEARCHES,

SEQUENCE ALIGNMENT: Python and R: Deep focus on advanced libraries (Biopython, Pandas, Scikit-Learn, Bioconductor). Cloud & Workflow Management: Using platforms like AWS or Google Cloud for biological big data; implementation of reproducible pipelines (Nextflow or Snakemake). Biological Big Data: Data management strategies for petabyte-scale genomic datasets
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 and use of programming for BIG Data

UNIT-III **12 Hrs.**

PHYLOGENETIC ANALYSIS AND PREDICTIVE METHODS USING SEQUENCES,

Introduction, concepts of trees, types of 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 (ORF finder, Gensan).
Protein Secondary Structure Prediction, Tertiary Structure Predictions: Homology modeling. Tutorials: Practices on prediction of phylogenetic trees

UNIT-IV	10 Hrs.

PLASMID MAPPING, PRIMER DESIGNING & MOLECULAR MODELING TECHNIQUES: Restriction mapping, Web based tools: Restriction Mapper and REBASE. 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 problems related to Restriction mapping and Primer designing

Reference Books:

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

Specialized Keys for e-Resources

- **Protein Structures:** Access and visualize 3D biological macromolecules via the RCSB Protein Data Bank. https://www.rcsb.org/
- **Genomic Context:** Explore reference sequences and assemblies using the UCSC Genome Browser.

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2, WK6)	2 (WK1,WK5,WK7)	2 (WK9)	2			3 (WK8)	3	2	2
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	3 (WK2, WK6)	3 (WK1,WK5,WK7)	2 (WK9)	2			3 (WK8)	3	2	2
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	3 (WK2, WK6)	3 (WK1,WK5,WK7)	3 (WK9)	2			3 (WK8)	3	2	2
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	3 (WK2, WK6)	3 (WK1,WK5,WK7)	3 (WK9)	2			3 (WK8)	3	2	2

	Code	:	BBTA502C	**Genetic Engineering & Applications**	Semester	:	04
	LTP	:	3:0:2		Course Type	:	IPCC
Hours/Sem.	Teaching	:	42 Hrs+26 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	44		SEE Marks	:	50
	Exam	:	03 Hrs		Total Marks	:	100
	Total Hrs.	:	120 Hrs		Credits	:	04

Professional Competency:

Apply the principles and techniques of molecular biology to analyze gene structure and gene expression, for solving problems in biotechnology, healthcare, agriculture, and research.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Apply the knowledge of various tools used in genetic engineering experiments.

CO2: Select and apply recombinant DNA techniques including nucleic acid detection, hybridization and amplification for gene cloning and molecular analysis.

CO3: Identify different methods of various gene transfer techniques in plants, animals and microbes for genetic improvement.

CO4:Apply the knowledge of various strategies of Gene therapy in therapeutics and engineer microbes for the production of biopharmaceuticals.

UNIT-I — 10 Hrs.

INTRODUCTION

Methodology of recombinant DNA technology, Tools of genetic engineering- vectors in recombinant DNA technology, biology and salient features of vectors, Types of vectors - plasmids, cosmids and 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 — 10 Hrs.

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 technology for plant and animal improvement-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. Viral, fungal, drought and salinity resistant transgenic plants, Antisense RNA technology (Flavr savr tomatoes). Transgenic mice and Transgenic cow. Cloning by Somatic Cell Nuclear transfer-Dolly.

UNIT-IV	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, Hepatitis B vaccine, Biopharming-plants and animals as biorectors.

List of experiments

1. Study of Safety Data Sheets (SDS/MSDS) for Chemicals Used in Genetic Engineering Laboratory
2. Preparation of competent *Escherichia coli* cells (Calcium chloride method)
3. Transformation of competent *E. coli* with plasmid
4. Blue-White Screening of recombinant colonies
5. Thermal denaturation of DNA
6. Restriction Digestion
7. Ligation Experiment
8. Southern Blotting – Agarose Gel Electrophoresis
9. Electroblotting and analysis
10. Maintenance and Storage of bacterial cells by Lyophilization (biologic samples)
11. SOP for UV-Vis Spectrophotometer and Thermal cycler
12. Polymerase Chain Reaction (PCR)

Text Books:

1. B.R. Glick, J.J. Pasternak and C.L Patten, "Molecular Biotechnology – Principles and applications of recombinant DNA", ASM Press, 6th edition, 2022
2. Watson et al., Recombinant DNA, second edition, Freeman Publishers 2010.
3. Primrose S.B, Principles of gene manipulation,., Blackwell Scientific Publications, 2010.
4. B.D.Singh, Biotechnology Expanding Horizon, 3rd revised edition, Kalyani Publishers,2010

https://onlinecourses.swayam2.ac.in/cec19_bt02/preview

Reference Books:

1. 2018.
2. Sambrook & Russell, Molecular Cloning, (3rd Edition), Cold Spring Harbor Lab, 2002.
3. Sadashiva and Manickam, Biochemical Methods, (2nd Edition), W.H. Freeman, 2017,
4. David S Latchman, From Genetics to Gene Therapy – the molecular pathology of human disease by, BIOS scientific publishers, 2010.
5. Analytical Biochemistry And Separation Techniques P. Palanivelu V Edition, Digital Printing Press, 2016

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3 (WK1 ,WK2, WK3WK4)	2 (WK1 ,WK2, WK3,WK4)	2 (WK5)	2 (WK8)	3 (WK2 and WK6)	2 (WK1, WK5, and WK7)	2 (WK9)	-	-	-	3 (WK8)	3	3	2
CO2	3 (WK1,WK2, WK3,WK4)	2 (WK1 ,WK2, WK3, WK4)	3 (WK5)	2 (WK8)	3 (WK2 and WK6)	2 (WK1, WK5, and WK7)	2 (WK9)	-	-	-	3 (WK8)	3	3	2
CO3	3 (WK1 ,WK2, WK3,WK4)	2 (WK1 ,WK2, WK3, WK4)	3 (WK5)	2 (WK8)	3 (WK2 and WK6)	1 (WK1, WK5, and WK7)	3 (WK9)	-	-	-	3 (WK8)	3	3	2
CO4	3 (WK1,WK2, WK3,WK4)	2 (WK1 ,WK2, WK3, WK4)	3 (WK5)	2 (WK8)	3 (WK2 and WK6)	2 (WK1, WK5, and WK7)	3 (WK9)	-	-	-	3 (WK8)	3	3	2

	Code	**: BBTA503C**	**BIOPROCESS AND BIOREACTION ENGINEERING**	**Semester**	**:**	**06**
	LTP	**: 3:0:0**		**Course Type**	**:**	**PCC**
Hours/Sem.	**Teaching**	**: 42 Hrs.**		**CIE Marks**	**:**	**50**
	Learning (TW+SL)	**: 42 Hrs.**		**SEE Marks**	**:**	**50**
	Exam	**: 6 Hrs.**		**Total Marks**	**:**	**100**
	Total Hrs.	**: 90 Hrs.**		**Credits**	**:**	**03**

Professional Competency:

Ability to apply Engineering and Biological principles to design, scale up, optimize, and operate bioreactor systems for the efficient production of biopharmaceuticals, biofuels, and industrial biomolecules while ensuring economic viability, safety, and regulatory compliance.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Formulate kinetic expressions for cell growth, substrate consumption, and product formation to simulate bioprocess profiles.

CO2: Apply fundamental design equations to size and evaluate performance criteria for Batch, CSTR, and PFR configurations.

CO3: Select appropriate bioreactor configurations for specific industrial bioprocess operations.

CO4: Quantify gas-liquid mass transfer rates and design aeration/agitation systems to prevent oxygen starvation in high-density cultures.

UNIT-I **10 Hrs.**

Kinetics of Microbial Growth and Media Sterilization

Microbial Kinetics: Stoichiometry of cell growth and product formation; elemental balances; electron balances and theoretical oxygen demand. Growth kinetics: Batch Growth, Balanced Growth, Effect of Substrate Concentration, Substrate utilization, Biomass production, Monod model and other growth models.

Product Formation and Substrate Kinetics: Growth-associated, non-growth-associated, and mixed-growth-associated product formation. Maintenance coefficient and yield concepts ($Y_{X/S}$ and $Y_{P/S}$)

Bioprocess Sterilization: Kinetics of thermal death of microorganisms and nutrient degradation. Design of batch sterilization processes (Del factor, sterilization time calculation). Design of continuous sterilization processes (plug flow and adiabatic sterilizers). Air sterilization: mechanisms of filtration, design of fibrous air filters

UNIT-II **12 Hrs.**

Ideal Reactor Engineering and Design Equations

Operating Characteristics of Ideal Reactors: **General features, comparisons, and operational workflows of Ideal Batch Reactor, Semi-Batch (Fed-Batch) reactor, Continuous Stirred Tank Reactor (CSTR / Mixed Flow Reactor), and Plug Flow Reactor (PFR).**

Fed-Batch and Continuous Operations: Chemostat kinetics, critical dilution rate, cell washout phenomena. Chemostat with cell recycle. Fed-batch operations: constant, exponential, and feedback feeding strategies for high cell density cultivation.

Core Performance Equations: **Basic design equations linking concentration and conversion (C_A and X_A). Basic equation for Batch, PFR and CSTR, Performance equations for steady-state Batch reactors operating at constant volume and density.**

Flow Metrics: **Formulation of Batch cycle time. Definition, mathematical expressions, and derivation of Space-Time, Space-Velocity, and Holding Time for flow reactors (CSTR and PFR).**

UNIT-III **12 Hrs.**

Bioreactor Configurations, Monitoring, and Control

Mechanically Driven Bioreactors: Stirred Tank Bioreactor (STR)—geometry, impeller types (Rushton turbine, hydrofoil), baffling, etc.

Pneumatic and Non-Stirred Bioreactors: Bubble Column reactors; Airlift Bioreactors (internal loop and external loop configurations, riser and downcomer fluid dynamics).

Immobilized and Heterogeneous Systems: Stirred and air-driven configurations including Packed Bed, Fluidized Bed, and Trickle Bed bioreactors.

Instrumentation and Bioprocess Control: On-line, in-line, and off-line sensors. Monitoring and control loop configurations for physical variables (temperature, pressure, volume/level, agitation speed), chemical variables (pH, DO, redox potential, exhaust gas analysis for O_2 and CO_2), and biochemical variables (biomass concentration via optical density).

UNIT-IV	**Hrs.**		

Mass and Heat Transfer in Bioreactors

Oxygen Transfer Operations: The demand for dissolved oxygen (DO) in aerobic cultures. Critical oxygen concentration. Two-film theory for gas-liquid mass transfer. Mass-transfer equations: Volumetric oxygen mass-transfer coefficient (kLa). Determination of kLa: Experimental methods to measure kLa (Sulphite oxidation, Static gassing-out, Dynamic gassing-out, and Oxygen balance method).

Heat Transfer: Biological heat generation (Q_{gr}) during fermentation. Heat transfer requirements, cooling jackets, internal coils, and heat exchangers. Calculation of heat transfer coefficients in bioprocess vessels.

Reference Books:

1. Bioprocess Engineering: Basic Concepts – Michael L. Shuler, Fikret Kargi, and Matthew DeLisa (Prentice Hall).
2. Chemical Reaction Engineering – Octave Levenspiel (John Wiley & Sons).
3. Bioprocess Engineering Principles – Pauline M. Doran (Academic Press).
4. Biochemical Engineering Fundamentals – James E. Bailey and David F. Ollis (McGraw-Hill).

Web links and Video Lectures (e-Resources)

- **NPTEL:** Fundamentals of Bioprocess Engineering (IIT Guwahati)
- **NPTEL:** Transport Phenomena in Bioprocesses (IIT Guwahati)
- **NPTEL:** Aspects of Biochemical Engineering (IIT Kharagpur)
- Digimat Video Learning Platform

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	CO 1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	2 (WK2, WK6)	-	-	-	-	-	1 (WK8)	3	2
CO2	CO 2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2, WK6)	-	-	-	-	1	3 (WK8)	2	3
CO3	CO 3	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)			3 (WK1, WK5, WK7)	1 (WK9)	-	-	2	2 (WK8)	3	3
CO4	CO 4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2, WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3

	Code	:	BBTA504E	**Environmental Biotechnology**	Semester	:	04
	LTP	:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90 Hrs		Credits	:	03

Professional Competency:

Design and apply biological systems using microorganisms and plants to treat waste, clean up environmental pollutants, recover metals, and conserve biodiversity.

Course Outcomes:

After completion of the course student will be able to

CO1: Interpret the scope of Envionmental Biotechnology and concepts of Bioaccumulation.

CO2: Develop different treatment methods for waste water and solid waste by using BT approach.

CO3: Apply bioleaching process for metal recovery and bioremediation processes to remove environmental contaminants.

CO4: Identify and apply BT approach for biodiversity conservation.

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, ultrafiltration 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	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.			
Text Books:			
1. Mahopatra P K., "Textbook of Environmental Biotechnology", I K International Publishing House Pvt. Ltd, 2006 2. Indu Shekhar Thakur, Environmental Biotechnology Basic concepts & Applications, 2nd Edition, IK International Pvt. Ltd, 2015			
Reference Books:			
1. Bimal C. B and Rintu B., Environmental Biotechnology, Oxford University Press, 2023 2. Dubey R C and Maheshwari D K., "Text book of microbiology" 5th edition, S Chand and Company Ltd., 2022			

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3 (WK1 to WK4)	2 (WK1 to WK4)	2 (WK5)	1 (WK8)							3 (WK8)	2	3	2
CO2	3 (WK1 to WK4)	2 (WK1 to WK4)	3 (WK5)	1 (WK8)		2 (WK1, WK5, and WK7).	2(WK9)				3 (WK8)	3	3	3
CO3	3 (WK1 to WK4)	2 (WK1 to WK4)	3 (WK5)	1 (WK8)		2 (WK1, WK5, and WK7).	2(WK9)				3 (WK8)	3	3	3
CO4	3 (WK1 to WK4)	2 (WK1 to WK4)	3 (WK5)	1 (WK8)		2 (WK1, WK5, and WK7).	2(WK9)				3 (WK8)	3	3	3

	Code	: BBTB504E	**Nutraceuticals**	Semester	:	5
	LTP	: 3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	: 42Hrs.		CIE Marks	:	50
	Learning (TW+SL)	: 42Hrs.		SEE Marks	:	50
	Exam	: 6Hrs.		Total Marks	:	100
	Total Hrs.	: 90Hrs.		Credits	:	03

Professional Competency:

Bridges the gap between nutrition and pharmaceuticals. Imparts multidisciplinary skill set encompassing evidence-based evaluation, regulatory compliance, product formulation, and targeted health applications

Course Outcomes:

After completion of the course student will be able to

1. Analyze the basic concepts of nutraceuticals and nutrition.
2. Analyze the scope of nutraceuticals and functional foods and identify the nutrition related health disorders and the role of Nutraceuticals.
3. Comprehend the classification of nutraceuticals and the role of nutraceuticals among different age groups and the basic aspects of nutraceuticals derived from microbial, plant and animal origin.
4. Distinguish about the role of biotechnology in production of plant secondary metabolites.

UNIT-I — **10 Hrs.**

INTRODUCTION TO NUTRACEUTICAL AND DIETETICS

Organizational elements, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and Phyto nutraceuticals. Scope involved in the industry, Indian and global scenario. Recommended dietary intake (RDA), acceptable dietary intake, nitrogen balance, protein efficiency ratio, net protein utilization. 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 — **12 Hrs.**

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. srael 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.
TimothtS. Tracy, Richard L. Kingston, Herbal Products 2nd Edition, 2007.

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3 (WK1, WK2, WK3, and WK4)	2(WK 1, WK2, WK3, and WK4)	- (W K5)	-	2(WK2, WK6)	1 (WK1 ,WK5, WK7)	2 (WK9)	2		-	3 (WK8)	3	3	1
CO2	3 (WK1, WK2, WK3, and WK4)	2 (WK1 , WK2, WK3, and WK4)	2 (W K5)	2 (WK8)	2 (WK2, WK6)	1 (WK1 ,WK5, WK7)	2 (WK9)	-	-	-	3 (WK8)	2	2	3
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1 , WK2, WK3, and WK4)	- (W K5)	1 (WK8)	- (WK2, WK6)	2 (WK1 ,WK5, WK7)	2 (WK9)	-	-	-	3 (WK8)	3	3	1
CO4	2 (WK1, WK2, WK3, and WK4)	2 (WK1 , WK2, WK3, and	2	2(WK	2 (WK2, WK6)	2 (WK1 ,WK5, WK7)	1 (WK9)	2	-	-	1 (WK8)	3	3	2

		WK4)												

	Code	:	BBTC504E	COMPUTATIONAL BIOLOGY	Semester	:	V
	LTP	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42Hrs.		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	90Hrs.		Credits	:	03

Professional Competency:

Professional Competency: Formulating biological hypotheses from data, developing algorithmic solutions, and applying machine learning to complex datasets like genomics and structural biology

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

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

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3 (WK 1, WK2 , WK3 and WK4)	3 (WK 1, WK2 WK3 and WK4)	3 (WK 5)		(WK 2,W K6)						2 (WK8)	2	1	
CO2	2 (WK 1, WK2 ,WK3	3 (WK 1, WK2 WK3	3 (WK 5)		(WK 2,W K6)						2 (WK8)	2	1	
CO3	3 (WK 1, WK2 WK3 and WK4)	3 (WK1, WK2 WK3 and WK4)	3 (WK 5)		(WK 2,W K6)						1 (WK8)	2	1	
CO4	3 (WK 1 WK2 WK3 and WK4)	3 (WK 1, WK2 WK3 and WK4)	3 (WK 5)		(WK 2,W K6)						1 (WK8)	2	1	

	Code : BBTD504E	Protein Engineering and Drug Design		Semester :	V
	LTP : 3:0:0			Course Type :	PCC
Hours/Sem.	Teaching : 42Hrs.			CIE Marks :	50
	Learning (TW+SL) : 42Hrs.			SEE Marks :	50
	Exam : 6Hrs.			Total Marks :	100
	Total Hrs. : 90Hrs.			Credits :	03

Professional Competency:

Developing protein engineers are tasked with designing diverse drug designing platforms

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.

UNIT-I **10 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 **12 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 **12 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.

Web links and Video Lectures (e-Resources)

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	**1** (WK1, WK2, WK3, and WK4)	-	**2** (WK5)	-	**1** (WK2 and WK6)	**1** (WK1, WK5, and WK7).	**2** (WK9)	**2 (WK1)**	-	-	**1** (WK8)	**2**	**1**	**1**
CO2	**1** (WK1, WK2, WK3, and WK4)	-	**2** (WK5)	-	-	**2** (WK1, WK5, and WK7).	**2** (WK9)	**3 (WK1)**	-	-	**1** (WK8)	**2**	**1**	**2**
CO3	-	-	**1** (WK5)	**1** (WK8).	**2** (WK2 and WK6)	-	**2** (WK9)	**2 (WK5)**	-	-	**1** (WK8)	**2**	**1**	-
CO4	**2** (WK1, WK2, WK3, and WK4)	-	**2** (WK5)	-	-	**1** (WK1, WK5, and WK7).	**2** (WK9)	**2**	-	-	**1** (WK8)	**2**	**1**	-

Course Code		:	BBTE504E	**Biorefineries and Biofuels**	Semester	:	05
L:T:P		:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	03 Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Develop the ability to design, evaluate, and optimize sustainable biofuel production processes and integrated biorefinery systems by applying principles of biotechnology, biochemical engineering, biomass conversion, and circular bioeconomy for renewable energy and value-added bioproducts.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Explain the principles of biomass resources, biofuel generations, and renewable energy technologies for sustainable biofuel production.

CO2: Apply biochemical and thermochemical conversion technologies for the production of various biofuels from renewable biomass.

CO3: Analyze the design, operation, and integration of biorefinery systems for the production of biofuels and value-added bioproducts.

CO4: Evaluate the sustainability, techno-economic feasibility, environmental impact, and future advancements in biofuels and biorefineries.

UNIT-I	**10 Hrs.**

INTRODUCTION TO BIOFUELS AND BIOMASS

Global energy scenario and renewable energy resources ,Bioeconomy and circular bioeconomy

Biomass resources and characterization ,Classification of biofuels ,First-generation biofuels ,Second-generation biofuels ,Third-generation biofuels ,Fourth-generation biofuels Feedstocks for biofuel production Advantages, limitations and applications of biofuels National Biofuel Policy and sustainability issues

UNIT-II	**12 Hrs.**

BIOFUEL PRODUCTION TECHNOLOGIES

Bioethanol production Feedstock preparation Pretreatment Hydrolysis Fermentation

Distillation Biodiesel production Oil extraction Transesterification Purification Biogas production Anaerobic digestion Biogas purification and upgrading Biohydrogen production Algal biofuels Biobutanol production

UNIT-III	**10 Hrs.**

BIOREFINERIES AND BIOMASS CONVERSION

Concept and principles of biorefineries, Types of biorefineries, Integrated biorefinery, Lignocellulosic biorefinery, Sugar platform, Syngas platform, Thermochemical conversion,Pyrolysis, Gasification Hydrothermal liquefaction, Torrefaction, Biochemical conversion Production of value-added biochemicals, bioplastics and bio-based products

UNIT-IV	**10 Hrs.**

Process Economics, Sustainability and Future Perspectives

Life Cycle Assessment (LCA)

Techno-economic analysis of biofuel production Carbon footprint and greenhouse gas mitigation Waste valorization and

circular bioeconomy Industrial biorefineries Recent advances in synthetic biology and metabolic engineering for biofuels Artificial Intelligence and digital technologies in biorefineries Future trends and commercialization challenges

Text Books:

1. C. M. Drapcho, N. P. Nhuan and T. H. Walker, **Biofuels Engineering Process Technology**, 2nd Edition, McGraw-Hill, 2020.
2. Pratima Bajpai, **Biorefinery in the Bioeconomy**, Springer, 2020

Reference Books:

1. Ayhan Demirbas, **Biofuels: Securing the Planet's Future Energy Needs**, Springer.
2. Amit Kumar and David Jones, **Biorefinery: From Biomass to Chemicals and Fuels**, Wiley..

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3(WK1, WK2, WK3 andWK4)	2(WK1, WK2, WK3 andWK4)	–	–	–	2(WK1, WK53 andWK7)	–	–	–	–	1(WK8)	2	3	2
CO2	3(WK1, WK2, WK3 andWK4)	3(WK1, WK2, WK3 andWK4)	2(WK5	2(WK8)	1(WK2, andWK6)	2(WK1, WK53 andWK7)	–	–	–	–	1(WK8)	2	3	2
CO3	2(WK1, WK2, WK3 andWK4)	3(WK1, WK2, WK3 andWK4)	3(WK5	3(WK8)	2(WK2, andWK6)	2(WK1, WK53 andWK7)	–	1	–	1	2(WK8)	2	3	2
CO4	2(WK1, WK2, WK3 andWK4)	3(WK1, WK2, WK3 andWK4)	2(WK5	2(WK8)	1(WK2, andWK6)	3(WK1, WK53 andWK7)	2(WK9)	–	1	2	3(WK8)	2	3	2

Course Code		:	BBTA505N	BIOFUELS TECHNOLOGY	Semester	:	05
L:T:P		:	3:0:2		Course Type	:	OEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	03 Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Graduate will apply the principles of biofuel science and technology to evaluate feedstocks, production processes, technological innovations, and the economic and environmental sustainability of biofuels for renewable energy applications

Course Outcomes:

After completion of the course, student will be able to:

CO1: Understand the basic principle involved in bioconversion process in energy and to differentiate the conventional fuels with biofuels .

CO2: Diagnose the types of feed stocks used for biofuels.

CO3: Produce the biofuels (biodiesel, bio alcohol biogas and biohydrogen) using current technologies and innovations involved

CO4: Understand and recall current issues related with production and use of biofuels, Research opportunities, economic feasibility of the biofuels

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 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.

Text 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.

Reference Books:

1. Biotechnology, Economic & Social Aspects: E.J. Dasilva, C Ratledge & A Sasson, Cambridge Univ. Press, Cambridge, 2000
2. Environmental Biotechnology by Pradipta Kumar Mahopatra, 2007

Web links and Video Lectures (e-Resources)

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	-	-	2 (WK2 and WK6)		1 (WK9)	-	-	-	1 (WK8)	3	2	-
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	-	3 (WK8)			2 (WK9)	-	-	-	1 (WK8)	2	-	-
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	-	3 (WK8)	3 (WK2 and WK6)		2 (WK9)	-	-	-	3 (WK8)	-	2	-
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	-	3 (WK8)			2 (WK9)	-	-	-	3 (WK8)	-	1	-

	Code	:	BBTA506L	Bioinformatics Lab	Semester	:	5
	LTP	:	0:0 :2		Course Type	:	PCCL
Hours/Sem.	Teaching	:	20 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	20 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	46 Hrs.		Credits	:	01

Professional Competency:

Integrating biological domain knowledge with computational tools and statistical methods to solve complex life science problems. Building practical expertise bridges traditional lab work with IT, opening doors in biotechnology, pharmaceuticals, and precision medicine

Course Outcomes:

After completion of the course, student will be able to:
CO1-Search literature and sequence databases.
CO2-Retrieve and search sequences from databases.
CO3-Align pair wise and multiple sequences. Evaluate the evolutionary relationships and functional sites in genomes.
CO4-Carry out primer designing and restriction mapping. Perform Docking and superimpose the structures.

List of Experiments OR Programs List

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.
6. Identification of functional sites in Genes / Genomes.
7. 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.
8. 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.
9. Docking studies – Analysis of substrate / ligand binding using homologous structures.

Reference 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.
   Bioinformatics – methods and applications: Genomics, proteomics and drug Discovery – s c Rastogi, N. Mendiratta & Prastogi, phi, 2006.

Web Links and Video Lectures (e-Resources):

How to Construct a Phylogenetic Tree in MEGA 11: A Step-by-Step Guide: https://www.youtube.com/watch?v=hHTMmaJuEbg
Protein - Protein Docking Beginner Tutorial https://www.youtube.com/watch?v=bbVBKZM31PI 2D image of protein and ligand by LigPlot+ https://www.youtube.com/watch?v=tuwGNwTQmiM

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	3 (WK2, WK6)	1 (WK1,WK5, WK7)	-	3				3	3	1
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	3 (WK2, WK6)	1 (WK1,WK5, WK7)	-	-				2	3	1
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	3 (WK2, WK6)	1 (WK1,WK5, WK7)	1 (WK9)	-				3	3	1
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2	2(WK8)	3 (WK2, WK6)	1 (WK1,WK5, WK7)		-				3	3	2

	Code : BBTA523C	**Environmental Studies**		Semester : 05	
	LTP : 1:0:0			Course Type : MC	
Hours/Sem.	Teaching : 14 Hrs.			CIE Marks : 50	
	Learning (TW+SL) : 13 Hrs.			SEE Marks : 50	
	Exam : 03 Hr.			Total Marks : 100	
	Total Hrs. : 30 Hrs.			Credits : 01	

Professional Competency:

Develop the ability to analyze environmental issues and implement sustainable solutions by applying environmental science principles, pollution control measures, and environmental legislation.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Identify natural resources and its uses.

CO2: Understand pollution and its effects on environment and to implement sustainable future in the work place.

CO3: Analyze current environmental issues.

CO4: Apply the waste management techniques in various fields.

UNIT-I **10 Hrs.**

Natural Resources:

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

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

UNIT-II **12 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, Sustainable development goals (SDGs). Environment economics – concept of green building, Circular Economy.

UNIT-III **10 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-IV **Hrs.**

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).

Text Books:

1. Benny Joseph, Environmental Studies, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., 2017.
2. Manjunath, D. L., Environmental Studies**,** 1st Edition, Pearson Education, New Delhi, 2007.
3. Anubha Kaushik and C. P. Kaushik, *Perspectives in Environmental Studies*, 8th Edition, New Age International (P) Ltd., New Delhi, 2025.
4. P. Meenakshi, Elements of Environmental Science and Engineering, 2nd Edition, PHI Learning Pvt. Ltd., New Delhi, 2012.

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	2 (WK1, WK2, WK3, and WK4)		2 (WK5)			3 (WK1, WK5 and WK7)					3 (WK8)	3		3
CO2	2 (WK1, WK2, WK3, and WK4)		2 (WK5)			3 (WK1, WK5 and WK7)					3 (WK8)	3		3
CO3	2 (WK1, WK2, WK3, and WK4)		2 (WK5)			3 (WK1, WK5 and WK7)					3 (WK8)	3		3
CO4	2 (WK1, WK2, WK3, and WK4)		2 (WK5)			3 (WK1, WK5 and WK7)					3 (WK8)	3		3

	Code : **BBTA507P**	**Mini Projects**		**Semester** :	**05**
	LTP :			**Course Type** :	**PP**
Hours/Sem.	**Teaching** :			**CIE Marks** :	**50**
	Learning (TW+SL) :			**SEE Marks** :	**50**
	Exam :			**Total Marks** :	
	Total Hrs. :			**Credits** :	**02**

Professional Competency:

Apply fundamental biotechnological principles, research methodology, ethical practices, and scientific communication skills to plan, execute, analyze, and present a mini research project that addresses a defined biotechnology problem using a systematic and professional approach.

Course Outcomes:

After completion of the course, student will be able to:

CO 1: Apply Biotechnological principles and techniques to design and conduct experiments.

CO 2: Able to develop research skills and methodical approach to maintain for the collection, storage and analysis of data.

CO 3: Able to demonstrate an awareness of ethical issues associated with their chosen field of research.

CO 4: Able to develop and demonstrate the ability to effectively communicate written and oral presentations scientifically

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
CO1	CO 1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	3 (WK1,WK5 & WK7)	2 (WK9)	2	2	3	2 (WK8)	3	3
CO2	CO 2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	2 (WK1,WK5 & WK7)	3 (WK9)	2	2	3	3 (WK8)	3	3
CO3	CO 3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	2 (WK1,WK5 & WK7)	3 (WK9)	3	2	2	2 (WK8)	3	3
CO4	CO 4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	3 (WK1,WK5 & WK7) (	3 (WK9)	3	2	2	3 (WK8)	3	3

	Course Code	:	BBTA601C	Downstream Processing	Semester	:	06
	L:T:P	:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:

Ability to systematically isolate, purify, and formulate biological products from complex harvesting media by integrating physical, chemical, and analytical unit operations, while simultaneously optimizing process economics, structural stability, yield, and regulatory product safety.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Analyze solid-liquid separation profiles and select mechanical clarification unit operations like filtration, sedimentation, or centrifugation.

CO2: Apply membrane separation mechanics, precipitation protocols, and advanced extraction principles to achieve partial purification of target fractions.

CO3: Design high-resolution purification strategies utilizing specific chromatography matrices, electrophoresis parameters, and analytical instrumentation footprints.

CO4: Formulate end-stage product finishing and preservation lines combining evaporation, crystallization, and freeze- drying setups.

UNIT-I **10 Hrs.**

Scope and Importance of Bioseparations technology in biotechnology, Characteristics of bioproducts, Criteria for selection of bio-separation techniques. Economics of bio separations in biotechnology, cost-cutting strategies. Recovery of Intracellular Products: Cell disruption methods: physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear) – chemical methods (alkali, detergents) – enzymatic methods. Isolation of insolubles: Filtration, Sedimentation, Coagulation, Flocculation, and Centrifugation. Types of centrifuges and rotors, Differential, Density gradient (zonal and isopycnic).

UNIT-II **10 Hrs.**

Product Recovery or Partial Purification:

Precipitation of Proteins, Nucleic acids, and Bioproducts by Ammonium Sulfate, Polyethylene Glycol, and Solvents;

Membrane separation processes: Dialysis, Reverse osmosis, Electrodialysis, Pervaporation, Ultrafiltration;

Extraction methods: Solid-liquid and liquid-liquid extraction methods, Advanced Extraction Methods like Ultrasound, Microwave-assisted, Supercritical fluid Extractions, Solid-phase Extraction (Adsorption).

UNIT-III **12 Hrs.**

Product Purification or Product Enrichment:

Selective Separation Techniques: Aqueous Two-phase Extraction, Micellar and Reverse Micellar Extraction;

Chromatographic separation and Electrophoresis methods: Principles of Chromatographic separation methods, Different types of chromatographic methods, Ion–exchange chromatography, Gel chromatography, Affinity chromatography. Principles of Electrophoresis and Electrophoresis mobility, applications.

Application of analytical techniques: High-Performance Liquid Chromatography; Gas Chromatography; LC-MS; GC-MS; FTIR etc. used in bioprocess Industries.

UNIT-IV **10 Hrs.**

Product Finishing:

Product polishing and finishing: Crystallization, Drying (Tray, Freeze Drying, Spray Drying), Evaporation (Rotary Evaporator), Lyophilization, and Product stabilization.

Reference Books:

1. Bioseparations: Downstream Processing for Biotechnology: Authors: Paul A. Belter, E. L. Cussler, and Wei-Shou Hu (John Wiley & Sons).
2. Bioseparations Science and Engineering: Authors: Roger G. Harrison, Paul W. Todd, Scott R. Rudge, and Demetri P. Petrides (Oxford University Press).
3. Bioseparations: Principles and Techniques: Author: B. Sivasankar (PHI Learning).

Web links and Video Lectures (e-Resources)

1. NPTEL: 1. Comprehensive Video Lecture Series (NPTEL / SWAYAM) Principles of Downstream Techniques in Bioprocess (IIT Madras) Instructor: Prof. Mukesh Doble

2. NPTEL: Membrane Technology (IIT Guwahati) Instructor: Prof. Kaustubha Mohanty

3. NCBI Bookshelf - Bioprocess and Separation Footprints

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	2 (WK2,WK6)	1 (WK1,WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2,WK6)	1 (WK1,WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2,WK6)	-	-	-	-	-	2 (WK8)	2	3	1
CO4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2,WK6)	2 (WK1,WK5, WK7)	1 (WK9)	-	-	2	1 (WK8)	2	3	2

Course Code		:	BBTA602C	**Biotransformation and Enzyme Technology**	Semester	:	06
L:T:P		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Derive the kinetic expressions for the enzyme catalysed and multi substrate reactions. Apply the techniques to immobilize enzymes, comprehend the importance of enzymes in disease diagnosis and industrial application.

Course Outcomes:

After completion of the course, student will be able to:

CO 1. To explain mechanism of enzyme catalyzed reactions

CO 2. To analyze enzymatic techniques to characterize and immobilize the enzymes for industrial application

CO 3. To interpret the importance of enzymes for disease diagnosis.

Co 4. To apply their knowledge of using enzymes in detergent, wool, leather and food industries.

UNIT-I **12 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.

Text 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.

Reference Books:

1. Nicholas C. Price and Lewis Stevens (2009). Fundamental of Enzymology, Oxford university Press, 3rd edition.
2. James R Hanson (2017). "An Introduction to Biotransformation in Organic Chemistry" 5th edition, Oxford university Press,
3. K. Faber (2018). Biotransformations in Organic: Springer- Verlag.4th Edition.
4. Bailey and Ollis (2017). "Biochemical Engineering Fundamentals", Mcgraw Hill 2nd Ed.

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 **(WK1, WK2, WK3, and WK4)**	3 **(WK1, WK2, WK3, and WK4)**	2 **(WK5)**	-	3 **(WK2 and WK6)**	-	3 **(WK9)**	-	-	-	3 **(WK8)**	3	3	3
CO2	3**(WK1, WK2, WK3, and WK4)**	3 **(WK1, WK2, WK3, and WK4)**	2 **(WK5)**	-	3 **(WK2 and WK6)**	-	2 **(WK9)**	-	-	-	3 **(WK8)**	3	3	3
CO3	3**(WK1, WK2, WK3, and WK4)**	2 **(WK1, WK2, WK3, and WK4)**	2 **(WK5)**	-	3 **(WK2 and WK6)**	-	3 **(WK9)**	-	-	-	3 **(WK8)**	3	3	3
CO4	3**(WK1, WK2, WK3, and WK4)**	3 **(WK1, WK2, WK3, and WK4)**	2 **(WK5)**	-	2 **(WK2 and WK6)**	-	3 **(WK9)**	-	-	-	3 **(WK8)**	3	3	3

	Course Code	**:**	**BBTA603C**	**Genomics and Proteomics**	**Semester**	**:**	**6**
	L:T:P	:	**3:0:0**		**Course Type**	**:**	**PCC**
Hours/Sem.	**Teaching**	**:**	**42Hrs.**		**CIE Marks**	**:**	**50**
	Learning (TW+SL)	**:**	**42Hrs.**		**SEE Marks**	**:**	**50**
	Exam	**:**	**6Hrs.**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90Hrs.**		**Credits**	**:**	**03**

Professional Competency:

To build professional competency among students to be mastered in multi-omics data integration and interpret the genomics and proteomics data

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. Use tools in DNA sequencing methods and Human genome project,
2. Understand cancer Genomics, Functional and 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

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.**

CANCER GENOMICS AND FUNCTIONAL GENOMICS

DNA and RNA alterations in tumors, genomic instability, oncogenes, and tumor suppressors drive oncogenesis. Next-Generation Sequencing (NGS) for distinguishing somatic from germline mutations, and applying this data to precision oncology.

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. Genomics and Proteomics: Principles, Technologies, and Applications (D. Thangadurai & J. Sangeetha): Examines DNA chip technology, gene expression analysis, and structure-based functional genomics
4. Albala J S & I Humprey -Smith Protein Arrays, Biochips and Proteomics, CRC Press, 1st Edition, 2003.
5. **Genomic, Proteomics, and Biotechnology** (R.C. Sobti & Mukesh Sobti): A comprehensive overview connecting genomic sequencing, transcriptomics, and computational biolog
6. Sabesan, Genomics & Proteomics–Ane Books, 2007.
7. Pennington S. R. and M J Dunn Proteomics

e-Resources to learn more about Genomics and Proteomics

- **NCI Genomic Data Commons (GDC):** The official data repository for NCI-sponsored programs, including The Cancer Genome Atlas (TCGA) and Therapeutically Applicable Research to Generate Effective Treatments (TARGET). Access, query, and download massive clinical and molecular datasets via the GDC Data Portal. [1, 2, 3]
- **Gene Expression Omnibus (GEO):** A highly utilized public repository maintained by the NIH that hosts high-throughput gene expression, microarray, and genomic datasets. Search global experiments using the NCBI GEO Database.
- NCBI: Houses a vast collection of interconnected databases, including GenBank (DNA sequences) and Gene Expression Omnibus (GEO) for sequence and array-based functional genomics data.
- Ensembl Project: A premier genome browser providing automated annotation, comparative genomics, and sequence variation data for vertebrate and model organism genomes.
- UCSC Genome Browser: A highly interactive, web-based genomic data visualizer featuring extensive annotation tracks, gene expression profiles, and comparative genomics.
- European Nucleotide Archive (ENA): Maintained by the EMBL-EBI, this platform provides free, comprehensive access to worldwide nucleotide sequencing data.

Course Outcomes:														
Course Outcomes	**Programme Outcomes**											**Program Specific Outcomes (PSOs)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	-	-	2 (WK1, WK5, and WK7).	2 (WK9)	-			1 (WK8)	-	2	3
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	1 (WK5)	-	-	2 (WK1, WK5, and WK7).		-			2 (WK8)	1	-	3
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	1 (WK8).	**2 (WK2 and WK6)**	-		-			1 (WK8)	1	2	2
CO4	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8).	**2 (WK2 and WK6)**	2 (WK1, WK5, and WK7).	2 (WK9)	2			1 (WK8)	1	2	2

	Course Code	:	BBTB604E	Food Biotechnology	Semester	:	06
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90 Hrs		Credits	:	03

Professional Competency:

Apply biotechnology principles and modern molecular techniques to develop, improve, process, and ensure the safety, quality, and nutritional value of food products while addressing global food security and regulatory requirements.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Explain the principles of food biotechnology, nutrigenomics, novel food bioprocesses, and their role in improving food quality and addressing global food security.

CO2: Apply microbial biotechnology concepts for the production of food ingredients, enzymes, nutraceuticals, microbial polysaccharides, and fermented food products.

CO3: Analyze molecular and genetic approaches for improving the nutritional quality, shelf life, and functional properties of plant-derived food products.

CO4: Evaluate transgenic animal technologies, chloroplast engineering, food safety regulations, genetically modified foods, and intellectual property rights in food biotechnology.

UNIT-I **10 Hrs.**

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 **11 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 **11 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.

Text 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

Reference Books:

1. Mahesh S.-" Plant Molecular Biotechnology"- first edition, New age international publishers, , 2008
2. Norman N.Potter and Joseph H. Hotchkiss- Food Science- fifth edition- CBS publishers and distributors, 2007.

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	–	1 (WK 8)	2 (WK2 ,WK6)	2 (WK1, WK5,W K7)	3 (WK9)	2	–	–	1 (WK8)	2	3	2
CO2	3(WK1, WK2, WK3, and WK4)	3(WK 1, WK2, WK3, and WK4)	2 (WK5)	2(W K8)	3(WK 2,WK 6)	1(WK1, WK5,W K7)	2(WK 9)	1	–	–	1 (WK8)	2	3	2
CO3	3(WK1, WK2, WK3, and WK4)	3(WK 1, WK2, WK3, and WK4)	3 (WK5)	2(W K8)	3(WK 2,WK 6)	2(WK1, WK5,W K7)	3(WK 9)	2	–	–	1 (WK8)	2	3	3
CO4	2(WK1, WK2, WK3, and WK4)	3(WK 1, WK2, WK3, and WK4)	2 (WK5)	3(W K8)	2(WK 2,WK 6)	3(WK1, WK5,W K7)	3(WK 9)	3	1	2	1 (WK8)	2	3	3

	Course Code	:	BBTD604E	Bioreactor Design	Semester	:	06
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Ability to apply mathematical, kinetic, and engineering transport principles to size, select, model, and operate scaled industrial bioreactor systems, translating cell line requirements into functional, stable, and highly productive automated fermentation equipment.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Bioreactor Fundamentals & Configurations: Analyze microbial, plant, and animal cell rate expressions alongside fundamental material and energy balances to select and categorize appropriate bioreactor configurations for submerged and solid-state fermentations.

CO2: Operational Management & Control: Identify and optimize critical environmental and physical control factors required to ensure the smooth, aseptic operation of bioreactors handling free or immobilized biocatalysts and shear-sensitive cultures

CO3: Sizing and Design of Submerged Systems: Formulate kinetic and transport design equations to size, configure, and evaluate the performance parameters of industrial Batch, Fed-Batch (Semi-continuous), and continuous flow (CSTR and PFR) bioreactors.

CO4: Advanced Reactor Synthesis: Design specialized bioreactor configurations—including cell recycle loops, multi- stage cascading systems, and packed/fluidized beds—to maximize product yields in enzyme reactions and highly demanding biological processes.

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**

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

UNIT-III — **12 Hrs**

BATCH, SEMICONTINUOUS AND CONTINUOUS BIOREACTOR 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. PBioreactor Design and Product Yield: Authors: BIOTOL Series (Butterworth-Heinemann).

2. Solid-State Fermentation Bioreactors: Authors: David A. Mitchell, Dr. Marin Berovič, and Dr. Nadia Krieger (Springer).
3. Bioreactor Engineering Research Horizon: Author: Samuel R. Catcheside (Nova Science Publishers).

Web links and Video Lectures (e-Resources)

1. NPTEL: Bioreactor Design and Analysis (IIT Madras): Instructor: Prof. Smita Srivastava
2. NPTEL: Aspects of Biochemical Engineering (IIT Kharagpur): Instructor: Prof. Debabrata Das
3. Interactive Process Design & Simulation Modules: LearnChemE - Biokinetics & Bioreactor Simulations (University of Colorado Boulder)

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	2 (WK2,WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2,WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2,WK6)	-	-	-	-	-	2 (WK8)	2	3	1
CO4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2,WK6)	2 (WK1, WK5, WK7)	1 (WK9)	-	-	2	1 (WK8)	2	3	2

	Course Code	:	BBTE604E	Biosensor Technology	Semester	:	06
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	03 Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Students will be able to design, evaluate, and apply biosensor technologies by integrating biological recognition systems, transduction mechanisms, advanced fabrication techniques, and emerging smart sensing technologies to solve real-world problems in healthcare, environmental monitoring, food safety, agriculture, and industry.

Course Outcomes:

After the completion of the course, students will be able to:

CO1: Explain the fundamental principles, components and classification of biosensors.

CO2: Compare different biosensor transduction mechanisms and evaluate their operating principles and performance.

CO3: Apply knowledge of biomolecule immobilization, fabrication techniques and performance evaluation in biosensor development.

CO4: Analyze the applications of biosensors in healthcare, environmental monitoring, food safety and emerging smart sensing technologies.

UNIT-I — **12 Hrs**

Fundamentals of Biosensors

Introduction to biosensors: Definition, history and scope. Components of a biosensor Classification of biosensors. Biological recognition elements: Enzymes, antibodies, nucleic acids, cells, microorganisms. Characteristics of biosensors: Sensitivity, specificity, selectivity, response time and stability.

UNIT-II — **10 Hrs**

Biosensor Transduction Mechanisms Electrochemical biosensors: Amperometric, potentiometric and conductometric biosensors. Optical biosensors: Fluorescence, Surface Plasmon Resonance (SPR), fiber-optic biosensors. Piezoelectric and thermal biosensors. Signal processing and data acquisition in biosensors

UNIT-III — **10 Hrs**

Design and Fabrication of Biosensors

Design and fabrication of biosensors: Design Considerations: calibration, dynamic range, linear range, signal to noise, sensitivity, selectivity, Interference, reproducibility, detection limit, stability. Fabrication techniques: self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS, Miniaturization, nanomaterial-based biosensors.

UNIT-IV — **10 Hrs**

Recent Advanced Applications

Clinical diagnostics and point-of-care testing. Biosensors in environmental monitoring, current challenges. Food quality and safety analysis, Agricultural and industrial biosensors Lab-on-a-chip devices, Internet of Medical Things (IoMT), AI-integrated biosensors and future trends

Text Books:

1. Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley& Sons, 2003, 1st Edition
2. Donald G. Buerk, Biosensors: Theory and Applications, CRC Press, 2009, 1st Edition
3. Chandra Mouli Pandey and Bansi Dhar Malhotra, Biosensors: Fundamentals and Applications, De Gruyter 2019, 1st Edition

Reference Books:

1. Florinel-Gabriel Banica, Chemical Sensors and Biosensors: Fundamentals and Applications, Wiley, 2012, 1st Edition Department of Biotechnology
2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley& Sons, 1st Edition Other Suggested Readings:

1. https://www.edx.org/course/principles-of-electronic-biosensors

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	-	2 (WK1, WK2, WK3, and WK4)	2 WK 5	3 WK8	2 WK2 & WK6	1 WK1, WK5 & WK7	2 W K9	3	-	1	2 WK8	3	2	2
CO2	-	3 (WK1, WK2, WK3, and WK4)	2 WK 5	3 WK8	-	2 WK1, WK5 & WK7	2 W K9	2	-	-	2 WK8	2	3	2
CO3	-	-	-	-	2 WK2 & WK6	3 WK1, WK5 & WK7	2 W K9	3	-	1	3 WK8	1	2	3
CO4	-	-	-	2 WK8	3 WK2 & WK6	2 WK1, WK5 & WK7	-	1	-	1	-	1	2	3

	Course Code	:	BBTF604E	**Quality Management System and Regulatory Affairs in Biotechnology**	Semester	:	06
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	03 Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Apply quality assurance and quality control principles to monitor, document, and continuously improve manufacturing processes, ensuring customer satisfaction and compliance with industrial quality standards.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Comprehend the principles and types of validation, regulatory affairs, good practices in lab, clinical , manufacturing practices and Qualification procedures.

CO2: Understand the ISO standards and environmental management systems and analyse the analytical methods of validation, issues and automated system and standards

CO3: Discuss the quality control measures used in industries

CO4: Analyse the Quality Assurance characteristics and Quality Management System**.**

UNIT-I **10 Hrs**

Introduction

Validation and Regulatory Affairs in Bio (Pharmaceutical) Manufacturing: An Introduction to FDA Operations & Industry Compliance Regulations, The Fundamentals of Regulatory Compliance with respect to Good Clinical Practice (GCP), Good Manufacturing Practice (GMP) & Good Laboratory Practice (GLP). An Introduction to the Basic Concepts of Process Validation & Qualification (IQ, OQ & PQ) Procedures, A Review of Prospective, Concurrent, Retrospective Validation & Revalidation . Validation of Water, Packaging Validation , Cleaning validation, Validation Master Plan, FAT,SAT.

UNIT-II **12 Hrs**

Validation of Analytical Methods, Validation of HVAC systems, Thermal system validation Computerized & Automated Systems **T**he Influence of Good Automated Manufacturing Practice (GAMP).

Standards Introduction**, ISO 9000 Series** of Standards, Management Responsibility, Quality System, Contract Review, Design Control, Document and Data Control, **ISO-9001-2000**, Scope, Normative Reference, Terms and Definitions, Quality Management, System, Documents Requirements, Management's Responsibility, Resource Management, Infrastructure, Product Realization, Measurement, Analysis and Improvement, **ISO-14001-2000**, Scope, Normative Reference, Terms and Definitions, Quality Management

MODULE-III **10 Hrs**

Quality Control :Quality System, Quality Objectives, Quality Policy, Quality Planning, Quality Control, Quality Characteristics, Quality Improvement, Handling, Storage, Packaging, Preservation and Delivery, Control of Quality Records, Internal Quality Audits, Training, Servicing, Statistical Techniques.

MODULE-IV **10 Hrs**

Quality Assurance

Terminology Relating to Quality, Quality Requirement, Customer Satisfaction, Capability; Terms Relating to Management, Management System, Quality Management System, Continual Improvement, Effectiveness, Efficiency; Relating to Process and Product, Process, Product, Procedure; Terms relating to Characteristics, Quality Characteristics; Terms Relating to Conformity, Non-Conformity, Defect, Preventive Action, Corrective Action, Correction, Rework, Regrade, Repair, Quality Manual, Objectives of Quality Assurance and its role in industries.

Text Books:

1. Validation of Pharmaceutical Processes: Sterile Products, Frederick J. Carlton (Ed.) and James Agalloco (Ed.), Marcel Dekker, 2nd Ed., 1998.

Reference Books:

1. Pharmaceutical Process Validation, 3rd Edition, Edited by Robert Nash and Alfred Wachter, Marcel Dekker, 2003
2. Good Manufacturing Practices for Pharmaceuticals: A Plan for Total Quality Control From Manufacturer to Consumer, Sidney J. Willig, Marcel Dekker, 5th Ed., 2000, 723 pp.,
3. Validation Standard Operating Procedures: A Step by Step Guide for Achieving Compliance
4. Pharmaceutical Equipment Validation: The Ultimate Qualification Handbook, Phillip A. . Cloud, Interpharm Press, 1998.
5. Commissioning and Qualification, ISPE Pharmaceutical Engineering Baseline Guides Series,

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK 1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	-	-	-	-	-	1	-	-	1	-	2	2
CO2	-	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	3 (WK 6)	1 (WK1, WK5 and WK7)	1 (W K9)	1	1	-	1 (WK8)	-	2	2
CO3	-	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	3 (WK 6)	1 (WK1, WK5 and WK7)	-	1	1	-	1 (WK8)	-	2	3
CO4	-	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	-	-	1 (WK1, WK5 and WK7)	-	1	1	-	1 (WK8)	-	2	

	Course Code	:	BBTA605N	Environmental Technology	Semester	:	06
	L:T:P	:	3:0:0		Course Type	:	OEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Assess renewable energy technologies and biodiversity conservation approaches for sustainable development

Course Outcomes:

After completion of the course, student will be able to:

CO1: Analyze current environmental issues, environmental impact, bioaccumulation processes, and sustainable development concepts.

CO2: Apply principles of environmental biotechnology for wastewater treatment, solid waste management, and pollution control.

CO3: Evaluate bioleaching, biomining, and bioremediation technologies for environmental restoration and resource recovery.

CO4: Analyse biofuel production technologies and biodiversity conservation strategies for sustainable environmental management**.**

UNIT-I **12 Hrs**

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

Text Books:

1. Pradipta Kumar Mahopatra, Text Book of Environmental Biotechnology, I K Publishers, 2006.
2. R.C Dubey and D K Maheshwari, Text book of Microbiology, S Chand and Company Ltd,2013

Reference Books:

1. M Y Young, Comprehensive Biotechnology Vol 1-4 (Eds). Pergamon Press, 2004
2. EJ Dasilva, C Ratledge & A Sasson, Biotechnology, Economic & Social Aspects Cambridge Univ. Press, 2003
3. Indu Shekhar Thakur,2012,Environmental Biotechnology Basic concepts and applications, Second Edition, I K international Publishing House, Pvt, Ltd.

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	-	-	-	2(WK1, WK5 and WK7)	3(WK9)	1	-	-	2(WK8)		1	1
CO2	3(WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2(WK8)	2 (WK6)	2 (WK1, WK5 and WK7)	3 (WK9)		1	-	2(WK8)	2	2	2
CO3	3(WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	3(WK8)	2 (WK6)	2 (WK1, WK5 and WK7)	3(WK9)			-	2 (WK8)	2	3	2

CO4	3(WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	2(WK8)	2(WK6)	2 (WK1, WK5 and WK7)	3(WK9)	1		-	3 (WK8)	2	3	1

	Course Code	:	BBTA606L	**Biokinetics and Enzyme Technology Lab**	Semester	:	06
	L:T:P	:	0:0:2		Course Type	:	PCCL
Hours/Sem.	Teaching	:	26 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	00		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	32		Credits	:	01

Professional Competency:

Derive the kinetic expressions for the enzyme catalysed reactions. Estimate the activity and specific activity of free and immobilized enzymes, comprehend the importance of enzymes in disease diagnosis and industrial application.

Course Outcomes:

Practical Content	**10 Hrs**

1. Preparation of reagents and buffers of constant strengths.
2. Maltose calibration curve by DNS method
3. Determination of Alpha-amylase activity.
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.

Note: (Prediction of % error, standard deviation need to be calculated from expt. no 5 and 6)

Text Books:

Pattabiraman 2017. Laboratory manual of Biochemistry, 4th Edition, International Book Publishers, India.

Reference Books:

Sadasivam and Manickam, 2017, Biochemical methods, 2nd Edition, New age International Publishers.

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK 5)	-	3 (WK2 and WK6)	-	3 (W K9)	-	-	-	3 (WK8)	3	3	3
CO2	3(WK1 , WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and	2 (WK 5)	-	3 (WK2 and WK6)	-	2 (W K9)	-	-	-	3 (WK8)	3	3	3

		WK4)												
CO3	3(WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK 5)	-	3 (WK2 and WK6)	-	3 (WK9)	-	-	-	3 (WK8)	3	3	3
CO4	3(WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK 5)	-	2 (WK2 and WK6)	-	3 (WK9)	-	-	-	3 (WK8)	3	3	3

Course Code		:	BBTA607L	**Bioseparation Techniques Lab**	Semester	:	06
L:T:P		:	3:0:0		Course Type	:	PCCL
Hours/Sem.	Teaching	:	26 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	00		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	32		Credits	:	01

Professional Competency:

Ability to design, execute, and troubleshoot a complete experimental purification sequence—transitioning smoothly from raw cell harvesting to high-resolution validation and stable formulation—while managing mass-transfer limitations, operating variables, and the structural integrity of sensitive biological entities.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Clarification & Cell Disruption: Evaluate the quantitative release of intracellular biomolecules by comparing physical and chemical cell disruption methods, and analyze biomass sedimentation behavior using coagulation and flocculation kinetics.

CO2: Mechanics of Centrifugation & Extraction: Apply centrifugal transport equations to model particle settling velocity, and implement liquid-liquid, advanced, or Aqueous Two-Phase Extraction (ATPS) systems to isolate target solute fractions.

CO3: Primary Fractionation & Analytical Profiling: Design primary fractionation protocols using salting-out, solvent, or polymer precipitation strategies, and validate the resulting product purity profile using High-Performance Liquid Chromatography (HPLC) instrumentation footprints.

CO4: Dehydration & Product Polishing: Formulate late-stage dehydration and finishing protocols by optimizing vacuum parameters in rotary evaporation and sublimation cycle kinetics in lyophilization to ensure long-term product stability.

LIST OF EXPERIMENTS	**26 per batch Hrs.**

1. Mechanical vs. Chemical Cell Disruption
2. Flocculation and Coagulation Kinetics
3. Centrifugation Mechanics
4. Fractional Protein Precipitation
5. Solvent and Polymer Precipitation
6. Advanced Extraction methods
7. Aqueous Two-Phase Extraction (ATPS)
8. Product Concentration via Rotary Evaporation
9. Lyophilization (Freeze-Drying) Operations
10. Quantitative Product Profiling via HPLC

Open Ended Experiment(s) OR Open Ended Program(s)

1. Separation and Purification of bioactive compounds/proteins/Enzymes any other products different sources

Reference Books:

1. Bioseparations Science and Engineering: Authors: Roger G. Harrison, Paul W. Todd, Scott R. Rudge, and Demetri P. Petrides (Oxford University Press).
2. Laboratory Manual in Bioprocess Engineering: Author: N. Shanthi (MJP Publishers).
3. Protein Purification Protocols: Editor: Paul Cutler (Humana Press / Methods in Molecular Biology series)

Web links and Video Lectures (e-Resources)

1. Practical Industrial Handbooks & Methodologies Cytiva (GE Healthcare) Protein Purification Handbooks
2. Lyophilization Technology Application Notes (SP Scientific / Labconco)

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	2 (WK2,WK6)	1 (WK1,WK5,WK7)	-	-	-	-	1 (WK8)	2	3	-
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2,WK6)	1 (WK1,WK5,WK7)	-	-	-	-	1 (WK8)	2	3	-
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2,WK6)	-	-	-	-	-	2 (WK8)	2	3	1
CO4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2,WK6)	2 (WK1,WK5,WK7)	1 (WK9)	-	-	2	1 (WK8)	2	3	2