VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. BIOTECHNOLOGY (BBT)

I Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14BBT11	Numerical Methods & Biostatistics	4	2	3	50	100	150	4
14BBT12	Concepts in Biotechnology	4	2	3	50	100	150	4
14BBT13	Principles of Chemical Engineering	4	2	3	50	100	150	4
14BBT14	Biomolecules and Molecular Biology	4	2	3	50	100	150	4
14BBT15X	Elective-I	4	2	3	50	100	150	4
14BBT16	Chemical Engg & Molecular Biology Lab	--	3	3	25	50	75	2
14BBT17	Seminar	--	3	--	25	--	25	1
	Total	**20**	**16**	**18**	**300**	**550**	**850**	**23**

Elective – I

14BBT151 Enzyme Technology
14BBT152 Instrumental Methods of Analysis
14BBT153 Genomics, Proteomics and Microarray

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II Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14BBT21	Bioprocess Technology	4	2	3	50	100	150	4
14BBT22	Microbial Biotechnology	4	2	3	50	100	150	4
14BBT23	Biopharmaceuticals	4	2	3	50	100	150	4
14BBT24	Advanced Bioinformatics	4	2	3	50	100	150	4
14BBT25X	Elective-II	4	2	3	50	100	150	4
14BBT26	Bioprocess & Biopharmaceuticals Lab		3	3	25	50	75	2
14BBT27	Seminar	--	3	--	25	--	25	1
	**Project Phase-I(6 week Duration)	--	--	--	--	--	--	--
	Total	**20**	**16**	**18**	**300**	**550**	**850**	**23**

****Between the III Semester and IV Semester after availing a vacation of 2 weeks.**

Elective-II

14BBT251 Environmental Biotechnology
14BBT252 Food Biotechnology
14BBT253 Molecular Modeling and Simulation

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III Semester: INTERNSHIP **CREDIT BASED**

Course Code	Subject	No. of Hrs./Week		Duration of the Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work		I.A.	Exam		
14BBT31	Seminar / Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	1
14BBT 32	Report on Internship	-	-	-		75	75	15
14BBT 33	Evaluation and Viva-voce	-	-	-	–	50	50	4
	Total	**-**	**-**	**-**	**25**	**125**	**150**	**20**

* The student shall make a midterm presentation of the activities undertaken during the first 8 weeks of internship to a panel comprising **Internship** Guide, a senior faculty from the department and Head of the Department.

The College shall facilitate and monitor the student internship program.

The internship report of each student shall be submitted to the University.

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IV Semester **CREDIT BASED**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Field Work / Assignment / Tutorials		I.A.	Exam		
14BBT41	Research Methodology, Biosafety and IPR	4	2	3	50	100	150	4
14BBT42X	Elective-III	4	2	3	50	100	150	4
14BBT43	Evaluation of Project Phase-I	-	-	-	25	-	25	1
14BBT44	Evaluation of Project Phase-II	-	-	-	25	-	25	1
14BBT45	Evaluation of Project Work and Viva-voce	–	-	3	-	100+100	200	18
Total		**8**	**04**	**09**	**150**	**400**	**550**	**28**
Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits								

ELECTIVE III

14BBT421 Clinical Biotechnology
14BBT422 Metabolic Engineering

14BBT423 Project Management, Entrepreneurship and Biobusiness

Note:

1) Project Phase – I**:** 6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carryout literature survey / visit to Industries to finalize the topic of dissertation.
2) Project Phase – II**:** 16 weeks duration during III Semester. Evaluation shall be taken during the Second week of the IV Semester. Total Marks shall be 25.
3) Project Evaluation: 24 weeks duration in IV Semester. Project Work Evaluation shall be taken up at the end of the IV Semester. Project Work Evaluation and Viva-Voce Examinations shall be conducted. Total Marks shall be 250 (Phase I Evaluation: 25 Marks, Phase –II Evaluation: 25 Marks, Project Evaluation marks by Internal Examiner (guide): 50, Project Evaluation marks by External Examiner: 50, marks for external and 100 for viva-voce).

   Marks of Evaluation of Project:

   - The I.A. Marks of Project Phase – I & II shall be sent to the University along with Project Work report at the end of the Semester.
4) During the final viva, students have to submit all the reports.
5) The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following:

   a) Head of the Department (Chairman)

   b) Guide

   c) Two Examiners appointed by the university. (Out of two external examiners at least one should be present).

I SEMESTER M. TECH (BIOTECHNOLOGY)

NUMERICAL METHODS & BIOSTATISTICS

Subject Code	**: 14BBT11**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Enable students to address the relevance of probability and statistics to advanced engineering problems in biotechnology including modeling of complex systems.

MODULE 1: **10 HOURS**

Introduction to statistics and study design: Introduction to statistics, data, variables, types of data, tabular, graphical and pictorial representation of data. Significance of statistics to biological problems, experimental studies; randomized controlled studies, historically controlled studies, cross over, factorial design, cluster design, randomized; complete, block, stratified design, biases, analysis and interpretation.

MODULE 2: **10 HOURS**

Descriptive statistics and Observational study design: Types of variables, measure of spread, logarithmic transformations, multivariate data. Basics of study design, cohort studies, case-control studies, outcomes, odd ratio and relative risks.

Principles of statistical inference: Parameter estimation, hypothesis testing. Statistical inference on categorical variables; categorical data, binomial distribution, normal distribution, sample size estimation

MODULE 3: **10 HOURS**

Comparison of means: Test statistics; t-test, F distribution, independent and dependent sample comparison, Wilcoxon Signed Rank Test, Wilcoxon-Mann-Whitney Test, ANOVA.

Correlation and simple linear regression: Introduction, Karl Pearson correlation coefficient, Spearman Rank correlation coefficient, simple linear regression, regression model fit, inferences from the regression model, ANOVA tables for regression.

Multiple linear regression and linear models: Introduction, Multiple linear regression model, ANOVA table for multiple linear regression model, assessing model fit, polynomials and interactions. One-way and Two-way ANOVA tables, F-tests. Algorithm and implementation using numerical methods with case studies.

MODULE 4: **10 HOURS**

Design and analysis of experiments: Random block design, multiple sources of variation, correlated data and random effects regression, model fitting. Completely randomized design, stratified design. Biological study designs. Optimization strategies with case studies.

MODULE 5: **10 HOURS**

Statistics in microarray, genome mapping and bioinformatics: Types of microarray, objectives of the study, experimental designs for micro array studies, microarray analysis, interpretation, validation and microarray informatics. Genome mapping, discrete sequence matching, programs for mapping sequences with case studies.

COURSE OUTCOMES:

After completion of the course, students are able to analyze and organize data graphically and numerically, Interpret and conclude the statistical problems.

TEXT BOOKS:

1. Alvin E. Lewis, Biostatistics, McGraw-Hill Professional Publishing, 2013
2. J.D. Lee and T.D. Lee. Statistics and Numerical Methods in BASIC for Biologists, Van Nostrand Reinhold Company, 1982.
3. T.P. Chapman, Statistical Analysis of Gene Expression Microarray Data, CRC, 2003.

REFERENCE BOOKS:

1. Wolfgang Boehm and Hartmut Prautzsch, Numerical Methods, CRC Press, 1993.
2. John F. Monahan. Numerical Methods of Statistics (Cambridge Series in Statistical and Probabilistic Mathematics), Cambridge University Press, 2011.
3. Joe D. Hoffman. Numerical Methods for Engineers and Scientists, CRC Press, 2nd Edition, 2001.
4. Warren J. Ewens Gregory Grant, Statistical Methods in Bioinformatics: An Introduction (Statistics for Biology and Health), Springer, 2005.

CONCEPTS IN BIOTECHNOLOGY

Subject Code	**: 14BBT12**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

To study cytology, physiology and genetics of the living organisms.
To cram microorganism, techniques and role in medicine, food, nutraceuticals and other allied industries.
To understand the basics of immune system and defence mechanism.
To comprehend about modern biotechnological techniques and their applications in broader domain.

MODULE 1: **10 HOURS**

Introduction to Biology; Macromolecules; Carbon chemistry; Proteins: Structure, folding, catalysis; Nucleic acids: DNA & RNA; storage and transfer of genetic information; Lipids: membranes, structure & function; Carbohydrate chemistry, energy storage, building blocks.

MODULE 2: **10 HOURS**

Cell Structure: Eukaryotic and Prokaryotic cells, plant and animal cells, structure of nucleus, mitochondria, ribosomes, Golgi bodies, lysosomes, endoplasmic reticulum, chloroplast, vacuoles; Cell cycle and cell division: Different phases of cell cycle, cell division: Mitosis and meiosis.

Mendelian law of inheritance: Monohybrid and dihybrid inheritance, law of segregation and independent assortment; Gene Interaction; Multiple alleles, supplementary and complementary genes, epistasis. Identification of genetic material: classical experiments; chromosome structure and organization, chemical composition of chromatin, structural organization of nucleosomes, heterochromatin, polytene and lamp-brush chromosomes, human chromosomes, chromosomal disorders.

MODULE 3: **10 HOURS**

Scope and History of microbiology, Introduction to the structure and functions of microorganism: Bacteria, Viruses, Fungi and Protozoan's. Microscopy and microbial techniques: Study of microscopes; sterilization techniques: Heat, steam, Radiation, Filtration and chemical methods; Pure culture techniques: Serial Dilution, Streak, Spread, Pour Plate.

Immune System, Innate and adaptive immunity, antigens and antibodies; types of immune response, hypersensitivity. Humoral immunity: B-lymphocytes, Immunoglobulin classes, Major Histocompatibility Complex (MHC). Cell mediated immunity. Thymus derived lymphocytes (T-cells), Antigen presenting cells (APC); Immunity to infection, Cytokines.

MODULE 4: **10 HOURS**

Scope of agricultural biotechnology, Role of Micorbes in agriculture, Biopesticides, Bio fertilizers (Nitrogen fixing microbes), GM crops. Plant metabolic engineering and industrial products: Molecular farming for the production of industrial enzymes, biodegradable plastics, antibodies, edible vaccines. Metabolic engineering of plants for the production of fatty acids, industrial oils, flavonoids etc. Basic aspects of Food & Nutrition.

MODULE 5: **10 HOURS**

Industrially important Microorganisms, Preservation techniques, Different media for fermentation, basic structure of fermentor and different types. Types of fermentation processes (surface, submerged, and solid state) and their products (ethanol, citric acid, lactic acid, enzymes, antibiotics)

Biological treatment of waste water, primary, secondary and tertiary treatments. Bio indicators, Bioremediation of xenobiotic compounds, Bioleaching of minerals from ores, Bio-sorption of toxic metals. Solid waste management. Biofuel production from agricultural wastes.

COURSE OUTCOMES:

After completion of the course, students will be aware of the cytology and physiology of living cell, Mendelism and interaction, tools and mechanism to understand microbe and their behavior along with immunology and application of biotechnology in food and other applied industries.

TEXT BOOKS

1. De Robertis EDP and De Robertis Jr. EMF, Cell and Molecular Biology, Wippincott Williams and Wiilkins publisher, 2001.
2. Strickburger M W, Principles of Genetics, 3rd edition, Prentice Hall Publication, India, 2011.
3. Prescott and Dunn, Industrial Microbiology, Macmillian, 1982
4. Ashim K Chakravarthy, Immunology & Immunotechnology, Oxford University Press, 2006.

REFERENCE BOOKS

1. Gardner, Simmonns and Snustad, Principles of Genetics, 8th edition, 2005
2. P S Verma, V R Agarwal, Cell Biology, Genetics, Evolution and Ecology, New Publisher Delhi, 2007.
3. K. Lindsey and M.G.K. Jones, Plant biotechnology in Agriculture, Prentice hall, New Jersey. 1989.
4. Munnecke DM, Johnson LM and others, Biodegradation and Detoxification of Environmental Pollutants CRC Press, 1982

PRINCIPLES OF CHEMICAL ENGINEERING

Subject Code	**: 14BBT13**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Analyze and apply chemical and biochemical systems, their principles using thermodynamic fundamentals.
Perform feasibility studies on chemical engineering processes along with fluid flow system and mechanical operation
Acquire knowledge for heat and mass transfer systems employed in industrial processes.

MODULE 1: **10 Hours**

Energy and Material Balances: Material Balance: Law conservation of mass, Material balance with and without reactions. Energy Balance: Law of conversation of energy, Energy balance with and without chemical reactions.

Introduction to Momentum Transfer: Types of fluids: Newtonian and Non Newtonian fluids. Measurement of viscosity, Laminar and Turbulent flow, eddy viscosity, flow of a fluid past a solid surface (Cells and immobilized systems), motion of particles in fluid (centrifugation & sedimentation), flow of fluid through granular bed (packed column), fluidization, and bubble column.

MODULE 2: **10 Hours**

Heat Transfer: Thermal conductivity and mechanism of energy transport, design principles of heat exchangers, measurement of heat transfer coefficient, principles, construction and application of evaporators and dryers.

Mass transfer: Diffusion, interfacial diffusion (Mass transfer), convective mass transfer, measurement of mass transfer coefficient, Mass transfer process (Principle, construction and application of Distillation, adsorption, extraction and crystallization).

MODULE 3: **10 Hours**

Thermodynamics: **F**irst and Second law of thermodynamics, application of first and second law in Biomolecular structure, PVT behaviour, PVT diagram of pure fluids, thermodynamics models used in process industries(Peng-Robinson model, EOS, NRTL,SRK etc). Chemical potential and activity of molecules, statistical thermodynamics, Bioenergetics: Energetic of metabolic pathways, energy coupling, thermodynamic efficiency of growth and yield co-efficients.

MODULE 4: **10 Hours**

Reaction Engineering: Kinetics of enzyme catalyzed reactions, kinetics of microbial growth, substrate utilization and product formation. Batch and continuous reactors, energy and mass balance in biological reactions. Heterogeneous reaction: Shell balance (Immobilized system), effect of mass transfer on reaction, Thiele modulus, solid liquid mass transfer correlations, minimizing mass transfer effects.

MODULE 5: **10 Hours**

Properties of solution, phase equilibrium. Diffusion, its types, measurement of diffusivities, theoretical estimation of diffusitivities, Drying; moisture content and its types, wet and dry moisture contents, drying curve, drying equipments, RTD curves-its interpretation, RTD for CSTR and PFR; calculations.

COURSE OUTCOMES:

After completion of the course, students are able to derive and calculate thermodynamic relations using energy equations, analyze fluid flow in pipes and mechanical operations, design transfer processes and equipments.

TEXT BOOKS:

1. Bhatt B. I and S.M. Vora Stoichiometry Tata McGraw Hill, 4th Edition, 2004.
2. McCAbe RL & J.C Smith "Unit operations of Chemical Engineering" McGraw Hill International Editions, 2001.
3. R. K. Bansal, Fluid Mechanics and Hydraulics of Machines, Laxmi Publications, New Delhi, 4th ed. 2005.

REFERENCE BOOKS:

4. O. Levenspiel, Chemical Reaction Engineering, 3rd Edition, John Wiley, 1999.
5. Bailey J.E. and Ollis D.F. Biochemical Engineering Fundamentals 2nd Edition, McGraw- Hill Book CO., Singapore, (1986).
6. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, PHI, 2002.
7. Pauline Doran, Bioprocess Engineering Principles, 1st Edition, Academic Press, 1995.

BIOMOLECULES AND MOLECULAR BIOLOGY

Subject Code	**: 14BBT14**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Portray the properties and metabolism associated with biomolecules

Enlighten on transcription, translation, and regulation of gene expression in prokaryotes and eukaryotes

MODULE 1: **10 Hours**

Introduction to Macromolecules**:** Biomolecules; Nucleic acids: storage and transfer of genetic information; Carbohydrates: energy transactions and structural blocks Proteins: structure, folding and catalysis; Lipids: membranes and energy transactions; Nucleic Acids: Structure of DNA, Alternative forms of DNA - A, B, Z and triplex DNA. Melting Curve of DNA double helix, Hyperchromoic effect and factors responsible for DNA double helical structure, Structure of RNA and Structural aspects of mRNA, tRNA and rRNA. Composition and primary structure of proteins; Conformational analysis and forces that determine protein structures and geometries; potential energy calculations, phi, psi, omega angles, Ramachandran or steric contour diagram, chi angles of side chains in proteins; hydrogen bonding; disulphide bonds; hydrophobic interactions; alpha helices; beta sheets; helix to coil transition, general features and thermodynamic aspects of protein folding and folding kinetics, protein-ligand interactions.

MODULE 2: **10 Hours**

Replication, Repair and Recombination**:** Mode of DNA Replication, basic Requirements for DNA Synthesis, Steps involved in DNA synthesis, Origin of replication in Prokaryotes and Eukaryotes, Replication initiation, elongation and termination in prokaryotes and eukaryotes; Repliosome and Replication Fork, Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA – Mitochondrial and Chloroplast DNA. DNA damage and DNA repair, DNA repair mechanisms - Photoreactivation; Nucleotide excision repair; Mismatch correction; Post replication repair and SOS repair; Recombination: Homologous and non-homologous; Site specific recombination

MODULE 3: **10 Hours**

Basic features of RNA synthesis and Steps involved in Transcription, Prokaryotic & Eukaryotic RNA Polymerases, Prokaryotic Transcription and regulation; Transcription unit, Promoters and Transcription process, Initiation; Attenuation; Termination: Rho-dependent and independent; Antitermination. Transcriptional control in lambda phage; Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA box binding protein (TBP) and TBP associated factors (TAF); Activators and repressors; Transcript processing; Processing of tRNA and rRNA,

MODULE 4: **10 Hours**

Gene regulation and Operon concept, Constitutive, Inducible and Repressible systems; Operators and Regulatory elements; Positive and negative regulation of operon; lac, trp, ara, his, and gal operons and their regulation; Transcriptional and post-transcriptional gene

silencing. Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA. ; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/ Lox recombination.

MODULE 5: **10 Hours**

Translation and Protein targeting; Requirements for protein biosynthesis, Steps involved in protein biosynthesis, Ribosomes; Composition and assembly; Genetic code; Evolutio of Triplet concept, Properties of genetic code. tRNA and its role in translation; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co- and post-translational modifications; Genetic codon variation in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation.

COURSE OUTCOMES:

After completion of the course, students are able to obtain a profound foundation in fundamental of biochemical concepts. Explain the expression, regulation, manipulation, of genes and genetic manipulation techniques in the living cells at transcriptional and post transcriptional level.

TEXT BOOKS:

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.

REFERENCE BOOKS:

3. Charles R. Cantor, Paul R. Schimmel, Biophysical Chemistry. W.H.Freeman, 1980.
4. G P Jeyanthi, Molecular Biology, MJP Publishers Chennai 2009.
5. By Veer bal Rastogi, Fundamentals of Molecular biology, Ane's Publication New Delhi 2011 .

ENZYME TECHNOLOGY

Subject Code	**: 14BBT151**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Conceptualize for product separation techniques from biological source and their utility in various industries.

Principles and techniques involved in kinetics and immobilization of enzymes.

MODULE 1: **10 Hours**

Introduction, current and potential uses of enzyme technology. Enzymes as biocatalysts: advantages and disadvantages over chemical catalysts and characteristics. Extraction and Purification of Enzymes: Extraction of enzymes: Extraction of soluble enzymes and membrane-bound enzymes, nature of extraction medium and conditions of extraction. Purification of enzymes: preliminary and secondary purification procedures, degree of purification and criteria of purity of enzymes. Determination of molecular mass of enzymes.

MODULE 2: **10 Hours**

Enzymatic Techniques: Principles of enzymatic analysis. End-point and kinetic methods, immunoassays, spectrophotometric, electrochemical and radiochemical. Test strips methods, automation in enzymatic analysis: fixed time, fixed and continuous concentration. Handling of enzymes and coenzymes. Applications of enzymes in medicine and diagnostic kits; therapeutic enzymes.

MODULE 3: **10 Hours**

Industrial Applications of Enzyme Technology: Textile industry, detergents, pulp and paper, leather, wood, animal feed, food and dairy industry - amylases, proteases, lipases, pectinases. Immobilization of Enzymes: Introduction, immobilization techniques and carriers. Immobilization techniques for soluble and insoluble (bound) enzymes. Immobilization of cells and organelles. Activity and kinetics of immobilized enzymes.

MODULE 4: **10 Hours**

Immobilized Enzyme Reactors: Types of bioreactors: Batch stirred tank, plug-flow tubular, continuous stirred tank, fixed (packed) bed, fluidized bed and membrane. Applications Of Immobilized Enzymes: Enzyme sensors for clinical analysis, therapeutic medicine (intracorporeal and extracorporeal applications). Production of high-fructose corn syrup, L-aspartic acid, L- alanine and acrylamide. Environmental applications. Economic aspects of immobilized enzymes, microorganisms, mammalian cells and plant cells. Safety aspects.

MODULE 5: **10 Hours**

Enzyme Engineering: Glucose isomerase, subtilisin, redesigned lactate dehydrogenase. Synthetic enzymes- peroxidase. Catalytic antibodies.

COURSE OUTCOMES:

After completion of the course, students are able to utilize the principles of enzyme purification and the product in various industries.

TEXT BOOKS:

1. Klaus Buchholz, Volker Kasche and Uwe Theo Bornscheuer. Biocatalisys and Enzyme Technology. 1st edn. Wiley-VCH, 2005.

2. Wolfgang Aehle. Enzymes in industry-production and applications. 3rd edn. Wiley-VCH, 2007.

3. Chaplin M.F. and C. Bucke. Enzyme Technology. CUP. Cambridge. 1990.

REFERENCE BOOKS:

4. Price N. C. and L Stevens. Fundaments of Enzymology: 3rd edn. Oxford University Press. 2003.

5. Trovor Palmer. Enzyme- Biochemistry, Biotechnology, Clinical chemistry. East West Press Pvt Ltd. 2004.
6. Bommanius A.S. and R. Riebel. Biocatalysis. Wiley-VCH. 2004
7. Octave Levenspiel. Chemical Reaction Engineering. 3rd Edition. John Wiley and Sons. 1999.

INSTRUMENTAL METHODS OF ANALYSIS

Subject Code	**: 14BBT152**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

To familiarize with spectroscopic, chromatographic, electrophoretic and scattering methods and techniques of instrumentation

To understand the underlying principles for different instruments used in the laboratory.

MODULE 1 INTRODUCTION **10 Hours**

Introduction to analytical methods, types of analytical methods, selection of analytical method (accuracy, precision, sensitivity, selectivity, scale, time and cost).

Measurement and error: Types of error, measurement of error and accuracy.

Electromagnetic radiation: Properties of electromagnetic radiation, interaction of radiation with matter, Born – Oppenheimer approximation.

Sources of radiation: Continuous sources of UV, visible and IR radiation (D2, Tungsten filament, Xenon arc lamps, Nernst glower, Globar sources).

Components of an analytical instrument, signal amplifiers (Transistors, Operational Amplifiers), noise, signal to noise ratio, sources of noise, signal to noise improvement.

Sampling: types of samples, sample preparation, sample size, sampling error, stock solutions, sample dilution.

Calibration methods: reagent blank, one point calibration, linear calibration, standard addition method, internal and external standard.

MODULE 2 ABSORPTION & EMISSION SPECTROSCOPY 10 Hours

Optical spectroscopy: Source, optical components, wavelength selector, sample holders, detectors.

UV-Visible spectroscopy: Theory (Beer – Lambert's law), chromophores and their characteristic absorption, instrumentation (single and double beam), qualitative and quantitative analysis, single and multiple component analysis, numericals.

Infrared spectroscopy: Theory, instrumentation, qualitative analysis, FT-IR. Atomic absorption spectroscopy: Theory, instrumentation and applications. Fluorescence and Phosphorescence spectroscopy: Theory, instrumentation and applications.

MODULE 3 RESONANCE & SCATTERING SPECTROSCOPY 10 Hours

Nuclear magnetic resonance spectrometry: Theory, environmental effects on pNMR, chemical shift, applications of pNMR, data interpretation, MRI.

Molecular mass spectrometry: Theory, methods of ionization, mass analyzers, MALDI-TOF, and applications.

Raman spectroscopy: Origin of Raman spectra, theory, instrumentation and applications. Turbidimetry: Theory, instrumentation and applications.

MODULE 4 CHROMATOGRAPHIC TECHNIQUES 10 Hour

Introduction to chromatographic separations, classification. Basic principles and theory of chromatography. Gas chromatography and HPLC: principle, instrumentation, column, detector, mobile phase, sample preparation. Application of chromatographic techniques.

MODULE 5 ELECTROPHORETIC TECHINQUES 10 Hours

General principle, support media- Agarose gel, starch gel, agarose starch gel, polyacrylamide gel. Electrophoresis of protein: SDS-PAGE, native gels, gradient gels, isoelectric focusing gels, 2D polyacrylamide gel electrophoresis, cellulose acetate electrophoresis. Detection, estimation and recovery of proteins in gels. Electrophoresis of nucleic acids. Capillary electrophoresis.

COURSE OUTCOMES:

After completion of the course student will be able to correlate the applications of various instrumentation and analytical methods used in academia and industry.

TEXT BOOKS:

1. Willard and Merit, Instrumental Methods of Analysis, CSS Publishers, 1986.
2. Douglas A. Skoog, F. James Holler and Timothy A. Nieman, Principles of Instrumental analysis, Harcourt Brace College Publishers.
3. R.M. Silverstein and W.P. Webster, *Spectrometric Identification of organic compounds*, Wiley & Sons, 1999.

REFERENCE BOOKS:

4. Chatwal & Anand, Instrumental Methods of Chemical Analysis, Himalaya Publishing House.
5. K. Wilson and J. Walker, Principles and techniques of Practical biochemistry, Cambridge University Press, Cambridge, 1994.
6. S. Ahuja & N. Jespersen, Modern Instrumental Analysis, Elsevier, 2006
7. B. Sivasankar, Instrumental methods of analysis, Oxford University Press, 2012

GENOMICS, PROTEOMICS AND MICROARRAY

Subject Code	**: 14BBT153**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Explain the molecular aspects of genome and proteome

Correlate the markers for various biotechnological purposes

To know the technology of microarray and protein array along with its application in the fields of medicine, agriculture and

environment.

MODULE 1: **10 Hours**

Introduction: Genomics and Proteomics. Structure, organization and features of Prokaryotic & Eukaryotic Genomes. Vectors, Genome mapping. Polymorphisms: Molecular markers – RFLP, AFLP, RAPD, SCAR, SNP, ISSR, and Protein markers - Allozymes and Isozymes, Telomerase, FISH - DNA amplification markers and Cancer biomarkers. Genome sequences databases and Genome annotation, Gene discovery. Gene Ontology. Haplotyping and Diplotyping. Genome Sequencing: Early sequencing efforts. DNA sequencing methods - Maxam-Gilbert Method, Sanger Dideoxy method, Fluorescence method, shot-gun approach and ultra-high-throughput DNA Sequencing using Microarray technology. Genome sequencing projects on *E.coli.* Arabidopsis and rice; Human-genome project and the genetic map. Recent developments and next generation sequencing. Raw genome sequence data, expressed sequenced tags (ESTs), Gene variation and associated diseases, diagnostic genes and drug targets. Genotyping - DNA Chips, diagnostic assays, diagnostic services. Comparative genomics and Functional Genomics. Studies with model systems such as Yeast, Drosophila, C. *elegans,* Arabidopsis. SAGE.

MODULE 2: **10 Hours**

Functional Genomics: C-Values of eukaryotic genomes. Organization of microbial, plant and animal genomes, repetitive and coding sequences. Identification and tagging of markers for important traits, T-DNA & trasposon tagging. Cloning of genes by map-based cloning, Construction & Screening of cDNAs libraries, differential display via RT-PCR. Micro-array in functionalgenomics. Genome annotation: Extrinsic, Intrinsic (Signals and Content), Conservative information used in gene prediction. Frameworks for Information integration – Exon chaining, Generative models: Hidden Morkov Models, Discriminative learning and Combiners. Evaluation of Gene prediction methods – Basic tools, Systematic evaluation and Community experiments (GASP, EGASP and NGASP).

MODULE 3: **10 Hours**

Proteomics: Scope, Experimental methods for studying proteomics, methods of protein isolation, purification and quantification. Methods for large scale synthesis of proteins. Applications of peptides in biology. Analysis of proteins - high throughput screening, engineering novel proteins, Mass-Spectroscopy based protein expression and post-translational modification analysis. Bioinformatics analysis - clustering methods, proteome functional information.

MODULE 4: **10 Hours**

Functional annotation of Proteins: Introduction, Protein sequence databases, UniProt, UniProtKB – Sequence curation, Sequence annotation, Functional annotation, annotation of protein structure, post-translational modification, protein-protein interactions and pathways, annotation of human sequences and diseases in UniProt and UniProtKB. Protein family classification for functional annotation – Protein signature methods and Databases, InterPro, InterProScan for sequence classification and functional annotation. Annotation from Genes and Protein to Genome and Proteome. Microarray: Basics of Biochips and Microarray Technology, Historical Development, Biochip technologies.

MODULE 5: **10 Hours**

Applications Of Biochip Technology: Molecular diagnostics, Pharmacogenomics, application of microarray technology in drug discovery and development, Gene expression studies, Use of DNA chip technology for drug safety, Use of microchips for drug delivery, Use of biochips in healthcare, Use of microarrays in population genetics and epidemiology, Use of microarrays in forensics, DNA chip technology for water quality management, Application of micro arrays in the agro-industry; use of microarrays in Genetic disease monitoring; Point of Care (P.O.C) applications, Limitations of biochip technology. Commercial Aspects of Biochip Technology: Markets for biochip technologies, Commercial support for the development of biochips, Government support for biochip development, Business strategies, and Patent issues. DNA computing.

COURSE OUTCOMES:

After completion of the course, students are able to demonstrate the construction concepts of various genome map, acquire the method involved in analysis of proteins, use the tools and techniques for microarray, data analysis in disease diagnosis.

TEXT BOOKS:

1. Bioinformatics, Genomics, and Proteomics By Ann Batiza, Ann Finney Batiza, Published by Chelsea House Publishers, 2005.
2. Biochips and Microarays – Technology and Commercial Potential Published by: Informa Global Pharmaceuticals and Health Care.
3. A. Malcolm Campbell, Laurie J. Heyer, Discovering genomics, proteomics and bioinformatics.Pearson/Benjamin Cummings, 2006.

REFERENCE BOOKS:

4. Grigorenko. E.V. DNA Arrays: Technology and Experimental Strategies CRC Press. 2002.

5. Mark Schena, Microarray Analysis. John Wiley & Sons. 2002.
6. Pharmacogenomics. Werner Kalow, Urs A. Meyer, Rachel F. Tyndale.
7. Sandor Suhai, Genomics and Proteomics, Springer publishing.

CHEMICAL ENGINEERING AND MOLECULR BIOLOGY LAB

Subject Code	**: 14BBT16**	**IA Marks**	**: 25**
No. of Practicals Hrs./ Week	**: 03**	**Exam Hrs**	**: 03**
		Exam Marks	**: 50**

COURSE OBJECTIVES:

To provide hands on training with procedures for real time problems in chemical engineering and to teach molecular biology technique.

Lab Experiments

1. Calculation minimum settling velocity of cells.
2. Calculation of fluidizing velocity of immobilized enzyme system.
3. Rate of drying.
4. Extraction of antibiotics from different organic solvent and studying its efficiency of extraction.
5. Study of adsorption of proteins on matrix by different isotherms.
6. Study of mass transfer effect on reaction of immobilized enzymes.
7. Isolation of genomic DNA from Bacteria/ Plant/ Animal cells and its quantification
8. Study of Denaturation and Renaturation of DNA and Calculation of Tm value of DNA
9. Isolation of total RNA from *E.coli*
10. Preparation of Competent *E coli* cells and Transformation.
11. Isolation of Plasmid DNA and its purification

12. Restriction analysis and agarose electrophoresis of DNA

COURSE OUTCOMES:

At the end of the sessions the student will be able to perform experiments related to methods in chemical engineering and basic molecular biology techniques.

TEXT / REFERENCE BOOKS:

1. Hans Peter Schmauder (Editor). Methods in Biotechnology Published by Taylor & Francis. 2004.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Keith Wilson and John Walker, Pricniples and Techniques of Biochemistry and Molecular Biology, 2000.

II SEMESTER M. TECH (BIOTECHNOLOGY)

BIOPROCESS TECHNOLOGY

Subject Code	**: 14BBT21**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

To understand the basic concept of bioprocessing along with its kinetics and interaction
Conceptualise the principle and mode of fermenter/bioreactors in accordance to its application
To comprehend the product formulation along with energy dynamics and its utility

MODULE 1: **10 Hours**

Bioprocess development: An interdisciplinary challenge, Biotechnology & Bioprocess Engineering, steps in bioprocess development, Media ingredients, medium formulation, media sterilization, medium optimization, Ingredients for mammalian cell culture and plant cell culture. Microbial kinetics: Growth yield, kinetic models, monod kinetics, transient growth kinetics, filamentous growth kinetics, substrate degradation and product formation kinetics, factors effecting kinetics.

MODULE 2: **10 Hours**

Fermentation process: Parts of fermenter: Body construction, Baffles, agitators, Sparger, valves, ports. Bioreactor configurations: Bubble column, airlift reactor, packed bed, fluidized bed, trickle bed, Solid state fermenter, Animal and plant cell bioreactors. Scale up of bioreactors. Numericals on scale-up.

Concept of bioprocess control, Elements of feedback controller, types of controller action, advanced control strategies, controller tuning, online and offline measurements (P,T, pH, agitator speed, DO, off gas analysis).

MODULE 3: **10 Hours**

Heat and Mass Transfer: Heat transfer in bioreactor, effect of heat transfer on microbial growth, role of diffusion, types of mass transfer (S-L, L-L, G-L), Oxygen requirements and uptake by cells, measuring DO, determination of K_La, factors affecting K_La, oxygen in large vessel**.** Numericals. Fermenter fluid rheology: Viscosity, broth rheology, viscosity measurement, factors affecting viscosity, mechanism of mixing, flow patterns in fermenter, mixing time, power requirement, effect of rheology on mixing, role of shear. Numericals.

MODULE 4: **10 Hours**

Downstream processing in Bioprocess technology. Process design criteria for various classes of bioproducts (high volume, low value products and low volume, high value products), General account of downstream processing steps: removal of insoluble’s, cell disruption, isolation,

MODULE 5: **10 Hours**

Heterogeneous system: Interaction b/w mass transfer and reaction, steady state shell balance, external and internal mass transfer effects. Numericals .

Product purification and product formulation, Quality analysis: Analysis of product purity: Chromatography, electrophoresis and spectroscopy.

COURSE OUTCOMES:

After completion of the course, students are able to demonstrate and apply the principles techniques and law of bioprocess in understanding and designing of fermenters along with product formulation with strong understanding of the concepts behind.

TEXT BOOKS:

1. Stanbury & Whittaker, Principles of Fermentation Technology. Pergamon Press, 2000.
2. Pauline M. Doran. Bioprocess Engineering Principles. Academic Press, 2003
3. E. I. Mansi & Bryce. Fermentation Microbiology & Biotechnology. Taylor & Francis, 2004.

REFERENCE BOOKS:

4. Bailey & Ollis. Biochemical Engineering Fundamentals, McGraw Hill, 1986.
5. Shuler and Kargi. Bioprocess Engineering. Prentice Hall, 1992.
6. Hans-Peter Schmauder. Methods in Biotechnology. Taylor & Francis, 2004

MICROBIAL BIOTECHNOLOGY

Subject Code	**: 14BBT22**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Apply and understand the techniques of genetic engineering in the field of microbial biotechnology

Develop methodology for production of various important metabolites along with production of vitamins and other adjuvants
Describe the role of microbe in mineral recovery and fuel production

MODULE 1: **10 Hours**

Industrially important microorganisms, aerobic and anaerobic microbial processes, introduction to microbial process development, scale - up and scale-down of microbial processes, Microbial Biotechnology: scope, techniques and examples. World of omics. Microbial cultures: Isolation of cultures, screening for activities, culture preservation and inoculum development, small-scale liquid and solid state fermentations, strain improvement: the random and empirical approach.

MODULE 2: **10 Hours**

Microbes and genetic engineering – Introduction to genetic engineering, producing genetically engineered microorganisms – *Escherichia coli and Saccharomyces cerevisiae*. Introduction of DNA into bacteria, use of vectors, detection of clone containing desired fragment, expression of clones genes, Recovery and purification of expressed proteins. Production of proteins in yeast, yeast cloning vectors, enhancing the expression of foreign genes in yeast, expression of foreign gene products in secreted form.

MODULE 3: **10 Hours**

Aerobic and anaerobic fermentation, types of fermenter, process of fermentation, Microbial culture system – batch culture, fed batch culture, continuous culture, measurement and control of bioprocess parameters, scale-up. Liquid and solid-state fermentation, Downstream processing – Solids removal, primary separation, purification and isolation of products (emphasis to proteins).

MODULE 4: **10 Hours**

Production of primary and secondary metabolites, Solvents - Alcohol, Glycerol. Organic acids – Citric acid, acetic acid, L-ascorbic acid, lactic acid. Antibiotics – Penicillins (Penicillin), Cephalosporins (cephalosporin), Aminoglycosides (streptomycin), Tetracyclines (chlortetracycline), Macrolides (erythromycin A). Amino acids – L-glutamic acid, L-lysine, L-tryptophan. Vitamins – Vitamin B12, Riboflavin, Beta-carotene. Beverages from microbes, Microbial polysaccharides and polymers.

MODULE 5: **10 Hours**

Microbes in Energy & Environment: Alcohol and methane from biomass, photo-biological hydrogen production, Electricity from biofuel cells. Microbial mining and metal biotechnology – Bioleaching and biosorption.

COURSE OUTCOMES:

After completion of the course, students are able to modify microbes for the production of various commercially important compounds and provide the strategy for production of primary and secondary metabolites.

TEXT BOOKS:

1. Alexander N glazer, Hiroshi nikaido, Microbial Biotechnology. 2nd Edition, Cambridge, 2008.

2. L.E. Casida Jr, Industrial microbiology. New age International publisher, 2008.

3. Lee yuan Kun (edi), Microbial biotechnology – Principles and applications World Scientific publisher, 2004.

REFERENCE BOOKS:

4. E I Mansi and Bryce. Fermentation Microbiology and Biotechnology Taylor & Francis, 2004.

5. Michael Waites, Neil Morgan John Rockey and Gary Higton. Industrial Microbiology: An Introduction. Blackwell publishing.

BIOPHARMACEUTICALS

Subject Code	**: 14BBT23**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Illustrate the process and mechanism of biopharmaceutical products. Enhance the knowledge and understanding of emerging aspects of biopharmaceuticals.

MODULE 1: **10 Hours**

Introduction to pharmaceutical industry, pharmaceutical products, Biopharmaceuticals & Biotechnology, Biopharmaceuticals: Current status & future prospects. Traditional pharmaceuticals of biological origin. Pharmaceuticals from plant, animal and microbial origin. Drug discovery & development process. Impact of genomics, Patenting, Delivery of biopharmaceuticals, pre-clinical trials, clinical trials, the role of regulatory authorities.

MODULE 2: **10 Hours**

Pharmacopeias, good manufacturing practices, manufacturing facilities, clean rooms, water systems, CDS practices, sources of biopharmaceuticals, production of final product & formulation, analysis of final product, labeling and packing, physico-chemical and biological tests applied to biopharmaceuticals, qualitative and quantitative tests for proteins, electrophoresis, HPLC, Mass spectrometry, Immunological approaches for the detection of impurities. Endotoxin testing, BET testing.

MODULE 3: **10 Hours**

The cytokines, growth factors, haemopoietic growth factors, growth factors, hormones of therapeutic interest, blood products & therapeutic enzymes (with appropriate case studies). Manufacturing activities for Monoclonal Antibodies, vaccines and adjuvants. Nucleic acid therapeutics, gene therapy, anti-sense technology.

MODULE 4: **10 Hours**

Chemical conversion processes, physic-chemical principles in drug metabolism, Action of drugs on CNS, CVS, Recombinant protein and drug development, Nutraceuticals and biological.

MODULE 5: **10 Hours**

Product processing and packaging, Scale-up techniques, packaging material science. Validation, stability testing, Quality Control & Quality Assurance, Drug regulatory Affairs. The Food and Drug Administration, European regulations, Drug regulation in Japan, World harmonization of drug approvals.

COURSE OUTCOMES:

After completion of the course, students are able to conceptualize the role of biopharmaceuticals. Exercise better professionalism by incorporating manufacturing of pharmaceutical products.

TEXT BOOKS:

1. Gary Walsh (Second Edition), Biopharmaceuticals: Biochemistry and Biotechnology Wiley Publishers, 2003.
2. Gray Walsh & B. Murphy, Biopharmaceuticals and industrial prospective, Kluwer publishers, 1999.
3. Bernard Glick, Jack Pasternak, Cheryl Patten. Molecular Biotechnology, ASM Press, 2009.

REFERENCE BOOKS:

4. Dann, J.A, Crommelin & Robert D., Sindelar, Pharmaceutical Biotechnology, Taylor & Francis, 2002.
5. Arnold Demain and Julian Davies, Manual of Industrial Microbiology and Biotechnology. ASM Press, 2004.

ADVANCED BIOINFORMATICS

Subject Code	**: 14BBT24**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

To have knowledge of molecular and genetic engineering principle to design and predict the structure of novel compounds.
To know the principle of drug design and its applications in proteomics and genomics.
Explore logical and critical thinking ability to solve biological problems with the help of BioPerl and other bioinformatic techniques

MODULE 1: **10 Hours**

Basic Concepts of Molecular Biology: Proteins, Nucleic Acids: DNA, RNA. Molecular Genetics: Genes and Genetic code, Transcription, Translation and Protein synthesis, Chromosomes Genome: Maps and Sequences, Sequencing Techniques, Human Genome project, Sequence Databases.

MODULE 2: **10 Hours**

Biological Databases: Types of databases – Primary and Secondary biological databases. Primary databases, secondary databases, genotype databases, molecular structure databases and genome databases. Hidden Markov Models: Forward and Backward algorithm, Viterbi algorithm, Applications: Modelling Protein sequence families, multiple alignments.

MODULE 3: **10 Hours**

Protein Modeling and *Insilico* Drug Design: Protein structure, signal peptides, transmembrane proteins, analysis of protein structures. Protein modeling, modeling protein structures using High Throughput methods. Insilico drug design, Virtual Library design, vHTS and Scaffold Hopping, Predictive Science (Biological Activity, ADMET). Structure based Drug Design (SBDD), Lead Optimization, Structural Mining: Protein Ligand work analysis. Study of drug-interactions, Docking.

MODULE 4: **10 Hours**

Perl and Bioinformatics: Basics of PERL, Intermediate and Advanced, Biological databases, Sequence analysis and alignment, Evolutionary analysis. Metabolomics.

Working with Discovery Studio (Molecular Modeling): 2D and 3D visualization, 2D and 3D molecular descriptors, Quantum mechanics / molecular, mechanics. SAR analysis, 2D and 3D QSAR. Bayesian statistics, neural networks, recursive partitioning, GFA, etc. Library analysis and Library design. Predictive ADME and toxicology (TOPKAT®), Conformation generation and Analysis. Structure-based and structure-guided design, docking, scoring. Virtual screening and compound ranking/scoring.

MODULE 5: **10 Hours**

Receptor-ligand interactions analysis, Fragment-based design, *de novo* design (LUDI), Pharmacophore generation (Catalyst), Scaffold hopping, 3D database screening, Simulations, molecular mechanics/dynamics (CHARMm). Explicit/implicit solvation models, Transmembrane protein modeling, Homology modeling, Antibody modeling, Electrostatics calculations, protein ionization and pK prediction, Protein modeling (MODELER®) and analysis, protein engineering. Protein-protein docking and refi nement, Sequence analysis, sequence alignment, phylogenetic analysis, • X-Ray (CNX), structure refi nement and analysis.

COURSE OUTCOMES:

After completion of the course, students are able to explain the overview of bioinformatics and biological databases, use the knowledge of docking to know the 3D structure of receptor; its scope and limitation.

TEXT BOOKS:

1. David W. Mount. "Sequence and Genome Analysis", Bioinformatics CSHL Press, 2nd Ed., 2004.
2. Baxevanis and F. B. F. Ouellette. "Bioinformatics: a practical, guide to the analysis of genes and proteins", JohnWiley, 2nd Ed., 2001.
3. Jonathan Pevsner. "Bioinformatics and Functional Genomics", Wiley-Liss, 1st Ed., 2003.

REFERENCE BOOKS:

4. Setubal Joao and meidanis Joao, Introduction to Computational Molecular Biology, Publisher: PWS Publishing; 1st edition, 1997.
5. R. Durbin, S. Eddy, A. Krogh and G. Mitchison, Biological Sequence Analysis, Cambridge. Cambridge University Press, 1998.
6. Paul M. Selzer, Richard J. Marhöfer, Andreas Rohwer, Applied bioinformatics: an introduction, Berlin Springer 2008.

ENVIRONMENTAL BIOTECHNOLOGY

Subject Code	**: 14BBT251**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

To explain and evaluate sustainable and cleaner environment,
To harness renewable enrgy and energy conversions
To asses environmental impact and audit.

MODULE 1: **10 Hours**

Concept and scope of environmental biotechnology. Elements of life and biodistribution of elements. Microbiology of air, water & soil, interactions among soil microorganisms. Role of environmental biotechnology in sustainable development.

Waste Water Biotechnology: Nature and components of Waste water, Eutrophication – causes: detergents, effects and control. Waste water treatment – primary waste water treatment: unit operations, secondary waste water treatment: design and modeling of activated sludge process - aerobic and anaerobic, and tertiary waste water treatment - reverse osmosis and ultra filtration, microbial removal of phosphorous and nitrogen. Wastewater composition and treatment strategies in food processing & pharmaceutical industries - sugar

factories, vegetable oil industries, potato processing industries, dairy industries, beverages industries distilleries & pharmaceuticals.

MODULE 2: **10 Hours**

Solid Waste Management: General composition of urban solid wastes, treatment: aerobic treatment, anaerobic treatment, biogass generation, solid waste management through biotechnological processes involving - hazardous wastes, Biomedical wastes, Dairy wastes, Pulp industry wastes, Textile industry wastes, leather industry wastes and pharmaceutical industry wastes, petroleum wastes treatment. Integrated waste management, super critical water oxidation of wastes.

MODULE 3: **10 Hours**

Xenobiotics: Characteristics of Xenobiotics, dose response relationship, effects of xenobiotics, Relationship of Bioaccumulation with Chemical Structures, Eco-physiology of Bioaccumulation - Process of toxicants uptake, Factors affecting bioaccumulation, measurement of bioaccumulation. Degradation of Xenobiotics in the Environment. Biodegradable alternatives for xenobiotics. Biomonitors of environment, Bioremediation using microbes, Phytoremediation.

Bioleaching & Biomining: Biometallurgy, Microbes in Bioleaching and Metal Recovery: Microbial recovery of phosphate, microbial extraction of petroleum and microbial production of fuels.

MODULE 4: **10 Hours**

Energy and Environment: Renewable and non-renewable resources. Conventional fuels and their environmental impacts. Modern fuels and their environmental impacts. Biotechnological inputs in producing good quality natural fibers. Plant sources like Jetropha, Pongamia etc. Waste as an energy core, energy recovery systems for urban waste, technology evaluation, concept of gasification of wastes with molten salt to produce low-BTU gas; pipeline gas from solid wastes by syngas recycling process; conversion of feedlot wastes into pipeline gas; fuels and chemicals from crops, production of oil from wood waste, fuels from wood waste, methanol production from organic wastes. Gasohol, Dye-pigments, sensitized solar cells.

MODULE 5: **10 Hours**

Green Technology and Environmental Protection: Principles of green technology, enzyme based detergents, alternative pesticides, alternative fuels, bio polymers, techniques and directions in practicing green technology, super critical liquid carbon dioxide solvent, polylactic acid polymers, use of hydrogen peroxide as a benign bleaching agent in paper industry, enzymatic production of cotton textiles, biodegradable builders in detergents, replacement of wood preservatives and synthesis of specialty compounds.

COURSE OUTCOMES:

After completion of the course, students are able to demonstrate and understand the principle of nonconventional energy, better management practices for better environment.

TEXT BOOKS:

1. Pradipta Kumar Mohapatra, Textbook of Environmental Biotechnology, I K International, 2007
2. Buckingham and Evans, Hazardous Waste Management, LaGrega, 2nd Edition, McGraw Hill International Edition, 2001.
3. Noel De Nevers Air Pollution Control Engineering, 2nd Edition, McGraw Hill International Edition, 2000

REFERENCE BOOKS:

4. Metcalf Eddy, Wastewater Engineering Treatment and Reuse, 4th Edition, Tata McGraw Hill, 2003
5. N K Uberoi, Environmental Management, 2nd Edition, Excel Books publication, 2007
6. Canter, Environmental Impact Assessment, 2nd Edition, McGraw Hill International Edition,1996
7. George Tchobanoglous, Hilary Theisen and Rolf Eliassen. Solid Wastes, McGraw Hill Kogakusha,Ltd.

FOOD BIOTECHNOLOGY

Subject Code	**: 14BBT252**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Understand the components of food and principles of food spoilage and techniques for food preservation.

Know the application of biotechnology for food preservation and food production with improved nutritional benefits

MODULE 1: **10 Hours**

Basic Constitutes of Food: Basic constituents of food, colloidal systems in food, molecular stability of colloidal systems, types of food starches, soluble fibers: pectin's, mucilage & gums, protein rich foods, oils in foods.

Food Microbiology: Microbial growth pattern, types of microorganisms associated with food: mold, yeast and bacteria. Contaminants of food stuff, milk and meat during handling and processing. Mechanism of food spoilage. Biochemical changes caused by microorganism. Determination of various types of food products. Food borne intoxicants and mycotoxins

MODULE 2: **10 Hours**

Food Preservation Technology: Food preservation by high and ultra high temperatures- canning, drying. Food dehydration: . Equipments for food dehydration: fixed tray dehydration, cabinet drying, tunnel drying. Freeze dehydration, controlled atmosphere, storage, Food preservation by irradiation treatment. Preservation by freezing and refrigeration. Frozen foods. Thermal properties of frozen foods. Food freezing equipments: Air blast freezers, plate freezers and immersion freezers. Preservation by Chemicals and Bacteriocins

MODULE 3: **10 Hours**

Food Production Technology: Importance of food industry, specific objectives of food processing, impact of food processing on food constituents. Production of single cell protein, Tailoring of milk proteins and milk fats, Production of fermented food products: yoghurt, pro-biotic cheese, nutritional value, labeling of constituents: Soya foods, organic foods, dietary foods, nutritional food supplements, Use of plant cell culture for the production of food additives (Vanillin, Capsaicin), microbial transformations, regulatory and social aspects of BT. Food packaging, edible films, Marketing of food and promotional strategies.

MODULE 4: **10 Hours**

Biotechnology for Improved Processing: Role of biotechnology in food industry, maintenance of nutritional quality, Enzymes in bakery and cereal products, utilization of hydrolases and lipases enzymes. Applications of immobilized enzymes in food industry, enzymes for enhanced flavor and aroma compounds, enzymes in fat and oil industries. Genetically modified plants for high nutritional food.

MODULE 5: **10 Hours**

Food Quality Assurance and Control: Importance and functions of quality assurance and control: Methods of quality, concept of rheology, assessment of food materials- fruits, vegetables, cereals, dairy products, meat and processed food products. Microbiological safety of food products, chemical safety of food products, contaminants by heavy metal, fungal toxins and pesticide residue. Food regulations, grades and standards, USFDA/ ISO 9000 Series. Food adulterations and safety, sensors and instrumental analysis in quality control food laws and standards.

COURSE OUTCOMES:

After completion of the course, students are able to enlighten with comprehensive knowledge of biotechnological applications to food industry.

TEXT BOOKS:

1. James M, Jay. Food Biotechnology CBS Publishers 2nd edition, 2005.
2. Kalidas shetty Food Biotechnology, CRC Press. 1st ed. 2005
3. T.Britze, R.K Robinson., Advanced Dairy Science and Technology. Wiley- Blackwell publisher. 1st edition. 2008

REFERENCE BOOKS:

4. H. Elmer, L James, Marath and Steele. Applied dairy microbiology, CRC press 2nd edition 2005.
5. R. Paul Singh., "Introduction to Food Engineering", Academic Press, 3rd Ed., 2004.
6. P. Fellows, "Food Processing Technology: Principles and practice". Woodhead Publishing Ltd., Cambrideg, 2nd Ed., 2005.

MOLECULAR MODELING AND SIMULATION

Subject Code	**: 14BBT253**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

To enhance conventional process and to emphasis on system simulation and to correlate with real processes

To experience the unexplored area at micro to macro level.

MODULE 1: **10 Hours**

Biomolecular Structure and Modeling: Historical Perspective, Introduction to Molecular Modeling, Roots of Molecular modeling in Molecular mechanics. Introduction to X-Ray crystallography and NMR spectroscopy. Introduction to PDB and 3D Structure data, Structure of PDB and other 3D Structure record.

Protein Structure Hierarchy: Structure Hierarchy. Helices – Classic α-Helix and π Helices, Left-Handed α-Helix and Collagen Helix. β-Sheets - Turns and Loops. Supersecondary and Tertiary structure. Complex 3D Networks. Classes in Protein Architecture – Folds, α-Class, Bundles, Folded leaves, Hairpin arrays. β-Class folds, Anti-parallel β domains, parallel and Anti-parallel Combinations. α/β and α+β-Class, α/β Barrels, Open twisted α/β folds, Leucine-rich α/β folds. α+β folds. Quaternary structure. Discussions with case studies.

MODULE 2: **10 Hours**

Force Fields: Formulation of the Model and Energy, Quantifying Characteristic Motions, Complex Biomolecular Spectra, Spectra as force constant sources, In-Plane and Out-of-Plane Bending. Bond Length Potentials - Harmonic term, Morse term, Cubic and Quadratic terms. Bond Angle Potentials - Harmonic and Trigonometric terms, Cross bond stretch / Angle bend terms. Torsional potentials - Origin of rotational barriers, Fourier terms, Torsional parameter Assignment, Improper torsion, Cross dihedral/Bond angle, Dihedral terms. Van der Waals potentials. Rapidly decaying potential. Parameter fitting from experiment. Two parameter calculation protocols. Coulomb potential - Coulomb’s Law. Slowly decaying potential, Dielectric function and Partial charges. Discussions with case studies.

MODULE 3: **10 Hours**

Molecular modeling: Modeling basics. Generation of 3D Coordinates Crystal data, Fragment libraries, and conversion of 2D Structural data into 3D form. Force fields, and Geometry optimization. Energy minimizing procedures - Use of Charges, Solvent effects and Quantum Mechanical methods. Computational tools for Molecular modeling. Methods of Conformational analysis - Systematic search procedures, Monte Carlo and molecular dynamics methods. Determining features of proteins - Interaction potential, Molecular electrostatic potential, molecular interaction fields, Properties on molecular surface and Pharmacophore identification. 3D QSAR Methods. Comparative protein modeling – Conformational properties of protein structure, Types of secondary structural elements, Homologous proteins. Procedures for sequence Alignments, Determination and generation of structurally conserved regions, Construction of structurally variable regions, Side-Chain modeling, Secondary structure prediction, Threading methods. Optimization and Validation of Protein Models with suitable case studies. Computation of the Free Energy: Free energy calculations in Biological Systems - Drug design, Signal transduction, Peptide folding, Membrane protein association, Numerical methods for calculating the potential of mean force, Replica-Exchange-Based Free-Energy Methods.

MODULE 4: **10 Hours**

Membrane Protein Simulations: Membrane proteins and their importance, Membrane protein environments *in vivo* and *in vitro*. Modeling a complex environment - Simulation methods for membranes, Membrane protein systems, Complex solvents, Detergent micelles, Lipid bilayers, Self-Assembly and Complex systems. Modeling and Simulation of Allosteric regulation in enzymes - Discussions with case studies.

Electrostatics and Enhanced Solvation Models: Implicit solvent electrostatics in Biomolecular Simulation, New distributed multipole methods. Quantum mechanical principles and applications to force field development with case studies.

MODULE 5: **10 Hours**

Virtual Screening and Docking: Introduction to Docking – Preparation of Partners, Compound Library, representation of Proteins and Ligands. Docking Algorithms. Simulation approaches for Protein model. Simulation of a Fluid Phase Lipid Bilayer Membrane, de novo Simulations of the Folding of GCN4 and its Mutants. Building a model of HIV-I Reverse Transcriptase (possible mechanisms for AZT resistance).

COURSE OUTCOMES:

Student will be able to analyse and comprehend the structure and other components of real processes. Also will be able to create the model for various components of life processes.

TEXT BOOKS:

1. Hans-Dieter Höltje, Wolfgang Sippl, Didier Rognan, Gerd Folkers, Molecular Modeling, 2008.
2. Alberte Pullman, Joshua Jortner, Modeling of Bimolecular Structures and Mechanisms, 1995.

REFERENCE BOOKS:

3. Jill P. Mesirov, Klaus Schulten, De Witt L. Sumners, Mathematical Approaches to Biomolecular Structure and Dynamics, 1996.
4. Peter T. Cummings, Phillip R. Westmorland, Brice Carnahan, Foundations of Molecular Modeling and Simulation, Published by American Institute of Chemical Engineers, 2001.
5. Timothy J. Barth, Michael Griebel, David E.Keyes, Risto M. Nieminen, Dirk Roose, Tamar Schlick, New Algorithms for Macromolecular Simulation, Published by Springer, 2006.

BIOPROCESS AND BIOPHARMACEUTICAL LAB

Subject Code	**: 14BBT26**	**IA Marks**	**: 25**
No. of Lecture Hrs./ Week	**03**	**Exam Hrs**	**: 03**
		Exam Marks	**: 50**

COURSE OBJECTIVES:

To provide hands on training with procedures for real time problems in bioprocess and biopharmaceutical Technologies.

Lab Experiments

1. Determination of thermal death kinetics of microorganism
2. Batch and Fed-batch growth kinetics
3. Media optimization.
4. Determination of K_La.
5. Product separation & concentration methods
6. Chromatographic techniques
7. Isolation, propagation and preservation techniques for cells.
8. Expression studies using prokaryotic microbial system (e.g. *E.coli* or *Bacillus*)
9. Expression studies using eukaryotic microbial system (e.g. *Saccharomyces* / *Pichia)*
10. Small scale liquid fermentation for therapeutic production
11. Solid state fermentation techniques.
12. Purification and characterization of proteins.

COURSE OUTCOMES:

At the end of the sessions the student will be able to perform laboratory experiments related to Bioprocess Engineering and gain experience in laboratory methods for Biopharmaceuticals. Also will be able to contribute to these domains.

TEXT / REFERENCE BOOKS:

1. Methods in Biotechnology Editor: Hans Peter Schmauder. Published by Taylor & Francis. 2004.
2. Manual of Industrial Microbiology and Biotechnology. Editors: Arnold Demain and Julian Davies. 2004.
3. Stanbury & Whittaker, Principles of Fermentation Technology. Pergamon Press, 2000.
4. Pauline M. Doran. Bioprocess Engineering Principles. Academic Press, 2003

IV SEMESTER M. TECH (BIOTECHNOLOGY)

RESEARCH METHODOLOGY, BIOSAFETY& IPR

Subject Code	*:* **14BBT41**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

To understand the concept of research its approach and methodology

To be acquainted with various aspects of Intellectual rights and their usage to modern technology

MODULE 1: **10 Hours**

Concept of Research: Types & classification, steps involved. Identification of the research question, hypotheses, and justification for the topic.

Literature Collection: Review of literature, review process and bibliography. Research Objectives and hypothesis.

Research Design: Detailed discussion of the conceptualization and operationalization of variables. Research method and materials, Research action. Data collection and analysis plan: data gathering – thorough description of methods of data gathering and sources.

Scientific writing: Organization and writing of a research papers, short communications, review articles, technical and survey reports, dissertations and books. Organization of reference material, bibliography, Endnote to be discussed with case studies. Research budget and resources.

MODULE 2: **10 Hours**

Introduction to Intellectual Property Rights: Types of IPR: Patents, Trademarks, Copyright & Related Rights, Issues related to plagiarism in research, copyright laws, acknowledging the sources etc to be discussed with case studies. Basics of Patents and Concept of Prior Art; Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, PATENTScope, WIPO, IPO, etc.).

MODULE 3: **10 Hours**

IPR in Research: Traditional Knowledge, Geographical Indications, Protection of GMOs, IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies. Patent filing procedures; National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting – disclosure/non-disclosure; Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringement- meaning, scope, litigation, case studies.

MODULE 4: **10 Hours**

Biosafety: Introduction & historical background; Primary Containment for Biohazards; Biosafety Levels for Microbes, Plants & Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs: RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication. Roles of Institutional Biosafety Committees.

MODULE 5: **10 Hours**

Patent laws: History, broad account & latest amendments (if any) of the provisions of Indian Patent Act 1970 & recent amendments, GATT & TRIPS Agreement, Madrid Agreement, Hague Agreement, WIPO Treaties, Budapest Treaty, PCT.

COURSE OUTCOMES:

After completion of the course, students are able to find appropriate method for research problems and hypothesis it, utilize research assets in principled manner with proper safety measures. They will be able to analyse the patentability of the inventions.

TEXT BOOKS:

1. C R Kothari Research Methodology, New Age International (P) Ltd. 2008
2. Wayne Goddard, Stuart Melville Research Methodology: An Introduction: Juta and Company Ltd, 2004
3. M. K. Sateesh. Bioethics and Biosafety By IK International 2008

REFERENCE BOOKS:

4. D K Bhattacharyya, Research Methodology By Excel Publisher Publishing Co. Pvt. Ltd., 2007
5. Kankanala C., Genetic Patent Law & Strategy 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007
6. P. Hambleton, J. Melling, T. T. Salusbury Biosafety in industrial biotechnology - Springer

CLINICAL BIOTECHNOLOGY

Subject Code	**: 14BBT421**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

To understand and emphasis on the various domain of clinical trials and drug metabolism

To evaluate the intensity and integrity of various diseases and implications of various governing agencies

MODULE 1: **10 Hours**

Introduction: Introduction to Clinical study and design of clinical studies. Epidemiological research and treatment studies: Double-blind and Single-blind Randomized controlled trial, Non-blind trial, Nonrandomized trial-quasi-experiment. Observational studies: Cohort study- Prospective cohort and Retrospective cohort. Time series study, Case-control study and Nested case-control study. Community survey and Ecological study. Seasonal studies: Conduction of studies in seasonal indications such as Allergies and Influenza.

MODULE 2: **10 Hours**

Statistical Analysis and Interpretation: Background and purpose, trial design consideration, Parallel group design, cross over design, factorial design. Introduction to Statistical Application Software (SAS), procedures and clinical data management.

MODULE 3: **10 Hours**

Drug Design and Synthesis: Synthesis of compounds in accordance with the molecular structure and biological activity concept: Analgesics, neuromuscular blocking agents, anti-fertility drugs and bactericidal & bacteriostatic agents (sulphonamides, mercury compounds and antiseptics).

Study of Therapeutic Proteins and Related Case Studies: Blood and Blood products: Clotting factors, anticoagulants, Thrombolytic Agents, Tissue plasminogen activator and streptokinase. Safety guidelines in Blood Transfusion. Therapeutic Proteins: Antibodies, Enzymes, Hormones, Growth factors (Erythropoietin), Vaccines (HIV and Cancer), Interferon and Interleukins.

MODULE 4: **10 Hours**

Cancer Biology and Therapy: Introduction to cancer biology and modes of treatment: radiotherapy, chemotherapy, surgery, Biological therapy, immunotherapy and gene therapy.

Clinical Toxicology: Basic concept in toxicology. Types and mechanism of toxin action- Epoxidation & drug toxicity, N-oxidation & drug toxicity and sulphur xenobiotics. Hepatotoxicity and Nephrotoxicity. Biotransformation of toxins, inactivation and removal from the body.

MODULE 5: **10 Hours**

Clinical Research Governance and Ethics: Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. Good Clinical Practices (GCP) and International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.

COURSE OUTCOMES:

After completion of the course, students are able to differentiate between drug toxicity and drugconcentration along with the mechanism of various interactions of health sectors.

TEXT BOOKS:

1. Designing clinical research by Stephen B. Hulley 3rd Edition, 2007
2. Principles and practice of clinical research by John I. Gallin, Frederick P. Ognibene 2nd Edition, 2006

3. Conducting GCP- Compliant Clinical Research: A Practical Guide by Wendy Bohaychuk, Graham Ball University Edition John Wiley & Sons Ltd, New York, 2009.

REFERENCE BOOKS:

4. Basic biotechnology by Colin Ratledge, Bjørn Kristiansen 3rd Edition Cambridge University Press, Cambridge, 2001.
5. Pharmaceutical Perspectives of Cancer Therapeutics by Ram I. Mahato, Yi Lu University Edition Springer Dordrecht Heidelberg London, 2001.
6. Design and analysis of clinical trials: concepts and methodologies by Shein-Chung Chow, Jen-pei Liu 2nd Edition John Wiley & Sons Ltd, New York, 2004
7. New drug development: design, methodology, and analysis by J. Rick Turner University Edition John Wiley & Sons Ltd, New York. 2004

METABOLIC ENGINEERING

Subject Code	**: 14BBT422**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Explore the importance of metabolic engineering in relation to cellular reaction
Analyse the strategy for product enhancement and yield along with metabolic flux.

MODULE 1: **10 Hours**

Introduction to Cellular Metabolism: Metabolic engineering and its multidisciplinary nature; Review of cellular metabolism; Models for cellular reactions; Material balances and data consistency-Block box model, elemental balances, heat balance and analysis.

MODULE 2: **10 Hours**

Regulation of Metabolic Pathways: Regulation of enzyme activity- Reversible and irreversible inhibition systems, regulation of enzyme concentration- Control of transcription and translation. Global control: Regulation at whole cell level- regulation of metabolic networks.

MODULE 3: **10 Hours**

Metabolic Pathway Manipulations: Enhancement of product yield and productivity- Ethanol, Amino acids and Solvents. Extension of substrate- Sucrose utilization and pentose metabolism for ethanol production. Product spectrum and novel products- Antibiotics, Polyketides, Vitamins, Biological pigments. Improvements of cellular properties-Nitrogen metabolism, Oxygen utilization, Overflow metabolism and genetic stability maintenance. Xenobiotics degradation of Polychlorinated Biphenyls (PCBs) and Benzene, Toluene, p-Xylene Mixtures (BTX).

MODULE 4: **10 Hours**

Metabolic Flux Analysis: Methods for determination of metabolic fluxes by isotope labeling- Fractional label enrichment, complete enumeration of TCA cycle metabolite isotopomers from labeled pyruvate and acetate. Applications of metabolic flux analysis: Amino acid production by Glutamic acid bacteria and mammalian cell cultures. Flux analysis of metabolic networks- Bottom-up Approach, Top-Down Approach.

MODULE 5: **10 Hours**

Metabolic Control Analysis (MCA): MCA theorems, determination of flux control coefficient. MCA of linear and branched pathways. Theory of large deviations

COURSE OUTCOMES:

After completion of the course, students are able to utilize the knowledge of cellular metabolic pathway and regulation to enhance the yield.

TEXT BOOKS:

1. Gregory N. Stephanopoulos, Aristos A. Aristidou and Jens Nielsen. Metabolic engineering – Principles and Methodologies. Academic press, USA 1998.
2. Nestor V. Torres and Eberhard O. Voit, Pathway analysis and optimization in metabolic, Cambridge University Press, 2002.

REFERENCE BOOKS:

3. Shuler M.L. and F. Kargi. Bioprocess engineering basic concepts, 2nd Edn, Prentice Hall, 2001.
4. Cortassa s., Aon, M.A., Lglesias, A.A., and L LyodD. An introduction and metabolic and cellular Engineering. World scientific publications Pvt ltd. Singapore. 2002.

PROJECT MANAGEMENT, ENTREPRENEURSHIP AND BIOBUSINESS

Subject Code	**: 14BBT423**	**IA Marks**	**: 50**
No. of Lecture Hrs./ Week	**: 04**	**Exam Hrs**	**: 03**
Total No. of Lecture Hrs.	**: 50**	**Exam Marks**	**: 100**

COURSE OBJECTIVES:

Describe logically various aspects of management, building blocks and their relationship

To encourage investment and innovation for technologies and reward innovativeness

MODULE I: **10 HOURS**

Project planning – scope – problem statement – project goals – objectives – success criteria – assumptions – risks – obstacles – approval process – projects and strategic planning. Project implementation – project resource requirements – types of resources – men –materials finance. Case studies.

MODULE II: **10 HOURS**

Project monitoring – evaluation – control – project network technique –planning for monitoring and evaluation – project audits – project management information system – project scheduling – PERT & CPM –project communication – post project reviews and Case studies. Project team management – recruitment – organizing – human resources – team operating rules – project organization – various forms of project organizations. Closing the project – types of project termination – strategic implications – project in trouble – termination strategies – evaluation of termination possibilities.

MODULE III **10 HOURS**

Fundamentals of Entrepreneurship, Ideas to Reality, Proof of Concepts to Product realization, Strategic Management, Forms of Ownership and Franchising, Buying an existing Business, Business Models, Mobilization of Financial resources; Bank loans & Venture capitalism. Building a good Marketing Plan, Concepts in MSME. Accounting for planning, control, and motivation. Factors influencing capital acquisition and allocation. Financial decision making; Decision making under uncertainty; positive and normative models; Current issues in financial management. Case studies.

MODULE IV: **10 HOURS**

Industrial R&D and product development. Product development and project management in Agri, Pharma, Health and other biotech industries. Overview of issues and techniques involved in conducting & outcome of research. The multidisciplinary nature of outcomes research: research design and methods, data collection measurement instruments and clinical endpoints, quality of life issues, behavior change, and cost-effectiveness. Analysis Transition from R&D to business units. Product development, market learning and transition from R&D. Management of radical innovation technologies vs. stage gate approach in product development. Case studies.

MODULE V: **10 HOURS**

Rights and responsibilities of business under the Indian Constitutional system. Basic standards, rules, principles and issues relating to the law of corporations; core issues affect the corporate governance of business; relationship between management, boards and shareholders. Business laws applied to Biotech industries.

Regulatory issues in Biotech industries with special reference to clinical trial of pharma products and field trials of Agricultural products. Regulatory processes details. Intellectual property in biotech. Business. Models around intellectual property, licensing issues. Product development for commercial ventures. Bioethics and Current legal issues. Ethics of new technology. Case studies.

COURSE OUTCOMES:

After completion of the course, students are able to understand the entrepreneurship opportunities, and importance of innovation with regard to industrial applications.They would also learn project management in the competitive environment existing globally.

TEXT/REFERENCE BOOKS

1. Beenet P Lientz, Kathyn, Project Management – for 21st Centrury- Academic Press, 1995
2. Martin Grossmann Entrepreneurship in Biotechnology: managing for growth from start-up to initial public offering. Verlag. Springer-2003
3. Holger Patzelt and Thomas Brenner. Handbook of Bioentrepreneurship By Springer 2008
4. Graham Dutfield, IPR, Trade and Biodiversity, Earthscan publications, 2000

TEXT/REFERENCE BOOKS

5. Damian Hine, John Kapeleris. Innovation and entrepreneurship in biotechnology, an international prospective. By Edward Elgar Publishing. 2006
6. P. S. Teng. Bioscience entrepreneurship in Asia: creating value with biology. By World scientific publishing. Co. Pte. Ltd. 2008
7. A.K. Singh. Entrepreneurship Development and Management by Firewall Media, 2006
8. Ramachandran, Entrepreneurship Development by. Tata McGraw-Hill Education, 2008