RAMAIAH
Institute of Technology

CURRICULUM

for the Academic year 2019 – 2020

DEPARTMENT OF BIOTECHNOLOGY

I - IV Semester M. Tech

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
Bangalore – 560054.

About the Institute:

Ramaiah Institute of Technology (RIT) (formerly known as M. S. Ramaiah Institute of Technology) is a self-financing institution established in Bangalore in the year 1962 by the industrialist and philanthropist, Late Dr. M S Ramaiah. The institute is accredited with "A" grade by NAAC in 2014 and all engineering departments offering bachelor degree programs have been accredited by NBA. RIT is one of the few institutes with prescribed faculty student ratio and achieves excellent academic results. The institute was a participant of the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. All the departments have competent faculty, with 100% of them being postgraduates or doctorates. Some of the distinguished features of RIT are: State of the art laboratories, individual computing facility to all faculty members. All research departments are active with sponsored projects and more than 304 scholars are pursuing PhD. The Centre for Advanced Training and Continuing Education (CATCE), and Entrepreneurship Development Cell (EDC) have been set up on campus. RIT has a strong Placement and Training department with a committed team, a good Mentoring/Proctorial system, a fully equipped Sports department, large air-conditioned library with over 1,35,427 books with subscription to more than 300 International and National Journals. The Digital Library subscribes to several online e-journals like IEEE, JET etc. RIT is a member of DELNET, and AICTE INDEST Consortium. RIT has a modern auditorium, several hi-tech conference halls and all are air-conditioned with video conferencing facilities. It has excellent hostel facilities for boys and girls. RIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association. RIT obtained Academic Autonomy for all its UG and PG programs in the year 2007. As per the National Institutional Ranking Framework, MHRD, Government of India, Ramaiah Institute of Technology has achieved 64th rank in 2019 among the top 100 engineering colleges across India.

About the Department:

The department of Biotechnology established in 2002 offers a four year B.E. Biotechnology Program with an intake of 60 students and a two years PG Program, M.Tech in Biotechnology with an intake of 18 students. The department is a recognized Research Centre by VTU, Belgaum, offering M.Sc (Engg.) by research and PhD programs. The Department also offers a Post Graduate Diploma in Biopharmaceutical Technology under the Biotechnology Skill Enhancement Programme (BiSEP), supported by the Department of IT & BT, Government of Karnataka with a sanctioned budget of Rs. 162.5 Lakhs.

The department has 15 faculty members, of them 11 are Ph.D holders and the others are M.Tech pursuing Ph.D. The faculty members have competence in Core areas of Biotechnology viz. Food and Agricultural Biotechnology, Health and Medical Biotechnology & Environmental Biotechnology and Bioprocess Engineering. The department research is focused towards these core areas and funded by national and state funding agencies like DST, KBITS, AICTE, VGST, VTU and RGUHS.

The department faculties and students have publications in Scopus Indexed peer reviewed Journals of Elsevier, Taylor and Francis and Springer. Faculties have published book chapters and presented their research work in National and International conferences. A sizeable number of students have pursued their higher education at various premier institutes in India and abroad after having qualified GATE, GRE & TOEFL exams. The students undergo internships at various premier institutes in India and abroad. Several students receive the Indian Science Academies Summer Internship every year. The department has collaborations with some of the leading biotech industries like: Biocon, Hindustan Unilever Limited (HUL), Bristol Myers Squibb India Ltd, Novozymes South Asia Pvt Ltd, Himalaya Drug Company, Beckman Coulter, Sami Labs, Sartorius AG, Genotypic Technology, Aristogene Biosciences, GangaGen, Connexios Life Sciences, Acquity Labs & Celest Pharma.

VISION OF THE INSTITUTE

To be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio-economic needs.

MISSION OF THE INSTITUTE

RIT shall meet the global socio-economic needs through

1. Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization.
2. Establishing research clusters in emerging areas in collaboration with globally reputed organizations.
3. Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs.

QUALITY POLICY

We at Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stakeholders concerned

DEPARTMENT VISION

To be a leading Biotechnology Engineering department that imparts quality technical education with strong research component, to develop solutions in the field of food, health and environment.

DEPARTMENT MISSION

To provide quality technical education in a conducive learning environment to produce professionals, researchers with a zeal for lifelong learning and a commitment to society.

Programme Educational Objectives (PEOs) of the program

PEO 1: To produce postgraduates who can articulate technical developments in the field of biotechnology and apply relevant tools to solve problems in real life situations

PEO 2: To enable postgraduates to have an ability to design and conduct research to meet desired needs within realistic economic, environmental, socio-political, ethical, health, safety & sustainability realms

PEO 3: To prepare postgraduates to be successful professionals in industry, academia, research, entrepreneurial pursuit and consulting firms

PEO 4: To prepare students to enrich their knowledge & skills throughout their career

Programme Outcomes (POs)

PO1: An ability to independently carry out research/investigation & development work to solve practical problem

PO 2: An ability to write & present a substantial technical report/document

PO 3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO 4: Demonstrate the ability to design, conduct experiments and analyze data in the field of Biotechnology

PO 5: Able to employ Biotechnology tools in biological research

SCHEME OF TEACHING FOR THE BATCH 2018-2020

I SEMESTER

SI. No.	Subject Code	Subject	Credit			
			L	T	P	Total
1	MBT11	Cell and Molecular Biology	4	0	0	4
2	MBT12	Experimental Design and Analysis	3	1	0	4
3	MBTE XX	Elective 1	4	0	0	4
4	MBTE XX	Elective 2	4	0	0	4
5	MBTE XX	Elective 3	4	0	0	4
6	MBTL13	Industrial Biotechnology Lab	0	0	1	1
7	MBTL14	Advanced Molecular Biology and Genetic Engineering Lab	0	0	1	1
8	MBT15	Technical Seminar-I	0	0	2	2
		Total	**19**	**1**	**4**	**24**

II SEMESTER

SI. No.	Subject Code	Subject	Credit			
			L	T	P	Total
1.	MBT21	Bioprocess Engineering	3	1	0	4
2.	MBT22	Biopharmaceutical Technology	4	0	0	4
3.	MBTEXX	Elective 4	4	0	0	4
4.	MBTEXX	Elective 5	4	0	0	4
5.	MBTEXX	Elective 6	4	0	0	4
6.	MBT L23	Bioprocess Modelling and Simulation Lab	0	0	1	1
7.	MBT L24	Biopharmaceutical Technology Lab	0	0	1	1
8.	MBT25	Technical Seminar-II	0	0	2	2
		Total	**19**	**1**	**4**	**24**

III SEMESTER

SI. No.	Subject Code	Subject	Credit			
			L	T	P	Total
1.	MBT31	Bioethics & Intellectual Property Rights	3	1	0	4
2.	MBTEXX	Elective 7	4	0	0	4
3.	MBT 33	Internship / Industrial Training	0	0	4	4
4.	MBT 34	Project Work -I	0	0	6	6
Total			**7**	**1**	**10**	**18**

IV SEMESTER

1.	MBTP	Project Work-II	0	0	22	22
		Total	**0**	**0**	**22**	**22**

L- Lecture **T-Tutorial** **P-Practical**

ELECTIVES

Sl No	Subject Code	Subject	Credit			
			L	T	P	Total
1	MBTE01	Industrial and Environmental Biotechnology	4	0	0	4
2	MBTE02	Recombinant DNA Technology	4	0	0	4
3	MBTE03	Advanced Upstream and Downstream Technology	4	0	0	4
3	MBTE04	Medical Biotechnology	4	0	0	4
4	MBTE05	Bioreaction Engineering	4	0	0	4
5	MBTE06	Toxicology and Forensic science	4	0	0	4
6	MBTE07	Plant Biotechnology	4	0	0	4
8	MBTE08	Applied Bioinformatics	4	0	0	4
9	MBTE09	Advanced Research Methodology	4	0	0	4
10	MBTE10	Applied Animal Biotechnology	4	0	0	4
11	MBTE11	Bioanalytical and Biophysical Techniques	4	0	0	4
12	MBTE12	Protein Engineering & Industrial Applications	4	0	0	4
13	MBTE13	Bioreactor Technology	4	0	0	4
14	MBTE14	Nanobiotechnology	4	0	0	4
15	MBTE15	Biotechnology of Alternative Fuels	4	0	0	4
16	MBTE16	Metabolic Engineering	4	0	0	4

CELL AND MOLECULAR BIOLOGY

Sub Code	**: MBT11**	**Contact Hours**	**: 56L**
Credit	**: 4:0:0**		

Course coordinator(s): Dr. Ravikumar Y S

UNIT-I

Cell Structure and Organization: Prokaryotic and Eukaryotic cell structure Membrane composition, structure, transport systems: cell-cell interaction**:** Cell - cell adhesion, cadherins, CAMS (NCAMS), selectins, integrins, desmosomes, hemidesmosomes, tight junction, gap junction, Catenins. Cytoskeleton: types, organization and their functions Cell organelles structure and functions Nucleus, mitochondria, chloroplast. Intracellular compartments and their characteristic features; membranes and proteins involved in transport-structures involved in trafficking of proteins. Protein sorting- secretory pathway; receptor mediated endocytosis, sorting of internalized proteins; vesiculation, transport and targeting;

UNIT-II

Cell Signaling and Cell Cycle: Cell Signaling- autocrine, paracrine, endocrine systems. Synaptic; role of Gap junction in signal sharing, Effect of concentration of signals. Structure and function of cell surface receptor; Intracellular receptors and nuclear receptors; signal mediated signal transduction for different types of signaling molecules G-protein and PI3 mediated signal transduction. RTKmediated signal transduction, Small intracellular signalling molecule. Cell cycle: cell cycle events in animal cells; check points during cell cycle-G1 to S, role of cyclins and CDKs, synthesis and degradation of cyclins, structural features of CDKs and cyclins, activation and inactivation of cyclin dependent kinases. Mitosis and meiosis and molecular events occur during mitosis and meiosis.

UNIT-III

DNA replication (prokaryotes and eukaryotes)**:** Mode of replication, DNA polymerases, composition and features, origin of replication, replication factors and the mechanism of replication, leading strand and lagging strand synthesis, procesessivity, fidelity and regulation of replication. Termination of replication. Eukaryotic-replication origins, replication initiation complexes and their assembly, licensing factors, DNA polymerases and their composition, telomerase and mode of action, replication factors, disassembly of chromatin components and DNA damage and repair: types and their repair.

UNIT-IV

Transcription and RNA processing: Prokaryotic Transcription: Promotor and their structure, *E. coli* RNA polymerase, Initiation, functions of s factors, elongation, termination. Eukaryotic transcription: types of RNA polymerases and promoters. RNA Pol II structure and subunit functions. General transcription factors, mechanism of Initiation, elongation, termination. rRNAs; Structural features of rRNAs-prokaryotic and eukaryotic. tRNAs: structural features, their anticodon feature tRNA charging and capping. mRNAs- prokaryotic and eukaryotic mRNAs, structural feature. RNA Processing: exons & introns, splicing, spliceosomes, snRNPs, self-splicing introns, Alternative splicing, trans splicing, capping, polyadenylation and RNA editing.

UNIT-V

Protein Synthesis and gene regulation: Translation: Translation initiating factors, ribosome structure & function, elongation factors, termination factors; mechanism of chain initiation, elongation and termination and genetic code. Protein folding: molecular chaperon, HAS 70 and Gro EL/Groes complex. Post translational modification: Regulation of prokaryotic gene expression: Operons and their types, Regulation of Lac operon, Tryptophan operon. Role of sigma factors in gene expression regulation. Regulation of eukaryotic gene expression: Levels of gene regulation, DNA binding proteins, Histone modification and Chromosome remodeling: RNA interference, siRNAs, miRNAs, & enhancers, protein degradation and turnover

Textbooks

1. Bruce A. et al (2007) Molecular Biology of the Cell, 5th edition, Garland science, New York, USA.
2. Pierce BA. (2012), Genetics A Conceptual Approach IV edn. W**.** H. Freeman and Company New York.

Reference Books

1. Hardin J et al. (2012) Becker's World of the Cell VIII edn. Pearson Benjamin Cummings, San Francisco, USA.
2. Gerald Karp. (1996). Cell and Molecular Biology. John Wiley and Sons. Inc
3. Lodish H et al (2016). Molecular cell Biology. W. H. Freeman and Company New York, USA.
4. Brown T A. G (2012) Genetics: A molecular approach, Garland Science, Taylor & Francis Group, New York, USA.
5. Krebs JE. (2014) Lewin's Genes XI, Jones & B artlett Learning, Burlington, USA.

Course Outcomes (COs):

On completion of this course student will have the improved ability to:

1. Acquaint cellular concepts and organization of cell membrane, cytoskeleton and different cell organelles. (PO1, PO3, PO4, PO5)
2. Describe the molecular mechanisms for cell growth, cell death, and renewal of the cells and interactions of cell with its environment. (PO1, PO3, PO4)
3. Understand the mechanism of DNA replication and repair and Identify the significance of techniques used to study them. (PO1, PO3, PO4, PO5)
4. Correlate the mechanism of prokaryotic and eukaryotic transcription process and appraise the different types of RNA processing methods. (PO1, PO3)
5. Explore the mechanism of prokaryotic and eukaryotic translation and differentiate various types of gene expression regulation. (PO1, PO3)

EXPERIMENTAL DESIGN AND ANALYSIS

Sub Code	**: MBT12**	**Contact Hours**	**: 42L+14T**
Credit	**: 3:1:0**		

Course coordinator(s): Dr. S H C V Subba Bhatta

UNIT-I

Random variables — discrete and continuous, Mathematical expectation and its laws, Moments, coefficient of skewness and kurtosis. Probability distributions — Bernoulli/Binomial, Poisson, Geometric, Normal Joint probability distributions for discrete and continuous random variables, conditional expectation, stochastic independence.

UNIT-II

Correlation, Regression analysis, Partial and multiple correlation and regression, Regression diagnostics - residuals, multicollinearity, testing adequacy of fit and validation in regression analysis; Sampling distribution of correlation and regression coefficients; Testing of hypothesis: z – test, t-test, Chi-square test and F-test.

UNIT-III

Concept of analysis of variance (ANOVA) for one-way and multi-classified experiments; Multiple Mean Comparison, Pair wise Contrasts, Type of Models (Fixed or Random), Incomplete Blocks/Missing data Fisher's principles, Basics of designing an experiment. Completely Randomized Design (CRD), Principles and Usage, Randomization, Data Analysis/Model (one-way ANOVA), Advantages/Disadvantages, Ideal Conditions. Randomized Complete Block Design (RCBD), Data Analysis, Advantages and disadvantages, Comparison with CRD.

UNIT-IV

Latin Square Design, Construction and arrangement, Analysis, Relative efficiency of LSD over CRD and RCBD. Graeco Latin Square Design: Construction and arrangement, data analysis. Factorial Experiments: 2^2 and 2^3 Designs, the general 2^k Design, Methods to find the factorial effects, Yate's algorithm of computing factorial effects.

UNIT-V

Blocking and confounding, blocking a 2^k factorial design, Confounding in 2^k factorial design, Partial and Complete Confounding. Two level fractional factorial designs, One half fraction of the 2^k design, One quarter fraction of the 2^k design, Plackett-

Burman design Analysis of Covariance (ANCOVA), Assumptions and Model for ANCOVA, Statistical analysis.

Test books

1. Douglas C. Montgomery (2009) Design and Analysis of Experiments, 7th Edition, Wiley publication.
2. Misra BL (2005) Design & Analysis of Experiments for Agricultural Workers, 1st Ed, Kalyan Pub.

Reference Books

1. Steel & Torrie (1980) Principals and Procedures of Statistics A Biometrical Approach, McGraw-Hill Publication.
2. Kuehl (2000) Design of Experiments: Statistical Principals of Research Design and Analysis. Duxbury press.

Course Outcome (COs):

On completion of this course student will have the improved ability to:

1. Identify the random variables and use standard discrete and continuous probability distributions. (PO-4)
2. Perform test of hypothesis for a given data using parametric and nonparametric tests. (PO-4)
3. Apply one way and two-way ANOVA for CRD and RCBD. (PO-4, 5)
4. Apply three way and four-way ANOVA for Latin Squares and Graeco Latin Squares and construct a factorial experiment. (PO-4, 5)
5. Apply Blocking and construct fractional factorial design. (PO-4, 5)

INDUSTRIAL BIOTECHNOLOGY LAB

Sub Code	**: MBTL13**	**Contact Hours**	**: 14P**
Credit	**: 0:0:1**		

Course coordinator(s): Dr. Sravanti V and Dr. Ahalya N

List of Experiments:

1. Biochemical characterization of microbes
2. Production & estimation of Amylase by solid-state fermentation
3. Demonstration of lysogeny in bacteria
4. Physicochemical analysis of wastewater
5. Analysis of organic content in wastewater
6. Production and estimation of citric acid and lactic acid from microbes
7. Production of antibiotic (Penicillin) by solid-state fermentation
8. HPLC: Instrumentation & SOP
9. HPLC based Analysis of amino acids in food samples
10. Production and estimation of Single Cell Protein
11. Effect of environmental factors on the growth of microbes
12. Production, isolation and quantification of Melanin pigment from microbes
13. Biosorption of dyes using biomass
14. Bioreactor: Instrumentation & SOP

Note: *At least any 12 experiments must be performed*

Textbooks

1. Richard H. Baltz1 et.al (2010) Manual of Industrial Microbiology and Biotechnology, 3rd Edition, ASM Press.
2. Pollack RA, Walter F, Mondschein W, Modesto R (2004) Laboratory Exercises in Microbiology, 2nd Edition. John Wiley Publication.

Reference books

1. Cappuccino J.G, Sherman N (2014) Microbiology: A Laboratory Manual, 10th Edition, Pearson.
2. Prescott, Harley and Klein (2008) Laboratory Exercises in Microbiology, 7th Edition, McGraw-Hill Education.

Course Outcome (COs):

On completion of this course student will have the improved ability to:

1. Estimate and quantify organic acids, proteins, sugars. (PO1, PO2, PO4, PO5)
2. Apply biochemical techniques and analytical techniques in environmental and food biotechnology. (PO2, PO3, PO5)
3. Isolate grow microbes and express secondary metabolites for various applications. (PO1, PO2, PO3, PO5)
4. Correlate the effect of environmental factors on microbial growth. (PO2, PO3, PO5)
5. Design, execute, analyse experiments independently and improve scientific writing skills. (PO1, PO2, PO3, PO4, PO5)

ADVANCED MOLECULAR BIOLOGY AND GENETIC ENGINEERING LAB

Sub Code	**: MBTL14**	**Contact Hours**	**: 14P**
Credit	**: 0:0:1**		

Course coordinator(s): Dr. Bindu S

List of Experiments

1. GMO detection using PCR
2. SNP detection using PCR
3. Amplification and quantification of DNA using QPCR
4. Gene expression analysis using QPCR
5. Establishment of plant/animal cell culture
6. Transfection of DNA in animal cell culture
7. Gene knockout using CRISPR CAS genome editing system
8. Detection of RNA using northern blot.
9. Genetic transfer - conjugation, gene mapping.
10. Phage titration with Lambda phage/M13
11. *In silico* structural and functional analysis of proteins
12. *In silico* screening of deleterious single nucleotide polymorphisms (SNP)
13. Molecular dynamics simulation of disease-associated mutations
14. Protein-ligand interaction studies using computational tools

Note: *At least any 12 experiments must be performed*

Textbooks:

1. Michael R. Green, Joseph Sambrook (2012). Molecular cloning: a laboratory manual. Volumes I -III. Cold Spring Harbor Laboratory Press, USA.
2. Michael Agostino. (2012) Practical Bioinformatics. Garland Science
3. Kalibulla Syed Ibrahim et.al. (2019) Bioinformatics-A Student's Companion. Springer.

Reference Books:

1. Brown T A. G. (2012) Genetics: A molecular approach, Garland Science, Taylor & Francis Group, New York, USA.
2. Sandy B. Primrose and Richard Twyman. (2006) Principles of Gene Manipulation and Genomics, Blackwell publishing.
3. Chandra Sekhar Mukhopadhyay et.al. (2017) Basic Applied Bioinformatics. John Wiley & Sons.

Course Outcomes (COs):

on completion of this course student will have the improved ability to:

1. Standardize the protocol for detection, amplification and quantification of DNA using PCR. (PO1, PO2, PO3, PO4)
2. Establish plant or animal cell cultures for transfection of DNA. (PO4, PO5)
3. Analyze sequences in genomics, metagenomics and edit genome using CRISPR CAS. (PO1, PO4, PO5)
4. Apply advanced techniques for detection of RNA, protein analysis and proteomics. (PO4, PO5)
5. Apply computational tools for biomolecular studies. (PO1, PO2, PO5)

BIOPROCESS ENGINEERING

Sub Code	**: MBT21**	**Contact Hours**	**: 42L+14T**
Credit	**: 3:1:0**		

Course coordinator(s): Mrs. Bhavya SG and Dr. Chandraprabha MN

UNIT-I

Bioprocessing Fundamentals:

Biotechnology and Bio-process engineering-Historical development of bioprocess technology-Difference in approaches by biologist and engineer-Introduction to Bioproducts- Bioprocess principles and operations- Outline of a bioprocess and the various unit operations involved in bioprocesses. Steps in bioprocess development-General material balance equation for steady state (for manufacture of penicillin and ethanol)-Generalized bioprocess flow sheets: example of penicillin/Bacitracin/ethanol. Bio-process regulatory constraints.

UNIT-II

Microbial growth and product formulation:

Quantification of cell concentration, Phases of cell growth in bath culture, growth associated and non-growth associated product formation kinetics, environmental factors affecting growth kinetics. Heat generation by microbial growth. Structured and unstructured models for microbial growth- Substrate limited growth-models with growth inhibitors- growth model for filamentous organisms. Microbial interaction in mixed cultures: Major classes of microbial interactions, microbial participation in the natural cycles of matter, Industrial utilization of mixed cultures in biological wastewater treatment.

UNIT-III

Enzyme kinetics:

Specificities of enzyme catalysis-Mechanistic models for simple enzyme kinetics: Michaelis-Menten Equation and Briggs-Haldane Equation. Experimental determination of rate parameters for Michaelis-Menten type kinetics, models for inhibited enzyme kinetics. Effect of pH and Temperature, Immobilized enzyme systems: Methods of Immobilization, Diffusional limitations in immobilized enzyme systems. Industrial utilization of enzymes.

UNIT-IV

Fermentation Principles:

Fermentation Process-General requirements of fermentation Process; An overview of aerobic and anaerobic fermentation process and their application in industry. Media Design: Medium requirements for fermentation process-examples of simple and complex media; Design and usage of commercial media for industrial fermentations, Sterilization: Batch and continuous heat sterilization-sterilization of Liquid media, Filter sterilization of liquids. Thermal death kinetics. Bioreactors and their modes of operations.

UNIT-V

Development of sustainable Bioprocesses:

Modeling and Assessment in Process Development- Types of Bioprocess and Biocatalysts, Raw Materials for industrial bioprocess- Biologics and Biosimilars-Process and fermentation models for development of processes for bioproducts and biopharmaceuticals –Sustainability assessment of Bioprocess. Process economics of bioproducts.

Textbooks

1. Pauline M Doran (2013) Bioprocess Engineering Principles, 2nd Edition, Academic Press, USA.
2. Michael L Shuler & Fikret Kargi. (2008) Bioprocess Engineering: Basic Concepts., 2nd Edition, Prentice Hall of India, New Delhi.
3. Elmar Heinzle, Arno P. Biwer, Charles L. Cooney. (2006) Development of Sustainable Bioprocesses Modeling and Assessment, John Wiley & Sons Ltd.

Reference Books

1. James E Bailey & David F Ollis. (1986) Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill Book Co.-Singapore.
2. Tapobrata Panda. (2011) Bioreactors: Analysis and Design, 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi.
3. Douglas S. Clark, Harvey W. Blanch. (1995) Biochemical Engineering, 2nd Edition, CRC Press.

Course Outcome (COs):

On completion of this course student will have the improved ability to:

1. Apply the bioprocessing fundamentals for process development. (PO1, PO4)
2. Apply the concept of microbial growth models in product formation. (PO3)
3. Assess the effect of transport processes in free and immobilised enzyme systems. (PO4, PO5)

4. Apply the principles of fermentation in design and development of industrial bioprocess. (PO4, PO5)
5. Analyse the sustainable practices in bioprocess industries. (PO1, PO5)

BIOPHARMACEUTICAL TECHNOLOGY

Sub Code	**: MBT22**	**Contact Hours**	**: 56L**
Credit	**: 4:0:0**		

Course coordinator(s): Dr. Lokesh KN and Dr. Dhamodhar

UNIT-I

Drug development process of protein-based therapeutics: Transforming New Molecular Entities into Drugs, Differences between Development of Biotechnology Products of Macromolecules and Chemical Products, Current Trends in Drug Development, Drug designing: Rational, combinatorial and High Throughput screening.

UNIT-II

Immuno-pharmacology: Overview to immunopharmacology**,** Antibody-mediated response, Vaccines, Cell mediated immune response, Cancer immunotherapy, Immunosuppressant and immunostimulators.

UNIT-III

Biotherapeutics: Hematopoietic Growth Factors and Coagulation Factors, Interferon's and Cytokines for Anti-infective and Cancer Therapy, Hormones, Enzymes, Antibodies and Derivatives.

UNIT-IV

Nanotechnology for the delivery of proteins and nucleic acids-based therapeutics: Introduction to Nanotechnology in drug deliver, Nano-sized Advanced Delivery Systems as Parenteral formulation Strategies for Hydrophobic Anti-cancer Drugs, Engineering of Amphiphilic Block Copolymers for Drug and Gene Delivery, Nanoemulsions for Intravenous Drug Delivery. Nanotechnology for Cancer Chemotherapy, Nanotechnology for Cancer Vaccine Delivery.

UNIT-V

Formulation of proteins and peptides: Making Small Protein Particles, Lyophilization, Multiphase Drug Delivery Systems, Protein Compaction, Self-Emulsifying Drug Delivery Systems, skin and parental drug delivery system.

Textbooks

1. Christine M. Bladon (2002) Pharmaceutical Chemistry, *John Wiley & Sons, Ltd.*
2. Manfred E. Wolff (2000) Burger's Medicinal Chemistry and Drug Discovery (5th edition) A Wiley & Sons, Inc.
3. Grietje Molema and Dirk KF. Meije (2002) Drug Targeting Organ-Specific Strategies r. Wiley-*VCH*.
4. Melgardt M. de Villiers (2007) Nanotechnology in Drug Delivery, Springer.

Reference Books

1. Rodney JY, Milo Gibaldi (2003) Biotechnology and Biopharmaceuticals transforming proteins and genes into drugs, A John Wiley & Sons, Inc., Publication.
2. Gavin Brooks (1998) Biotechnology in Healthcare**,** An introduction to biopharmaceuticals, Pharmaceutical Press (London).
3. Shayne cox gad (2007) Handbook of pharmaceutical Biotechnology A John Wiley & Sons, Inc., Publication
4. Grietje Molema and Dirk KF (2002) Drug Targeting Organ-Specific Strategies by Meijer. Wiley-*VCH*.
5. Gary Walsh (2003) Biopharmaceuticals Biochemistry and Biotechnology, Wiley.

Course Outcome (COs):

On completion of this course student will have the improved ability to

1. Comprehend the development, characterization and evaluation of bio therapeutic proteins. (PO1, PO5)
2. Applying the knowledge of immunology in development of immuno-therapeutics and diagnostics. (PO1, PO3)
3. Explore the principles and applications of novel bio therapeutics (PO1, PO3, PO5)
4. Apply the principles of nanotechnology in research and development of nano-medicines. (PO1, PO3, PO5)
5. Formulate protein-based drugs and study their physico-chemical and pharmacological properties. (PO4, PO5)

BIOPROCESS MODELLING AND SIMULATION LAB

Sub Code	**: MBTL23**	**Contact Hours**	**: 14P**
Credits	**: 0:0:1**		

Course coordinator(s): Mr. Krishna Murthy T P and Dr. Chandraprabha M N

List of Experiments

1. Introduction to modelling, simulation, and optimization in the bioprocess engineering
2. MATLAB® and Microsoft Excel® for bioprocess engineering applications
3. Linear and nonlinear regression analysis of mathematical models
4. Statistical analysis of experimental biological data
5. Screening of significant process parameters by factorial and Plackett-Burman designs using Microsoft Excel® / Design Expert® / Origin Pro® V10
6. Optimisation of process parameters by Response Surface Methodology (RSM) using Microsoft Excel® / Design Expert® / Origin Pro® V10
7. Development of bioprocess flow sheets using SuperPro Designer® or Aspen One®
8. Simulation of biofuel/bioproducts production plant using SuperPro Designer® or Aspen One®
9. Simulation of Biopharmaceutical production using SuperPro Designer® or Aspen One®
10. Techno-economic analysis of a bioprocess to produce industrial products using SchedulePro® or Aspen One®
11. Basics of Finite Element Analysis for CFD Applications
12. Numerical Modelling for Bioprocess Engineering with COMSOL Multiphysics ®
13. Literature collection, preparation of research data, professional writing of research paper and reference management
14. Report/Thesis writing and reference management using LaTeX® software

Note: *At least any 12 experiments must be performed*

Textbooks

1. Montgomery, D. C. (2017). Design and analysis of experiments. 9th Edition John Wiley & sons.
2. Verma, A. K. (2014). Process modelling and simulation in chemical, biochemical and environmental engineering. CRC Press.
3. Burstein, L. (2011). MATLAB® in Bioscience and Biotechnology. Elsevier.

References

1. Gunter Jagschies Eva Lindskog Karol Lacki Parrish Galliher (2017) Biopharmaceutical Processing: Development, Design, and Implementation of Manufacturing Processes, 1st Edition, Elsevier
2. Elmar Heinzle Arno P. Biwer Charles L. Cooney (2006) Development of Sustainable Bioprocesses: Modeling and Assessment, John Wiley & Sons, Ltd.

Course Outcome (COs):

On completion of this course student will have the ability to: -

1. Gain the practical exposure to various software tools to perform modelling and simulation studies in biological and bioprocess research. (PO1 and PO4)
2. Implement appropriate experimental design for screening & optimizing the process parameters. (PO1, PO3 and PO4)
3. Develop bioprocess models and simulate them using various software. (PO1, PO3 and PO5)
4. Apply CFD tools to simulate the hydrodynamics of bioprocess systems. (PO1, PO3 and PO5)
5. Effective management of literature data and utilization of modern tools in report writing. (PO1, PO2, PO3 and PO4)

BIOPHARMACEUTICAL TECHNOLOGY LAB

Sub Code	**: MBTL24**	**Contact Hours**	**: 14P**
Credits	**: 0:0:1**		

Course coordinator(s): Dr. Lokesh K N

List of Experiments

1. Test for sterility: Bacteriological Test for Water for injection (WFI).
2. Determination of minimum inhibitory concentration of given antibiotic.
3. Handling and working principles of dissolution test apparatus:
4. To profile PK properties of given biopharmaceuticals by using dissolution test apparatus.
5. Standardization of given herbal formulation by TLC.
6. Validation of Autoclave by biological indicator method.
7. Handling and working of lyophilizer for freeze drying of protein formulation.
8. Detection of HIV antibodies Tri- dot test.
9. Determination of Partition coefficient of given formulation.
10. Determination of antioxidant activity of given formulation by DPPH method
11. Extraction and isolation of Caffeine from tea powder.
12. Detection of antigen in the given sample by ELISA
13. Preparation and evaluation of controlled release formulation.
14. Preparation and characterization of blank / loaded liposome.

Note: *At least any 12 experiments must be performed*

Textbooks

1. Heinrich Klefenz. (2002) Industrial Pharmaceutical Biotechnology, Wiley-VCH.
2. Gary Walsh (2011) Biopharmaceuticals: Biochemistry and Biotechnology, Wiley-VCH.

Reference Books

1. Gregory Bock, Dalia Cohen, Jamie Goode, Novartis and J. Craig Venter (2001) From Genome to Therapy: Integrating New Technologies with Drug Development, Wiley-VCH.
2. Susanna Wu-Pong, Yongyut Rojanasakul, and Joseph Robinson (2010) Biopharmaceutical Drug Design and Development, Humana Press.

3. Herbert A Kirst, Wu-Kuang Yeh, Milton J (2001) Enzyme technologies for pharmaceutical and biotechnological applications, Marcel Dekker, Inc.

Course Outcome (COs):

On completion of this course student will have the improved ability: -

1. Perform quality control tests to validate quality of product. (PO1, PO2, PO4, PO5)
2. Standardize the purity and efficacy of therapeutics. (PO1, PO2, PO4, PO5)
3. Apply the knowledge of formulation of biopharmaceuticals for extended release of therapeutics. (PO1, PO2, PO3, PO5)
4. Develop skill sets to understand basic workflow in Pharmaceutical organization. (PO1, PO2, PO3, PO4)
5. Improve the research aptitude of students by imparting the knowledge of advanced drug delivery systems. (PO1, PO2, PO 3, PO4, PO5)

BIOETHICS & INTELLECTUAL PROPERTY RIGHTS

Sub Code	**: MBT31**	**Contact Hours**	**: 42L+14T**
Credits	**: 3:1:0**		

Course coordinator(s): Dr. Bindu S

UNIT-I

Introduction to Bioethics and Biosafety: definition and needs of Bioethics, Social and Ethical issues in biotechnology. Application of bioethics: the expanding scope of ethics from biomedical practice to biotechnology. Introduction to Biosafety: definition and needs of biosafety, levels of biosafety, applications of biosafety at workplace, Biosafety during development of biotech products. Examples and case studies.

UNIT-II

Ethical Issues: Ethical issues regarding genetically modified organisms (foods and crops); bioethics in biodiversity and resource management. Animal cloning and human cloning and their ethical aspects. Testing of drugs on human volunteers, organ transplantation and ethical issues; Xenotransplantion and its ethical and social issues. Human Genome project.

UNIT-III

Biosafety regulations in transgenic research: National and international guidelines on rDNA technology. MOEF guidelines, Good laboratory practice, Good manufacturing practice and FDA regulations, Regulations for recombinant DNA research and manufacturing process, Public perception. National Institute of health (NIH) guidelines, guidelines for research in transgenic organisms.

UNIT-IV

Introduction to IPR: IP definition and needs, GATT & WTO, Different forms of IPR – Copyrights, Trademarks, Industrial designs, Geographical Indications, Traditional Knowledge, Plant varieties, Trade Secrets. WIPO, TRIPS, Role of IPR in Research and Development.

Trademarks and copyrights: nature of trademarks and branding, tips on names for trademarks, acquiring trademarks protection, brand valuation, packaging and selling, increase the value of a technology through the use of trademark. Introduction and characteristics of copyrights and neighboring rights, performers and broadcasting organizations rights, transfer of copyrights.

UNIT-V

Patents: Introduction of Patents, patent as an intellectual property, Brief history of patents-Indian and global scenario, types of patents, patent life cycle, criteria for patenting, novelty, inventiveness, utility, patentable subject matter, inventions that are not patentable, term of patent, maintenance of a patent, granted patents Vs. patent publications.

Ideas: Generation and review of ideas, documenting ideas, literature scanning for possibility of IP rights, decision to go for IP protection or not, and consideration of choice of IP protection, disclosure, inventors interview, Process and Product Patents.

Textbooks

1. Sateesh M.K (2008) Bioethics & Biosafety, IK Publishers.
2. Traynor PL (2000) Biosafety Management, Virginia Polytechnic Institute Publication.
3. Acharya N K (2007), Textbook on Intellectual Property Rights, 4th Edn, Asia Law house.

Reference Books

1. Sasson A (1993) Biotechnologies in developing countries present and future, UNESCO Publishers.
2. Rao MB (2003) WTO and International Trade, Vikas Publishing House Pvt. Ltd.
3. Erbisch FH and Maredia KM (2003) Intellectual Property Rights in Agricultural Biotechnology, Orient Longman Ltd.
4. Deborah E Bouchoux (2005) Intellectual Property Rights, Delmar Cengage learning
5. Thomas T Gordon and Arthur S Cookfair (1995), Patent Fundamentals for Scientists and Engineers, CRC Press.

Course Outcome (COs):

On completion of this course student will be

1. Capable of understanding biosafety practices. (PO5)
2. Aware of the ethical issues relevant to Biotechnology. (PO3)
3. Conversant with biosafety regulations (PO4).
4. Have thorough understanding of intellectual property rights. (PO4)
5. Conversant with procedures used to protect intellectual property rights. (PO5)

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INDUSTRIAL & ENVIRONMENTAL BIOTECHNOLOGY

Sub Code	**: MBTE01**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Mrs. Bhavya SG and Dr. Chandraprabha MN

UNIT-I

Introduction to industrial biotechnology: An introduction to fermentation processes - the range of fermentation processes. Microorganisms used in industrial microbiological processes - the isolation, preservation, Screening for Productive Strains and Strain Improvement in Biotechnological Organisms – Manipulation of the genome of industrial organisms. Use of recombinant system for the improvement of industrial microorganisms, Media and materials required for industrial microbiological processes - sources, formulation, antifoams and optimization.

UNIT-II

Metabolic Pathways for the Biosynthesis of Industrial Products: The Nature of Metabolic Pathways, Industrial Microbiological Products as Primary and Secondary Metabolites, Trophophase-idiophase Relationships in the Production of Secondary Products, Role of Secondary Metabolites in the Physiology of Organisms, Pathways for the Synthesis of Primary and Secondary Metabolites of Industrial Importance. Carbon Pathways for the Formation of Some Industrial Products Derived from Primary Metabolism.

UNIT-III

Production of enzymes, organic acids and solvents: Carbon Pathways for the Formation of Some Products of Microbial Secondary Metabolism of Industrial Importance. Mechanisms Enabling Microorganisms to Avoid Overproduction of Primary Metabolic Products Through Enzyme Regulation, Derangement or Bypassing of Regulatory Mechanisms for the Over-production of Primary Metabolites, Regulation of Overproduction in Secondary Metabolites. Industrial products produced by microorganisms - Enzymes (amylase, proteases), organic acids (lactic acid, citric acid, vinegar), Ethyl alcohol.

UNIT-IV

Production of antibiotics and health care products: Mechanisms Enabling Microorganisms to Avoid Overproduction of Primary Metabolic Products Through Enzyme Regulation, Derangement or Bypassing of Regulatory Mechanisms for the Over-production of Primary Metabolites, Regulation of Overproduction in Secondary

Metabolites - Production of important antibiotics - penicillin, Cephalosporins, streptomycin, erythromycin, bacitracin, Other beta-lactam antibiotics and tetracyclines. Production of Vitamins B12 &. Baker's yeast production and hormones. Microbial transformation of Steroids and sterols. amino acids (L-lysine, L-glutamic acid) as food supplement.

UNIT-V

Environmental Biotechnology: Treatment of Wastes in Industry- Wastes from Major Industries, Systems for the Treatment of Wastes- Aerobic breakdown of raw waste waters, Treatment of the Sludge- Anaerobic Breakdown of Sludge. Hazardous waste management - Bioremediation, Biological detoxification- examples of biotechnological applications for hazardous waste management. Mining and Metal biotechnology, microbial transformation, accumulation and concentration of metals, metal leaching, extraction and future prospects.

Textbooks

1. Nduka Okafor, Modern industrial microbiology and biotechnology (2007), Science publishers.
2. Prescott and Dunn, Industrial Microbiology (2002), AVI Publishing Company Inc.
3. Alan Scragg, Environmental Biotechnology (2005), Oxford university press.

Reference Books

1. Stanbury PE, Whitaker A, and Hall SJ (1999) Principles of Fermentation Technology by, Butterworth Heineman, Aditya Books (P) Ltd.
2. Wulf Crueger and Anneliese Crueger, (2002) A textbook of Industrial Microbiology, Panima Publishing Corporation.

Course outcomes (COs):

Upon completion of this course, the students will be able to:

1. Assess the methods involved in isolation and screening of potential microorganisms for production of industrial bioproducts. (PO4, PO5)
2. Compare and analyse various metabolic pathways involved in biosynthesis of industrial products. (PO3, PO4)
3. Apply the metabolic pathway engineering principles in improvement of primary metabolites production. (PO3, PO4)
4. Choose and manage appropriate metabolic pathway mechanism for secondary metabolite production. (PO3, PO4)
5. Apply the principles of waste management to treat the effluents from bioprocess industries. (PO1, PO5)

RECOMBINANT DNA TECHNOLOGY

Sub Code	**: MBTE02**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Prabha M

UNIT-I

Introduction to Recombinant DNA technology: Introduction to recombinant DNA technology. The importance of recombinant DNA technology. Vectors: Structure and function of cloning and expression vectors. Regulatory sequences of prokaryotic and eukaryotic genes. Different host systems for cloning and expression. Transformation techniques: physical, chemical and biological.

UNIT-II

Important enzymes used in the recombinant DNA technology: Enzymes are the molecular tools. Enzymes cleave nucleic acids: nucleases, restriction endonucleases, RNases. Enzymes synthesize nucleic acids: DNA and RNA polymerases, ligases. Enzymes in modification of DNA: DNA methylases, phosphatases, kinases, topoisomerases. Construction and screening of genomic and cDNA libraries.

UNIT-III

Advanced techniques used in recombinant DNA technology: Isolation of DNA and RNA. Estimation of purity and quantity of nucleic acids, Polymerase chain reaction (PCR), Autoradiography, DNA sequencing. Detection of DNA, RNA and proteins by Southern blotting, Northern blotting, western blotting and *in situ* hybridization techniques. Site-specific mutagenesis, Gene mapping and Microarrays.

UNIT-IV

Applications of recombinant DNA technology in Medicine and Health: Production of specialty chemicals and proteins: secondary metabolites, phytochemicals. Genetically modified microbes (Recombinant bacteria) for the production of commercial scale production of proteins and pharmaceuticals, antibiotics, enzymes, insulin, growth hormones, monoclonal antibodies. Applications rDNA in diagnosis of pathogens and abnormal genes. Transgenic animals. Transgenic animals for production of proteins and pharmaceuticals. Genetically modified insect cells for the production of commercially important bioproducts.

UNIT-V

Applications of recombinant DNA technology in agriculture, industry and environment: Transgenic plants, Transgenic crops for increased yield, resistance to biotic and abiotic stresses, clearing oil spills. Application of transgenic plants. Industrial production of specialty chemicals and proteins: organic molecules and commercially important proteins. Biosafety regulations and evaluation of genetically modified microorganisms (GMOs), plants and animals.

Textbooks

1. Brown TA. (2010) Gene cloning and DNA analysis: An Introduction. 6th ed. Wiley-Blackwell.
2. Primrose SB, Twyman RM. (2006) Principles of gene manipulation and genomics. 7th ed. Blackwell Publishing.
3. Nicholl DST. (2008) An Introduction to Genetic Engineering. 3rd ed. Cambridge University Press.
4. Channarayappa (2006) Molecular Biotechnology: Principles and Practices. Universities Press (India) Pvt. Ltd. Worldwide publishing: CRC Press, Taylor and Francis.

Reference Books

1. Lodge J. (2007) Gene cloning: principles and applications. Taylor & Francis Group.
2. Singh BD. (2008) Biotechnology: Expanding Horizons. 2nded. Kalyani Publishers.
4. Benjamin Lewis (2008) Genes VIII. Oxford University & Cell Press
5. Lodish H, Berk A, Zipursky SL et al. (2007) Molecular Cell Biology. 6th ed. W. H. Freeman.
6. Sambrook et. al. (2000) Molecular cloning: a laboratory manual. Volumes I - III. Cold Spring Harbor Laboratory Press, New York, USA.

Course Outcome (COs):

On completion of this course student will have improved ability to:

1. Apply cloning and transformation techniques in prokaryotic and eukaryotic systems. (PO1, PO4, PO5)
2. Utilize enzymes for construction and modification of rDNA. (PO1, PO4, PO5)
3. Isolate and detect nucleic acids and analyze advanced techniques of rDNA. (PO2, PO4, PO5)
4. Apply rDNA techniques in development of genetically modified organisms for medical applications. (PO3, PO4, PO5)
5. Apply recombinant DNA technology in agriculture, industry and environment. (PO3, PO4, PO5)

ADVANCED UPSTREAM AND DOWNSTREAM TECHNOLOGY

Sub Code	**: MBTE03**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Chandraprabha MN and Dr. Lokesh KN

UNIT-I

Media development and Design of Biological reactors: Introduction, Types of cell culture media, components of animal origin, inoculum development strategies, Ideal reactors, Reactor dynamics, Sterilization of reactors, Immobilized biocatalysts, Multiphase Reactors, Animal and plant cell reactor technology.

UNIT-II

Mammalian and plant cell culture technology: Introduction. Cell line transfection and selection, increase in efficiency in selecting a producer cell line, Stability of gene expression, Optimization of the fermentation process, Bioreactors. Bioreactor consideration for plant cells.

UNIT-III

Cell disruption and protein enrichment operations: Centrifugation; Sedimentation; Flocculation; Microfiltration; Sonication; Bead mills; Homogenizers; Chemical lysis; Enzymatic lysis. Membrane based purification: Ultrafiltration; Reverse osmosis; Dialysis; Diafiltration; Pervaporation; precipitation (Ammonium sulfate solvent). Extraction (solvent aqueous two phase, supercritical).

UNIT-IV

Adsorption and chromatography: size, charge, shape, hydrophobic interactions, Biological affinity; Process configurations (packed bed, expanded bed, simulated moving beds). Electrophoretic technique, Electrophoresis.

UNIT-V

Product polishing techniques: Crystallization; Drying. Case studies; product formulation and additives, freeze drying process.

Textbooks

1. Harris ELV and Angal S (1988) Protein Purification Methods, Ed. IRL Press at Oxford University Press.
2. Belter PA, Cussler EL and Wei-Shou Hu (2001) Bioseparations-Downstream Processing for Biotechnology, Wiley-Interscience Publication.

Reference Books

1. Michael Butler (2007) Cell Culture and Upstream Processing, T & F informa.
2. James E. Bailey and David F. Ollis (1997) Bioprocess Engineering fundamentals. Mc Graw Hill Book Publication.
3. Bailey JE and Ollis DF (2010) Biochemical Engineering Fundamentals, 2nd Edn, Mc-Graw Hill, Inc.
4. Scopes RK Berlin (1982) Protein Purification: Principles and Practice, Springer.

Course Outcome (COs):

On completion of this course student will have improved ability to: -

1. Acquire real-time working knowledge on media formulation, sterilization and optimization process which are considered as pre-requisites of upstream processing. (PO3, PO4)
2. Apply the knowledge of animal cell culture technology in upstream processing. (PO3, PO4)
3. Apply principles of separation & purification of fermented products and utilize membrane-based operations for product purification. ((PO4, PO5)
4. Design and apply principles of various chromatographic techniques with respect to product recovery. (PO4, PO5)
5. Design various techniques with respect to product polishing. (PO4, PO5)

MEDICAL BIOTECHNOLOGY

Sub Code	**: MBTE04**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Prabha M and Dr. Lokesh KN

UNIT-I

Introduction scope and applications in Medial Biotechnology: Disease: bacterial, viral, fungal and parasitic. Investigation of epidemics. Methods of culturing and assaying: bacterial, viral and parasitic. Viral vaccines: conventional: killed/attenuated; DNA; peptide; recombinant proteins. Future development and scope of vaccines.

UNIT-II

Hemopoeitic Stem Cells: Haematopoietic stem cells differentiation, transdifferentiation and growth factors. Classification and manifestations of Hemopoeitic stem cell disorders, aplastic Hemopoeitic stem cell disorders, clinical applications of colony stems, complications of germ therapy, replacement therapy and bone marrow transplantation, immunological principles, preservation and clinical use of blood and blood components.

UNIT-III

Regenerative and nano medicine: Encapsulation technology and therapeutics- Diabetes, Hypothyroidism, Haemophilia Bioartificial organs, Stem cell therapy - Embryonic and adult Stem Cells, Totipotent, Pluripotent and Mulltipotent Cells. Nanomedicine – Nanoparticles, Nanodevices- medical microrobotics, nanorobotics, Microbiovers, Nanomedicine.

UNIT-IV

Molecular Diagnostics: Molecular techniques for analysis of these disorders; Biochemical disorders; Immune, Genetic and Neurological disorders; Assays for the Diagnosis of inherited diseases; Antibody based diagnosis; Monoclonal antibodies as diagnostic reagents; Production of monoclonal antibodies with potential for diagnosis

UNIT-V

Gene and molecular therapeutics: General introduction, potential target diseases for gene therapy, gene transfer methods, and their applications, clinical studies, pharmaceutical production and regulation. Liposome and nanoparticles mediated gene delivery. Antisense technology, Clinical applications of recombinant technology; Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone.

Textbooks

1. Daan Crommelin, Robert D Sindelar and Bernd Meibohm (2007). Pharmaceutical Biotechnology and Fundamental Applications, 2nd edition. Informa Health care USA, Inc.
2. Willam Irving, Time Boswell and Dlawar Ala'Aldeen (2006) BIOS Instant notes in Medical Microbiology. BIOS Scientific Publication.
3. Sambamurthy K and Ashutosh Kar (2006) Textbook of Pharmaceutical Biotechnology, Paperback 1st edn. New Age International.

Reference Books

1. Judit Pongracz and Mary Keen (2009) Medical Biotechnology, Churchill Livingstone publication.
2. Albert Sasson (2006) Medical Biotechnology, Brookings Institution Press.
3. Bernhard O Palsson and Sangeeta N Bhatia (2003) Tissue Engineering, Pearson Prentice Hall.
4. Pamela Greenwell, Michelle McCulley. (2007) Molecular Therapeutics: 21st century medicine, 1st Edition.
5. Lela Buchingham and Maribeth L Flawsm. (2007) Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, 1st Edition, F A Davis Company, Philadelphia, USA.

Course Outcome (COs):

On completion of this course student will have improved ability to: -

1. Apply the concepts of medical biotechnology in disease diagnosis, prevention and treatment (PO1, PO4, PO5)
2. Asses the benefit of hemopoietic stem cells in the treatment of cancer and other diseases (PO1, PO4, PO5)
3. Apply encapsulation technology and stem cells for therapeutics, Regenerative and Nanomedicine. (PO3, PO4, PO5)
4. Utilize the molecular techniques for diagnosis of Biochemical, Immune, Genetic and Neurological disorders. (PO2, PO4, PO5)
5. Apply gene therapies, molecular and rDNA techniques for treatment of various diseases. (PO3, PO4, PO5)

BIOREACTION ENGINEERING

Sub Code	**: MBTE05**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Mr. Gokulakrishnan and Mr. Samrat K

UNIT-I

Kinetics of Microbial Growth and Product Formation: Phases of cell growth in bath culture, simple unsaturated kinetic models for microbial growth, growth associated and non-growth associated product formation kinetics, Mono and Leudeking-piret models, Introduction to structured models for growth and product formation.

UNIT-II

Media Design and Sterilization for Fermentation Process: Medium requirements for fermentation process-examples of simple and complex media; Design and usage of commercial media for industrial fermentations, Thermal death kinetics of microorganisms, Batch and continuous heat-sterilization of Liquid media, Filter sterilization of liquids

UNIT-III

Transport Phenomena in Bioreactors: Mass transfer in heterogeneous biochemical reaction systems, Oxygen transfer in submerged fermentation process, Oxygen uptake rate and determination of oxygen transfer coefficients (k_La), role of aeration and agitation in oxygen transfer, Heat transfer process in biological systems

UNIT-IV

Mechanical Design of Bioreactors and Ancillary Equipments: Basic design and construction of fermenters and its ancillaries; Material of construction, Vessel geometry, Bearing assemblies, Motor drives, Aseptic seals, Flow measuring devices, Valves, Agitator and Spurges Design, Sensor.

UNIT-V

Process Design and Operation Bioreactors: Operational models of reactors, Batch continuous, Fed Batch, repetitive batch, recycle and continuous cultivation, novel bioreactors, stirred tank, Air lift and loop reactors, Packed bed and Hollow fiber membrane bioreactors, Bioreactors for waste treatment processes; Scale-up of bioreactors, SSF bioreactors.

Textbooks

1. Bailey and Ollis (2010) Biochemical Engineering Fundamentals, McGraw Hill (2nd Ed)
2. Schuler M L and Kargi F (2002) Bioprocess Engineering- Basic concepts, 2nd Edition, Prentice Hall
3. Levenspiel O (2006) Chemical reaction Engineering, 3rd ed., John Wiley.

Reference Books

1. Ghose TK (Ed)(1994) Process computation in Biotechnology Tata Mc-Craw Hill.
2. Athinson B and Maviuna F (1993) Biochemical Engg. And Biotechnology Handbook, Mc-Graw hill (2nd Edition)
3. Pauline M. Doran (2009): Bioprocess Engineering Principles, Reed Elsevier India.
4. HC Vogel, Noyes. (1996) Fermentation & Biochemical Engineering Handbook, Elsevier.

Course Outcome (COs):

On completion of this course student will have improved ability: -

1. Describe the algorithm that allows the student to solve chemical reaction engineering problems through logic rather than memorization. (PO1, PO4)
2. Size isothermal and non-isothermal reactors for homogeneous and heterogeneous reactions. (PO3, PO5)
3. Analyze multiple reactions carried out both isothermally and non-isothermally in flow, batch and semi batch reactors to determine selectivity and yield. (PO1, PO3, PO4)
4. Analyze the various parameters for bioreactor design. (PO1, PO4)
5. Analyze different reactors for bioprocess operations. (PO3, PO4)

TOXICOLOGY AND FORENSIC SCIENCE

Sub Code	**: MBTE06**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Ravikumar YS

Unit-I

Introduction to toxicology: History and scope of toxicology, Source of toxicants. Classification of toxic agents. Occupational toxicology: Workplace, hazardous exposure, and occupational diseases. Mechanism of toxicity: Toxicant delivery, reaction with the target molecule, cellular dysfunction, inappropriate repair and adaptation. Non target organ toxicity: Chemical carcinogenesis mechanisms of carcinogens. Genetic toxicology mechanisms of genetic alterations. *Teratology:* teratogens, teratogenesis. Cytotoxicity mechanisms of cell death mitochondrial dysfunction,

Unit-II

Target organ toxicity and metabolism of toxicants: Toxic effects on liver, kidney, nervous, endocrine, respiratory, immune and reproductive systems. Metabolism of toxicants: Phase I Reactions: Microsomal oxidation Nonmicrosomal oxidations Reduction Reactions, Hydrolysis, Epoxide Hydration. cooxidation. Phase II Reactions: Conjugation reactions, Methyltransferases and Acylation. Reactive Metabolites**:** nature, stability and fate of reactive metabolites, Elimination of Toxicants: renal, hepatic and respiratory elimination

Unit-III

Toxicology Testing: Food toxicology: introduction, safety standards for foods and food ingredients and contaminants. *In Vivo* Toxicology: Testing *of* acute, subchronic and chronic toxicity. *In Vitro testing:* Cell Culture Methods, Ames forward mutation assay, Assessing genotoxicity: mitotic index, chromosomal aberrations, micronucleus assay, cytotoxicity and apoptosis assay. Neurotoxicity testing.

Unit-IV

Introduction to Forensic science: Introduction, Definition and Scope, History and Development of Forensic science, basic Principles of Forensic Science. Organization of crime Laboratory services, services provided by full-service crime laboratories, Physical Science unit, Biological Unit, Firearms Unit, Documentation Examination Unit- Function and Duties Performed by each unit and lab. The Crime Scene investigation- Making and recording observations (including sketches with

measurements and digital photographs), Chain of Custody, Locard Exchange principle, Evidences and Collection techniques, Firearms, Marks and impressions, Drug of abuse. Ploygraphy. Computer Forensics.

Unit-V

Forensic Biology: Forensic Pathology: Rigor mortis, Lovor mortis, Algor mortis. Forensic Anthropology, Forensic Entomology, Forensic Psychiatry, Forensic Odontology, Forensics Engineering, forensic serology, DNA Analysis, Dactyloscopy, Fingerprints: history, fundamental principle of Fingerprints, Classification and patterns, AFIS, Mrthod of Detecting fingerprint. Trace evidence and contact evidence- targeting potential traces, recovery of trace material assessment of significance- Hair, fiber and Paint.

Textbooks

1. Barile FA (2008) principles of toxicology testing CRC Press is an imprint of the Taylor & Francis Group New York
2. Hodgson E (2004) A Textbook of Modern Toxicology Third edition John Wiley & Sons, Inc., publication
3. Curtis D. Klaassen (2001) Casarett and Doull's Toxicology The Basic Science Of Poisons Sixth Edition Mcgraw-Hill publishers New Delhi

Reference books

1. Osweiler G D (1996) Toxicology, Wiley-Blackwell Publisher
2. Marquardt H (1999) Toxicology, Academic Press
3. Derelanko M J (2002) Handbook of toxicology, CRC Press

Course Outcome (COs):

On completion of this course student will have improved ability: -

1. Describe the general toxicology principles, chemical basis of toxicity carcinogenesis and genotoxicity (PO3)
2. Recognize that toxic outcomes result from interaction between the toxic substance and the metabolic machinery of the organ and identify the damage process, action and metabolism of toxic chemicals. (PO3, PO5)
3. Apply analytical techniques to test the toxicity of various chemical compound. (PO1, PO4, PO5)
4. To describe the historical development of the forensic sciences and Demonstrate the crime scenes, physical evidence and organization of forensic laboratory. (PO1, PO5)
5. Develop skills in the basic scientific methods and the use them in forensic science. (PO1, PO5)

PLANT BIOTECHNOLOGY

Sub Code	**: MBTE07**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Bindu S

UNIT-I

Introduction: Introduction and historical developments and applications of Plant tissue and cell culture. Laboratory Design and Developments. Instrumentation. Sterilization techniques, Plant Tissue Culture Media, Cellular totipotency, Factors affecting Tissue Culture success: (Media explant, light, Temperature, Polarity, Subculture, Genotype, Season), Hormones.

UNIT-II

Plant Tissue and cell culture: Micropropagation, organ culture, Establishing callus and cell culture, Dynamics of callus growth, callus subculture and maintenance, organogenesis. Embryogenesis, variant selection, Somaclonol variation, cell suspension culture, Somatic embryogenesis in plant. Protoplast isolation and culture. Acclimatization of micro propagated plant. Primary and secondary metabolic products (Phytochemicals) of plant cells, Biosynthesis of secondary metabolites of biotechnological importance.

UNIT-III

Genetic Engineering in Plants: Structure and organization of plant genome, regulation of plant genome expression, transcriptional, translational regulation of plant genome. Transposons, Transfer of DNA to plant cells- Direct transformation by electroporation and particle gun bombardment. Agrobacterium, Ti plasmid vector Theory and techniques for the development of new genetic traits, conferring resistance to herbicide, pesticide, plant pathogens.

UNIT-IV

Methods in Plant Biotechnology: Amplification of DNAs by Polymerace Chain Reaction (PCR). Gene transfer technology Vectors, Gene transfer using Particles Bombardment, Microinjection method, Marker assisted selection (RAPD, RFLP, AFLP, SNP`s etc.). Methods for crop improvement.

UNIT-V

Application of Plant Biotechnology: Herbicide resistance, disease resistance, novel proteins, vaccines, antibodies and antigens. Immobilized cell systems and Biotransformation. Plant Genome Project: Rice genome project. Hairy root culture and its importance.

Textbooks

1. Singh BD (2014) Biotechnology- Expanding Horizons. Kalyani Publishers, Rajindernagar, Ludhiana.
2. Reinert J and Bajaj YPS (2013) Applied and Fundamental aspects of Plant Cell, Tissue and organ Culture. Springer Verlag, Berlin.
3. Narayanaswamy S (2008) Plant Cell and Tissue Culture. Tata McGraw Hill, New Delhi.
4. Sathyanarayana B. N. and Varghese, D.B. (2007) Plant Tissue Culture: Practices and New Experimental Protocols. I. K. International Pvt Ltd.

References

1. Bengochea T and Doods JH (2012) Plant Protoplasts: A Biotechnological Tool for Plant Improvement. Chapman and Hall. London.
2. Gamborg OL and GC Phillips (2013) Plant Cell, Tissue and organ culture. Narosa Publishing House, New Delhi.
3. Razdan MK (2003) An Introduction to Plant Tissue Culture, Oxfsord & IBH Pub. Co, Pvt., Ltd., New Delhi
4. Bhojwani SS and Razdan MK (2003) Plant Tissue Culture: Theory and Practice, a revised edition. Elsevier Publication.
5. Dodds JH and Roberts LW (1995) Experiments in plant Tissue Culture. Cambridge University Press, Cambridge.

Course Outcome (COs):

On completion of this course student will have improved ability:

1. Acquire the concept of plant tissue culture and its Applications (PO1, PO5)
2. Optimize and formulate media and design plant tissue culture techniques to conduct research (PO1, PO3, PO4, PO5).
3. Acquire the knowledge of gene transfer techniques in plants (PO1, PO 5).
4. Asses the transgenic plants using various molecular markers (PO4, PO5).
5. Apply the concepts of recombinant DNA techniques in developing transgenic plants (PO1, PO4, PO5)

APPLIED BIOINFORMATICS

Sub Code	**: MBTE08**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Mr. Krishna Murthy T P

UNIT-I

Elementary algorithmics: Introduction, Prediction algorithms; Asymptotic Notations, Efficiency of Algorithms, BLAST algorithm, *K*tup identification, PSSM, Progressive alignment procedure, Dynamic Programming: UPGMA method, Nighbour Joining method, Randomized algorithm.

UNIT-II

Database Warehousing in bioinformatics: Data, transforming data into knowledge, data warehousing and architecture, data quality. Data mining for bioinformatics: Biomedical data analysis, DNA data analysis, protein data analysis, machine learning in bioinformatics: Artificial neural networks, neural network architectures and applications, genetic algorithms, fuzzy systems.

UNIT-III

Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays, EST database. Rearrangement of genes.

UNIT-IV

Molecular modeling and simulations: Macro-molecular force fields, salvation, long-range forces, Geometry optimization algorithms: Steepest descent, conjugate gradient Various simulation techniques: Molecular Dynamics, Monte Carlo, docking strategies etc. Molecular mechanics, conformational searches. **Drug design:** Drug discovery process, Role of Bioinformatics in drug design, Target identification and validation, lead optimization and validation, Structure-based drug design and ligand-based drug design, Modeling of target-small molecule interactions.

UNIT-V

DNA microarray: understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process and computational analysis tools (especially clustering approaches). DNA microarray database and basic tools, Gene Expression Omnibus (GEO), ArrayExpress, SAGE databases.

Textbooks

1. Yi-Ping Phoebe Chen (2005) Bioinformatics Technologies, Springer International Edition
2. Shui Quing Ye (2007) Bioinformatics A Practical Approach, Chapman and Hall/CRC,
3. Mathematical and Computational Biology Series.

Reference Books

1. Andreas D. Baxevanis (2002) Bioinformatics – A practical guide to the analysis of genes and proteins, 2nd John Wiley & Sons.
2. David W Mount (2005) Bioinformatics Sequence & Genome Analysis, 2nd CBS Publishers & Distributors
3. Jin Xiong (2005) Essential of Bioinformatics, 2nd edition, John Wiley & Sons.
4. Benson G and Page R (2003) Algorithms in bioinformatics; Springer.
5. Basu O and SK Thukral SK (2007) Bioinformatics: Databases, tools and algorithms; Oxford Press.
6. Clote P and Backofen R (2000) Computational molecular biology: an introduction. Wiley & Sons.

Course Outcome (COs):

On completion of this course student will have improved ability: -

1. Use bioinformatics tools and software to analyze DNA and protein sequence (PO1, PO4, PO5)
2. Apply the database management system concept in manage the biological data (PO1, PO3, PO5)
3. Apply *in silico* and *in vivo* methods to comprehend whole proteome interactions and evaluate methods for quantifying and comparing proteomes. (PO1, PO2, PO3, PO4)
4. Get hands on experience of using online tools to analyze genome sequences. (PO5, PO4)
5. Ability to write computer programs in various programming techniques to analyze bioinformatics data. (PO1, PO2, PO3, PO4, PO5)

ADVANCED RESEARCH METHODOLOGY

Sub Code	**: MBTE09**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Sravanti V and Mr. Krishna Murthy T P

UNIT-I

Introduction to Research Methodology: definition and objectives. Types of research: descriptive research, experimental method of research, inter and multi-disciplinary research. Design of research: basic principles of experimental designs, features of good research design, types of designs. Literature search & formulation of research project.

UNIT-II

Different techniques of research: observation, the interview, the questionnaire & the case study method. Survey methods and sampling techniques: sampling design, random sample and complex random sample design. Data collection: collection of primary and secondary data.

UNIT-III

Basic statistical methods, concepts and techniques: Processing and analysis of data-types of analysis, measure of dispersion; Correlation: Simple, partial and multiple correlations. Regression: linear and non liner regression.

UNIT-IV

Research report/paper writing: types of reports, steps in report writing, meaning and techniques of interpretations. Dissertation/ Thesis writing: Introduction, review of literature, materials and methods, experimental results, discussion/ interpretation of results in the light of earlier research findings, summary and bibliography.

UNIT-V

Computers – its application in research: Computer Skills: Spread sheet and DBMS. Graphics- histograms, line diagrams, bar diagrams and Pie charts. Statistical analysis using computer packages: Design Expert/Statistica /Minitab software's, SPSS

Textbooks

1. Debbie Holmes, Peter Moody, and Diana Dines (2006) Research Methods for the Biosciences, 2nd Edition, Oxford University Press.
2. Oxford University Press Inc., New York.
3. Kothari, C.R. (2002) Research Methodology, 7th Print, 2nd Edition, New Age International, Bangalore.

Reference Books

1. Suresh C. Sinha and Anil K. Dhiman (2002) Research Methodology, 2 volumes, Ess. Ess. Publishers, New Delhi,
2. Kumar (2008) Research Methodology, 7th Edn, Lakshmi Narayan Agarwal, Agra, India
3. Panneerselvam, R. (2004) Research Methodology, 1st Edition, Prentice-Hall of India Pvt. Ltd., New Delhi.

Course Outcome (COs):

On completion of this course student will have improved ability to:

1. Conceptualise the process of research and formulation of research project. (PO1, PO4, PO5)
2. Analyze various sampling and data collection methodologies in research. (PO1, PO3, PO4)
3. Process and analyze data by applying various statistical tools. (PO1, PO3, PO4)
4. Interpret the results and report the research work in a comprehensive thesis. (PO1, PO2)
5. Enhance computer skills for analysing, interpreting and summarizing the results. (PO1, PO2, PO4)

APPLIED ANIMAL BIOTECHNOLOGY

Sub Code	**: MBTE10**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Ravikumar YS N

UNIT-I

Animal Tissue culture and Hybridoma Technology: Cell culture media and preparations. Cell culture techniques: Monolayer and suspension culture, cell lines, organ culture- techniques, three-dimensional culture. Somatic cell fusion and its applications (cybrids, membrane fluid mobility and hybridoma technology). Cryopreservation and storage of animal cells. Primary and immortalized cells, Cell transformation and malignancy.

UNIT-II

Advanced cell culture techniques and application of cultured cells

Microscopic techniques: light, electron microscopic, fluorescent and phase contrast microscopic studies. cell culture and viability, Cell Synchronization and cell cycle Analysis (mitotic and flow cytometry). Gene transformation: Transfection, electroporation and liposome). Immuno-techniques IFA (membrane, cytoplasmic and nuclear proteins) Detection of contamination in cell culture.

UNIT-III

Artificial animal Breeding and Transgenic Technology: Artificial insemination, Transplantation, *in vitro* fertilization and embryo transfer, Advantages of cell manipulation, Nuclear transplantation and cell cloning, selective animal breeding and their potential. Production and uses of transgenic animals. Animals as a bioreactor for production various chemicals. Application of functional genomics and discovery of new genes, animal welfare and human health

UNIT-IV

Stem cells and its application: Source and isolation of stem cells, Embryonic and adult stem cells, culture and maintenance of stem cells. Generation and manipulation of mouse and human embryonic stem cells. Germ Cell Development: Epigenesis and Reprogramming of adult-stem cells. Molecular mechanisms of self-renewal and differentiation, pluri/multi potency and lineage differentiation. Bone transplant and reconstitution of hematopoietic system. Stem cells and therapeutics. Novel sources of multipotent stem cells. Science policies and Ethics in Stem Cell Research

Unit-V

Applications of Animal Biotechnology: Animal improvement: diary, fishery and poultry). Medicine: diagnosis of diseases, detection of genetic disorders. Treatment: vaccines, gene and cell therapy, tissue transplantations. Production of pharmaceutical chemicals, interferons, interleukins, stem cell factors and hormones. Industrial applications: metabolites production, bio control agents, industrially important enzymes. Drug testing and evaluation.

Textbooks

1. Freshney RI (2005) Culture of Animal Cells, 5th Edn, Wiley-Liss.
2. Spier RE and Griffiths JB (1988) Animal Cell Biotechnology, Academic Press.
3. Clynes (1998) Animal Cell Culture Techniques, 1st Edn, Springer.

Reference Books

1. Channarayappa (2006) Molecular Biotechnology**:** Principles and Practices. University Press (India) Pvt. Ltd., Worldwide CRC Press.
2. Channarayappa (2010) Cell Biology: Universities Press (India) Pvt Ltd.
2. John RW, Masters, (2000) Animal Cell Culture: Practical Approach, 3rdEdn, Oxford.
3. Murray Moo-Young (1989) Animal Biotechnology, Pergamon Press, Oxford.
4. Doyle A, Hay R, and Kirsop BE (1990) Living Resources for Biotechnology, Animal cells, Cambridge University Press

Course Outcome (COs):

On completion of this course student will have improved ability to:-

1. Understand the principles of various cell culture techniques and hybridoma technology (PO1, PO5)
2. Apply advanced techniques in the field of cell culture research and development (PO1, PO5)
3. Impart knowledge on artificial breeding, production and applications of transgenic animals (PO3, PO-5)
4. Impart knowledge on isolate and culture of stem cells and their application in biomedical field. (PO2, PO3, PO4)
5. Apply the concepts of cell culture techniques in the field of modern life science. (PO4, PO5)

BIOANALYTICAL & BIOPHYSICAL TECHNIQUES

Sub Code	**: MBTE11**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Sravanti V and Dr. Ahalya N

UNIT-I

Sequencing and separation techniques: DNA sequencing- Principle & technique of Pyrosequencing, Introduction to Next generation sequencing. Protein sequencing: Edman degradation, Separation techniques: Capillary electrophoresis, 2D- Gel Electrophoresis, Chromatographic technique- High Performance Liquid Chromatography, Reverse Phase-HPLC. Centrifugation- Preparative centrifugation, Analytical Ultra centrifugation, Flow cytometry- Fluorescence activated cell sorting (FACs) and its applications.

UNIT-II

Spectroscopic techniques I: Nature of Electromagnetic radiation, Electromagnetic spectrum; Atomic energy levels, Molecular electronic energy levels- Translational, Vibrational, Rotational Electronic states; Principle and applications of Infrared Spectroscopy, Raman spectroscopy, UV-visible spectroscopy in biomolecular analysis. Fluorescence, Quenching, Quantum yield, Chromophore, Fluorophore, Principle, technique and applications of Fluorescence Resonance Energy Transfer (FRET) in biological systems.

UNIT- III

Spectroscopic techniques II: Polarization of light, Plane polarized vs Circularly polarized light, Optical rotation; Circular Dichroism, Principle and applications of CD for structural analysis. Principle and applications of Dynamic Light Scattering (DLS), Mass spectrometry- Ionization methods-EI, ESI, DI, MALDI; Mass analysis- Magnetic sector, Double-focus, Quadrupole, TOF analyzer, detection and quantitation of spectrum. Applications in Proteomics- Peptide Mass finger printing, Protein sequencing, and Post translational modification analysis.

UNIT-IV

Macromolecular structure determination: X-ray crystallography: protein crystal growth X-ray crystallography: protein crystal growth methods, X-ray diffraction; Bragg's law, single crystal techniques of data collection, Phase problem, Phase determination methods; Structure Refinement, structure validation-Ramachandran Plot. NMR spectroscopy, Nuclear spin states, Electronic spin behavior. Chemical shift

& Shielding, Nuclear Magnetic Spectrometer, NMR- 1-D, 2-D, Nuclear Overhauser effect (NOE), COSY, NOESY. Structure, Function/applications of Green Fluorescent Protein (GFP) and Proteasome complex.

UNIT-V

Functional studies of biomolecules: Principle of Surface Plasmon Resonance (SPR) and its applications, Calorimetric application in binding studies-Isothermal Titration Calorimetry (ITC), Differential scanning calorimetry (DSC), Microarrays- DNA, Protein Microarray and their applications, Phage display, Yeast-two-hybrid (Y2H), Three-hybrid assay for identifying interaction partners for biomolecules.

Textbooks

1. M. Daniel (2012), Basic Biophysics for Biologists, AgroBios
2. Keith Wilson & John Walker (2010), 7th Edition, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press.
3. Douglas A. Skoog, F. James Holler, Stanley R. Crouch (2006), Principles of Instrumental Analysis, Cengage Learning.
4. Donald L. Pavia, Gary M. Lampman, George S. Kriz and James A. Vyvyan (2008), Spectroscopy, Cengage Learning.

R**eference Books**

1. Roland Glaser (2004), Biophysics: An Introduction, Springer.
2. Cantor CR and Schimmel PR (1980) Biophysical Chemistry: Part I, The conformation of biological macromolecules.
3. Kensal Edward Van Holde, W. Curtis Johnson, Pui Shing Ho (2006), Principles of Physical Biochemistry. Peasrson Printice Hall.

Course Outcome (COs):

On completion of this course student will have improved ability:

1. Isolate, purify and sequence biomolecules. (PO1, PO3, PO4)
2. Apply spectroscopic techniques to characterize biomolecules. (PO3, PO4)
3. Characterize biomolecules by advanced spectroscopic techniques for proteomic applications. (PO3)
4. Elucidate the structure of macromolecules by NMR and X-ray crystallography. (PO1, PO4, PO5)
5. Choose appropriate analytical techniques to study biomolecules at research labs and industries. (PO1, PO5)

PROTEIN ENGINEERING AND INDUSTRIAL APPLICATIONS

Sub Code	**: MBTE12**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Prabha M

Unit-I

Outline and Characterization for Protein engineering - Definition, applications; Features or characteristics of protein that can be engineered (definition and methods of study)-affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, tempearture and amino acid sequence, aggregation propensies etc. Forces stabilizing proteins - Van der waals, electrostatic; hydrogen bonding weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation;

Unit-II

Experimental methods of Protein engineering and Protein design: Outline of bioengineering of macromolecules a multidisciplinary approach; Methods to alter primary structure of protein: Examples of engineered proteins, protein design, principles and examples. Steps involved in protein engineering and protein modeling to the desired needs. Site directed mutagensis; by the rational design method. Module shuffling; Guided protein recombination etc., Optimization and high throughtput screening methodologies like Giga Metrix, High throughput microplate screens etc., Protein Engineering for Biosensors.

Unit-III

Control of Protein Function: Mechanisms of Regulation, Protein Interaction Domains, regulation by Location, Effector Ligands: Competitive Binding and Cooperativity, Conformational Change and Allostery, Protein Switches Based on Nucleotide Hydrolysis, GTPase Switches: Small signaling G Proteins, Signal Relay by Heterotrimeric GTPases, Protein Synthesis, Motor Protein Switches, Regulation by Degradation, Control of Protein Function by Phosphorylation, Regulation of Signaling Protein Kinases: Activation Mechanism, Cdk Activation, Protein trafficking.

Unit-IV

Making of proteins and Health care: Native and fusion proteins, Yeast expression systems, The baculovirus expression system, Mammalian cell lines. Creation of Hybrid proteins: StEP and ITGHY method. Improving enzymes: Oxidation-resistant variants of a1-antitrypsin (AAT). Enhanced Recovery and Folding of Recombinant

Proteins Using Fusion Protein Strategies. Protein Engineering for Affinity Purification: The Strep-tag Protein Engineering in Vaccine Development. Expression and Use of Tagged Cell Surface Receptors for Drug Discovery: Estrogen Receptor as a Target for New Drug Discovery.

Unit-V

Protein Biocatalysis and Enzyme engineering: Random and rational approach of protein engineering; Directed evolution and its applications in the field of biocatalysis; Various approaches of creating variant enzyme molecules; Future of biocatalysis; Ideal Biocatalyst. Stabilization of Industrial Enzymes by Protein Engineering Engineering ß-Glycoside Hydrolases. Biocatalysis for the synthesis of some chiral pharmaceutical intermediates such as synthesis of ACE inhibitors; Synthesis of anti-cholesterol drugs by biocatalytic routes; Calcium channel blocking drugs; Potassium channel openers; Anti-psychotic compounds; Anti-infective drugs; Anti-inflammatory drugs; Antiviral agents.

Textbooks

1. Edited by T.E. Creighton (1997) Protein structure: A practical approach, 2nd Edition, Oxford University Press.
2. Cleland and Craik (1998) Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands.

Reference Books

1. Mueller and Arndt. (2006) Protein Engineering protocols, Ist Edition, Humana Press.
2. Ed. Robertson DE, Noel JP (2004) protein Engineering Methods in Enzymology, 388 Elsevier Academic Press.
3. J Kyte, Structure in protein chemistry, 2nd Edition, Garland publishers, 2006.
4. Lilia Alberghina (200) Protein engineering in industrial Biotechnology, CRC Press
5. Graham Ramsay (1998) Commercial Biosensors, John Wiley Publishers.

Course Outcomes (COs):

On completion of this course student will have the improved ability to:

1. Evaluate the parameters and characteristics of protein for engineering them. (PO3, PO4, PO5)
2. Identify different approaches for design and construction of proteins. (PO1, PO3, PO4, PO5)
3. Apply concepts of regulatory mechanisms of proteins to modify their function. (PO3, PO4, PO5)

4. Analyze various protein expression methods for applications in Healthcare. (PO4, PO5)
5. Apply Biocatalysis and protein engineering concepts in therapeutics applications. (PO4, PO-5)

BIOREACTOR TECHNOLOGY

Sub Code	**: MBTE13**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course Coordinator(s): Dr. Chandraprabha MN and Mr. Krishna Murthy TP

Unit-I

Introduction:

Overview of biological reactions and bioproducts. Purpose and importance of bioreactors in bioprocess industries, Requirements for a bioreactor, Development of bioreactors, classification of bioreactors. Elements in bioreactor design. Major components of bioreactor and their purpose, Basics of energy transfer and mass balance. Biochemical engineering aspects of bioreactors. Bioreactor configurations-Classification of bioreactors based on application: Microbial Process, Mammalian cell culture, plant cell culture, immobilized catalyst, environmental applications.

Unit-II

Bioreactors for Submerged Liquid Fermentation (SLF)

Batch Bioreactors, Continuous Flow Bioreactors, Semi-Continuous Bioreactors, Recycle Bioreactors, Combination of Bioreactors-Bioreactors for enzyme reactions and Immobilized Cells-Rheological properties of fermentation broths-Mixing in bioreactors- Gas liquid hydrodynamics- Heat transfer process in SLF, Mass transfer in SLF-Molecular diffusion, Oxygen uptake and solubility. Role of aeration and agitation SLF bioreactors. Case studies of SLF in bioproducts production.

Unit-III

Bioreactors for Solid State Fermentation (SSF):

General Considerations about Solid-state Fermentation Processes- Factors Affecting Solid-state Fermentation- Aerobic and anaerobic Solid State Fermentation- Kinetics in Solid-state Fermentation- Water Relations in Solid-state Fermentation- Heat and Mass Transfer in Solid-State Fermentation Bioreactors- Aspects of Design of Bioreactors in SSF- Scale-up Challenge for SSF Bioreactors- Groups of SSF Bioreactors: Unaerated and Unmixed, Forcefully-Aerated Bioreactors Without Mixing, Rotating-Drum and Stirred-Drum Bioreactors, Continuously-Mixed, Forcefully-Aerated Bioreactors, Intermittently-Mixed Forcefully-Aerated Bioreactors, Continuous Solid-State Fermentation Bioreactors. Instrumentation and Controls in SSF-Case studies.

Unit-IV

Bioreactors for Cell Culture Technology:

An Overview of Cell Culture Technology and its application importance in biopharmaceutical industries. Cell Culture Bioreactors, Aeration, Mixing and Hydrodynamics in Cell culture Bioreactors. Instrumentation and Process Control. Perfusion bioreactors, hallow fiber bioreactors. Disposable/ Single-Use Bioreactors for mammalian cells. Bioreactors for Immobilized biocatalysts. Fed-Batch Cultivation of Mammalian Cells. Bioreactor systems for tissue engineering. Design of Bioreactors for Plant Cell and Organ Cultures. Bioreactors for bioartificial Organs. Plant Bioreactor for Bioactives. Production of Biomass and Bioactive Compounds Using Bioreactor Technology.

UNIT-V

Membrane Bioreactors (MBR):

Principle of MBR, Brief History of MBR Technology-Comparison of CAS and MBR Processes- Operational Condition and Performance of MBR- Direction in Research and Development (R&D) of MBR-Biological Wastewater Treatment-Microbial Stoichiometry and kinetics in MBR-Membranes, Modules, and Cassettes-Membrane Fouling-MBR Operation: Operation Parameters, Aeration for Biotreatment and Membrane Aeration- Design of MBR. Bioreactors for waste gas treatment. Case studies.

Textbooks

1. Tapobrata Panda. (2011) Bioreactors: Analysis and Design, 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2011.
2. Mitchell, David A., Krieger, Nadia, Berovic, Marin.(2006) Solid-State Fermentation Bioreactors: Fundamentals of Design and Operation, Springer-Verlag Berlin Heidelberg.
3. Michael C. Flickinger. (2013) Upstream Industrial Biotechnology. John Wiley & Sons, Inc.
4. Hee-Deung Park, In-Soung Chang, Kwang-Jin Lee.(2015) Principles of Membrane Bioreactors for Wastewater Treatment. CRC Press.

Reference Books

1. Kee-Yoeup Paek, Hosakatte Niranjana Murthy Jian-Jiang Zhong. 2014) Production of Biomass and Bioactive Compounds Using Bioreactor Technology., Springer Science+Business Media Dordrecht.
2. William L. Hochfeld.(2006) Producing Biomolecular Substances with Fermenters, Bioreactors, and Biomolecular Synthesizers. CRC Press.
3. Sar faraz K. Niazi. (2012) Disposable Bioprocessing Systems, CRC Press.

4. Regine Eibl, Dieter Eibl, Ralf Pörtner, Gerardo Catapano, Peter Czermak. (2009) Cell and Tissue Reaction Engineering., Springer-Verlag Berlin Heidelberg.

Course outcome (COs):

On completion of this course student will have the improved ability to:

1. Comprehend the principles of design, operation and major components of industrial bioreactors. (PO1, PO4)
2. Compare the parameters which affect various submerged fermentation bioreactors. (PO1, PO3, PO4, PO5)
3. Analyze the design aspects of solid-state fermentation bioreactors. (PO3, PO4, PO5)
4. Apply concepts of bioreactor design for cell culture technologies. (PO3, PO4, PO5)
5. Conceptualize the principles of Membrane bioreactors and utilize them for various industrial applications. (PO3, PO4, PO5)

NANO-BIOTECHNOLOGY

Sub Code	**: MBTE14**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Dr. Ravikumar YS and Dr. Bindu S

UNIT-I

Introduction to Nanotechnology and Nanobiotechnology. History and scope of nano technology; role of size in nanomaterials: Properties of nano materials- Physical & Chemical properties. Classification of nano particles- nano-clusters, nanotubes, nanowires and nanodots. Electronic structure: quantum dots, quantum wires and quantum wells, confinement of electrons energy quantization, Semiconductor nanocrystals, carbon nanotubes, quantum wells.

UNIT –II

Synthesis of Nanomaterials: Chemical Method: Chemical precipitation and coprecipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, myle formation; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis; , Photochemical synthesis, Synthesis in supercritical fluids. Physical Methods: Vapor deposition and different types of epitaxial growth techniques- pulsed laser deposition - Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning). Biological Methods: Microbial production of inorganic nanoparticles – Magnetosomes. DNA based nanostructures

UNIT-III

Characterization of Nanomaterials : Structural Characterization: X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), **,** Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM). Spectroscopic characterizations: application of UV-VIS-IR Raman spectroscopy for analysis of nanomaterials, Surface Characterization: X-ray Photoelectron Spectroscopy (XPS), Auger electron spectroscopy, Low Energy Ion, Scattering Spectroscopy (LEISS), Secondary Ion Mass Spectroscopy (SIMS), Rutherford Backscattering Spectroscopy (RBS). Resonance Methods: Electron Spin Resonance (ESR), Ferromagnetic Resonance (FMR), Nuclear Magnetic Resonance (NMR), Mossbauer Spectroscopy.

UNIT-IV

Biological Nanomaterials: Protein based nanostructures building blocks and templates – Proteins as transducers and amplifiers of biomolecular recognition events – Nanobioelectronic devices and polymer nanocontainers. DNA based nanostructures – Topographic and Electrostatic properties of DNA and proteins – Hybrid conjugates of gold nanoparticles – DNA oligomers – Use of DNA molecules in nanomechanics and Computing. Nano diamonds. Biocompatable polymers: liposomes, dendrimers, chitosan

UNIT –V

Biological Application of Nanotechnology: Nanoparticles in Therapeutic applications– Drug delivery, imaging and cancer treatment, bone substitutes and dentistry, Implants and Prosthesis, Reconstructive Intervention and Surgery, Nanorobotics in Surgery, Photodynamic Therapy, Neuro-electronic Interfaces, Protein Engineering. Nanotechnology in Agriculture and Food Technology, Biosensors: Principles- DNA based biosensors – Protein based biosensors, Nanosensors in Diagnosis. DNA Templated Electronics, Sequence –specific molecular lithography, Single Biomolecule. Manipulation for Bioelectronics, DNA as a semiconductor. Environmental issues, toxicity of nanomaterials., ethical issues, the future of nanotechnology in medicine.

Textbooks

1. Edelstein A.S, Cammaratra R.C (1996) Nanomaterials: Synthesis, Properties and Applications, Second Edition, CRC PressTaylor and Francis group New York USA
2. Christof M. Niemeyer, Chad A. Mirkin (2004)Nanobiotechnology: Concepts, Applications and Perspectives John Wiley & Sons
3. Yubing Xie (2012) The Nanobiotechnology Handbook CRC Press Taylor and Francis group New York USA

Reference Books

1. Richard Booker and Earl Boysen (2005) Nanotechnology, Wiley Dreamtech.
2. Chapman & Hall (2002) Nanobiotechnology–Basic Science & Emerging Technologies, CRC Press.
3. Eric K Drexler, Pelerson C, Pergamit G (1993) Unbounding the future. William Marrow and Company
4. Mark Ratner and Daniel Ratner (2005) Nanotechnology. Prentice Hall
5. Murthy DVS (1995) Transducers and instrtumentation. Prentice Hall of India
6. Jing Chung & Larry J. Kricka (2001) Biochip Technology. Harwood academic publishers.

Course Outcome (COs):

On completion of this course student will have the improved ability to:-

1. Develop an understanding of the fundamental concepts in nanotechnology and different classes of nano-materials. (PO1, PO3)
2. Impart basic knowledge on various synthesis techniques involved in Nanotechnology and characterization. (PO3, PO4)
3. Describe applications of various techniques used in characterization of nano-materials (PO3,PO4).
4. Think of novel, future applications of nanotechnology in biotechnology and for molecular medicine. (PO4, PO5)
5. Have knowledge in Applications of Nano-Drug Delivery, Diagnostics and Nanotherapeutics. (PO4, PO5)

BIOTECHNOLOGY OF ALTERNATIVE FUELS

Sub Code	**: MBTE15**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course coordinator(s): Mr. Samrat K and Dr. Ahalya N

UNIT I

Aspects of biofuels: Types of fuels. Types of Biofuels and their production. Generations of biofuels. Conventional versus renewable energy resources. Need and availability of different alternative fuels. Comparison of Bio-energy Sources. Biofuel feedstocks and their properties. Biochemical Pathways for various of fuel production from biological sources. Biorefinery process. System biology for biofuel production.

UNIT II

Bioethanol and biobutanol: Feedstock Production: Sugar crops, Starch crops, Cellulosic crops. Bioethanol and biobutanol Production: Sugar-to-Ethanol Process, Starch-to-Ethanol Process, Cellulose-to-Ethanol Process, Distillation and Dehydration Process. Properties of Bioethanol and biobutanol. Pre-treatment processes and fermentation process. Fermenter design for bio alcohol production and types of fermenters. Technology Applications for Bioethanol: Spark Ignition Engines, Compression Ignition Engines. Fuel Cells. Standardization of Bioethanol Energy Balance of Bioethanol. Bioethanol Emissions: Greenhouse Gas Emissions, Toxic Exhaust Emissions. Sustainability of Bioethanol: Water Issues, Land Use and Biodiversity, Human Health. Economy of Bioethanol

UNIT III

Biodiesel: Conventional Diesel. Feedstock Production: Oilseed Crops, Microalgae, Animal Fats, Waste Oils. Fuel production: Oil Extraction, Oil Refining, Blending, preheating Transesterification and emulsification. Biodiesel production by using various microorganisms and algae. Biodiesel Refinery. Properties and Use of Lipid Biofuels: Properties of Pure Plant Oil (PPO), Properties of Biodiesel. Scale up of biodiesel production. Technology Applications for Lipid Biofuels: Compression Ignition Engines for Biodiesel Use, Compression Ignition Engines for PPO Use. Standardization of Lipid Biofuels: Standardization of PPO, Standardization of Biodiesel. Energy Balance of Lipid Biofuels. Emissions of Lipid Biofuels: Greenhouse Gas Emissions, Toxic Exhaust Emissions. Sustainability of Lipid Biofuels: Water Issues, Land Use and Biodiversity, Human Health. Economy of Lipid Biofuels

UNIT IV

Biogas, biohydrogen as fuels: Conventional gaseous fuels (Natural gas and LPG). Production methods of Biogas. Feedstock Production. Biomethane Production: Digestion Process, Digester Types, Biogas purification. Properties and Use of Biomethane. Technology Applications for Biomethane: Infrastructure Requirements for Biomethane, Vehicle Technologies for Biomethane. Standardization of Biomethane. Biomethane Emissions: Greenhouse Gas Emissions, Toxic Exhaust Emissions. Sustainability of Biomethane. Economy of Biomethane. Biohydrogen: Biohydrogen Processing, Use of Biohydrogen. Microbial fuel cell

UNIT V

Waste materials as source of Biofuels and life cycle assessment: Biofuels from different wastes (waste water & biomass) as sources of biofuels. Life cycle assessment of various biofuels by GREET software. Calculate the biofuel cost benefit ratios for various biofuels. Economic impact of biofuels. Status of bio fuel production in India and World.

Textbooks

1. Yebo Li, Samir Kumar Khanal (2016). Bioenergy: Principles and Applications,1st Edition Wiley-Blackwell Publications.
2. Dominik Rutz and Rainer Janssen (2008). Biofuel Technology Handbook, WIP Renewable Energies, Germany.

Reference Books

1. Sterling MacMillan (2017). Bioenergy: Principles, Technology and Applications, Larsen and Keller Education
2. Nigel G Halford (2015). An Introduction to Bioenergy, Rothamsted Research, UK

Outcome of the course (COs):

The students will be able to:

1. Identify the biofuel sources to use as an alternative energy to fossil fuel. (PO2)
2. Standardize the process to convert raw material into bioethanol and biobutanol. (PO4)
3. Standardize the designs and improve the biodiesel production. (PO4)
4. Standardize the process of conversion to biogas. (PO4)
5. Exploring different wastewater/waste materials as different biofuel sources and study various parameters to meet the national and international standards and work out economic feasibility of different energy sources. (PO5)

METABOLIC ENGINEERING

Sub Code	**: MBTE16**	**Contact Hours**	**: 56L**
Credits	**: 4:0:0**		

Course Coordinator(s): Mr. Krishna Murthy T P and Dr. Chandraprabha M N

UNIT-I

Cellular Metabolism

Solute transport processes in the cell- transporter classification system- catabolism and metabolic fuelling: thermodynamics of fuelling processes, products of fuelling processes, redox potentials and mobile electron carriers-biosynthesis of cellular building blocks-polymerization of building blocks to macromolecules-rare metabolic conversions-transcriptional regulation of metabolism.

UNIT-II

Balances and Reaction Models

Growth nutrients and diversity- rates and mass balances-biomass specific conversion rates-mathematical models for the batch experiment from mass balances and q-based kinetics-data reconciliation and error detection peter-black box models for growth and product formation-metabolic models for growth and product formation-thermodynamic description of microbial growth and product formation.

UNIT-III

Modelling in Metabolic Engineering

Metabolic flux analysis-metabolic flux quantification methods-metabolic control analysis: definitions and structure of metabolic reaction networks, mathematical models of metabolic-structure and flux analysis of metabolic networks-constraint based genome-scale models of cellular metabolism-multiscale modeling of metabolic regulation-validation of metabolic models.

UNIT-IV

Tools in Metabolic Engineering

Improving Protein Functions by Directed Evolution-Engineering DNA and RNA Regulatory Regions through Random Mutagenesis and Screening-Evolving Pathways and Genomes for the Production of Natural and Novel Compounds-Models Predicting Optimized Strategies for Protein Evolution-Application of Emerging Technologies to Metabolic Engineering: Genome-Wide Technologies: DNA Microarrays, Phenotypic

Microarrays, and Proteomics, Monitoring and Measuring the Metabolome- *In Silico* Models for Metabolic Systems Engineering

UNIT-V

Developing Appropriate Hosts for Metabolic Engineering: Escherichia coli, Yeast, Bacillus subtilis, Streptomyces, Mammalian Cells.

Future Applications of Metabolic Engineering: Energy and Cofactor Issues in Fermentation and Oxyfunctionalization- Microbial Biosynthesis of Fine Chemicals- Applications of Metabolic Engineering for Natural Drug Discovery-Metabolic Engineering for Alternative Fuels.

Textbooks

1. George Stephanopoulos Aristos Aristidou, Jens Nielsen (1998). Metabolic Engineering: Principles and Methodologies, 1st edition, Academic Press.
2. Christina D. Smolke (2009), The Metabolic Pathway Engineering Handbook: Fundamentals, 1st edition, CRC Press.
3. Christina D. Smolke (2009), The Metabolic Pathway Engineering Handbook: Tools and Applications, 1st edition, CRC Press.

References

1. S Y Lee and E T Papoutsakis (1999). Metabolic Engineering, Marcel Dekker, NewYork, 1999.
2. Néstor V Torres, Eberhard O. Voit (2002). Pathway Analysis and Optimization in Metabolic Engineering, 1st Edition, Cambridge University Press.
3. Stephen Van Dien (2016) Metabolic Engineering for Bioprocess Commercialization, Springer International.

Course Outcomes (COs):

The students will be able to:

1. Understand the central metabolic reactions and regulations in cellular metabolism. (PO- 3, 4, 5)
2. Describe the various models for regulation of metabolic pathways at different levels. (PO-3, 4, 5)
3. Analyze the metabolic flux for real time industrial applications. (PO-3, 4, 5)
4. Utilize various scientific tools for engineering microbial pathway. (PO-3, 4, 5)
5. Development of effective solutions for various industrial and environmental problems using metabolic engineering. (PO-3, 4, 5)