DEPARTMENT OF BIOTECHNOLOGY, MIT Manipal

M.Tech. INDUSTRIAL BIOTECHNOLOGY

Program Structure (Applicable to 2019 admission onwards)

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**C**
I	MAT 5158	Mathematical and Numerical Techniques in Chemical and Biological Engineering	3	1	0	4	BIO 5251	Bioprocess Modeling Analysis and Simulation	3	1	0	4
	HUM 5151	Research Methodology and Technical Communication	1	0	3	2	BIO 5254	Bioreactor Design and Analysis	3	1	0	4
	BIO 5151	Advanced Bioprocess Engineering	3	1	0	4	BIO ****	Elective I	4	0	0	4
	BIO 5152	Advanced Bioseparation Processes	3	1	0	4	BIO ****	Elective II	4	0	0	4
	BIO 5153	Molecular Biology And R-DNA Technology	3	1	0	4	BIO ****	Elective III	4	0	0	4
	BIO 5154	Transport Phenomena in Bioprocess Engineering	3	1	0	4	*** ****	Open Elective	3	0	0	3
	BIO 5161	Bioprocess Engineering Lab	0	0	6	2	BIO 5265	Biomolecular Data Analytics Lab	0	0	3	1
	BIO 5162	Tissue Culture and Separations Lab	0	0	3	1	BIO 5266	Modeling, Simulation and Control Lab	0	0	3	1
		Total	**16**	**5**	**12**	**25**		**Total**	**21**	**2**	**6**	**25**
II	THIRD AND FOURTH SEMESTER											
	BIO 6098	Project Work							0	0	0	25
								Total	0	0	0	**25**

PROGRAM ELECTIVES			
BIO 5001	Animal and Plant Biotechnology	BIO 5007	Immunotechnology
BIO 5002	Biomolecular Data Analytics	BIO 5008	IPR Issues in Biotechnology and Biosafety
BIO 5003	Biopolymer Technology	BIO 5009	Pharmaceutical Biotechnology
BIO 5004	Design and Development of Biological Treatment Processes	BIO 5010	Solid Waste Management
BIO 5005	Environmental Biotechnology	BIO 5011	Statistical Design and Analysis of Experiments in Biotechnology
		BIO 5012	Systems Biology

OPEN ELECTIVES			
BIO 5051	Bionanotechnology	BIO 5052	Introduction to Biofuels and Biopolymers

SEMESTER I

MAT 5158 MATHEMATICAL AND NUMERICAL TECHNIQUES INCHEMICAL AND BIOLOGICAL ENGINEERING [3 1 0 4]

Solution of system of linear equations by direct and iteration methods., Eigen values and Eigen vectors of Matrices by iterative methods, Rayleigh's Power method, Numerical Integration by composite integration methods, Regression-Linear, Polynomial, multiple linear, Non-linear regression, Orthogonal polynomials and functions.Algebraic and transcendental equations-Iterative methods. Numerical solution of differential equations-Initial value problems and boundary value problems- Single and multistep methods. Multivariate non-linear optimization without constraints

References:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and engineering computation, New age international (P) Limited, Publishers.
2. SanthoshK.Gupta, Numerical methods for Engineer, Wiley Eastern Ltd, New Delhi.

HUM 5151 RESEARCH METHODOLOGIES AND TECHNICAL COMMUNICATION [1 0 3 2]

Mechanics of Research Methodology; Basic concepts: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation; Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem; Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, Need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing; Sampling Methods: Introduction to various sampling methods and their applications; Data Analysis: Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis; Thesis Writing and Journal Publication: Writing thesis, Writing journal and conference papers, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

References:

1. Dr Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE, 2005.
2. Geoffrey R. Marczyk, David DeMatteo & David Festinger, Essentials of Research Design and Methodology, John Wiley & Sons, 2004.

BIO 5151 ADVANCED BIOPROCESS ENGINEERING [3 1 0 4]

Structure, properties and classification of carbohydrates, lipids, proteins & nucleic acids; Prokaryotes & Eukaryotes; Bacterial Taxonomy, Microscopy,; Isolation, Preservation and Improvement of Industrial Micro-Organisms; Medium requirement; Sterilization - batch and continuous, filter sterilization. Design of sterilization equipment;Classification of Enzymes; Mechanism of Enzyme Action; Determination of elementary step rate kinetics, patterns of substrate concentration dependence, modulation and regulation of enzyme activity; Phases of cell growth in batch cultures - transient growth kinetics, Simple unstructured kinetic models for microbial growth, Growth of filamentous organisms; Conditions affecting growth kinetics, substrate & product inhibition on cell growth & product formation; structured kinetic models, segregated kinetic models of growth; Material-Balance calculations, Stoichiometry of microbial growth & Product formation, Energy – Balance Calculations with and Without Reactions; A brief outline of processes for the production of some commercially important Organic acids, amino acids and alcohols, study of production processes for various classes of low molecular weight secondary metabolites: Antibiotics, quinones, aromatics, Vitamins and Steroid.

References:

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts (2e), Prentice Hall, Englewood Cliffs, NJ, 2002.
2. Pauline M Doran, Bioprocess engineering principles (1e), Academic Press, 1995.

BIO 5152 ADVANCED BIOSEPARATION PROCESSES [3 1 0 4]

Role of Downstream Processing in Biotechnology; Economics and downstream processing, Cost cutting, Cell disruption; flocculation, sedimentation, centrifugation and filtration; Precipitation methods; Extraction: Batch, staged - cross current, co current, counter current, Differential, fractional, Aqueous two-phase, Reverse micelle extraction, supercritical fluid extraction, Design & configuration of membrane separation equipment; R.O., dialysis, electro dialysis, IEF; Adsorption isotherms, industrial adsorbents, adsorption equipments for batch and continuous operations, adsorption in fixed beds; Chromatography: Gel filtration, reversed-phase, hydrophobic interaction, ion-exchange, expanded bed adsorption, bio affinity and IMAC, supercritical fluid; Preparation of commercial enzymes: prolyl-t RNA synthetase; intracellular foreign proteins from recombinant *E.coli and* extracellular protease recovery, biosurfactants.

References:

1. Belter P.A, Cussler E and Wei Shan Hu, Bioseparation – Downstream Processing for Biotechnology, Wiley Interscience, 1988.
2. Asenjo and Juan A. Asenjo, Separation Processes in Biotechnology, CRC Press, 1990.

BIO 5153 MOLECULAR BIOLOGY & r-DNA TECHNOLOGY [3 1 0 4]

Forms of DNA & RNA, Organization of DNA; DNA Replication in Prokaryotes & Eukaryotes, Telomeric Replication; Replication of Viral DNA; Transcription in Prokaryotes & Eukaryotes, Post-transcriptional Modifications, Genetic Code, Wobble Hypothesis, Translation in Prokaryotes & Eukaryotes, Post-translational Modifications; Operons; DNA Repair, Mutations and Mutagenesis; Basics of rDNA Technology; Enzymes in Genetic Engineering; Nucleic Acid Hybridization, Probes & DNA Libraries; Restriction Mapping, Adaptors & Linkers, PCR, RFLP, RAPD, DNA Sequencing; SNPs, VNTRs; Therapeutic proteins from Transgenic plants & animals, Gene Therapy; Recombinant DNA Vaccines; Resistance to Herbicides, virus, insect and pests, Stress tolerance; DNA fingerprinting, Directed mutagenesis, Antisense Technology.

Reference:

1. David Friefelder, Molecular Biology (2e), Jones and Bartlett Publishers Inc, 1987.
2. Benjamin Lewin, Genes VIII , Prentice Hall , 2004.

BIO 5154 TRANSPORT PHENOMENA IN BIOPROCESS ENGINEERING [3 1 0 4]

Introduction to Momentum, heat and mass transfer, Unified equation of momentum heat and mass transfer, Shell Momentum balances and velocity distributions in laminar flow -flow of a falling film, circular tube, flow through an annulus, flow of two adjacent immiscible fluids. The equations of change for isothermal systems, equation of motion and dimensional analysis. Heat conduction and convection in different systems using shell energy balance to find out temperature distribution. Diffusivity and the Mechanisms of Mass Transport, Diffusion through a

stagnant gas film, homogeneous and heterogeneous chemical reaction, gas absorption and porous catalyst. Velocity distributions with more than one Independent variable, The equations of change for non-isothermal systems, Temperature distributions with more than one independent variable, Equations of change for multicomponent systems.

References:

1. *Arthur T. Johnson*, Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied to Biological Systems, John Wiley and Sons, 1998.
2. Blanch H.W and Douglas S. C, Biochemical Engineering, CRC Press, 1997.

BIO 5161 BIOPROCESS ENGINEERING LAB [0 0 6 2]

Pure culture techniques,SDS – PAGE of proteins, Microbial growth kinetics, Effect of substrate concentration on kinetics of invertase enzyme,Enzyme immobilization protocol by entrapment method in alginate gel,Deactivation kinetics of invertase enzyme,Studies on mass transfer effects on the performance of enzyme entrapped in alginate gel,Batch recycle immobilized packed bed bioreactor,Continuous flow immobilized enzyme packed bed bio reactor,Fluidized bed bioreactor (FBR) for enzyme kinetics,Batch heat sterilization and thermal death kinetics

BIO 5162 TISSUE CULTURE AND SEPARATIONS LAB [0 0 3 1]

Characterization of plant cell suspension cultures-cell growth, Cell count, heterogeneity and viability, Isolation, identification and quantification of secondary metabolite berberine from in vitro cultures and field grown plants, Isolation of RNA from Plants, Isolation of RNA from Plants, Organelle isolation and marker enzyme assay, Determining cell viability, Thawing of frozen cell line, Sub-culturing of cells, Ultra-filtration, Size Exclusion Chromatography, Partitioning of Protein

SEMESTER II

BIO 5251 BIOPROCESS MODELING, ANALYSIS & SIMULATION [3 1 0 4]

Perspective on modeling of physical, chemical & biological phenomena, uses and limitations of mathematical models; Examples involving algebraic, ordinary differential, difference, partial differential, integral & integro-differential equations; Probability theory, stochastic models parameter estimation model forms for parameter estimation. Parameter estimation using moments, design of experiments; Accuracy of parameter estimates. Design of experiments for model discrimination; Non linear systems; Plane analysis in classical bioreactor models; Nonlinear dynamics; Chaotic behavior, cob web diagrams, stability of fixed point solutions. Bifurcations behavior, Chaos; Lorenz equations; Population balance modeling, Budding of yeast population – Modeling of cells with dynamic morphology – Modeling for biological populations with correlation between life spans of siblings. Modeling of Industrial sterilization processes

References:

1. Wayne Bequette.B, Process dynamics modeling and analysis and simulation,. Prentice Hall Inc, 2004.
2. John H. Seinfeld and Leon Lapidus., Mathematical Methods in Chemical Engg., (Vol. 3), Process Modeling, Estimations and Identification. Prentice Hall, 1974.

BIO 5254 BIOREACTOR DESIGN AND ANALYSIS [3 1 0 4]

Mass transfer effects in heterogeneous reaction system; Chemostat with cell cultures; CSTR with immobilized enzymes, operation of CSTR in constant feed rate policy; Chemostats in series; Plug flow reactor; Performance equation with M-M kinetics, substrate & product inhibition kinetics, PFR for immobilized enzymes, Simulation for conversion; Fed–batch reactor; Stability analysis, Eigen values; Bioreactor control; Controllability matrix; Design of P-controller for Turbidostat & Nutristat operation; Biological waste water treatment with Feed forward control; Various industrial Bioreactors; aeration and oxygen mass transfer in bioreactor system, RTD, E, C ,F-curves, Micro & Macro fluid.

References:

1. Blanch H.W and Douglas S. Clark, *Biochemical Engineering,* CRC Press, 1997.
2. Michael L Shuler and Fikret Kargi, *Bioprocess Engineering: Basic Concepts*, Prentice-Hall of India Pvt Ltd, 2008.

BIO 5265 BIOMOLECULAR DATA ANALYTICS LAB [0 0 3 1]

Information retrieval from databases, Sequence alignment: Pairwise and Multiple sequences, Basics of PERL programming, Primer Design, Protein secondary structure prediction, Structure visualization & analysis, Protein modeling, analysis, and validation, Protein-ligand docking, Protein-protein docking, 3D-printing of biomolecules.

BIO 5266 MODELING, SIMULATION AND CONTROL LAB [0 0 3 1]

Representation of transfer functions and input-output models using Matlab commands, Response plots, stability analysis and design of proportional controller for bioreactor,Performance analysis of fed batch and chemostat reactors –solution for set of differential equations, Performance analysis of bioreactor using Matlab-use of phase plane analysis, Introduction to Simulink and building a dynamic model for fermentation process with Simulink, Design of chemostat using grapher (GUI interface), Flow control trainer, Temperature measurement and calibration of thermometers & first order systems, Non interacting & interacting system, First order & second order system

SEMESTER III and IV

BIO 6098 PROJECT WORK [0 0 0 25]

Students are required to undertake innovative and research oriented projects, which not only reflect their knowledge gained in the previous two semesters but also reflects additional knowledge gained from their own effort. The project work can be carried out in the institution/ industry/ research laboratory or any other competent institutions. The duration of project work should be a minimum of 36 weeks. There will be a mid-term evaluation of the project work done after about 18 weeks. An interim project report is to be submitted to the department during the mid-term evaluation. Each student has to submit to the department a project report in prescribed format after completing the work. The final evaluation and viva-voice will be after submission of the report. Each student has to make a presentation on the work carried out, before the departmental committee for project evaluation. The mid-term & end semester evaluation will be done by the departmental committee including the guides.

PROGRAM ELECTIVES

BIO 5001 ANIMAL AND PLANT BIOTECHNOLOGY [4 0 0 4]

Plant Genome; Totipotency, Regeneration of plants; Autotrophic and heterotrophic growth, Plant growth regulators and elicitors, Cell suspension culture development; Production of secondary metabolites, Hairy root cultures & their cultivation; Direct and indirect methods; Chemical; Biological; Patents & PBRs; Animal cell metabolism & growth characteristics, Regulation & nutritional requirements; Substrate and product transport through mammalian cell, growth kinetics and shear force. Micro & Macro carrier attached growth, Cell culture in continuous, perfusion & hollow-fiber reactor; Hybridioma technology, Livestock improvement, Gene transfer methods, Transgenic animals, Xenotransplantation, cell preservation; IPR issues

References:

1. Dixon R.A and Gonzales, Plant Cell Culture: A Practical Approach, IRL Press, 1995.
2. Lindsey. K and M.G.K. Jones, Plant Biotechnology in Agriculture, Prentice Hall, New Jersey, 1990.

BIO 5002 BIOMOLECULAR DATA ANALYTICS [4 0 0 4]

DNA, RNA, Flow of genetic information, Genetic code, Transcription, Translation, HGP & Digital code of Life; Sequence Databases, Nucleotide & protein databases. Information retrieval; PDB; MMDB at NCBI, Structure file formats; evolutionary basis of sequence alignment, Modular Nature of proteins, Optional Alignment Methods, BLAST, FASTA, Low-Complexity Regions, Repetitive Elements. Pairwise & Multiple sequence alignment; Proteins - Secondary structures, Motifs, Domains, Tertiary & quaternary structures- Ramachandran plot; RNA structure; Ribosome; RNA Secondary Structure Prediction, Set & Graph theory, Strings & Algorithms, Chemical graphs; Hierarchical Levels in Biodiversity, Genetic diversity; Biodiversity issues; Methods for species identification & classification, Biodiversity Databases; Tree of life project, Elements of phylogenetic Models, Phylogenetic Data Analysis, Substitution Model Building, Tree Building & Evaluation, Building the Data Model (Alignment), Determining the Substitution Model, Tree -Building Methods, Searching for Trees, Rooting Trees, Evaluating Trees & Data, Phylogenetic software; companies & patents, IPR issues, Patents, copyright & Patenting.

References:

1. David W Mount, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor, 2001.
2. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, 2002.

BIO 5003 BIOPOLYMER TECHNOLOGY [4 0 0 4]

Biopolymers produced from various renewable resources, characteristics, merits and demerits over conventional polymers; Biopolymers and Artificial Biopolymers in BiomedicalApplications, an Overview, Novel Synthesis of Biopolymers and Their Medical Applications, Composite Films Based on Poly (Vinylalcohol) and Lignocellulosic Fibres: Preparation and Characterizations, Composite Materials Based on Gelatin and Fillers from Renewable Resources: Thermal and Mechanical Properties, Properties of PHAs and Their Correlation to Fermentation Conditions; Synthesis and modification of xanthum gum, PHA, PHB Biosurfactants: Source, characteristics and properties of Biosurfactants; Production of Biosurfactants via the fermentation and biotransformation routes; Production of Biosurfactants with immobilized cells; Integrated bioprocess for continuous production of Biosurfactants including downstream processing; Applications of Biosurfactants – Food Industry, Environmental Control; Material Testing and Analytical Methods: Comparison of Test Systems for the Examination of the Fermentability of Biodegradable Materials, Structure-Biodegradability Relationship of biopolymers;Case studies: Optimization of production and purification of Xanthum gum and other biopolymers like PHA, PHB

References:

1. Emo Chiellini and Helena Gil, Biorelated Polymers: Sustainable Polymer Science and Technology, Springer 2001.
2. Johnson .R.M, L.Y. Mwaikambo and N. Tucker, Biopolymers, Rapra Technology, 2003.

BIO 5004 DESIGN AND DEVELOPMENT OF BIOLOGICAL TREATMENT PROCESSES [4 0 0 4]

Introduction, decomposition of organic carbon compounds; Biology, Mass, energy balance for aerobic & anaerobic respiration, Aerobic and anaerobic decomposition of glucose, protein, carbohydrates, lipids; Nitrogen removal, phosphorous removal, biosorption, Parametrs effecting the biological treatment: MLSS, MLVSS, F/M ratio, BOD and significance, Model and fitting kinetic parameter-Least square, Fujimoto, Daily difference, Thomas and Moments-Methods, Activated sludge process - plant configurations; Modeling of aerobic waste water treatment process; Design of activated sludge process for BOD removal, Nitrification & Denitrification, Design of the final (secondary) clarifier, Design of SBR, Reactor systems for anaerobic process, Disinfection-various methods, CHICKS –WATSON EQUATION AND APPLICATION ,Water reuse – Processes involved, risk assessment, Water Reclamation Technologies, Industrial water reuse

References:

1. Jordening H.J and J. Winter, Environmental Biotechnology- Concepts and Applications, Cambridge University Press,2006.
2. George Tchobanoglous and Franlin L. Burton, Wastewater Engineering-Treatment, Disposal and Reuse, Tata McGraw Hill Publishing Co.Ltd,1990.

BIO 5005 ENVIRONMENTAL BIOTECHNOLOGY [4 0 0 4]

Microbial flora of soil, growth, interactions among soil microorganisms, biogeochemical role of soil microorganisms.Simple aromatics, chlorinated, polyaromatic, petroleum products, pesticides and surfactants. Waste water characteristics, biological waste water treatment, activated -sludge process, mathematical modeling of anaerobic-digester dynamics; Biotechnology processes for oil; Bioremediation processes Ultra filtration systems for waste water contaminant removal; industrial waste treatment opportunities for reverse osmosis and ultrafiltration. Bio-hazard Monitoring and Control; Energy recovery systems for urban waste gasification of wastes fuels and chemicals from crops, production of oil from wood waste, fuels from wood waste, methanol production; Renewable and non-renewable resources. Biotechnological inputs in producing good quality natural fibres. Treatment of municipal waste and industrial effluents.Degradation of Pesticides and other toxic chemicals by Microorganisms Thuringiensis toxin as a natural pesticide.Biological control of other insects swarming the agriculture fields. Enrichment of ores by microorganisms.Biofertilizers Nitrogen fixing microorganisms

References:

1. Foster C.F. and D.A. John Ware, Environmental Biotechnology, Ellis Horwood Limited, 1987.
2. Larry Anderson and David A, Fuels from waste, Tillman, Academic Press, 1997.

BIO 5007 IMMUNOTECHNOLOGY [4 0 0 4]

Innate and adaptive immunity. Lymphocytes - their origin and differentiation; antigens - their structure and classification; complement; types of immune responses; anatomy of immune response; B-lymphocytes and activation; structure and function of immunoglobulins;. Genetic control of antibody production. monoclonal antibodies; idiotypes and idiotypic antibodies. MHC; Blood Typing; Cellular Immunology: Thymus-derived lymphocytes - classification. APC - macrophages. dendritic cells. langerhans cells;; mechanisms of phagocytosis; immunosuppression. Immune tolerance; Antigen Antibody interactions; RIA, ELISA, Chemiluminescence, ELIspot, FACS, western blotting, Immuno fluorescence, immuno precipitation, immuno diffusion, immunoelectrophoresis. Immuno Histochemistry and IHC methods. Immuno electron microscopy; stem cells and applications to immunology, Immunosuppressive drugs. HLA; Autoimmunity; Vaccines, Immunotherapy.

References:

1. Roitt I, Essential Immunology , Blackwell Scientific Publications, Oxford press ,1991.
2. Kuby J and WH Freeman, Immunology (6e), New York, 2007.

BIO 5008 IPR ISSUES IN BIOTECHNOLOGY AND BIOSAFETY [4 0 0 4]

Public acceptance issues for biotechnology: Case studies/experiences from developing and developed countries. The Cartagena protocol on biosafety. Biosafety management: Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons. The legal and socioeconomic impacts of biotechnology, Biosafety regulations and National and International guidelines with regard to rDNA technology, transgenic science, GM crops, Good manufacturing practice and Good lab practice (GMO and GLP). Environmental aspects of biotech application. Special procedures for rDNA based product production. Intellectual property rights (IPR), WTO-GATT, TRIPS, international conventions patents and methods of applications of patents. Plant breeder's rights.Examples of patents in biotechnology.Special application of patent laws in biotechnology. Licensing and cross licensing; Identification of directions for yield, effect in agriculture, aquaculture;.Ethics and Biosafety aspects in Bioremediation.

References:

1. Biotechnologies and Development, UNESCO Publications, 1988
2. A Biotechnologies in developing countries present and future, UNESCO Publishers, 1993

BIO 5009 PHARMACEUTICAL BIOTECHNOLOGY [4 0 0 4]

Pharmaco-Kinetics-absorption of drugs, distribution of drugs, protein binding of drugs, Manufacture of Macromoleucles, Traditional pharmaceuticals; Compartment modeling- non linear kinetics, bioavailability & bioequivalence, excretion of drugs; Drug discovery, Patenting; Role and remit of regulatory authorities; European regulations, Guides to good manufacturing practice, Formulation and Delivery Issues of Therapeutic Proteins, Biotechnology-Derived Drug Products: Formulation Development, Stability Testing, Dosage Forms, Excipients, wet & dry granulation, tablet formulation, coating, capsules, oral liquids, ointments, therapeutic enzymes, laxatives, analgesics, non steroidal contraceptives, antiseptics, antacids, antibiotics; Strategy & Phasing for Drug Safety Evaluation; Human Pharmaceutical Safety, Acute Toxicity Testing, Preclinical Evaluation, Immunotoxicology Quality Assurance

References:

1. Heinrich Klefenz, Industrial pharmaceutical biotechnology, John Wiley sons, 2002.
2. Susanna Wu-Pong, Yongyut Rojanasakul, and Joseph Robinson, Biopharmaceutical drug and design and development, Humana Press, 2007.

BIO 5010 SOLID WASTE MANAGEMENT [4 0 0 4]

Integrated solid waste management, operation of waste management systems. Legislative Trends and Impacts; Composition of municipal solid wastes, Properties of MSW; transformations of solid waste; Properties, classification and transformation of Hazardous wastes and its management; Collection of solid waste, Separation, processing and Transformation of solid waste, Transfer and Transport, Disposal; Landfill methods & its design; Biological principles, aerobic composting, Anaerobic digestion, Biological transformation processes. Energy production from biological conversion products, Fermentation and compost processes: design parameters & Applications; Meeting federal and state mandated diversion goals; Recycling, Implementation of solid waste management options; planning, siting and permitting of waste management facilities.

References:

1. George Tchobanoglous, Integrated solid waste management: Engineering principles and management issues, McGraw Hill, 1993.
2. William D Robinson, The solid waste handbook: A practical guide, John Willy & sons, 1986.

BIO 5011 STATISTICAL DESIGN AND ANALYSIS OF EXPERIMENTS IN BIOTECHNOLOGY [4 0 0 4]

Errors in Data and calculations, presentation of experimental data, data analysis, general procedures for plotting data, process flow diagrams; Classical versus statistical approaches to experimentation, diagnosing the experimental environment, good design requirements. Introduction to factorial designs, definitions and principles, Basic Two-level factorial design experiments, 2k factorial design; Fractionating factorial designs, fractional factorial designs, Plackett-Burmann screening designs; Response surface methodology – concepts & methods, design considerations, central composite designs and Box-Behnken response surface design; Optimizations of Media components, fermentation process and purification process with specific case studies by using statistical software.

References:

1. Lawson J & Erjavec J, Modern Statistics for Engineering and Quality Improvement (1e), Duxbury Press, 2001.
2. Montgomery Douglas C , Design and analysis of experiments (6e), John Wiley, 2009.

BIO 5012 SYSTEMS BIOLOGY [3 1 0 4]

Introduction to systems biology:The challenge of biological complexity,Modularity, Trends and drivers; Basic principles:Model assignment,Purpose and adequateness of models; System structure identification, Approaches to building a system,System behavior analysis, Typical aspects of biological systems and corresponding models: Robustness and Sensitivity; Data integration in systems biology; Modeling of Biochemical Systems:Enzyme kinetics and thermodynamics, Deriving a rate equation; Parameter estimation and linearization; Metabolic flux analysis: Systems equations, Elementary flux modes and extreme pathways; Flux balance analysis; Compartments and transport across membranes, Metabolic control analysis, Modeling of Signaling Pathways:Structural components of

signaling pathways, MAP kinase cascades, Jak-Stat pathways Signaling: Dynamic and Regulatory Features, Applications and case studies of systems biology.

References:

1. Theoretical and Applied Aspects of Systems Biology Series: Computational Biology 27, Fabricio Alves Barbosa da Silva, Nicolas Carels, Floriano Paes Silva Junior, Springer International Publishing AG, 2018.
2. Systems Biology, Jens Nielsen Stefan Hohmann, Wiley VCH Verlag GmbH & Co. KGaA, 2017.

OPEN ELECTIVES

BIO 5051 BIONANOTECHNOLOGY [3 0 0 3]

Introduction and scope of Bionanotechnology, Bionanomachines: Negligible gravity & inertia, atomic granularity, thermal motion, water environment, Role of biomolecules in biomaterials; Synthesis of Biomolecules: rDNA Tech, Site-directed mutagenesis, Fusion Proteins. Quantum Dot structures; X-Ray crystallography, NMR spectroscopy, Electron & Atomic force microscopy. Molecular modeling tools; Protein folding prediction, homology modeling, Docking simulation & Computer-assisted molecular design; Protein folding; Self assembly, Self-organization; Energetics, allosteric motion & covalent modification; Structure & functional properties of Biomaterials, Bimolecular motors; Traffic across membranes; Bimolecular sensing, Self replication, Machine-Phase Bionanotechnology; Designer proteins, Peptide nucleic acids, Nanomedicine, Drug delivery, DNA computing, Molecular design using biological selection, Harnessing molecular motors, Artificial life, Hybrid materials, Biosensors.

References:

1. David S Goodsell , Bionanotechnology, John Wiley & Sons, 2004.
2. Greco Ralph S , Nanoscale Technology in Biological Systems, CRC Press, 2005.

BIO 5052 INTRODUCTION TO BIOFUELS AND BIOPOLYMERS [3 0 0 3]

Biofuels: Renewable energies and significance; Feedstocks for various biofuels; LCA of biofuels; Ethanol from fermentation and comparison of different technologies; Diesel from Jatropha, waste cooking oils & Microalgae; Biogas and biological hydrogen; Basic concepts of microbial fuel cells. Biopolymers: Introduction; Biopolymers vs Synthetic polymers; Synthesis of biopolymers; Commercially available biopolymers; Uses of biopolymers; Manufacturing technologies; Fillers & Reinforcement; Market & Economics; Biodegradability.

References:

1. Caye M. Drapcho, N.P. Nhuan and T. H. Walker, Biofuels Engineering Process Technology , Mc Graw Hill Publishers, New York, 2008.
2. Jonathan R.M, Biofuels – Methods and Protocols (Methods in Molecular Biology Series), Humana Press, New York, 2009.
3. Mohanty, A.K., et al., Natural Fibers, Biopolymers, and Biocomposites, CRC Press, 2005
4. R.M. Johnson, L.Y. Mwaikambo and N. Tucker, Biopolymers, Rapra technology 2003