DEPARTMENT OF BIOTECHNOLOGY

M.Tech. - Biotechnology

CURRICULUM AND SYLLABUS

2018 REGULATION

KALASALINGAM ACADEMY OF RESEARCH AND EDUCATION
(Deemed to be University)
Anand Nagar, Krishnankoil - 626126

Institute Vision	Institute Mission
To be a University of Excellence of International Repute in Education and Research	1. To provide a scholarly teaching learning ambience which results in creating graduates equipped with skills and acumen to solve real-life problems 2. To promote research and create knowledge for human welfare, rural and societal development 3. To nurture entrepreneurial ambition, industrial and societal connect by creating an environment through which innovators and leaders emerge.
Department Vision	**Department Mission**
To be a department of excellence in quality education and research in the multidisciplinary areas of Biotechnology.	1. To imbibe the ability of critical thinking, scholastic attitude and provide solutions for critical problems. 2. To embed acumen of life-long learning and zeal to pursue research in various disciplines of Biotechnology. 3. To nurture the ability to create sustainable solutions with a blend of socio-ethical understanding.

Program Outcomes- M.Tech. Biotechnology

PO1-An ability to independently carry out research /investigation and development work to solve practical problems.

PO2-An ability to write and present a substantial technical report/document.

PO3-Students should be able to demonstrate a degree of mastery over various areas in biotechnology.

PO4-Capability to recognize problems, provide solutions related to industrial biotechnological processes that involve production of sustainable bioproducts.

PO5-Demonstrated ability to address issues related to environmental and health care biotechnology using modern computational and analytical tools.

Program Educational Outcomes-M.Tech. Biotechnology

PEO1- Established themselves as competent professionals excelling in various fields of biotechnology or in allied industries.

PEO2- Demonstrated their ability in problem solving skills and act with global, ethical, ecological and commercial awareness in the service of the society.

PEO3- To appreciate the significance of team work and collaborations in designing, planning, and implementing solutions for practical problems and facilitate the modern biotechnology with national research and academic organizations.

M. Tech BIOTECHNOLOGY CURRICULUM STRUCTURE

S. No	Category	Credits
1.	Program Core Courses	23
2.	Supportive Courses	4
3.	Program Elective Courses	15
4.	Open Elective (Interdisciplinary Elective / General Elective)	3
5.	Mini Project	2
6.	Project Work	26
7.	Audit Course	-
	Total	**73**

Program Core Courses

Theory Courses

S. No	Course Code	Course Name	Course Type	L	T	P	C
1.	BIT18R5001	Bioprocess and Bioseparation Technology	T	3	0	0	3
2.	BIT18R5002	Advanced Bioinformatics	T	3	0	0	3
3.	BIT18R5003	Immunotechnology	T	3	0	0	3
4.	BIT18R5004	Genomics and Proteomics	T	3	0	0	3
5.	BIT18R5005	Bioprocess Modeling and Simulation	T	3	0	0	3
		Total					15

Laboratory Courses

S. No	Course Code	Course Name	Course Type	L	T	P	C
1.	BIT18R5081	Advanced Immunology Laboratory	L	0	0	6	2
2.	BIT18R5082	Bioinformatics and Drug Design Laboratory	L	0	0	6	2
3.	BIT18R5083	Recombinant DNA Technology Laboratory	L	0	0	6	2
4.	BIT18R5084	Bioprocess Engineering Laboratory	L	0	0	6	2
		Total					8

Supportive Courses

S. No	Course Code	Course Name	Course Type	L	T	P	C
1.	MAT18R5002	Statistics and Computational Techniques	T	3	0	0	3
2.	BIT18R5006	Research Methodology	T	1	0	0	1
		Total					4

Program Electives

S. No	Course Code	Course Name	Course Type	L	T	P	C
1.	BIT18R5007	Developmental Biology	T	3	0	0	3
2.	BIT18R5008	Enzyme Technology	T	3	0	0	3
3.	BIT18R5009	Bioremediation	T	3	0	0	3
4.	BIT18R5010	Industrial Wastewater Treatment and Management	T	3	0	0	3
5.	BIT18R5011	Microbial Technology	T	3	0	0	3
6.	BIT18R5012	Bioprocess Plant and Equipment Design	T	3	0	0	3
7.	BIT18R5013	Biofuels	T	3	0	0	3
8.	BIT18R5014	Monitoring and Control of Bioprocess	T	3	0	0	3
9.	BIT18R5015	Bioethics, IPR and Biosafety	T	3	0	0	3
10.	BIT18R5016	Tumor Biology	T	3	0	0	3

11.	BIT18R5017	Infectious Diseases	T	3	0	0	3
12.	BIT18R5018	Clinical Physiology	T	3	0	0	3
13.	BIT18R6001	Biomaterials	T	3	0	0	3
14.	BIT18R6002	Drug Design and Targeting	T	3	0	0	3
15.	BIT18R6003	Metabolic Regulation and Metabolomics	T	3	0	0	3
16.	BIT18R6004	Plant Molecular Biology	T	3	0	0	3
17.	BIT18R6005	Clinical Trials	T	3	0	0	3
18.	BIT18R6006	Stem Cell Technology	T	3	0	0	3
19.	BIT18R6007	Neuroscience and Cognitive Diseases	T	3	0	0	3
20.	BIT18R6008	Tissue Engineering	T	3	0	0	3
21.	BIT18R6009	Bio-Entrepreneurship	T	3	0	0	3
22.	BIT18R6010	System Biology	T	3	0	0	3
23.	BIT18R6011	Molecular Pathology	T	3	0	0	3
24.	BIT18R6012	Cell Signaling	T	3	0	0	3
25.	BIT18R6013	Recombinant DNA technology	T	3	0	0	3
26.	BIT18R6014	Biopolymer Technology	T	3	0	0	3
27.	BIT18R6015	Algal Biotechnology	T	3	0	0	3

Mini Project

S. No	Course Code	Course Name	Course Type	L	T	P	C
1	BIT18R6097	Mini Project	L	0	0	6	2

Project Work

S. No	Course Code	Course Name	Course Type	L	T	P	C
1	BIT18R6098	Project Phase I	L	0	0	18	10
2	BIT18R6099	Project Phase II	L	0	0	30	16
		Total					26

Audit Course

S. No	Course Code	Course Name	Course Type
1	AUD18R5001	English for Research Paper Writing	T
2	AUD18R5002	Pedagogy Skills	T

CORE COURSES

BIT18R5001	BIOPROCESS AND BIOSEPARATION TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:
To provide an insightful overview on the fermentation process, basic design of fermenter, sterilization, kinetics of growth and product formation and the fundamental concepts and applications of several downstream processes used in recovery of biochemical products.

Course Outcomes:
At the end of the course, students would be able to

- **CO1:** Understand the fermentation process, bioreactors and its design features, instrumentation
- **CO2:** Describe the microbial media, optimization, kinetics of living cells and to develop a strategy to solve the issues emerging during fermentation processes.
- **CO3:** Summarize various cell disruption methods and identify appropriate isolation techniques
- **CO4:** Express the principles and methods used for product purification viz electrophoresis and chromatography
- **CO5**: Understand the importance of unit operations involved in polishing units

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	H	M
CO2	H	M	H	H	L
CO3	H	H	H	H	L
CO4	H	M	H	H	
CO5	H	M	M	H	

Unit 1: OVERVIEW OF FERMENTATION PROCESSES AND BIOREACTOR CONFIGURATIONS **9 hours**

Range of fermentation processes - The chronological development of the fermentation industry- The component parts of a fermentation process- Process show sheeting- Role of bioprocess engineer- outline of an integrated bioprocess and the various upstream and downstream process- Unit operations involved in bioprocess-Introduction to bioreactors- The structural components of the fermenter- Basic functions of a fermenter- Design of a basic fermenter, design features, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices, probes for online monitoring- Different configurations of fermenter- Acetators and cavitators-tower fermenter-Cylindro-conical vessels-Air-lift fermenters-deep-jet fermenter-cyclone column-The packed tower- bubble columns

Unit 2: MICROBIAL MEDIA, METABOLIC STOICHIOMETRY AND KINETICS 9 hours

Media for industrial fermentations- Media optimization- batch growth, balanced growth, effect of substrate concentration. Monod model- Production kinetics in cell culture- Determining cell kinetic parameters from batch data- Kinetics of cell growth- Batch and Fed-batch bioreactors- Continuous Bioreactors- Metabolic Stoichiometry- mass balances and energy balances-The oxygen requirements of industrial fermentation- Oxygen supply- determination of kLa- Factors affecting oxygen transfer rate in fermenters like bubble size, gas hold up, gas velocity, temperature, pressure etc- Power required for sparged and agitated vessels- The relationship between power consumption and operating variables. Role of shear in stirred fermenters.

Unit3: CELL DISRUPTION AND PRODUCT ISOLATION 9 hours

Types of cells and cell-wall architectures: Plant, Animal, Bacterial and Fungal – Intracellular location of product and kinetics of product, Removal of insolubles: Biomass and particulate debris separation techniques–flocculation – sedimentation- centrifugation and filtration methods. Adsorption: Principles – Langumir- Freundlich isotherms – Extraction: Basics-Batch and continuous, aqueous two-phase extraction-supercritical extraction- Precipitation: Methods of precipitation with salts-organic solvents and polymers

Unit4: PRODUCT PURIFICATION 9 hours

Electrophoresis and chromatograph principles for product purification; Different electrophoresis techniques viz. Isoelectric focusing, chromatographic techniques viz, Paper gel, column, ion exchange, affinity, GLC, HPLC, pseudo-affinity chromatography, IMAC chromatography, Dialysis, ultrafiltration.

Unit5: PRODUCT FORMULATION AND POLISHING 9 hours

Product Polishing: Crystallization – Principles and crystal growth kinetics, drying – Principles and water in biological materials, Freeze drying; Purification of cephalosporin, aspartic acid, Recombinant Streptokinase, Monoclonal antibodies, Tissue plasminogen activator, Taq Polymerase and Insulin

TEXT BOOKS

1. Peter, F., Stanbury., Stephen, J., Hall and A. Whitaker., Principles of Fermentation Technology, Elsevier, Science and Technology Books, New Delhi, 2nd Edition, 2005.
2. Doran, P.M., Bioprocess Engineering Principles, 2nd Edition, Academic Press (An Imprint of Elsevier), New Delhi, 2nd Edition, 2013.
3. Harrison, R.G, Todd, P., Todd, P.W, Petrides, D.P, Rudge, S.R., Bioseparations Science and Engineering, Oxford University Press, USA, 2015.
4. Belter, P.A. Cussler, E.L. and W.S. Hu, Bioseparations; Downstream Processing for Biotechnology, John Wiley, New York,1988.

REFERENCES

1. Doran, P.M., Bioprocess Engineering Principles, 2nd Edition, Academic Press (An Imprint of Elsevier), New Delhi, 2nd Edition, 2013.
2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Macel Dekker Inc., 1st Edition, 1997.
3. Sivasankar B., Bioseparations: Principles and Techniques, PHI Learning Pvt. Ltd. - 2005.

BIT18R5002	ADVANCED BIOINFORMATICS	L	T	P	C
		3	0	0	3

Course Objective:
Objective of this course is to impart in students a depth and breadth of knowledge of bioinformatics including recent advancements in this field. Knowledge on bioinformatics databases, sequence and structure analysis, molecular dynamics and functional analysis is demonstrated to students through this course along with a glimpse of practical part.

Course Outcomes:
At the end of the Course Students would be able to,
CO1: Access various databases and tools to retrieve and analyze biological data
CO2: Compare and analyze sequences to infer the evolutionary relationship among the corresponding organisms
CO3: Understand the aspects molecular structure representation and dynamics
CO4: Recapitulate various structure prediction algorithms and tools
CO5: Understand the use of various tools and methods for prediction of protein functions

CO and PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		L		H
CO2	H		L		H
CO3	H		L		H
CO4	H		L		H
CO5	H		L		H

Unit1: DATABASES **9 hours**
Primary and Secondary Databases; GenBank, EMBL, DDBJ, Swissplot, MIPS, PIR, TIGR, Hovergen, TAIR, PlasmoDB, ECDC; Databases - mapping, sequence, structure, non-redundant

Unit 2: SEQUENCE ANALYSIS AND DATABASE SIMILARITY SEARCHING **9 hours**
Scoring Matrices and their use: Computational complexities; Analysis of Merits and demerits; Sequence pattern; - pattern recognition, hidden Markov models - neural networks; Pattern databases; PROSITE, PRINTS, Viterbi algorithm; Baum-Welch algorithm; FASTA and Blast Algorithm: Needleman-Wusch & Smith-Waterman algorithms –Overview of Molecular Phylogenetics

Unit 3: REPRESENTATION AND DYNAMICS OF MOLECULAR STRUCTURES 9 hours
Representation of molecular structures; External and internal coordinates; Concept of free energy of molecules; Introduction to various force fields; Molecular energy minimization techniques - intra molecular interactions; Monte Carlo and Molecular Dynamics simulation; Physicochemical parameters - Ionization constants, chelation, solubility and partition Co-efficient - Over view of Molecular Descriptors

Unit 4: STRUCTURE PREDICTION **9 hours**

Molecular structure Determination - Principles of X-ray crystallography and NMR spectroscopy; 2D Protein Data bank and Nucleic Acid Data bank; Storage and Dissemination of molecular structures; Methods for predicting secondary structure- Chau and Fasman Method, GOR method and Neural Networks; Homology Modeling, *ab initio* and Threading

Unit 5: FUNCTION PREDICTION **9 hours**

Gene Ontology; Enzyme Classification; Structure Based, Homology based and Sequence motif-based methods of Function Prediction of proteins; Detecting functional sites in DNA – ORF Finder; Promotor Prediction

TEXT BOOKS

1. Baxevanis, A.D. Ouellette, B.F.F. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiley Inderscience, New York, 3rd Edition, 2005.
2. David W. Mount, Bioinformatics: Sequence and Genome Analysis, CSHL Press, New York, 2nd Edition, 2004.

REFERENCES

1. Jonathan, P., Bioinformatics and Functional Genomics, Wiley-Blackwell, 2nd Edition, 2009.
2. Merz, K.M., Ringe, D. Reynolds, C.H., Drug Design: Structure- and Ligand-Based Approaches, Cambridge University Press, 2010.
3. Branden, C. and J. Tooze, J., Introduction to Protein Structure, 2nd Edition, Garland Publishing, 1999.

<table>
<tr><td rowspan="2">BIT18R5003</td><td rowspan="2">IMMUNOTECHNOLOGY</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
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Course Objective:

To provide an in-depth knowledge on the functioning of the immune system and to inculcate knowledge in various immunological assays and treatment strategies

Course Outcomes:

At the end of the course, students would be able to

CO1: Elaborate the concept of antigen processing and presentation and understand the role of cytokines in immune response.

CO2: Explain the classes of antibodies and to understand the production and applications of polyclonal and monoclonal antibodies.

CO3: Describe various kinds of vaccines used in the prevention of infectious diseases

CO4: Summarize the concepts of immunotherapy for the treatment of immune mediated diseases.

CO5: Comprehend various immunoassays that are used in the diagnosis of diseases

CO and PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	M	H
CO2	H	M	H	M	H
CO3	H		H	M	M
CO4	H		H		M
CO5	H		H		M

Unit 1: ANTIGEN PRESENTATION AND CYTOKINES 9 hours

Cells of the immune system, Cellular basis of immunity, T cell receptor - Antigen processing and presentation: MHC - class I and class II, measurement of MHC-peptide interaction; Cytokines: Interleukins, Interferons: types, production and role in immune system

Unit 2: ANTIBODIES AND ANTIBODY ENGINEERING 9 hours

Active and passive immunization; Immunoglobulin: classes and subclasses, structure-function relationship, isotypes, idiotypes and allotypes; Production of Polyclonal antibodies with different types of antigens: antigen preparation and modification, adjuvants (Freund's complete and incomplete); does and route of antigen administration, collection of sera and purification of antibodies; Hybridoma technology: production and applications of monoclonal antibodies for diagnosis and therapy; Culturing of lymphocytes - Characteristics of animal cells and their implication on process design - Nutritional requirements and serum free culture of mammalian cells - Kinetics of growth and product formation; Reactor systems for large-scale production using animal cells - Antibody Engineering; Catalytic antibodies, Commercial production of antibodies

Unit 3: INFECTIOUS DISEASES AND VACCINES 9 hours

Immunity to infections by viruses, bacteria, fungi and parasites - Vaccines: live and attenuated; Subunit vaccines, recombinant vaccines, Vaccines directed against viruses and bacteria, DNA vaccines. Anti-fertility vaccines

Unit 4: IMMUNOTHERAPY FOR INFLAMMATORY DISEASES 9 hours

Concept of immunotherapy, immune mediate diseases - Allergy, tumor and autoimmune diseases: aetiology, pathogenesis and treatment - Auto immune diseases - Animal model for autoimmune diseases; mechanism for the induction of autoimmunity; treatment of autoimmune diseases -tumor antigens, tumor evasion of the immune system and cancer immunotherapy.

Unit 5: IMMUNOASSAYS 9 hours

Immunological Assays: Immuno-diffusion, immunoelectrophoresis, ELISA, RIA, immunofluoresence, FACS, complement fixation, T cell assays: CTL assay, cytokine secretion - ELISpot, ICS, Tetramer staining, HLA Typing, Western blot

TEXT BOOKS

1. Murphy, K., Weaver, C. Janeway's Immunobiology, Garland Science, New York, 9th Edition, 2016.
2. Coico, R., Sunshine, G. Immunology: A Short Course, Wiley-Blackwell, 7th Edition, 2015.

REFERENCES

1. Moran, A., Gosling, J. and Gosling, J.P. Immunotechnology: Principles, Concepts and Applications, John Wiley & Sons, 2008.
2. George, A.J.T. and Urch, C.E. Diagnostic and Therapeutic antibodies (Methods in Molecular Medicine) Humana Press, 2000.
3. Coligan, J.E., Bierer, B.E., Margulies, D.H., Shevach, E.M. and Strober, W. Current Protocols in Immunology, John Wiley & Sons, 2017.

BIT18R5004	**GENOMICS AND PROTEOMICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:
To provide an overview of the organization of genomes and the analysis of genome and proteome, differential expression analysis and various tools used in proteomics

Course Outcomes:

At the end of the course, students would be able to

- **CO1:** Explain the organization and sequencing of genome and list various sequencing technologies.
- **CO2:** Summarize the role of structural and functional genomics.
- **CO3:** Describe the principles of DNA microarrays
- **CO4:** Apply the principles of proteomics in assessing and analyzing the proteomic data.
- **CO5**: Explore the advanced topics in proteomics.

CO and PO Mapping

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	H	M	H	M	H
CO2	M	L	M	M	H
CO3	M	M	H	M	H
CO4	H	M	M	M	H
CO5	H	M	M	M	H

Unit 1: ORGANIZATION AND SEQUENCING OF GENOME 9 hours

Organization of genome – Introns, Pseudogenes, Retropseudogenes, Transposons, Retrotransposons; Sequencing of genome – History of sequencing of DNA, RNA and whole genomes; DNA sequencing methods - Basic methods of sequencing (Maxam-Gilbert, C-termination); Shot gun sequencing; MPSS, Polony, 454, IIlumina, SOLiD, Ion Torrent, SMRT, nanopore; Genome sequence databases; applications of next generation sequencing – molecular, evolutionary biology, metagenomics, medicine and forensics; Genome analysis.

Unit 2: STRUCTURAL AND FUNCTIONAL GENOMICS 9 hours

Introduction to structural genomics – *de novo* methods, *ab initio* modeling, sequence-based modeling, threading, protein structural databases and classification; Functional genomics – Genomics age, epigenetics, forward against reverse genetics; Genome examination – Genome editing methods, transcriptomics; Comparative genomics –Genomics and evolution, outcome of comparative genomics.

Unit 3: DNA MICROARRAYS 9 hours

Principle; Uses and classifications – manufacturing process, spotted and *in situ* synthesized arrays, 2 and 1 channel recognition; generation of heat map, Bioinformatics – experimental design, standardization, data analysis, annotation, data warehousing; optional technologies; Multi-stranded DNA microarray.

Unit 4: PROTEOME ANALYSIS 9 hours

Basics of proteins and proteomics- Introduction to amino acids and proteins, protein folding/mis-folding, introduction to proteomics; Gel-based proteomics- preparation of samples and pre-analytical dependencies, protein purification and estimation; 1-D electrophoresis; 2-D electrophoresis- 2nd dimension, staining, destaining, gel examination, uses and difficulties; DIGE and systems biology- introduction, data analysis, uses, systems biology and proteomics; Basics of MS and sample preparation- fundamentals, techniques, LC-MS, MALDI, In-gel/In-solution digestion.

Unit 5: ADVANCED TOPICS IN PROTEOMICS 9 hours

Introduction to quantitative proteomics- SILAC, iTRAQ, TMT, phosphoproteome, data analysis; Applications of proteomics; difficulties in proteomics; OMICS and translational exploration

TEXT BOOKS

1. Saccone, C. and Pesole, G., Hand book of Comparative Genomics – Principles and Methodology, John Wiley and Sons Publication, New Jersey, 1st Edition, 2003.
2. Lesk, A.M., Introduction to Protein Science. Architecture, Function and Genomics, Oxford University press, New York, 3rd Edition, 2016.
3. Primrose, S. B. and Twyman, R.M., Principles of Genome Analysis, Blackwell Publishing, Singapore, 3rd Edition, 2002.

REFERENCES

1. Creighton, T.E., Protein Structure – A Practical Approach, Oxford University Press, New York, 4th Edition, 2004.
2. Brown, T.A., Genomes IV, Garland Science, Taylore and Francis Group, New York, 4th Edition, 2017.

BIT18R5005	BIOPROCESS MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

Course Objectives:
To introduce the different aspects of modeling and analysis in bioprocess system and to familiarize the simulation of bioprocess modeling

Course Outcomes:
At the end of the course, students would be able to
CO1: Explain the basic modeling principles and fundamentals of bioprocess modeling
CO2: Apply numerical methods to derive solutions for model equations
CO3: Understand various models in bioprocesses
CO4: Explain the basics of MATLAB, data analysis and interpretation of data
CO5: Apply MATLAB and SIMULINK in simulation of bioprocess systems

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	H	H
CO2	H	M	H	M	M
CO3	H	M	H	H	M
CO4	H	H	H	H	H
CO5	H	M	H	H	H

Unit 1: BASIC MODELING PRINCIPLES 9 hours
Introduction to process modeling - Basic modeling principles- Systematic approach to model building- classification of models- Conservation principles, thermodynamic principles of process systems- continuity equation - equations of motion -transport equations - equations of state - chemical and biochemical kinetics-examples- Development of steady state and dynamic lumped and distributed parameter models based on first principles- Deterministic and Stochastic models.

Unit 2: ANALYSIS OF MATHEMATICAL MODELS 9 hours
Analysis of ill-conditioned systems- Models with stiff differential equations - Examples involving algebraic equations- ordinary differential equations- partial differential equations, integral equations - Euler's methods, Newton – Raphsen methods, Runga – Kutta methods- Solution methods for initial value and boundary value problems

Unit 3: BIOPROCESS MODELING 9 hours
Unstructured models- examples- Monod model-Study of structured models for analysis of various bioprocesses – Compartmental models (two and three), cybernetic models - Models of cellular energetic and metabolism - Single cell models, plasmid replication and plasmid stability model - Models for Product formation- Genetically structured models- Stochastic model for thermal sterilization of the medium- Modeling for activated sludge process- Model for anaerobic digestion- Models for lactic acid fermentation and antibiotic production.

Unit 4: MATLAB BASICS AND DATA ANALYSIS 9 hours

Basics-Data analysis-curve fittings, Input and Output in MATLAB- Solving problems using MATLAB- Euler and Fourth order Runge Kutta methods.

Unit 5: SIMULATIONOF BIOPROCESS 9 hours

Dynamic simulation of batch, fed batch, steady and transient culture metabolism using Berkeley Madonna software - Simulation of biochemical system models – Simulation of batch reactor using MATLAB, SIMULINK for dynamic systems- Simulation of non- isothermal CSTR-Simulation of chemostat.

TEXTBOOKS:

1. Harvey W. Blanch., Douglas S. Clark, "Biochemical Engineering", Marcel Decker Inc. 2007.
2. Bequette W.B. "Process Dynamics- Modeling analysis with simulation", Prentice Hall; 1st edition, 1998.
3. Singiresu S. Rao, Applied Numerical Methods for Engineers and Scientists, Prentice Hall, Upper Saddle River, NJ, 2001

REFERENCES:

1. Luben W.L. "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill, International New York, 1990.
2. Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall of India, 2nd Edition, 2011
3. http://www.mathworks.com

Laboratory Courses

BIT18R5081	ADVANCED IMMUNOLOGY LABORATORY	L	T	P	C
		0	0	6	2

Course Objective:
To make students practice various advanced techniques used in immunology

Course Outcomes:
After completing this course, the student will be able to:

CO1: Raise antibodies and conduct assays for estimation of antibody
CO2: Perform techniques for assaying antibody and purification of antibodies
CO3: To isolate splenocytes and make hybridomas
CO4: To design and conduct T cell assays

CO and PO mapping:

CO/PO	1	2	3	4	5
CO1	H	H	H	H	L
CO2	H	H	H	H	H
CO3	H	H	H	H	L
CO4	H	H	H	M	L

LIST OF EXPERIMENTS

1. Routes of immunization and bleeding
2. Kinetics of antibody production – dot blot assay
3. Affinity purification of antibodies
4. Macrophage migration assay
5. Isolation of splenocytes and culture of T cells
6. T cell assays – cytotoxicity assays, ELISPOT
7. Macrophage inhibition assays

BIT18R5082	BIOINFORMATICS AND DRUG DESIGN LABORATORY	L	T	P	C
		0	0	6	2

Course Objective:
To develop practical skills of the students in the area of bioinformatics and drug design.

Course Outcomes:
At the end of the course, students would be able to
CO1: Retrieve and visualize information from various biological databases.
CO2: Execute and analyze pairwise and multiple sequence alignments and construct phylogenetic trees.
CO3: Access the annotation and functional characterization information of genomes and perform gene, ORF and promotor prediction.
CO4: Predict secondary structure, tertiary structure and active/binding sites of proteins
CO5: Utilize computer aided drug design tools for molecular docking and pharmacophore modeling and ADMET prediction.

CO and PO mapping:

CO/PO	1	2	3	4	5
CO1	H	H	M		H
CO2	H	H	M		H
CO3	H	H	M		H
CO4	H	H	M		H
CO5	H	H	M		H

LIST OF EXPERIMENTS:
1. Information retrieval from GenBank, Uniprot, PDB, KEGG, TAIR and GEO.
2. Pairwise and Multiple sequence Alignment- EMBOSS Needle, EMBOSS water and Clustal Omega.
3. Phylogenetic Analysis using MEGA5 and PHYLIP.
4. Accessing genome annotations and functional characterization data using ASAP.
5. Restriction sites, Promotor, ORF prediction
6. Primer Designing
7. Secondary structure prediction of proteins- GOR, ANN and SOPMA
8. Homology Modeling using Swiss-Model and Modeller; Validation of the model using Ramachandran Plot, What Check and Verify3D.
9. Active site prediction using PyMol
10. Retrieval of drug information from Drug Bank, ChemEMBL and PubChem Compounds databases.
11. Molecular Docking using Autodock.
12. Pharmacophore modeling using PharmaGist
13. ADMET prediction of drug molecules using PreADMET.

REFERENCES:

1. Mohammed, Bioinformatics Practical Manual - Biocuration Info Labs, 2014.
2. Michael Agostino, Practical Bioinformatics- Garland Science, 2013.

BIT18R5083	RECOMBINANT DNA TECHNOLOGY LABORATORY	L	T	P	C
		0	0	6	2

Course Objectives:
To make students to practice various genetic engineering techniques including cloning of a gene and producing recombinant proteins

Course Outcomes:
After completing this course, the student will be able to:
CO1: Isolation of plasmid and genomic DNA
CO2: Design primers to introduce new restriction enzyme sites
CO3: Manipulate DNA by setting reactions with enzymes and perform transformation
CO4: Identify recombinant clones by PCR or restriction analysis

CO-PO Mapping:

CO/PO	1	2	3	4	5
CO1	H	H	H	L	L
CO2	H	H	H	L	H
CO3	H	H	H	L	M
CO4	H	H	H	L	M

LIST OF EXPERIMENTS:
1. Isolation of Genomic DNA
2. Isolation of Plasmid DNA
3. Designing of primers
4. Polymerase Chain Reaction
5. Restriction digestion of PCR product and vector
6. Ligation reaction
7. Preparation of competent cells and transformation
8. Identification of recombinant clones by Blue/White selection
9. Extraction and purification of plasmid DNA from white colonies
10. Restriction enzyme analysis to confirm clones
11. Clone confirmation by PCR and agarose gel electrophoresis

Reference Books:

1. Sambrook, Joseph, Edward F. Fritsch, and Tom Maniatis. Molecular Cloning: a laboratory manual. Cold Spring Harbor Laboratory Press, 2nd Edition,1989.
2. Wilson, Keith, and John Walker; Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, 7th Edition, 2010.

BIT18R5084	BIOPROCESS ENGINEERING LABORATORY	L	T	P	C
		0	0	6	2

Course Objectives:
To develop practical skills of the students in the area of Bioprocess Engineering with emphasis on upstream and downstream processing in bioprocess.

Course Outcomes:
At the end of the course, students would be able to
CO1: Appreciate upstream processing like media optimization, fermenter conditions and production
CO2: Demonstrate growth, substrate utilization and product formation kinetics and understand design, operation and analysis of bioreactor
CO3: Simulate batch, fed batch and continuous fermentation
CO4: Demonstrate methods of isolation and separation of bioproducts
CO5: Establish product purification techniques

CO & PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	H	H	H	H
CO2	H	H	H	H	M
CO3	M	H	H	H	H
CO4	H	H	H	H	M
CO5	H	H	H	H	M

LIST OF EXPERIMENTS:
1. Enzyme Production by batch cultivation, Enzyme kinetics and Enzyme immobilization techniques
2. Microbial Growth and Product Formation Kinetics
3. Media optimization by Plackett and Burman method and Response Surface Methodology
4. Fermenter Design and its parts; Preparation of Bioreactor and Utilities for Bioreactor operation, integrated process control systems
5. Batch Sterilization Kinetics
6. Estimation of mixing time in batch reactor.
7. Residence time distribution analysis- CSTR and PFR
8. Determination of volumetric mass transfer coefficient k_La: a. Static gassing out Method b. Sulphite Oxidation Method
9. Simulation of Batch, Fed Batch and Continuous fermentation process using Berkeley Madonna software
10. Model simulation using MATLAB-SIMULINK
11. Cell disruption: Ultrasonication and Homogenization
12. Product Isolation: Iso Electric Precipitation of Protein
13. Product Isolation: Adsorption Equilibria
14. Product Enrichment: Precipitation of protein by salting out method
15. Product Enrichment: Extraction of protein by aqueous two-phase Extraction

16. Product Purification: Chromatographic techniques

REFERENCES:

1. P.A. Belter, E.L. Cussler and Wei-Houhu – Bioseparations – Downstream Processing for Biotechnology, Wiley Interscience Publications, 1988.
2. P.F. Stanbury, A Whitaker - Principles of Fermentation Technology, 2^{nd} edition, Elsevier Publication, 2008.

Supportive Courses

MAT18R5002	STATISTICS AND COMPUTATIONAL TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objective(s):

The purpose of this course is to acquire more knowledge in statistics and its applications to engineering fields.

Course Outcome(s):

After completing this course, the student will be able to:

- **CO1:** Understand the types of probability distributions and their properties
- **CO2:** Analyse the correlation and regression
- **CO3:** Analyse the estimation for given data.
- **CO4:** Analyse the appropriate test for given data.
- **CO5:** Distinguish various designs of experiments.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M				
CO2	M	M	L		
CO3	M	M	L		
CO4	M	M	L	L	L
CO5	M	M	L	L	L

Unit 1: PROBABILITY DISTRIBUTIONS **9 hours**

Probability basic concepts - Binomial, Poisson, Geometric, Normal, Uniform, Exponential, Gamma and Weibull - distributions - Mean, Variance, Moment generating functions.

Unit 2: CORRELATION AND REGRESSION ANALYSIS: **9 hours**

Bivariate correlation – correlation in multivariate systems; Bivariate linear regression – statistical optimization – principle of least squares – reliability of the regression equation – reliability of point estimates of regression coefficients – confidence interval of the regression equation – correlation versus regression - Multiple Regression Analysis: Matrix solution of the standardized model - criteria for evaluating a multiple regression model – Analysis of residuals

Unit 3: ESTIMATION THEORY **9 hours**

Estimation of parameters - Principles of least squares - Maximum likelihood estimation - Method of moments - Interval estimation

Unit 4: TESTING OF HYPOTHESIS **9 hours**

Sampling distribution, large sample tests - Mean and Proportion, Small sample tests - t -test, F-test and Chi-Square test. -Goodness of fit -Independence of attributes.

Unit 5: DESIGN OF EXPERIMENTS **9 hours**

Design of Experiments: Basic Designs, Factorial Design, ANOVA

TEXT BOOK(S):

1. Jay, L. Devore, Probability and Statistics for Engineering and Sciences, Brooks Cole Publishing Company, Monterey, California, 1982.
2. Gupta, S.C. and Kapoor, V.K, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi, 12th Edition, 2014.
3. Paul Mac Berthouex and Linfield C. Brown, “Statistics for Environmental Engineers”, , Lewis Publishers, Washington D.C., 2nd Edition 2002

REFERENCES:

1. Trivedi, K.S., Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI, 2nd edition, 2001.
2. Kapur, J.N. and Saxena, H.C, Mathematical Statistics, S.Chand and Co. Ltd., 18th Revised Edition, 1997.
3. Douglas C. Montgomery, Design and analysis of experiments, John Wiley and sons, 7th edition, 2010.

<table>
<tr><td rowspan="2">BIT18R5006</td><td rowspan="2">RESEARCH METHODOLOGY</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td></tr>
</table>

Course Outcomes:

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

CO1 -Understand the basic concepts of research and hypothesis development in biological research.

CO2 – Retrieve relevant research articles and documents through literature survey

CO3 – Understand the process of designing the research

CO4 – Develop the art of reporting the research and publishing

CO5 – Apply basic statistical methods used in biology research.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H				
CO2	H		M		
CO3	H		M		
CO4	M	H			
CO5	M		H	M	

Unit 1: INTRODUCTION TO RESEARCH METHODOLOGY

Definition of Research - Basic and applied research, essentials steps in research, plural inductivism vs empirical falsification, defining the research problem, Deriving hypothesis in biological research, Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. Ethics in research.

UNIT 2: LITERATURE SURVEY

Literature citation, research report: components, Search engines. Format of thesis and dissertation, manuscript/research article, Review monographs, bibliography and reference, significance of research

UNIT 3: RESEARCH DESIGN

Concept and Importance in Research – Features of a good research design –Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. Drafting research proposal.

UNIT 4: RESEARCH REPORTING

Journals, Impact factors, H-index, Eigen factor score, Scientific index. Components of a research paper – title, authorships and affiliations, abstract, graphical abstract, acknowledgements, references, tables and illustrations, foot notes, legends, Submission of manuscript, Oral and poster presentation of research papers in conferences/symposia. Conflict of interest, podcast Plagiarism, Retraction.

Unit 5: STATISTICAL METHODS

Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); sampling distribution; difference between parametric and non-parametric statistics; confidence interval errors levels of significance; regression and correlation; t-test; analysis of variance; X2 test; basic introduction to multivariate statistics.

REFERENCE

C.R. Kothari, Research methodology, Methods and Techniques New Age International (P) Ltd, Publishers New Delhi, 2nd Edition, 2004.

PROGRAM ELECTIVES

BIT18R5007	DEVELOPMENTAL BIOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

To understand the concept of various stages of embryonic development, metamorphosis, anteroposterior patterning and molecular basis of stem cell derivatives.

Course Outcomes:

At the end of the course, students would be able to

- **CO1:** Explain the concept of embryology, different stages of embryonic development, cell fate and morphogenesis
- **CO2:** Understand metamorphosis of insects and amphibians, development of model organisms and anteroposterior patterning
- **CO3:** Explain the concept of stem cells and ecto, meso and endodermal derivatives of organ development
- **CO4:** Explain how differential gene expression led to developmental process through signalling pathways
- **CO5**: Apply various techniques involved in the development including histology, *in situ* localization, and microinjection

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M				M
CO2	M	M	H		H
CO3	H	H	H	H	M
CO4			M	H	M
CO5	M	H	M	M	H

EARLY EMBRYONIC DEVELOPMENT 9 hours

Theory and concept of embryology, structure of gametes, sperm, egg, recognition of egg and sperm, acrosome reaction, external and internal fertilization, patterns of embryonic cleavage, cell specification and axis formation, gastrulation, invagination and evagination, cell fate map and lineages, cell determination and axis formation, early development in tunicate, morphogenesis, cell adhesion, cell migration

POST-EMBRYONIC DEVELOPMENT AND MAJOR MODEL ORGANISMS 9 hours

Metamorphosis the hormonal regulation of insect and amphibian development, disc development, regional patterning of the wing disc, epimorphic regeneration of salamander limbs, morphallactic regeneration in hydra, compensatory regeneration in the mammalian liver, genes and aging, epigenetic cause of aging, normal development, regional specifications and postembryonic development of model organism, *Caenorhabditis elegans*, programmed cell death, Drosophila, developmental genetics, dorsoventral and anteroposterior pattern, imaginal discs, zebrafish, mutagenesis, organogenesis in chick, mouse: regional specification in development, other topics in mouse development

STEM CELL CONCEPT INTRODUCING ORGANOGENESIS **9 hours**

Stem cell concept, multipotent adult stem cell and niches, mesenchymal stem cells, tissue organization and stem cells, the emergency of ectodermal derivatives central nervous system, brain, neural crust cell and axonal specificity, development of mesodermal organs, kidney, gonadal and heart development, development of endodermal organs, pancreas, sex determination, post embryonic development metamorphogeneis; Growth, regeneration and evolution, regeneration of missing parts.

MOLECULAR BIOLOGY OF DEVELOPMENT **9 hours**

Principles of genes and development, origin of gene theory, evidence for genomic equivalence, genetic core of development: differential gene expression, cell-cell communication in development, induction and competence, paracrine factors, RKT pathway and cell–cell induction: fibroblast growth factors, Hedgehog pathway, *wnt* pathway, *smad* pathway, JAK-STAT pathway, TGF-β pathway, notch pathway, crosstalk between pathways

TECHNIQUES FOR THE STUDY OF DEVELOPMENT **9 hours**

Microscopy, digital imaging, histology, study of gene expression by biochemical methods, Study of gene expression by *in situ* methods, protein, DNA and RNA localization methods, Reporter genes, Microinjection, Cell-labelling methods, Cell sorting

TEXT BOOKS

1. Gilbert, S.F., Barresi, M.J., Developmental Biology Sinauer Associates, 11^{th} Edition, 2016.
2. Slack, J.M.W., Essential Developmental Biology, Wiley-Blackwell, 3^{rd} Edition 2012.

		L	T	P	C
BIT18R5008	**ENZYME TECHNOLOGY**	**3**	**0**	**0**	**3**

Course Objectives:

To understand the basics of catalysis, classification of enzymes and its mechanisms, kinetics of enzymes, production and application of enzymes in various field

Course Outcomes:

At the end of the course, students would be able to:

CO1: Understand the catalysis and classification of enzymes
CO2: Articulate the concepts of active site, mechanism and the stability of enzymes
CO3: Describe the kinetics and parameters on enzyme activity
CO4: Design enzyme reactors and analyze parameters affecting its performance
CO5: Describe enzyme production and its applications

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M	M			
CO2	H	M	M		
CO3	M	H	M		
CO4	M	H			
CO5	H	H	H	M	

CATALYSIS AND CLASSIFICATION OF ENZYMES **9 hours**

Basics of catalysis-Transition state theory -The significance and the application of transition state theory-The Hammond postulate -Principles of catalysis- General-acid-base catalysis-Intramolecular Catalysis-Electrostatic Catalysis-Metal ion catalysis-Covalent catalysis-Electrophilic Catalysis-Nucleophilic Catalysis-Classification of enzymes- oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases.

MECHANISM AND STABILITY OF ENZYMES **9 hours**

Active site characterization - The role of metal ions and cofactors like pyridoxal phosphate, Thiamine -pyrophosphate, folate, biotin, flavin, nicotinamide nucleotides and lipoate in enzyme catalytic mechanisms- mechanism of enzyme action-Chemical modifications and site directed mutagenesis - Integration of kinetic, chemical, and structural data towards enzyme mechanisms - Protein engineering to improve enzyme stability

CONCEPTS OF RATE PROCESSES IN BIOLOGICAL SYSTEMS **9 hours**

Factors contributing to enzyme catalytic rates - Single and multi-substrate system - Regulatory enzymes - Steady-state kinetics - Initial velocity, product inhibition, enzyme activation analysis - Effect of pH and temperature on enzyme rates - Modeling of rate equations for single and multiple substrate reactions- kinetics of immobilized enzymes

DESIGN AND ANALYSIS OF ENZYME REACTORS **9 hours**

Types of Reactors - General design of enzyme reactors under Ideal conditions, Batch and continuous mixed reactors, continuous packed bed reactor under plug flow regime, Parameters affecting the performance of enzyme reactors, Reactor dynamics, Operational stability and optimization- design and configuration of immobilized enzyme reactors

ENZYME PRODUCTION AND APPLICATIONS **9 hours**

Production of enzymes, Chemical modification of enzyme to improve physico-chemical properties and enzymatic reaction, Enzymes in industrial production of drugs and natural products, fine chemicals and chiral intermediates - analytical applications of enzymes

TEXT BOOKS

1. Fersht, A.R., Enzyme Structure and Mechanism, W.H. Freeman & Co, New York, 5th Edition, 2000.
2. Segel, I.H., Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems, Wiley Interscience, New York, 6th Edition, 1994.

REFERENCES

1. Plownan, K.M., Enzyme Kinetics, McGraw-Hill & Co, London, 4th Edition, 1972.
2. Walsh, C.S., Enzymatic Reaction Mechanisms, W.H. Freeman & Co, New York, 4th Edition, 1978
3. Trevan, M.D., Immobilized Enzymes, John Wiley & Sons, New York, 3rd Edition, 1980

BIT18R5009	BIOREMEDIATION	L	T	P	C
		3	0	0	3

Course Objectives:
To learn and integrate the current pollution problems with potential biological remediation techniques and to understand biodegradation of toxic and hazardous compounds often encountered in bioremediation application.

Course Outcomes:
At the end of the course, students would be able to:

CO1: Understand the nature and impacts of contaminant characteristics to bioremediation practices

CO2: Impart sufficient scientific understanding of various microbial transformation reactions and kinetics

CO3: Express the understanding of various bioremediation systems and process

CO4: Explain the pathways and processes involved in biodegradation of common contaminants

CO5: Relate phytoremediation and advance molecular technique to facilitate bioremediation

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		M	M	M
CO2	H		H	H	H
CO3	H		H	M	M
CO4	H		M	M	H
CO5	H		M	M	M

INTRODUCTION **9 hours**

Microbial systems for bioremediation –aerobic, anaerobic and anoxic; metabolic processes involved in bioremediation, Environmental persistence of contaminants and pollutants, Factors influencing bioremediation- environmental factors, physical factors and chemical factors

MICROBIAL TRANSFORMATION REACTIONS **9 hours**

Microbial Energy Yields, Enzyme Activity, Reactions Mediated by Enzymes, Electron Acceptors; Constraints, advantages and applications of Aerobic and anaerobic biodegradation; Acclimation, bio-availability, effect of chemical structure on biodegradation, recalcitrance, predicting products of biodegradation, co-metabolism and biotransformation. Factors affecting biodegradation

BIOREMEDIATION SYSTEMS AND PROCESSES **9 hours**

Types of bioremediation (definition)- Natural (attenuation) and engineered, ex-situ and in-situ techniques such as prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wet lands, use of bioreactors for bioremediation; Bioaugmentation and biostimulation, solid phase and slurry phase bioremediation, Oxygen delivery for Bioremediation. Microbial cleaning of gases (biofiltration and bioscrubbing)

BIOREMEDIATION OF COMMON CONTAMINANTS **9 hours**

Bioremediation of phenols, chlorinated phenols, chlorinated aliphatic compounds, heterocyclic compounds, cyanides, dyes - Bioremediation of fuel oils and lubricants in soil and water; biodegradation of sulphur compounds present in coal and petroleum - Microbial interactions with heavy metals – resistance & tolerance; Microbial transformation– Biosurfactants. Advantages of biosurfactants over chemical surfactants

PHYTOREMEDIATION AND MOLECULAR TECHNIQUES **9 hours**

Rhizoremediation: a beneficial plant-microbe interaction; Phytoremediation: Mechanisms & techniques of Phytoremediation. Mechanisms of biosorption & bioaccumulation; Molecular techniques in bioremediation, Enhanced biodegradation through pathway engineering; Biodegradation of polyhalogenated compounds by genetically engineered bacteria

TEXT BOOKS

1. Ronald L. Crawford, Don L. Crawford F., Bioremediation; Principles and Applications, Cambridge University Press, 2nd Edition, 2005.
2. P. Rajendran and P. Gunasekaran, Microbial Bioremediation, MJP Publishers, 2011.

REFERENCES

3. Bruce E. Rittmann, Perry L. McCarty, “Environmental Biotechnology: Principles and Applications” McGraw-Hill, 2001.
4. Singh, A., Ward, O., Applied Bioremediation and Phytoremediation, Springer Publications, 2004.

BIT18R5010	INDUSTRIAL WASTEWATER TREATMENT AND MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

This course acquaints students to biological processes to remove organic material, nutrients from wastewaters of municipal and industrial origin. The course evaluates microorganism interactions, metabolism, nutrient requirements, substrate requirements, environmental conditions controlling growth, and other factors that are important to understanding microbial activity in biological wastewater treatment.

Course Outcomes:

At the end of the course, students would be able to

CO1: Differentiate the characteristics of distinct industrial wastewater and develop and relationship between measuring parameters

CO2: Use stoichiometric and kinetic relationships to estimate net degradation of contaminants, consumption of electron acceptors and carbon sources, and production of cells over a biological treatment process

CO3: Understand the biochemical reactions and design criteria pertaining to anaerobic treatment processes

CO4: Differentiate and estimate the applicability of suspended and attached microbial growth processes

CO5: Summarize the importance of combination of physico-chemical and biological treatment for emerging and persistent pollutants

CO and PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	H		M	M	M
CO2	H		H	H	H
CO3	H		H	M	M
CO4	H		M	M	H
CO5	H		M	M	M

WASTEWATER CHARACTERISITCS 9 hours

Measurement of Organic Pollutant: Parameters - BOD, COD &TOC, Factors affecting on BOD, BOD equations, methods of estimating BOD, Biological v/s Physicochemical analysis, importance of ratios such as BOD/COD and C/N, Sources and type of industrial wastewater, Effects of industrial effluents on sewers and natural water bodies Regulatory requirements for treatment of industrial wastewater

AEROBIC BIOLOGICAL TREATMENT PROCESS 9 hours

Types of biological processes for wastewater treatment, suspended and attached growth systems, Municipal wastewater treatment, Unit operations of Pre and primary treatment, Aerobic biological oxidation, rate of utilization of soluble substrates, rate of biomass growth with soluble substrate, rate of oxygen uptake, effects of temperature, total volatile suspended solids and active biomass, net biomass yield and observed yield.

ANAEROBIC BIOLOGICAL TREATMENT PROCESS 9 hours

Anaerobic process description; Comparison with the aerobic processes - Types of anaerobic reactors; Mechanism of anaerobic fermentation – a multistep process, Microbiology and biochemistry of anaerobic processes, Production of biogas and energy balances, substrate inhibition, Anaerobic digesters, anaerobic filters, Up flow anaerobic sludge blanket reactor

ATTACHED AND MEMBRANE TREATMENT SYSTEMS 9 hours

Introduction to attached aerobic and anaerobic growth systems, Mass transfer limitations, trickling filtrations, Oxygen transfer and utilization, Applications of rotating biological contactors, Bio-Towers, Process description considerations -Membrane bioreactors; MBR System Features, Fouling and fouling control, Membrane Module Design Considerations.

COMBINED BIOLOGICAL AND CHEMICAL METHODS 9 hours

Electro-coagulation and electro-oxidation process, Theory of advanced oxidation, Types of oxidizing agents, ozone based and non-ozone-based processes, Fenton and photo Fenton Oxidation, Solar Photo Catalytic Treatment Systems, Nutrient removal – nitrogen and phosphorous.

TEXT BOOKS

1. Metcalf and Eddy, Wastewater Engineering, Treatment and Reuse. Tata McGraw-Hill Publishing Company Limited, Third Edition, New Delhi, 4th edition, 2003.

REFERENCES

1. Qasim, S.R., Wastewater Treatment Plant; Planning, Design and operation, Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, McGraw Hill Publishers, New Delhi, 2nd Edition, 2004.
2. Arceivala, S.J. Wastewater Treatment for Pollution Control, TMH Publishers, New Delhi, 2008.

BIT18R5011	MICROBIAL TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives

The course will cover the concepts in fermentative production of metabolites and applications of microbial technology in various fields. This course will provide a strong understanding of applied microbiology.

Course Outcomes

At the end of the course, students would be able to

CO1: Understand the principles of industrial microbiology

CO2: Describe the preparation of media, inoculum and, fermentation procedure

CO3: Explain the production of various primary metabolites

CO4: Explain the production of various secondary metabolites

CO5: Exhibit the applications of microbial technology in various fields

CO and PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		M	H	
CO2	M		H	H	
CO3	M		H	H	
CO4	H		H	H	
CO5	H		H	H	

SCOPE AND PRINCIPLES INDUSTRIAL MICROBIOLOGY 9 hours

Scope of industrial microbiology: A review of industrial fermentation and enzymatic processes and products- A survey of industrially important microorganisms- Isolation of industrially important micro-organisms- Screening methods: primary and secondary metabolites- Preservation of industrially important micro-organisms- Strain improvement: mutation and mutant selection-applications of auxotrophic mutants- examples- protoplast fusion, rDNA technology for overproduction of primary and secondary metabolites.

FERMENTATION MEDIA AND PRODUCTION 9 hours

Stock cultures - Inoculum preparation - Sources of raw materials for fermentation-Media for industrial fermentations- Fermentation procedures- Biochemical basis of production processes-Purification and recovery of products

PROCESS TECHNOLOGY FOR PRODUCTION OF PRIMARY METABOLITES 9 hours

Production of industrially important enzymes: Production of Amylases, Proteases - Solid state fermentation, submerged fermentation, Extraction, Purification of industrial enzymes-Applications- High Fructose Corn Syrup- Production of Citric acid, amino acids - Microbial biomass production: baker's yeast, SCP production, mushroom cultivation

PROCESS TECHNOLOGY FOR PRODUCTION OF SECONDARY METABOLITES 9 hours

Production of secondary metabolites- antibiotics like penicillin, Tetracycline, streptomycin, Vitamins, Polysaccharides, nucleosides and bioplastics (PHA, PHB), Production of steroids (biotransformation)

APPLICATION OF MICROBES IN FOOD, AGRICULTURE, ENVIRONMENT 9 hours

Bacteriocins and their application in food preservative (Nisin, *Lactococcus lactis*), food additives, Production of biofertilizers, biopesticides, Biofuel production – production of biogas (CH_4), biodiesel and biohydrogen, microbial fuel cell, Bio-mining: Extraction of Cu, Au, U from ore by microbes; Bio-recovery of petroleum, Bioremediation of pollutants

TEXTBOOKS

1. Stanbury, P.E., A. Whitaker, and S. J. Hall, Principles of Fermentation Technology, , Butterworth-Heinemann, 3rd Edition, 2016.
2. A. H. Patel, Industrial microbiology, Trinity Press, India, 2nd edition, 2012.
3. Crueger and A. Crueger, Biotechnology: A Textbook of Industrial Microbiology (Ed. T. D. Brook). Sinaeur Associates, 2nd Edition, 1990.

REFERENCES

1. G. Reed (Ed.), Prescott and Dunn's Industrial Microbiology, CBS Publishers, 4th edition 1999.
2. L. E. Casida, Industrial Microbiology, New Age International Private Limited, 2nd edition 2019.

BIT18R5012	BIOPROCESS PLANT AND EQUIPMENT DESIGN	L	T	P	C
		3	0	0	3

Objective

To impart basic concepts of process, mechanical design of process plants and knowledge of scale up of bioprocesses

Course Outcomes:

At the end of the course, students would be able to

CO1: Describe the basic principles in bioreactor design and analysis

CO2: Design equations to determine the performance of ideal and non- ideal reactors

CO3: Appreciate different configurations of bioreactors

CO4: Analyse the scale up criteria of bioreactors and downstream process

CO5: Understand the mechanical design of bioreactors

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		M	H	M
CO2	H		M	H	M
CO3	H		M	H	M
CO4	H		M	H	M
CO5	H		M	H	M

PRINCIPLES IN BIOREACTOR DESIGN **9 hours**

Principles of kinetics for chemical and biochemical reactions - Fundamentals of homogeneous reactions - Energy and mass balances in biological reaction modelling-empirical modeling for kinetics- components of bioreactors and their operation- Classification based Schuegerl, Kafarov- Mass transfer in biochemical processes- determination of oxygen transfer rates- Overall 'kla' estimation and power requirements for sparged and agitated vessels- Heat transfer correlations

NON-IDEAL REACTOR ANALYSIS **9 hours**

Review of ideal reactors – Batch, PFR and CSTR, Performance and design equations, Concept of ideal and non-ideal reactor - residence time distribution and functions- Estimation of Mean and Variance- Experimental Tracer Techniques- Models of non-ideal reactors- Tanks in series- Axial dispersion models- Design of continuous sterilizer- Stability analysis of bioreactors

BIOREACTOR DESIGN **9 hours**

Fed batch reactors design-- Multiphase bioreactors-fluidized bed reactor- bubble column - Airlift bioreactors- packed bed with immobilized enzymes or microbial cells - Trickling bed reactor – Unconventional bioreactors- Hollow fiber reactor, membrane reactor, perfusion reactor for animal and plant cell culture- chemostat with cell recycle- two stage reactors- CSTR with enzyme catalyzed reactions

SCALE UP OF BIOPROCESS **9 hours**

Scale up concepts - Bioreactor scale up based on constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer coefficients- Design, scale up and optimization of various equipment and biosystems used for biotechnological process industries-Mechanical design of stirred batch fermenter -Scale up of downstream processes: Chromatography (constant resolution), Filtration (constant resistance), centrifugation (equivalent times).

PROCESS AND EQUIPMENT DESIGN **9 hours**

Process flow sheeting- P&I Diagrams- Pump and compressor selection- Pipe size selection. Materials of construction, Facility design aspects, utility supply aspects, equipment cleaning aspects, safety in bioprocess plant -Process Economics-Process design of distillation columns, extraction equipment.

TEXTBOOKS

1. Anton Moser, Bioprocess Technology - Kinetics and Reactors, Springer Verlag, London, 2nd Edition,1988.
2. Levenspiel, O., Chemical Reaction Engineering, John Wiley Eastern Ltd, San Francisco, 3rd Edition, 2006.
3. Robert H. Perry and Don W. Green., Perry's Chemical Engineers' Handbook, McGraw Hill Book Co., 8th Edition, 2008.

REFERENCES

1. Bailey, J.E., Ollis, D.F., Biochemical Engineering Fundamentals, McGraw-Hill, London, 3rd Edition, 1990
2. Max Peters &Klans D Timmerhauss. Plant Design & Economics for Chemical Engineers, Mc Graw Hill Book Co., 4th Edition, 1991.
3. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 3rd Edition, 2010.
4. Asenjo, J.A., Bioreactor System Design, CRC Press, 1st Edition,1994.

BIT18R5013	BIOFUELS	L	T	P	C
		3	0	0	3

Course Objectives

This course will provide an overview of existing energy sources and utilization, as well as the consequences of our energy choices on the environment. To understand the important feedstocks, the biochemical, genetic and molecular approaches being developed to advance the next generation of biofuels and the economical and global impacts of biofuel production.

Course Outcomes

At the end of the course, students would be able to

- **CO1:** Understand the importance of biomass, conversion techniques, social, economic and environmental impacts of biofuels
- **CO2:** Understand the design of a biogas plant and kinetics of biogas production.
- **CO3:** Recognise the importance of modern biotechniques for bioethanol production
- **CO4:** Summarize various conversion techniques for biooil and biohydrogen production
- **CO5:** Express the recent trends and application of green technology

CO and PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	L		H	H	H
CO2	L		H	H	H
CO3	L		M	H	H
CO4	L	L	M	H	H
CO5	L		M	H	H

OVERVIEW OF ENERGY FROM BIOMASS 9 hours

Overview of Energy Sources & Utilization, Climate Change & the Impact of Carbon Dioxide, History of Fossil Fuels, Renewable Energy Sources & Utilization, Biomass Sources and Classification, Chemical composition and properties of different biomass materials and bio-fuels, Biochemical Conversion Technologies. Socio economic and environmental impact of the production and use of biofuels, Waste to energy facilities

BIOGAS TECHNOLOGY 9 hours

Worldwide perspective of anaerobic digestion, Microbiology of biogas production, Different designs of biogas plants, Methods to enhance the biogas production, Design parameters affecting the success and failure of biogas plants, Immobilization of biogas plant system – principle, application, Alternate feedstock for biogas production.

BIOETHANOL 9 hours

Ethanol production: Present Status and Future Prospects. Sources and treatment of bioethanol production, Biotechnology of Bioethanol Production, Traditional methods, Metabolic Engineering of Novel Ethanologens, Gene manipulation for Ethanol Production, Biochemical Engineering and Bioprocess Management for Fuel Ethanol.

BIO-OIL AND BIOHYDROGEN 9 hours

Vegetable oils and chemically processed biofuels, Biodiesel composition and production processes (thermochemical and biochemical), Biodiesel economics, Energetics of biodiesel production and effects on greenhouse gas emissions, Issues of ecotoxicity and sustainability with expanding biodiesel production, Alternate feedstock for Biodiesel (Microalgae and Microbes). Bioproduction of gases, Production of H_2 by photosynthetic organisms & Microbial Fuel Cells.

GREEN TECHNOLOGY 9 hours

Microbial Fuel Cell: Types of Biological fuel cells – Principle and Applications. Hydrogen production by photosynthetic bacteria, biophotolysis of water and by fermentation, Microbial recovery of petroleum by biopolymers (Xanthum gum), biosurfactants

TEXT BOOKS

1. Venkataramana, P., and Srinivas, S.N., Biomass Energy Systems, Tata Energy Research Institute, 1996
2. Rai, G.D., Non-Conventional Energy Sources, Khanna Publishers, 2011

3. Sorensen, B., Hydrogen and Fuel Cells: Emerging Technologies and Applications. Burlington: Elsevier, 2005.
4. Aye, D., John, N., Terry, W., Biofuels Engineering Process Technology, McGraw Hill, 1st Edition, 2008.

REFERENCE BOOKS

1. Mousdale, D.M., Biofuel: Biotechnology, Chemistry, and sustainable Development, 1st Ed., CRC Press, 2008.
2. Nijaguna, B.T., Biogas Technology, New Age International publishers (P) Ltd.,2002
3. Lee, S., Alternate Fuels, Taylor and Francis, 1996.
4. Demirbas, A., Green Energy and Technology: Biofuels, Securing the Planet's Future Energy Needs, 1st Edition, Springer, 2009.

BIT18R5014	MONITORING AND CONTROL OF BIOPROCESS	L	T	P	C
		3	0	0	3

Course Objective:
To impart knowledge on instrumentation and process control strategies adopted in bioprocess systems.

Course Outcomes:

At the end of the course, students would be able to
CO1: Classify instruments for the measurement of various bioprocess variables
CO2: Understand the dynamic behaviour of process systems
CO3: Develop the ability to describe quantitatively the behaviour of simple control systems
CO4: Tune control loop and apply this knowledge in measurements
CO5: Apply the concepts of process control in bioprocess systems

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		M	H	M
CO2	H		M	H	
CO3	M		M	M	
CO4	M		M	M	
CO5	H		M	H	

SENSORS FOR MONITORING AND CONTROL **9 hours**

Online and offline monitoring of bioreactors- Principles of measurements and classification of process control instruments- Biochemical Reactor Instrumentation, measurementsof physical, chemical and bio-chemical parameters like temperature, pH, foam, DO, redox, level measurements, pressure, fluid flow, liquid weight and weight, viscosity and consistency, concentration, electrical and thermal conductivity, humidity of gases, microbial biomass sensors for medium and gases- microbial calorimetry- Flow injection analysis for measurement of substrates, product and other metabolites

INTRODUCTION TO PROCESS CONTROL SYSTEMS **9 hours**

General introduction of a process control system- Design elements of a control system. Development of Block diagram, Controllers and Final Control Elements, positioners, valve body, valve plugs, Valve characteristics, final control elements. Transfer functions for controllers and final control element, proportional, derivative, integral control; proportional reset (integral) (PI); proportional rate derivative (PD); proportional reset & rate controller (PID), actuators, numerical.

CLOSED AND OPEN LOOP CONTROL SYSTEMS **9 hours**

Linearization of non-linear systems, Qualitative analysis of a response of a system, Dynamic behaviour of first order systems; Study of different order systems. Dynamic behaviour of higher order systems- Laplace transformation, application to solve ODEs. Open-loop systems, first order systems and their transient response for standard input functions, first order systems in series, linearization and its application in process control, second order systems and their dynamics; transportation lag.

STABILITY ANALYSIS **9 hours**

Concepts of stability, stability criteria, Routh test for stability, Root-locus method, Bode plots and stability criteria, tuning of controllers

BIOPROCESS CONTROL SYSTEMS **9 hours**

Process control in bioprocess systems- Direct regulatory control - Cascade control of metabolism- Programmed batch bioreaction- Design and operating strategies for batch plants and continuous process control- Computer applications in fermentation technology- Data logging and data analysis

TEXT BOOKS

1. Gary Montague, Monitoring and Control of Fermenters, Institution of Chemical Engineers, United Kingdom, 1997.
2. Seborg, D. E. and Mellichamp, D. A., Process Dynamics and Control, Wiley, New York, 3rd Edition, 2010.
3. Coughnowr, D. P., Process Systems Analysis and Control, McGraw Hill, New York, 2nd Edition, 1991.

REFERENCES

1. Harriot, P., Process Control, Tata McGraw Hill, New Delhi, 4th Edition, 2005.
2. Smith, C. A. and Corripio, A. B., Principles and Practice of Automatic Process Control, Wiley, New York, 2nd Edition, 1997.

BIT18R5015	BIOETHICS, IPR AND BIOSAFETY	L	T	P	C
		3	0	0	3

Course Objectives:

To make students familiar with ethical issues in biological research and to provide basic knowledge on intellectual property rights and their implications in biological research and product development; To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products

Course Outcomes:

At the end of the course, students would be able to

CO1: Understand various bioethical aspects in healthcare, animal experiments and agriculture

CO2: Know about IPR and its global perspectives.

CO3: Explain various patenting in national and international level

CO4: Apply biosafety protocols following in various organisms

CO5: Identify national and international regulation in biosafety

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	M		M
CO2	M	M	M		
CO3	M	M	M		
CO4	M	M	M		
CO5	M	M	M		M

BIOETHICS

Introduction -Ethical conflicts in biological sciences - interference with nature - Bioethics in health care - Artificial reproductive technologies -Prenatal diagnosis - Genetic screening - gene therapy –Transplantation - Bioethics in research – Cloning and stem cell research -Human and animal experimentation - Animal rights/welfare - Agricultural Biotechnology - Genetically engineered food - Environmental risk.

INTRODUCTION TO IPR

Introduction to intellectual property rights - Types of IP- Patents – Trademarks - Copyright & related rights - Industrial design- Traditional knowledge - Geographical indications - Protection of new GMOs - International framework for the protection of IPR - IPRs of relevance to biotechnology with case studies -GATT, WTO, WIPO and TRIPS.

PATENTING

Basics of patents - Types of patents - Indian patent acts with recent amendments - WIPO Treaties - Budapest Treaty - Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application - Filing of a patent application -Types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting.

BIOSAFETY

Biological safety cabinets - Primary containment for biohazards - Biosafety levels - GRAS organisms- Biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals - Risk assessment of transgenic crops vs ‘cis’genic plants or products derived from RNAi, genome editing tools.

NATIONAL AND INTERNATIONAL REGULATIONS

International regulations – Cartagena protocol, OECD consensus documents - Indian regulations – RCGM, GEAC, IBSC and other regulatory bodies -Draft bill of Biotechnology Regulatory authority of India - Containments –Standard operating procedures - Guidelines of state governments; GM labelling – Food Safety and Standards Authority of India (FSSAI).

TEXT BOOKS

1. Goel, D., & Parashar., G. IPR, Biosafety and Bioethics, Pearson 1st Edition, 2013.

REFERENCE BOOKS

1. Steinbock, G., The Oxford Handbook of Bioethics. Oxford University Press, 2007
2. Ganguli, P., Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub, 2001.

BIT18R5016	**TUMOR BIOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objective(s):

To make students understand the regulation of cell cycle and the role of signalling events that leads to cancer, and to provide them the molecular tools available for early diagnosis of cancer

Course Outcomes

At the end of the course the students would be able to:
CO1: Understand the modulation of cell cycle leading to cancer
CO2: Explain and compare various mechanisms of carcinogenesis
CO3: Describe the role of receptors and the activation of other factors in the induction of cancer
CO4: Explain invasion, metastasis, stromal signal and its significant clinical cancer markers
CO5: Describe various tools used in the early diagnosis of cancer and different therapeutic strategies

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M		M		
CO2	M		M		
CO3	M		M		
CO4	M		M		
CO5	M		M		M

RETINOBLASTOMA AND CONTROL OF CELL CYCLE AND CLOCK **9hrs**

Introduction- Regulation of cell cycle- central governor of growth and proliferation, external signal influence cell cycle, pRb control cell cycle and its phosphorylation, cyclin and cyclin dependent kinase, CDK inhibitors, E2F transcription factors- mitogen and '*myc'* regulation of pRb- mutations that cause changes in signal molecules

CARCINOGENESIS **9hrs**

Theory of carcinogenesis- Chemical carcinogenesis and its types, mechanism and action of chemical carcinogenesis -metabolism of carcinogenesis - principles of physical carcinogenesis - x-ray and gamma ray radiation- Mechanisms of radiation carcinogens – exposure of gamma radiation to patients- diet and cancer

MOLECULAR CELL BIOLOGY OF CANCER **9hrs**

Different forms of cancers - receptors, signal targets and cancer – hedgehog, 'Wnt' and GPCR signaling- activation of kinases- Ras, Src kinase, PKB kinase, and Jak-STAT –oncogenes and tumour suppressor genes identification and its mechanism- retroviruses and oncogenes – Growth factors related to transformation – Telomerases

METASTASIS **9hrs**

Clinical significances of invasion- Three step theory of invasion – invasion to metastasis cascade- EMT transition- cadherin shift, metastasis marker, EMT induced by stromal signal, extracellular protease play a key role in invasiveness- cell adhesion, cell shape and cell motility- primary tumors and their metastatic tropisms. Metastasis of bone osteoblast and osteoclast

NEW MOLECULES FOR CANCER THERAPY **9hrs**

Screening and early detection of cancer, using biochemical assays, tumor markers - Molecular tools for early diagnosis of cancer- Different forms of therapy - Chemotherapy, radiation therapy detection of cancers, prediction of aggressiveness of cancer - advances in cancer detection, use of signal targets towards therapy of cancer - Gene therapy

TEXT BOOK:

1. Weinberg, R.A., The Biology of Cancer, Garland Science, 2nd Edition,2013
2. Kleinsmith, L.J., Principles of Cancer Biology, Pearson Education Inc., San Francisco, 1st Edition,2006

REFERENCE:

1. DeVita, V.T. Jr., T.S. Lawrence, S.A. Rosenberg, DeVita, Hellman, and Rosenberg's Cancer: Principles and Practice of Oncology, Wolters Kluwer, 10th edition, 2014.

<table>
<tr><td rowspan="2">BIT18R5017</td><td rowspan="2">INFECTIOUS DISEASES</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

Course Objective:

To provide students with a deeper knowledge on various infectious diseases caused by Bacteria, Viruses, Fungi and Parasites, and to make them understand the host-pathogen interaction mechanisms and molecular basis of pathogenesis

Course Outcomes:

At the end of the course, Students would be able to:

CO1: To understand the basics of infectious diseases, diagnosis and control of infections

CO2: To recapitulate the pathogenesis, mode of action and treatment strategies of major bacterial infections

CO3: To demonstrate the role of viruses as infectious agents, their pathogenesis, diagnosis, and treatment

CO4: To explain various fungal diseases, their diagnosis and treatment

CO5: To understand the pathogenesis, treatment and control of parasitic infections.

CO and PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		M		H
CO2	H		M		H
CO3	H		M		H
CO4	H		M		H
CO5	H		M		H

GENERAL PRINCIPLES OF INFECTIOUS DISEASES 9 hours

Structure and function of microbes-Host defense versus microbial pathogenesis and the mechanisms of microbial escape- Human Microbiome in Health and Disease - Infection: Infectious agents and immune response to infection- Laboratory diagnosis of microbial infections: microscopic, serologic and molecular diagnosis –Infection Control: Sterilization, disinfection - Emergence and global spread of infection.

BACTERIAL DISEASES 9 hours

Mechanisms of Bacterial Pathogenesis, *Staphylococcus* and *Streptococcus* infections; Tuberculosis: diagnosis and treatment; Neisseria and Haemophilus; Cholera: symptoms, treatment and prevention; Diseases caused by Enterobacteriaceae, Helicobacter and Clostridium;

Chlamydial, Mycoplasma and Rickettsial diseases - anthrax, Botulism, Diphtheria, syphilis, Antibacterial Agents

VIRAL DISEASES **9 hours**

Viruses as pathogens; Mechanisms of Viral Pathogenesis; Laboratory Diagnosis of Viral infections; Antiviral Agents; Papillomaviruses and Herpesviruses; Poxviruses; Rhabdovirus; Filoviruses; Reoviruses; Flaviviruses; Hepatitis Viruses - Polio treatment and vaccination- measles, mumps and rubella- Paramyxo and Orthomyxoviruses: evolution, transmission, symptoms, treatment and prevention- Retroviruses: subtypes of HIV, transmission, life cycle of HIV, diagnosis, treatment and prevention of HIV; Emerging Infectious Diseases; Prions and infections

FUNGAL DISEASES **9 hours**

Pathogenesis of Fungal Disease, Laboratory Diagnosis of Fungal Disease; Antifungal Agents, Superficial, Cutaneous and Subcutaneous Mycoses; Systemic Mycoses Caused by Dimorphic Fungi, Opportunistic Mycoses, Mycotoxins and Mycotoxicosis.

PARASITIC DISEASES **9 hours**

Pathogenesis of Parasitic Diseases; Role of Parasites in Disease; Laboratory Diagnosis of Parasitic Disease; Antiparasitic Agents; Intestinal and Urogenital Parasites; Blood and Tissue Protozoa: Malaria: diagnosis and treatment, Nematodes, Trematodes and Cestodes as disease causing agents.

TEXTBOOKS:

1. Murray, P., K. Rosenthal and M. Pfaller Medical Microbiology, 8th Edition, Elsevier. 2015
2. Ryan, K., C.G. Ray, N. Ahmad, W. Lawrence Drew, M. Lagunoff, P. Pottinger, L.B. Reller, C.R. Sterling, Sherris Medical Microbiology, - McGraw-Hill Education, 6th edition, 2014.

REFERENCES:

1. Shetty, N., J.W. Tang, J. Andrews, Infectious disease: pathogenesis, prevention, and case studies, John Wiley and Sons, 1st Edition, 2009.
2. Rogers, K. (Ed.) Infectious Diseases, Britannica Educational Publishing, UK, 2011.
3. Cohen, J., W.G. Powderly and S.M. Opal Infectious Diseases, 4th Edition, Elsevier, 2016.

		L	T	P	C
BIT18R5018	**CLINICAL PHYSIOLOGY**	**3**	**0**	**0**	**3**

Course Objectives:

To provide knowledge of homeostasis, cellular physiology, anatomy and functional regulation of different physiological systems and its metabolism

Course Outcomes:

At the end of the course, students would be able to

CO1: Explain the general concept of homeostasis, cellular process including membrane potential, transport, and endocytosis

CO2: Summarize the anatomy and functional regulation of gastrointestinal and hepatic systems
CO3: Describe the structure and function of skeletal muscle and nervous system including the functioning of general sensory organs
CO4: Comprehend the functioning of cardiovascular, pulmonary and renal systems
CO5: Demonstrate endocrine physiology and its metabolism

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	L		M		
CO2	L		M		
CO3	L		M		
CO4	L		M		
CO5	L		M		

GENERAL AND CELL PHYSIOLOGY **9 hrs**

General physiological concept, extra cellular fluid and homeostasis, control system of the body, cells and cellular process, cell membrane transport process, membrane potential and action potential, sensory generator potential, functional system of cells, endocytosis, synthesis and formation of cellular structures by endoplasmic reticulum and Golgi apparatus, locomotion of cells.

GASTROINTESTINAL PHYSIOLOGY **9 hrs**

Overview of the gastrointestinal system, functional anatomy and regulation, gastric secretion, pancreatic and salivary secretion, intestinal mucosal immunology, functional anatomy of liver and bilary system, bile formation and secretion, digestion, absorption and assimilation

SKELETAL, MUSCLE AND NEURAL PHYSIOLOGY **9 hrs**

Skeletal muscle structure and function, overview of muscle function, introduction to nervous system, brain, spinal cord, central and cranial nervous system, reflex arch, autonomous nervous system, general sensory system, touch and pain, vision, hearing and equilibrium, smell and taste, control of posture and movement.

CARDIOVASCULAR, PULMONARY AND RENAL PHYSIOLOGY **9 hrs**

Overview of cardiovascular system, cardiac function assessment, peripheral vascular system and its control, arterial pressure regulation, cardiovascular response to physiological stress, function, structure and mechanism of respiratory system, ventilation, perfusion, transport of oxygen and carbon dioxide, control of breathing, renal function, basic process, anatomy, renal blood flow, tubular transport mechanism, regulation of sodium and water excretion, potassium, calcium and phosphate balance.

ENDOCRINE AND METABOLIC PHYSIOLOGY **9 hrs**

General principles of endocrine physiology, pituitary gland, thyroid and parathyroid gland, calcium and phosphate regulation, adrenal gland, pancreas, male and female reproductive system, control of body temperature, hypoxia and hyperbaria.

TEXTBOOKS

1. Raff, H., M. Levitzky, Medical Physiology: A Systems Approach, The McGraw-Hill Companies Inc, 2011.
2. Hall, J.E., Guyton and Hall Textbook of Medical Physiology, Saunders, 13th Edition, 2015.

BIT18R6001	BIOMATERIALS	L	T	P	C
		3	0	0	3

Course objectives:

The objective of this course is to teach the basic concepts in material science, different type of materials, structure and chemistry of biomaterials. This course encompasses variety of medicinal applications of biomaterials, issues related to it and ways to overcome the medical problems.

Course Outcomes:

At the end of the course, students will be able to
CO1: Understand the fundamental concepts of material science
CO2: Explain about biological responses to implanted biomaterials.
CO3: Discuss various types of biomaterials used in biomedical field.
CO4: Summarize the methods used for characterizing biomaterials and analysis of medical implants
CO5: Apply principles in designing biomaterials for medicinal applications.

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M		M		H
CO2	M		M		H
CO3	M		M	M	H
CO4	M		M		H
CO5	M		M	M	H

BASIC CONCEPTS IN MATERIAL SCIENCE 9 HOURS

Fundamental concepts in material science – Metals, Ceramics and Polymers - Polymerization reactions - Metals Structure and -Types of alloys (e.g., ferrous and nonferrous) - Ceramics and Glasses: characterization of crystalline and non-crystalline materials - Mechanical properties and processing methods.

BIOLOGICAL RESPONSE TO BIOMATERIALS 9 HOURS

Familiarity with biocompatibility and hemocompatibility, Mechanisms of the foreign body response to implanted biomaterials-Blood-biomaterials and its interactions- Biodegradation of biomaterials-intentional and un-intentional degradation mechanisms–Techniques in modification of biomaterial surfaces to control the biological response - Instrumentations to examine surface chemistry.

APPLICATIONS OF BIOMATERIALS 9 HOURS

Classes of materials used in medicine- Design of materials for biomedical application: Cardiovascular-Dental implants- Orthopaedic applications- Skin- Ophthalmologic applications- Wound healing- Sutures- Biosensors- Implantation techniques in soft tissue and hard tissue replacements.

EVALUATION OF BIOMATERIALS 9 HOURS

Materials Characterization -*In Vitro* and *In Vivo* Methods - Regulation of Medical Devices- Problems and possible solutions in implant fixation- Failure analysis of medical devices and implants.

BIOMATERIALS IN ENGINEERING DESIGN 9 HOURS

Fundamental principles for designing biomaterials to be used in a various medical application- Familiarity with legal and ethical issues in biomaterials used in medical applications.

TEXTBOOKS

1. Temenoff, J.S. and Mikos, A.G., Biomaterials: The Intersection of Biology and Materials Science by, Pearson Prentice Hall, 2008.
2. Ratner, B.D., Hoffman, A.S., Schoen, F.J., Lemons, J.E., Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 3rd Edition 2012.

REFERENCES:

1. Wong, J.Y., Bronzino, J.D., Peterson, D.R., Biomaterials: Principles and Practices, CRC Press, 2012
2. Park, J., Lakes, R.S., Biomaterials: An Introduction, 3rd Edition, Springer, 2007.

BIT18R6002	DRUG DESIGN AND TARGETING	L	T	P	C
		3	0	0	3

Course Objective:

To provide an overview of drug discovery and development process and educate students in the advanced aspects of drug design, drug targeting and drug delivery strategies.

Course Outcomes:

At the end of the course students would be able to:

CO1: Outline the organized drug discovery and development process
CO2: Explore various computational approaches used in the process of drug design
CO2: Exemplify enzyme inhibitors and receptor agonists and antagonists as drug targets
CO3: Describe the advanced strategies in drug design
CO4: Summarize various drug delivery and targeting systems

CO and PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	H		M		M
CO2	H		M		H
CO3	H		M		H
CO4	H		M		H
CO5	H		M		H

ORGANIZED DRUG DISCOVERY AND DEVELOPMENT 9 hours

Pipeline of Drug Discovery and Development- Pharmacological, Microbial, Recombinant, Biochemical and Molecular level screening systems and their construction strategies - Alternative strategies in Lead identification - Lead optimization - Preclinical development - Clinical trials, Patenting, and clearance for application

COMPUTER AIDED DRUG DESIGN 9 hours

Structure Based Drug Design; Molecular Docking- Ligand Based Drug Design; QSAR and Pharmacophore modeling- Objectives and approaches in the native ligand modification - Molecular graphic and dynamical methods in peptide and protein mimicry - Drug design by receptor site fit - Active site Prediction – ADMET prediction

TARGETING ENZYMES AND RECEPTORS 9 hours

Rational design of enzyme inhibitors - Enzyme catalytic principles - Affinity Labels -Principle of Suicide Inactivation; Transition state mimicry; HIV protease inhibitors; Influenza neuraminidase inhibitors- Renin and ACE inhibitors- Cyclooxygenase II inhibitors; Molecular Biology of Receptors; Receptor agonists and antagonists- Adenosine receptor agonists and antagonists; Partial and Full agonists; Alternative medicine- Targeting virulence factors- Anti-virulence drugs.

ADVANCED DRUG DESIGN APPROACHES 9 hours

Peptidomimetics - Selection strategies and screening methodologies – Combinatorial Synthesis of Compound libraries and Peptide libraries- Peptide libraries through Phage Display - Applications in Epitope mapping and in synthetic vaccine design - Perspectives in Gene Therapy- Retrometabolic Drug Design and Targeting

DRUG DELIVERY AND TARGETING 9 hours

Routes of Drug Delivery- Novel Drug delivery systems: Carriers, Micelles, Liposomes, Nanoparticles and Dendrimers- Rate controlled Release of drugs- antibody-directed enzyme/prodrug therapy (ADEPT) - virus-directed prodrug/enzyme therapy (VDEPT)- ‘Magic Bullet’ Drug Targeting.

TEXT BOOK

1. Hansch, C., (Ed.), Comprehensive Medicinal Chemistry (Vols. I-VI), Pergamon Press, London, 3rd Edition, 1990.

REFERENCES

1. Sandler, M., Smith, H. J., Design of Enzyme Inhibitors as Drugs, Oxford University Press, London, 4th Edition, 2002
2. Perun, T. J., Propst, C. L., Computer Aided Drug Design, Marcel Dekker, New York, 5th Edition, 1989.

BIT18R6003	METABOLIC REGULATION AND METABOLOMICS	L	T	P	C
		3	0	0	3

Course Objectives:

To provide information pertinent to the biochemical aspects of metabolism and to make them understand the fundamental energetics of biochemical processes and the chemical logic of metabolic pathways. Understand the integration of metabolic processes in cellular systems.

Course Outcomes:

At the end of the course, students would be able to

- **CO1:** Explain the fundamental energetics of biochemical processes
- **CO2:** Describe the metabolism and regulation of carbohydrate and lipid
- **CO3:** Explain the biochemistry of macromolecules such as DNA, RNA and proteins
- **CO4:** Discuss basic analytical methods in metabolomics
- **CO5**: Describes the electron transport chain and oxidative phosphorylation

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M		M		M
CO2	M		M		M
CO3	M		M		M
CO4	M		M		M
CO5	M		M		M

OVERVIEW OF METABOLISM **9 hours**

Concept of flow of matter and energy – Thermodynamic principles-coupled systems and non-equilibrium reactions - Biological energy currencies - high energy bond, reducing power and inter conversions of energy forms - Carbon, nitrogen cycles in biosphere - Classification of living system based on carbon and energy requirements - Methods to study metabolism- catabolism versus anabolism Regulation of metabolic pathway.

CARBOHYDRATES AND LIPID METABOLISM **9 hours**

Gluconeogenesis - Cori cycle - Glycogen metabolism – Glycolysis - TCA cycle - Biogenesis of fatty acids and sterols. Biosynthesis of membrane phospholipids - Fatty acid oxidation-Utilization of ketone bodies and its regulation

METABOLISM OF PROTEIN AND NUCLEOTIDES 9 hours

Sources of organic nitrogen; flow of nitrogen into biosynthesis and catabolism of amino acids; the urea cycle - Digestion and absorption of proteins - Protein turnover, Biosynthesis of purine and pyrimidine nucleotides - Catabolism of purine and pyrimidine nucleotides - metabolic disorders-Lesch Nyhan Syndrome, Gout, Adenosine deaminase deficiency

ELECTRON TRANSPORT AND OXIDATIVE PHOSPHORYLATION 9 hours

Electron flow as source of ATP energy - Electron transferring reactions - Electron carriers and electron transport complexes - Site of oxidative phosphorylation, Inhibitors and uncouplers of oxidative phosphorylation

METABOLOMICS 9 hours

Fundamental concept, Tools of metabolomics- Capillary electrophoresis, Gas chromatography, Criteria for the selection of chromatography methods and their importance in metabolomics. Application of cellular metabolomics for metabolic pathway structure, Metabolite profiling for infectious diseases

TEXTBOOK

1. Nelson, D.L. and Cox, M.M., Lehninger Principles of Biochemistry, W.H. Freeman & Company, 6th Edition, 2013.
2. Voet, D., and Voet, J.G., Biochemistry, John Wiley and Sons, 4th Edition 2010
3. Lindon, J., Nicholson, J., Holmes, E. The hand book of metabonomics and metabolomics, Elsevier B.V. Netherlands.2006.

REFERENCES

1. Atkins, P.W., Paula, J.D., Physical Chemistry, W.H. Freeman & Co, New York, 8th Edition, 2006.
2. Stryer, L., Berg, J.M., Tymoczko, J.L., Biochemistry, W.H. Freeman & Co, New York, 5th Edition, 2003.
3. Nikolau B.J. Wurtele, E.S., Concepts in Plant Metabolomics, Springer.USA.2007
4. Rodwell, V.W., Bender, D., Weil, P.A., Kennelly, P., Botham, K., Harper's Illustrated Biochemistry, MGH publications, 30th Edition, 2015.

BIT18R6004	**PLANT MOLECULAR BIOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

To make students to understand the advanced concepts in plant molecular biology and to introduce techniques such as gene editing and transient expression.

Course Outcomes:

After completing this course, the student will be able to:
CO1: Explain the genome structure of model plant and their gene expression methods.
CO2: Design methods by which plants can be transformed with gene of interest
CO3: Outline strategies with modern tools to make transgenic plants
CO4: Analyze the importance of traits needed for crop improvement
CO5: Articulate different methods used in plant breeding

CO and PO Mapping

CO/PO	1	2	3	4	5
CO1	H		M		
CO2	H		M		
CO3	H		M		
CO4	H		M		
CO5	H		H		

PLANT GENOME AND GENE EXPRESSION 9 Hours

Chloroplast and Mitochondrial DNA, Genome organization of model plant Arabidopsis thaliana, Nucleosome structure and its biological significance, Eukaryotic gene expression with transcriptional factors, alternative splicing, trans-splicing, constitutive and inducible promoters.

PLANT GENETIC ENGINEERING 9 Hours

Plant transformation – Vectors used in plant transformation, *Agrobacterium*-mediated gene transfer to Chloroplasts – Plastid transformation with direct gene transfer method – Comparison of plastid transformation with nuclear transformation. Reporter genes, selectable markers and generation of marker-free transgenic plants, Gene stacking or engineering of many genes in plants

GENOME EDITING AND TRANSIENT EXPRESSION 9 Hours

Introduction to genome editing, CRISPR is new genome editing tool by DNA nuclease Cas9; Agroinfiltration method to express proteins and vaccines; Conversion of plant virus to virus vector, Virus vector-mediated expression of proteins and vaccines.

GENES AND TRAITS OF INTEREST 9 Hours

Plant pathogen interaction: Hypersensitive response and cell death, R genes and pathogen resistance by gene silencing - Herbicide resistance, insect resistance traits for improved products and food quality, Molecular pharming. Bio-safety issues related to production and release of transgenic plants.

PLANT BREEDING 9 Hours

Seed Companies in India and Abroad; Plant breeding is a numbers game; Conventional versus Marker-assisted breeding; Genomics assisted breeding for crop improvement; Mutation breeding; Hybrid seed production technology and Development of Male sterile lines.

TEXT BOOKS:

1. Neal Stewart, Jr., Plant biotechnology and genetics: Principles, Techniques, and Applications. John Wiley & Sons Inc., 2nd Edition 2016.
2. Adrian Slater., Nigel, W., Scott, and Mark R Fowler., Plant biotechnology The Genetic Manipulation of Plants, Oxford University Press, London, 1st Edition, 2003.

BIT18R6005	CLINICAL TRIALS	L	T	P	C
		3	0	0	3

Course Objectives

The objectives of this course are to teach students about various phases of clinical trials and study design. To make them understand the necessity of data collection, quality control and assessment of health-related issues.

Course Outcomes:

CO1: Understand about basic concepts in clinical trails
CO2: Explain the importance of study design in clinical trails
C03: Articulate the importance of data collection and quality control
CO4: Understand the assessment of health-related quality of life
CO5: Summarize multicentre clinical trials and regulatory issues

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		M		H
CO2	H		M		H
CO3	H		M		H
CO4	H		M		H
CO5	H		M		H

INTRODUCTION TO CLINICAL TRIALS 9 Hours

Need of clinical trials - Clinical trial phases: Phase 0, Phase I, II, III and IV - Types of trial (Pharma & devices, etc.,) - Study protocol - Ethical issues in planning and design- Conduct and reporting.

STUDY POPULATION, BASIC STUDY DESIGN, RANDOMIZATION PROCESS, BLINDING 9 Hours

Definition of Study Population – Pharmacogenetics – Generalization – Recruitment - Randomized Control Trials - Nonrandomized Concurrent Control Studies - Historical Controls and Databases - Cross-Over Designs – Violations - Withdrawal Studies - Fixed allocation randomization - Adaptive Randomization Procedures - Mechanics of Randomization - Types of Blinding - Protecting the double-blind design.

DATA COLLECTION AND QUALITY CONTROL 9 Hours

Problems in Data Collection - Minimizing poor quality data - Techniques to reduce variability – Central Adjudication of Events - Quality Monitoring - Case report forms

ASSESSMENT OF HEALTH-RELATED QUALITY OF LIFE 9 Hours

Types of HRQL measures -Uses of HRQL measures - Design issues - Selection of HRQL instruments -Utility measures/preference scaling and comparative effectiveness research

REPORTING AND INTERPRETING OF RESULTS, MULTICENTER TRIALS AND REGULATORY ISSUES **9 Hours**

Guidelines for reporting – Interpretation - Publication bias - Adherence and concomitant treatment - Clinical implications of the findings - Data sharing - Reasons and conduct of multicenter trials - Globalization of trials - Large, simple trials - Regulatory requirements – Pretrial requirements - post-trial requirements - Key links.

TEXT BOOK

1. Lawrence, M., Friedman, D., Furberg, D.L. DeMets, Reboussin, C., Granger, B. Fundamentals of Clinical Trials, 5th Edition, Springer, 2015.

REFERENCES

1. Liu, M.B. and Davis, K., Clinical trials manual from the Duke Clinical Research Institute: lessons from a horse named Jim., John Wiley & Sons, 2ndEdition 2010
2. Machin, D., and Fayers, P.M., Randomized Clinical Trials: Design, Practice and Reporting. Wiley-Blackwell, 2010.
3. Piantadosi, S., Clinical Trials: A Methodologic Perspective, John Wiley & Sons, New Jersey, 3nd Edition, 2017.

		L	T	P	C
BIT18R6006	**STEM CELL TECHNOLOGY**	**3**	**0**	**0**	**3**

Course Objective:
To introduce students the basics of stem cell biology and to make them understand classification, characterization, culturing and therapeutic applications of stem cells.

Course Outcomes:
At the end of the course, students would be able to
CO1: Describe the fundamental concepts and characteristics of stem cell biology.
CO2: Classify stem cells and conceptualize somatic cell nuclear transfer and generation of iPS cells
CO3: Explain the methods of isolating stem cells from various tissues.
CO4: Discuss the role of stem cells in therapeutics and tissue regeneration.
CO5: Summarize various issues and ethical considerations in stem cell research and applications.

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	M	M
CO2	H	M	H	M	M
CO3	H	M	M	M	M
CO4	H	M	M	M	M
CO5	H	M	H	M	M

Unit 1: FUNDAMENTALS OF STEM CELL BIOLOGY 9 hours

Embryo -Formation and developmental stages - Stem cells- History of stem cell research- Definition of terms (Renewal, Plasticity, Redifferentiation and Dedifferentiation, Pluripotency, Totipotency, Multipotency)- Properties of stem cells - Identification and characterization of pluripotent stem cells in animal and humans.

Unit 2: STEM CELLS CLASSIFICATION AND CHARACTERIZATION 9 hours

Embryonic Stem Cells-Properties -Isolation of human embryonic stem cells-Culturing of embryos -Growing ES cells -Adult stem cell and its types-Somatic stem cells and its properties -SCNT, iPS - Adult stem cell differentiation - Transdifferentiation- Methods for identification of adult stem cells-Germ Line Stem Cell- Properties- Identification, Characterization and Purification of Germ Line Stem cells- Germline Stem cell Niche- Establishment of Germ Line cells *in vitro.*

Unit 3: SOURCES OF STEM CELLS 9 hours

Adult cardiac stem cells -Epithelial stem cells - Hematopoietic stem cells -Bone marrow stromal stem cells -Neural stem cells – Cancer Stem cells.

Unit 4: STEM CELLS IN THERAPEUTICS AND TISSUE ENGINEERING 9 hours

Stem cells in gene therapy- Application of Stem cells for the treatment of Parkinson disease – Cardiac and neurological disorders - Spinal cord injuries - Diabetes - Alzheimer's Disease- Mechanisms for stem cell manipulation in controlled micro-environments- Growing organs from stem cells in kidney, eyes, heart and brain.

Unit 5: ISSUES AND ETHICAL CONSIDERATIONS IN STEM CELL RESEARCH 9 hours

Establishment of human stem cell bank- Commercialization of human stem cells -Recent ethical controversies about embryonic stem cell research and legal issues- Government policies on stem cell research and applications.

TEXT BOOKS

1. Panno, J., Stem Cell Research: Medical Applications and Ethical Controversy, Infobase Publishing. 1st Edition, 2014.
2. Humber, J.M., Almeder, R.F., Stem Cell Research, Totowa, N. J., Humana Press, 1st Edition 2004.
3. Viegas, J., Stem Cell Research, The Rosen Publishing Group. 1st Edition, 2003.

REFERENCES

1. Turksen, K., Embryonic Stem cells - Protocols, 2nd Edition, Humana Press, 2002.
2. Stem cell and future of regenerative medicine, By committee on the Biological and Biomedical applications of Stem cell Research, 1st Edition, National Academic Press. 2002.

BIT18R6007	NEUROSCIENCE AND COGNITIVE DISEASES	L	T	P	C
		3	0	0	3

Course Objectives:

The course will introduce to the students the basic anatomy and physiology of nervous systems, neurotransmitters, cognitive diseases and their treatments

Course Outcomes:

At the end of the course, students would be able to

- **CO1:** Explain the general physiology and anatomy of nervous system including spinal cord and brain
- **CO2:** Understand the functions of autonomous, motor and sensory nervous system including pain and brain learning
- **CO3:** Describe the anatomy and regulation of different types of synaptic transmitters
- **CO4:** Articulate the pathology of different types of cognitive diseases and their treatments
- **CO5**: Explain various techniques used in neuroscience and neuroimaging

CO and PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	M		M		M
CO2	M		M		M
CO3	M				M
CO4	M				M
CO5	M		M		M

GENERAL PHYSIOLOGY AND ANATOMY OF THE NERVOUS SYSTEM 9 HRS

Introduction, general neurological concept - spinal cord, internal structure, spinal gray matter, segment and spinal lesion, - Brain stem, medulla, pons and cerebellum, mid brain, fore brain, organization - development and histology of neuron and neuroglia, central and cranial nervous system, molecular regulation of ion channels, blood supply of the nervous system. Overview of integrative functions of hypothalamus,

AUTONOMUS, MOTOR AND SENSORY NERVOUS SYSTEM 9 HRS

Autonomous nervous system and adrenal medulla– major functions, sympathetic and parasympathetic innervations of salivary and lachrymal gland, Motor function of spinal cord and reflexes, general sensory nervous systems – Compare the pathway that mediates sensory input from touch, vibratory senses to modulate transmission in pain pathways headache and thermal sensation, special senses – vision, hearing and equilibrium, smell and taste, Electrical activity of the brain sleep – wake states and circadian rhythms, learning, memory, language, and speech

SYNAPSES, NEUROTRANSMITTER AND RECEPTORS 9 HRS

Physiologic anatomy of the synapse, types of synapses, chemical substances that regulate the function of synaptic transmitters, fring, neuronal excitation, synaptic transmission, functions of Specific Neurotransmitter, functions and electrical events during neuronal and dendrites excitation, neuroendocrine function and regulation of neurotransmitters, types and sensitivity of sensory receptors and stimuli into nerve impulses, adaptation of receptors, stimulation of muscle spindle and sensory receptors, receptors on the effectors organ

COGNITIVE DISEASES 9 HRS

Brain abnormalities, dysfunction and neurochemical factors, drug treatment, hereditary factors, dopamine, norepineprine, serotonin, role of lithium treatment for bipolar disorder, – schizopherinia, behavioural aspects, major subtype, Brain stem syndrome, ataxia disorder, regulation of posture and movement disorder – parkinsonian disease, Wilson’s disease, Dystonia, – Alzheimer’s disease amyloid plaques and depressed memory, depressive and other mood disorder – unipolar, bipolar, dysthymia and cyclothymic disorder, - Huntington disease – multiple sclerosis - Cerebral vascular syndrome, cerebral, midbrain, pontine and medullary vascular syndromes, stroke, anxiety disorders and drug treatments, substances abuse and brain function

TECHNIQUES FOR NEUROSCIENCES AND NEUROIMAGING 9 HRS

Electrophysiology of neuron, patch clamp, system biological approaches of synsptic transmission pathways, Electromyography (EMG), computed tomography, magnetic resonance imaging, magnetic resonance spectroscopy, positron emission tomography, single - photon emission computed tomography, angiography (Arteriography)

TEXT BOOKS

1. Siegel, A., H.N. Sapru, Essential Neuroscience, Wolters Kluwer, 3rd Edition, 2014.
2. Hall, J.E., Guyton and Hall Textbook of Medical Physiology, Saunders, 13th Edition 2015.

REFFERENCES

1 Raff, H., M. Levitzky, Medical Physiology: A Systems Approach, The McGraw-Hill Companies Inc, 2011
2 Daroff, R., J. Jankovic, J. Mazziotta and S. Pomeroy, Bradley’s Neurology in Clinical Practice, 7th Edition, 2015.

BIT18R6008	TISSUE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:
To understand basics of tissue engineering, morphogen signalling, scaffold, biomaterials and their applications including bone, blood, mound healing, cardiac process and dental tissues.

Course Outcomes:

At the end of the course, students would be able to

CO1: Understand the basics of tissue engineering and morphogen signalling

CO2: Explain cell to cell communication, scaffolds and bioreactor
CO3: Understand the biomaterials and their immune responses to engineered tissue
CO4: Apply the knowledge of biomaterials in engineering of various tissues
CO5: Discuss the regulatory processes and ethical issues in tissue engineering

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M		M		L
CO2	M		M		L
CO3	M		M		L
CO4	H		H		H
CO5	H		M		H

FUNDAMENTALS OF TISSUE ENGINEERING **9 hours**

Origins of Tissue engineering – History -Scope and challenges -Tissue engineering triad - Signals for tissue engineering - Growth factors and morphogens.

CELL MOTILITY AND TISSUE ARCHITECTURE **9 hours**

Extracellular Matrix: Structure and Function - Mechanical forces on cells–Cell adhesion -Cell migration - Polymeric scaffolds - Tissue engineering bioreactors.

BIOMATERIALS **9 hours**

Biomimetic materials –Nanocomposite scaffolds - Thermodynamic state and molecular mobility in biopreservation - Immune responses to engineered tissues

TISSUE ENGINEERING APPLICATIONS **9 hours**

Bone tissue engineering- Cartilage tissue engineering- Engineering blood components- Cornea – Wound healing process- Breast reconstruction- Cardiac tissue engineering - Hepatic tissue engineering- Bioengineering of dental tissues - Bioengineering of human skin substitutes- Nerve regeneration- Gene therapy and tissue engineering.

REGULATIONS, COMMERCIALIZATION AND ETHICS **9 hours**

The Regulatory Process from Concept to Market: Regulatory Background -Early Stage Development -Business Issues: - Rise of Regenerative Medicine - Product Development - Ethical issues.

TEXT BOOK

Robert L., Robert L., Joseph V. Principles of Tissue Engineering, Elsevier Publications, 4th Edition 2014.

REFERENCE:

John P. Fisher, Antonios G. Mikos and Joseph D. Bronzine: Tissue Engineering, CRC Press, 2007.

BIT18R6009	BIOENTREPRENEURSHIP	L	T	P	C
		3	0	0	3

Course Objectives

The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Course Outcomes:

At the end of the course, students would be able to

CO1: Understand the basics of entrepreneurship in bio-business
CO2: Articulate the business strategy and marketing in bio-business
CO3: Explain various innovation networks in biotechnology
CO4: Discuss finance and accounting techniques
CO5: Summarize various technology management available in bio-entrepreneurship

CO and PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1		M	M	M	
CO2		M	M	M	
CO3		M	M	M	
CO4	M	M	M		
CO5		M	M	M	

Unit 1: OPPORTUNITIES AND QUALITIES **9 Hours**

Scope in Bio-entrepreneurship - Types of bio-industries: Pharmaceutical based, Agriculture based products – Hybrid seed companies – Industrial Enzymes – Biofuel – Nutraceuticals- Diagnostics Kits and other products – services-based business opportunities. Qualities of a successful entrepreneur – creativity, leadership, managerial, team building and decision making.

Unit 2: FINANCE AND ACCOUNTING **11 Hours**

Business plan preparation: Statutory and legal requirements to start Company - Business feasibility study – Accounting Practices: Balance sheet – Profit and loss statement – double entry book keeping- Estimation of revenue generation, expenditure, profit, income tax. Sources of Financial Assistance and Guidance: Financial Institutions, Banks, Angel Investors, Association of Biotechnology Led Enterprises and Venture capitals. Entrepreneurship development programs from Government: MSME, DBT, DST-IEDC, BIRAC – Technology Business Incubator from DST and MSME.

Unit 3: BIOMARKETS: BUSINESS STRATEGY AND MARKETING **9 Hours**

Strategic dimensions of patenting & commercialization strategies. Negotiating the road from lab to the market - Pricing strategy - Challenges in marketing in bio business- Basic contract principles - Different types of agreement and contract terms - Joint venture and development agreements - Dispute resolution skills.

Unit 4: INNOVATION NETWORKS IN BIOTECHNOLOGY 7 Hours

The Nature of Innovation Networks - The Entry of New Firms - The Changing Role of Universities - Theories of Industrial Organization - Innovation Networks - Recent Developments in Network Dynamics.

Unit 5: TECHNOLOGY MANAGEMENT 9 Hours

Technology – Assessment - Development & upgradation - Managing technology transfer- Quality control & transfer of foreign technologies - Knowledge centers and Technology transfer agencies - Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

TEXT BOOKS

1. Adams, D. J., & Sparrow, J. C., Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion. 2008.
2. Patzelt, H., & Brenner, T., Handbook of Bioentrepreneurship. Springer Science Business Media, LLC, 2008.
3. Shimasaki, C. D., Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier Publisher, 2014.

REFERENCE:

1. Jordan, J. F., Innovation, Commercialization, and Start-Ups in Life Sciences, London: CRC Press. 2014.

BIT18R610	SYSTEMS BIOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

To provide overview of systems biology, data management and acquirement, modelling and study of networks, synthetic and executable biology

Course Outcomes:

At the end of the course, students would be able to

CO1: Explain the principles of systems biology and list its various elements

CO2: Summarize the role of various techniques in data acquirement and management in systems biology

CO3: Describe the principles of modelling and study of networks

CO4: Apply the principles of synthetic biology in natural systems

CO5: Explore the advanced topics in executable biology and its applications.

CO and PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	H		M		
CO2	H		M		M
CO3	H		M		M
CO4	H		M		
CO5	H		M		

Unit1: INTRODUCTION TO SYSTEMS BIOLOGY 9 hours

Physiology and cognitive problem of a cell; Detection and quantification of diverse molecules (proteins, nucleic acids and metabolites); Elements of transcription networks; Nature of modern biological science in relation to the conception, advancements, methods and tools of Systems Biology; Contextualized mathematical and computer modelling in systems biology. Dynamics and response time of simple gene circuits.

Unit2:DATA ACQUIREMENT AND MANAGEMENT IN SYSTEMS BIOLOGY 9 hours

Techniques used to acquire data in a range of 'omics' approaches (transcriptomics, proteomics and metabolomics) and in high-throughput genetics; *in vivo* examination of single cells using sophisticated microscopy, cell-to-cell variation and spatial control.

Unit3: MODELLING AND STUDY OF NETWORKS 9 hours

Arithmetical and statistical methods used to assess and study large-scale data sets; Usage of methods for the modernization of biological networks; Methods for the analysis of metabolic, gene-regulatory, and large-scale networks. Auto-regulation network motif; Feed forward loop network motif; Single input module network motif; Negative feedback motif; Oscillator motif.

Unit4: SYNTHETIC BIOLOGY 9 hours

de novo design of biological systems using the techniques of Synthetic Biology and computational simulation; designing paradigm biological systems to test natural systems – *E. coli*, *C. elegans*, *D. melanogaster*; Systems design and fabrication to produce novel devices of commercial or medical utility.

Unit5: EXECUTABLE BIOLOGY 9 hours

Design, simulation, and analysis of biological modules using techniques in Executable Computational Biology Techniques (ECBT). Designing a system using typical synthetic biology components and testing its viability by computer simulation in cancer research, aging, infectious diseases and vaccines, metagenomics.

TEXT BOOKS

1. Kriete, A. and Eils, R., Computational Systems Biology: From Molecular Mechanisms to Disease, Academic press, 2013.

REFERENCES

1. Boogerd, F, Bruggeman, FJ, Hofmeyr, JHS and Westerhoff HV., Systems biology: philosophical foundations, Elsevier, 1st Edition, 2007.
2. Alon, U., An introduction to systems biology: design principles of biological circuits. CRC Press, 2006.

BIT18R6011	MOLECULAR PATHOLOGY	L	T	P	C
		3	0	0	3

Course Objective:
To enhance the knowledge of concept of cell death, pathogen entry, infection, activation of defense mechanism, promote systemic disease in both plant and humans

Course Outcomes:
At the end of the course, students would be able to
CO1: To understand the key concept, molecular genetics and cell death concept of both plant and animals
CO2: The mode of deface mechanism are triggered and how they transmit within host and pathogen
CO3: To enumerate mode of pathogen entry, infection and how they are promoting disease in plant systems
CO4: To review the general and molecular principles of systemic disease in human systems
CO5: To provide practice of molecular medicine and agriculture

CO and PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1			M		
CO2			M		H
CO3			M		H
CO4			M		
CO5			M		H

Unit 1: ESSENTIALS OF MOLECULAR PATHOLOGY **9 hours**
Introduction: key concepts, terms, and challenges, pathogen lifestyles, molecular Koch's Postulates- Molecular genetics tools for bacterial, fungal and oomycetes of plant pathogens, -pathogen altered genomics changes of plant, resistance, susceptible and tolerant- Molecular mechanism of animal – pathogen interaction, cell death – structural features and pathways of necrosis and apoptosis- organelle role in cell death- acute and chronic inflammation induces disease pathogenesis and their acquired immune response- neoplasia and its classification

Unit 2: HOST PATHOGEN INTERACTIONS **9 hours**
Infection and host response of both plant and animals- Systemic acquired resistance, reactive oxygen and nitrogen species as defense signals and antimicrobials, defense molecules: from callose synthase to PR proteins, phytoanticipins: constitutive, small-molecule antimicrobials, elicitors, phytoalexins: inducible, small-molecule antimicrobials tolerated by some necrotrophs, translational research advances and potential

Unit 3: PLANT DISEASES **9 hours**
Mode of pathogen entry in both plant and animal, pectic enzymes to kill and macerate plant tissues, necrotrophic fungi use host-selective toxins and effector proteins to defeat plants, bacterial small-

molecular toxins to promote disease, Molecular basis of nematode-plant interactions, Virus-plant interactions

Unit 4: HUMAN DISEASES **9 hours**

General and molecular principles of cardiovascular and ischemic disease – molecular basis of myeloid and lymphoid diseases- pulmonary diseases, liver diseases, liver development and regeneration, liver cirrhosis- pituitary, thyroid and pancreatic diseases

Unit 5: PRACTICE OF MOLECULAR PATHOLOGY IN MEDICINE AND AGRICULTURE **9 hours**

Diagnostic analysis – ELISA test for identifying disease of Typhoid, Dengue, Malaria, HIV, Genetic disorder confirmation, thousand genome sequence based personalized medicine, Syndrome based diagnostic test - identification of virulence of plant host– pathogen interaction, Tolerant of host.

TEXT BOOKS

1. William B. Coleman, Gregory J. Tsongalis: Molecular Pathology: The Molecular Basis of Human Disease: Academic Press, 2nd Edition, New York, 2017.

BIT18R6012	**CELL SIGNALLING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

To provide an understanding of various cellular events and the importance of signal transduction in facilitating these events

Course Outcomes:

At the end of the course, students would be able to

- **CO1:** Understand the role of various transport molecules
- **CO2:** Explain the organization of eukaryotic genome and intra-nuclear processes
- **CO3:** Elucidate the role of various receptors and their role in communication
- **CO4:** Demonstrate the mechanism of various signal transduction events
- **CO5**: Describe the structure and function of components involved in cellular adhesion

CO and PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	M		M		L
CO2	M		M		L
CO3	M		M		L
CO4	M		M		M
CO5	M		M		M

Unit1: PROTEIN SORTING IN ORGANELLES **9 hours**

Overview of major protein-sorting pathways in eukaryotic cells, signal sequences, The transport of protein molecules between *nucleus and cytosol, mitochondria, chloroplast, endoplasmic reticulum* and folding proteins - Transporter and active membrane transport, ABC transporter – Vesicular trafficking, various types of vesicle formation, clathrine coated vesicles, trafficking of SNARE complex - Transcriptional regulation, helix turn helix motif, Zn finger motif, leucine zipper motif - cytoskeleton filament, actin, microtubule assembly, molecular motor proteins kinesin and dyanin regulation.

Unit2: MACROMOLECULES IN NUCLEUS **9 hours**

Forces stabilizing nucleic acid structures, DNA denaturation and renaturation, nucleic acids are and ionic interactions, RNA structure are highly variable – Eukaryotic chromosome structure, histones, DNA coils around histone to form nucleosomes, chromatin forms higher order structures, differences of prokaryotic and eukaryotic replications, DNA mutations, DNA damage can be directly reversed – transcription in eukaryotes, types of RNA polymerase, recognizing promoters, transcription factors required to initiate transcription.

Unit 3: RECEPTORS **9 hours**

Extracellular receptor, G-protein coupled receptor, tyrosine kinase receptor, integrin receptor, Toll gate receptor, ligand gated ion channel receptor - intracellular receptor, NOD like receptor, cytokine and interleukin receptor, Ligand binding nuclear receptor, ion channel coupled receptor, g-protein coupled receptor, and enzyme coupled surface receptors, integrin receptor. EGF and TGF-β growth factor receptor, insulin receptor, GPCR regulate cyclic nucleotide gated ion channels, First messengers and second messengers.

Unit 4: SIGNAL TRANSDUCTION **9 hours**

Mechanism of phosphorylation, phosphorylation of activation and inactivation, Molecular switches, patched and smoothened signaling, wnt – β catenin signaling, notch signaling, src homolog function as tyrosine kinase, structure and function of SH2 domain, ERK pathway, Akt/PKB kinase pathway, ras regulatory pathway, Jak-STAT pathway, MAPK pathway, NF-kβ pathway, signaling pathway in plant ethylene blocks auxin transporter and plant growth phytochrome.

Unit 5: CELL JUNCTION, CELL ADHESION AND EXTRACELLULAR MATRIX **9 hours**

Cell–Cell and Cell–Matrix Adhesion: An Overview, Major families of cell-adhesion molecules (CAMs) cadherins, immunoglobulin (Ig) superfamily, integrins, and selectins, adhesion receptors. Junctions and Adhesion Molecules of epithelial tissues and extracellular matrix, adhesive molecules in plant

Text Books

1. Alberts, B., A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter. Molecular Biology of the Cell**,** Garland Science; New York: 6th edition, 2014.
2. Lodish, H., A. Berk, C.A. Kaiser and M. Krieger, Molecular Cell Biology, W. H. Freeman and Company, New York, 6th edition, 2016.
3. Voet, D., J.G. Voet, C.W. Pratt, Fundamentals of Biochemistry Life at molecular level, John Wiley and Sons Inc, New York, 5th edition, 2016.

BIT18R6013	RECOMBINANT DNA TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:
The objectives of this course are to teach various approaches to conducting rDNA technology and their applications in biological research as well as in biotechnology industries.

Course Outcomes:
CO1: Understand the role of various tools employed in rDNA technology
CO2: Elucidate the organization and functions of vectors in genetic engineering
CO3: Explain the applications of different types PCR techniques
CO4: Interpret cDNA analysis and its relevance in rDNA technology
CO5: Apply knowledge in gene silencing and genome editing technologies

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		H	M	H
CO2	H		H	M	
CO3	H		H		M
CO4	H		H	M	M
CO5	H		H		M

UNIT 1: INTRODUCTION AND TOOLS FOR rDNA TECHNOLOGY 9 hours
General requirements for performing -rDNA technology experiments; Restriction endonucleases and methylases - DNA ligase, Klenow enzyme - T4 DNA polymerase- Cohesive and blunt end ligation –Linkers –Adaptors -Homopolymeric tailing -Labelling of DNA-Nick Translation-Random priming, Radioactive and non-radioactive probes -Hybridization techniques: northern, southern, south-western and far-western and colony hybridization -Fluorescence *in situ* hybridization.

UNIT 2: DIFFERENT TYPES OF VECTORS 9 hours
Plasmids- Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs -Expression vectors, pMal, GST, pET-based vectors; Intein-based vectors; Mammalian expression and replicating vectors; Baculovirus and *Pichia* vectors system - plant based vectors - Ti and Ri plasmids as vectors- shuttle vectors.

UNIT 3: DIFFERENT TYPES OF PCR TECHNIQUES 9 hours
Principles of PCR- Primer design- Fidelity of thermostable enzymes - DNA polymerases-Types of PCR – Multiplex-Nested-Reverse transcription PCR-Real time PCR, Touchdown PCR-Hot start PCR-Colony PCR -Asymmetric PCR

UNIT 4: cDNA ANALYSIS **9 hours**

Insertion of foreign DNA into host cells –Transformation – Electroporation-Transfection; Construction of libraries - cDNA synthesis - cDNA and genomic libraries - Construction of microarrays – Genomic arrays - cDNA arrays and oligo arrays

UNIT 5: GENE SILENCING AND GENOME EDITING TECHNOLOGIES 9 hours

Gene silencing techniques-Introduction to siRNA- siRNA technology - Micro RNA; Construction of siRNA vectors - Principle and application of gene silencing- Gene knockouts and gene therapy- Creation of transgenic plants- Debate over GM crops-Transgenics - Creation of transgenic and knock-out mice -Introduction to genome editing by CRISPR-CAS.

TEXT BOOK

1. S. Primrose, R. Twyman, B. Old, and G. Bertola, Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited. 7th Edition, 2006.

REFERENCES

1. Green, M. R., & Sambrook, J., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, NY, 2012.

BIT18R6014	BIOPOLYMER TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Outcomes:

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

CO1: Understand the definition, sources and types of biopolymers

CO2: Elaborate the methods in biosynthesis and production of various biopolymers

CO3: Describe how biopolymers are analyzed and characterized using various techniques.

CO4: Analyse the biodegradability of various biopolymers

CO5: Portray the applications of biopolymers in diverse fields.

CO and PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	L	L	H	H	M
CO2	H	L	H	H	M
CO3	H	L	M	H	H
CO4	H	M	H	H	H
CO5	H	L	H	H	H

Unit 1: INTRODUCTION **9 hours**

Definition of Biopolymers and types of biopolymers, Basic information on the biopolymers derived from natural sources: starch, cellulose, hemicellulose, chitin, Hyaluronic Acid and other polysaccharides from plants, microbes and algae; lignin, keratin, collagen, Types of bioplastics, such as starch based, cellulose based plastics and some aliphatic polyesters (PLA, PHB), polyamides

Unit 2: TECHNOLOGY OF BIOPOLYMER PRODUCTION 9 hours
Microbial polysaccharides (cellulose, dextran, pullulan, xanthan, gellan gum etc.), and polyhydroxyalkanoate, bioactive polymer (heparin), biosynthesis of the polymer, Production of biopolymers by fermentation- Enzymatic synthesis of polyesters, polyamides, polyphenols and other polymers- Polymers obtained by classical synthesis from monomers obtained by biological methods.

Unit 3: BIOPOLYMER: CHARACTERIZATION AND ANALYSIS 9 hours
XRD, FTIR, DSC, TGA- Surface analysis methods applied to the study of biomaterials (SEM, TEM, AFM)- Mechanical test: wear, friction, flexibility, fatigue, etc.

Unit 4: BIODEGRADABILITY 9 hours
Measuring of biodegradation of polymers- Enzyme assays, Plate test, Respiratory test, Natural environment, Field trial, Gas evolution test (CO_2& CH_4)

Unit 5: APPLICATIONS OF BIOPOLYMERS 9 hours
Chemical and enzymatic modification of biopolymers, Processing and application of biopolymers, Applications in areas of biomedicine: cosmetic implants, controlled drug delivery system, artificial heart valves, bone replacement, artificial organs, dental applications, membranes, water treatment, food packaging, in constructions

TEXT AND REFERENCE BOOKS:

1. Susheel Kalia S, Avérous L. (Editors) Biopolymers: Biomedical and Environmental Applications, Scrivener Publishing LLC, 2011.
2. Walton, A and Blackwell J, Biopolymers, Academic Press, 1st Edition, 1973.
3. Williams, R (Editor) Surface Modification of Biomaterials, Methods Analysis and Applications**,** Woodhead Publishing, 1st Edition, 2010.
4. Bastioli, C, Handbook of Biodegradable Polymers, Smithers Rapra Press, 2005.

<table>
<tr><td rowspan="2">BIT18R6015</td><td rowspan="2">ALGAL BIOTECHNOLOGY</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
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Course Outcomes:
After successful completion of course, the students will be able to,
CO1: Understand the classification, occurrence, distribution and characteristics of algae.
CO2: Describe the metabolic reactions in algae including photosynthesis, electron transport and Light reactions
CO3: Elaborate the role of algae in environment.
CO4: Portray the methods of culturing microalgae
CO5: Describe the applications of algae in diverse areas

CO and PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	H		H	H
CO2	H	L		H	H
CO3	H	H	H	H	H
CO4	H	L		H	H
CO5	H	H	H	H	H

Unit 1: ALGAE – OVERVIEW 9 hours

A general account and classification of Algae – Occurrence and distribution - range of thallus organization – Pigmentation – flagellation - reserve food – Reproduction (vegetative – asexual - sexual); Lifecycle patterns – - salient features of algal divisions (Harold C Bold) – phylogeny - Fossil algae. Photo - chromatic effects and their adaptations of microalgae.

Unit 2: METABOLISM OF ALGAE 9 hours

Photosynthesis: Light Dependent Reactions, PSI and PSII: Structure, Function and Organization, ATP-Synthase, ETC Components, Electron Transport (The Z-Scheme), Proton Transport (Mechanism of Photosynthetic Phosphorylation, Pigment Distribution in PSI and PSII Super-Complexes of Algal Division), Light-Independent Reactions, RuBisCO, Calvin Benson Bassham Cycle, Carboxylation, Reduction, Regeneration, Photorespiration

Unit 3: ROLE OF ALGAE 9 hours

Energy Relationships in Photosynthesis: The Balance Sheet, Biogeochemical Role of Algae., Roles of Algae in Biogeochemistry, Limiting Nutrients, Algae and the Phosphorus Cycle, Algae and the Nitrogen Cycle, Algae and the Silicon Cycle, Algae and the Sulfur Cycle, Algae and the Oxygen/Carbon Cycles.

Unit 4: CULTIVATION OF MICROALGAE 9 hours

Microalgae – Basic cultural techniques. Indoor (photobioreactor) and open pond mass culture methods, enrichment of micro algae with micronutrients. Biotechnological approaches for production of value-added products: Single cell protein, vitamins, minerals and omega 3 fatty acids from micro algae

Unit 5: DOWNSTREAM PROCESSING AND APPLICATIONS 9 hours

Economic importance of algae: Algae as food and fodder, use of algae in agriculture and space research, commercial products of algae: Agar Agar, Alginates, Carrageenin, diatomite, mucilage, minerals and elements - Algae in medicine and biofuels. Industrial Utilization of microalgal Fatty Acids. Toxins and Public Health. Bio-fertilizers and pesticides, Bioremediation and Bioactive Compounds. Production of Nutraceuticals and Antioxidant. Genetic manipulation in algae for value added products.

Texts Book:

1. Gordon**,** Richard**,** Seckbach, Joseph (Eds.). The Science of Algal Fuels Phycology, Geology, Biophotonics, Genomics and Nanotechnology, Springer, ISBN 978-94-007-5110-1. 2012.

2. R.A. Andersen, Algal Culturing Techniques, Academic Press, Burlington, San Diego, London. ISBN: 9780080456508, 2005.
3. H. D. Kumar and H. N. Singh. A Textbook on Algae. Macmillan Publishers Limited, 2nd edition,1979.

Reference Books

1. Harold C. Bold and Michaels, J. Wynne, Introduction to the Algae. Prentice Hall, Inc, New Jersey, 1985.
2. Morris, J., An Introduction to the Algae. Cambridge University Press, U.K. 1986
3. Round, F.E., The Biology of Algae. Cambridge University Press, U.K., 1986.

BIT18R6097	MINI PROJECT	L	T	P	Credit
		0	0	6	2

Course Outcomes:

At the end of the course, students would be able to

CO1: Identify and formulate problem statements related to research.

CO2: Collect and analyze relevant scientific literature.

CO3: Acquire experience and knowledge to work in a professional setup.

CO4: Conduct experiments and interpret the results.

CO5: Present data systematically and write a dissertation at the end of the project

CO and PO Mapping:

CO/PO	1	2	3	4	5
CO1	H	H	H	H	H
CO2	H	H	H	H	H
CO3	H	H	H	H	H
CO4	H	M	H	H	H
CO5	M	H	H	H	H

BIT18R6098	PROJECT PHASE I	L	T	P	Credit
		0	0	18	10

Course objective(s):

To integrate the knowledge gained from various courses and apply them in doing a project work.

Course Outcomes:

At the end of the course, students would be able to:

CO1: Identify and formulate problem statements to address research.

CO2: Collect and analyze relevant scientific literature.

CO3: Understand the rationale of experimental design and Conduct experiments in selected areas of biotechnology.

CO4: Present authentic experimental work in a coherent sequence using modern presentation tools.

CO5: Document data meticulously and write a dissertation at the end of the project.

CO and PO Mapping:

CO/PO	1	2	3	4	5
CO1	H	H	H	H	H
CO2	H	H	H	H	H
CO3	H	H	H	H	H
CO4	H	M	H	H	H
CO5	M	H	H	H	H

BIT18R6099	PROJECT PHASE II	L	T	P	Credit
		0	0	30	16

Course Objective:

To provide sufficient hands-on learning experience and enhance the technical skill sets in the chosen field of biotechnology.

Course Outcomes:

At the end of the course, students would be able to

CO1: Identify and formulate problem statements to address research.

CO2: Collect and analyze relevant scientific literature.

CO3: Understand the rationale of experimental design and conduct experiments in selected areas of biotechnology.

CO4: Present authentic experimental work in a coherent sequence using modern presentation tools.

CO5: Document data meticulously and write a dissertation at the end of the project.

CO and PO Mapping:

CO/PO	1	2	3	4	5
CO1	H	H	H	H	H
CO2	H	H	H	H	H
CO3	H	H	H	H	H
CO4	H	M	H	H	H
CO5	M	H	H	H	H