NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL



RULES AND REGULATIONS

SCHEME OF INSTRUCTION AND SYLLABI

for M.Tech. Biotechnology Program

(Effective from 2021-22)

DEPARTMENT OF BIOTECHNOLOGY

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society.

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for a globally competitive environment.
- Allowing stakeholders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department

Department of Biotechnology

VISION

To become a global centre of excellence for quality education, research, technological services and entrepreneurship in emerging areas of biotechnology.

MISSION

- Providing a quality education in pursuit of knowledge that establishes a strong foundation for understanding developments in the rapidly advancing field of biotechnology through research and instruction.
- Promoting scientific discovery and development in diversified fields of biotechnology through a fusion between engineering and life sciences.
- Fostering relationships with institutes of higher learning and research, alumni and industries.

Department of Biotechnology:

Brief about the Department:

The Department of Biotechnology was established in the year 2006 with a B.Tech program in Biotechnology with an intake of 60 candidates. It also offers doctoral program in Biotechnology. The department also launched its M.Tech program in Biotechnology from July 2020. The Department has highly motivated, experienced and young faculty members carrying out research in key areas of biotechnology.

At present 20 Ph.D. scholars are carrying out their research work under the guidance of faculty in the department. The department has sophisticated instruments such as RT-PCR, HPLC, FPLC and GC etc. The department has already executed research projects and at present it has 10 research projects funded by DBT/DST/CSIR, Govt. of India. The Department extensively collaborates with premier research institutes in India and abroad to transform research outcomes into integrated commercial technologies.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Biotechnology
M.Tech.	Biotechnology
Ph.D.	Biotechnology

Note: Refer to the following weblink for Rules and Regulations of M.Tech. program:
https://www.nitw.ac.in/main/MTechProgram/rulesandregulations/

M.Tech. – Biotechnology

Program Educational Objectives

PEO-1	Pursue successful industrial, academic and research careers in specialized fields of Biotechnology.
PEO-2	Apply the knowledge of advanced topics in Biotechnology to meet industrial and research needs.
PEO-3	Use modern computational, analytical tools and techniques to address biotechnological challenges.
PEO-4	Identify issues related to ethics, society, safety and environment in the context of biotechnology applications.
PEO-5	Engage in lifelong learning for career and professional growth for society and the environment.

Program Articulation Matrix

PEO / Mission Statements	PEO1	PEO2	PEO3	PEO4	PEO5
Providing a quality education in pursuit of knowledge that establishes a strong foundation for understanding developments in the rapidly advancing field of biotechnology through research and instruction.	2	2	3	3	3
Promoting scientific discovery and development in diversified fields of biotechnology through a fusion between engineering and life sciences.	2	2	2	3	3
Fostering relationships with institutes of higher learning and research, alumni and industries.	1	1	2	2	2

1-Slightly; 2-Moderately; 3-Substantially

M.Tech. – Biotechnology

Program Outcomes

PO-1	Carryout independent research, investigation and development work to solve practical problems.
PO-2	Write and present a substantial technical report and document.
PO-3	Design modern Biotechnological methods for bioprocess plant and allied processes.
PO-4	Apply research-based knowledge and biotechnological methods to investigate complex biological problems.
PO-5	Identify measures for energy, environment, health, safety and society following ethical principles.
PO-6	Pursue life-long learning to enhance knowledge and skills for professional advancement.

SCHEME OF INSTRUCTION

M.Tech. Biotechnology – Course Structure

I - Year, I – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	BT5101	Advanced Bioprocess Engineering	3	0	0	3	PCC
2	BT5102	Molecular and Cellular Biology	3	0	0	3	PCC
3	BT5103	Biostatistics and Quantitative Biology	3	0	0	3	PCC
4	BT5104	Advanced Stem cell and Tissue Engineering	3	0	0	3	PCC
5		Elective - I	3	0	0	3	PEC
6		Elective - II	3	0	0	3	PEC
7	BT5105	Biotechnology Laboratory - I	0	0	4	2	PCC
8	BT5106	Biotechnology Laboratory - II	0	0	4	2	PCC
9	BT5148	Seminar - I	0	0	2	1	SEM
		Total	**18**	**0**	**10**	**23**	

I - Year, II – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	BT5151	Advanced Bioseparation Technology	3	0	0	3	PCC
2	BT5152	Advanced Modelling, Simulation and optimization of Bioprocesses	3	0	0	3	PCC
3	BT5153	Advanced Recombinant DNA Technology	3	0	0	3	PCC
4	BT5154	Biocomputing and Computational Biology	3	0	0	3	PCC
5		Elective – III	3	0	0	3	PEC
6		Elective – IV	3	0	0	3	PEC
7	BT5155	Biotechnology Laboratory – III	0	0	4	2	PCC
8	BT5156	Biotechnology Laboratory – IV	0	0	4	2	PCC
9	BT5198	Seminar – II	0	0	2	1	SEM
		Total	**18**	**0**	**10**	**23**	

Note: PCC – Professional Core Courses
PEC – Professional Elective Courses
SEM – Seminar

SCHEME OF INSTRUCTION

M.Tech. Biotechnology – Course Structure

II - Year, I – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	BT6147	Comprehensive Viva-Voce	-	-	-	2	CVV
2	BT6149	Dissertation Work Part-A	-	-	-	12	DW
		Total				**14**	

II - Year, II – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	BT6199	Dissertation Work Part-B	-	-	-	20	DW
		Total				**20**	

Note: CVV – Comprehensive Viva-Voce
DW – Dissertation Work

Credits in Each Semester					
Cat. Code	**Sem-I**	**Sem-II**	**Sem-III**	**Sem-IV**	**Total**
PCC	16	16	0	0	32
PEC	6	6	0	0	12
CVV	0	0	2	0	2
DW	0	0	12	20	32
SEM	1	1	0	0	2
Total	**23**	**23**	**14**	**20**	**80**

Professional Elective Courses

Elective-I (I Year, I Semester)		
S. No.	**Course Code**	**Course**
1	BT5111	Advanced Fermentation Technology
2	BT5112	Molecular Virology
3	BT5113	Protein Engineering
4	BT5114	Nutrigenomics
5	BT5115	OMICS Technology
Elective-II (I Year, I Semester)		
S. No.	**Course Code**	**Course**
1	BT5116	Biotechnology for Waste Management
2	BT5117	Advanced Metabolic Pathway Engineering
3	BT5118	Infection and Immunity
4	BT5119	Phytochemicals and Molecular Techniques in Plant Biotechnology
5	BT5120	Statistical Programming
6	BT5121	Systems and Synthetic Biology
7	BT5122	Advanced Plant and Animal Biotechnology
Elective-III (I Year, II Semester)		
S. No.	**Course Code**	**Course**
1	BT5161	Enzyme Engineering
2	BT5162	Pharmaceutical Biotechnology
3	BT5163	Molecular Pathogenesis
4	BT5164	Agricultural Biotechnology
5	BT5165	Machine Learning
6	BT5166	Drug and Vaccine Informatics
Elective-IV (I Year, II Semester)		
S. No.	**Course Code**	**Course**
1	BT5167	Bioeconomy and Biorefineries
2	BT5168	Advanced Bioprocess Control & Instrumentation
3	BT5169	Advanced Biomaterials Engineering
4	BT5170	Medical Biotechnology
5	BT5171	Nanotechnology for Medicine and Healthcare
6	BT5172	Entrepreneurship, IPR, Biosafety & Bioethics
7	BT5173	Research Methodology
8	BT5174	Applied Environmental Microbiology

DETAILED SYLLABUS

M.Tech. – Biotechnology

Course Code: BT5101	Advanced Bioprocess Engineering	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Apply Kinetics and Statistics to bioprocesses.
CO2	Design different types of bioreactors.
CO3	Develop the bioprocess economics to industrial bioprocesses.
CO4	Analyze the bioreactors' detailed design of bioprocess industry equipment.
CO5	Perform experiments of enzyme kinetics and production of Bioproducts.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	-	-	-
CO2	-	1	-	3	-	-
CO3	-	-	1	-	-	3
CO4	-	2	-	-	3	-
CO5	-	-	3	-	-	2

Syllabus:

Introduction to Bioprocess Engineering and Bioreactors: Basics of Bioprocess Engineering; Principles of microbial growth kinetics; Michaelis-Menten kinetics; Effect of pH and temperature on Enzyme Kinetics; Immobilized enzymes: methods, Production of Industrial enzymes.

Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation.

Mass transfer in Bioreactors: Sterilization, Rheology of fermentation fluids and Mass Transfer in Bioreactors, Sterilization of media; Batch kinetics; Continuous kinetics; Sterilization of Air; Theory of fibrous filters; Chemical and Radiation Sterilization.

Rheology of fermentation fluids; Nature of fluids, Types of flow; Agitation; Power requirement for gassed and un-gassed systems; Mass transfer in Bioreactors; Mass Transfer Coefficients; Oxygen Transfer in Bioreactors; Factors affect the Oxygen Transfer Methodology.

Learning Resources:

Text Books:

1. Bioprocess Engineering: Basic Concepts, Michael Shuler and Fikret Kargi, Prentice Hall, Englewood Cliffs, NJ, 2002, 2nd Edition.
2. Bioprocess Engineering Principles, Pauline Doran, Academic Press, 2018, Latest Edition.

Reference Books:

1. Basic Biotechnology, Colin Ratledge, Bjorn Kristiansen, Cambridge University Press, 2001, 2nd Edition.
2. Bioseparations Science and Engineering, Roger Harrison et al., Oxford University Press, 2003, 4th Edition.

Online Resources:

1. https://www.kgi.edu/news/what-is-bioprocess-engineering/

Course Code: BT5102	Molecular and Cellular Biology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Illustrate mechanisms of Intracellular compartments and protein sorting in the cell.
CO2	Describe the intracellular molecular signaling pathways.
CO3	Explain the molecular mechanisms of cell cycle and cell division.
CO4	Compare the molecular mechanism of cell death and cell renewal process.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	-	1	2
CO2	-	-	2	1	-	-
CO3	3	2	2	3	1	3
CO4	3	2	2	3	3	3

Syllabus:

The molecular membrane structure of the cell: The molecular mechanisms of Intracellular compartments and protein sorting, The transport of molecules between the nucleus and the cytosol, The molecular mechanisms of endocytosis, and exocytosis.

Cell signaling: Principles of cell signaling, signaling through G-protein-coupled receptors, signaling through enzyme coupled receptors, alternative signaling routes in gene regulation secondary messengers, signal integration.

Cell cycle and Cell division: Overview of cell cycle; the molecular mechanism of cell-cycle control system: G1 phase, S phase, G2 phase, mitosis, cytokinesis, meiosis, control of cell division and cell cycle checkpoints.

Cell death and cell renewal: Programmed cell death by apoptosis, Cell-surface death receptors activate the extrinsic pathway of cell death, Molecular basis of cancer, cell division and cancer development, Stem cells and cell differentiation.

Learning Resources:

Text Books:

1. Molecular Cell Biology, Berk A, Kaiser CA, Harvey L, Amon A, Ploe H, Bretscher A, Krieger M, Martin KC, WH Freeman, 2016, 8th Edition.

Reference Books:

1. The Cell: A Molecular Approach, Geoffrey M. Cooper, Robert E. Hausman, ASM Press, 2009, 5th Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/106/102106025/

Course Code: BT5103	Biostatistics & Quantitative Biology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Summarize biological data using statistical methods.
CO2	Explain the application of statistical models in biology.
CO3	Analyze genome data using statistical methods.
CO4	Apply the principles of quantitative genetics to understand the complex traits.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	2	-	3
CO2	3	-	-	2	-	3
CO3	3	-	-	2	-	3
CO4	3	1	-	3	-	3

Syllabus:

Summarization of biological data and significance test: Visualization of biological data, numerical summary measures of data, dispersion, theoretical probability distributions, Central limit theorem, Testing hypothesis (Parametric and Non-parametric), chi-square test, sign test, Wilcoxon sign rank test, Wilcoxon rank-sum test, methods of sampling.

Statistical model building: Introduction of Bayesian statistic, evaluation of Bayesian model: Sensitivity and Specificity, Finding relationship in biological data: correlation analysis (Pearson and spearman), regression analysis: Linear, multiple and logistic regression, regression analysis with categorical variable; Principal component analysis, cluster analysis.

Quantitative approaches in Genotype-Phenotype prediction: Experimental approach in quantitative biology and high-throughput experiments; Introduction to genomic data, Differential gene expression analysis; Gene set enrichment analysis; concept of genetic correlation. Genotype-Phenotype Relationships, Mendelian Genetics: Patterns of Inheritance and Single-Gene Disorders, beyond Mendelian Genetics.

Linkage analysis and biomarker identification: Linkage analysis, linkage disequilibrium in human genome, quantitative trait locus (QTL), genetic polymorphism and Genome-wide association studies, case study: use of statistical tools for biomarker identification.

*Along with theory classes, Hands-on sessions will be conducted.

Learning Resources:

Text Books:

1. Pharmaceutical Statistics, Practical and Clinical Applications, Sanford Bolton, Charles Bon, Marcel Dekker, Inc. U.S.A. 2004, 4th Edition.
2. Handbook of Statistical Genomics, David J. Balding, Martin Bishop, Chris Cannings, Wiley, 2007, 3rd Edition.

Reference Books:

1. The Fundamentals of Modern Statistical Genetics (Statistics for Biology and Health), Nan M. Laird, Christoph Lange, Springer, 2011.
2. Intuitive Biostatistics, Motulsky H, Oxford University Press, 2013, 3rd Edition.

Online Resources:

1. Biological data sciences in genome research, Genome Res. 2015. 25: 1417-1422 (https://genome.cshlp.org/content/25/10/1417.full)
2. 10 years of GWAS discovery: biology, function, and translation. Am. J. Hum. Genet. 101, 5–22 (2017). https://www.cell.com/ajhg/fulltext/S0002-9297(17)30240-9 (https://www.sciencedirect.com/science/article/pii/S0002929717302409)
3. Chapter 11: Genome-Wide Association Studies, PLoS Comput Biol 8(12): e1002822 (https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1002822).
4. Patterns of linkage disequilibrium in the human genome, Nature Review Genetics, 3, 299–309 (2002) (https://www.nature.com/articles/nrg777).

Course Code: BT5104	Advanced Stem cell and Tissue Engineering	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Classify different stem cells.
CO2	Explain the construction of connective tissues.
CO3	Select the process for isolation and identification of stem cells.
CO4	Analyze the construction of biomaterials.
CO5	Identify regulatory considerations for design of biomaterials.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	-	1	-
CO2	1	3	-	1	2	-
CO3	2	-	3	1	-	2
CO4	-	2	-	1	3	-
CO5	-	1	-	2	3	2

Syllabus:

Cell culture medium: Introduction to the balanced salt solutions and growth medium, Chemical, physical and metabolic functions of different constituents of culture medium, role of carbon-di- oxide and role of serum and its supplements in maintaining cells in culture medium, serum and protein free defined media and their application.

Maintenance of Cells: Biology and characterization of cultured cells, Maintenance and management of cell lines, Scale-up of animal cells in culture, Scale-up of anchorage dependent cells and suspension cultures: Cell isolation and selection; cell preservation.

Stem Cells: Definition, classification and sources, Properties and application of embryonic stem cells, Cell adhesion – Extracellular matrix, *In vitro* cell proliferation, Induced pluripotent stem cells.

Tissue Engineering: Elements of biomaterials, Mechanical concepts in biomaterials, Characterization of biomaterials, Methods for the determination of biocompatibility, Basic techniques to manufacture scaffolds, Bioreactor for tissue engineering –Design and scale up, Hollow fiber systems, Microcarrier based systems.

Learning Resources:

Text Books:

1. Essentials of Stem Cell Biology, Robert Lanza, Anthony Atala, 2013, 3rd Edition.
2. Stem Cell Biology, David Gottlieb, Cold Spring Harbor, 2002.

Reference Books:

1. Tissue Engineering, Clemens van Blitterswijk, Academic Press, 2008.
2. Principles of Tissue Engineering, Robert Lanza, Academic Press Inc, 2020, 5th Edition.

Online Resources:

1. https://www.sciencedirect.com/science/article/pii/S1672022915000029
2. https://www.nibib.nih.gov/science-education/science-topics/tissue-engineering-and-regenerative-medicine

Course Code: BT5105	Biotechnology Laboratory - I	Credits 0-0-4: 2

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Find the effect of pH and temperature on enzyme activity.
CO2	Measure the Monod parameters in batch, fed-batch and continuous cultures.
CO3	Estimate MM constants.
CO4	Prepare nutrient media and learn sterilization methods in plant tissue culture.
CO5	Develop the *in vitro* techniques to regenerate plants and produce synseeds from somatic embryos.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	3	2	2
CO2	3	2	3	2	1	3
CO3	1	1	2	1	3	3
CO4	3	1	1	2	3	3
CO5	3	2	1	3	2	3

Syllabus:

Advanced Bioprocess Engineering Laboratory:

1. Effect of Enzyme concentration on kinetics of invertase enzyme
2. Measurement of cell biomass concentration
3. Effect of Substrate concentration on kinetics of invertase enzyme
4. Yogurt fermentation.
5. Effect of pH on kinetics of invertase enzyme
6. Effect of Temperature on kinetics of invertase enzyme

Plant Biotechnology Laboratory:

1. Preparation of tissue culture media (MS and B5).
2. Surface sterilization of plant explants.
3. Micropropagation through induction of multiple shoots by using shoot tips and auxiliary buds.
4. Callus propagation, organogenesis, transfer of plants to soil.
5. Encapsulation of somatic embryos and synseed production.

Learning Resources:

Text Books:

1. Bioprocess Engineering Principles, Paulin M. Doran, Elsevier Science & Technology Books, 2008.
2. Plant Cell and Tissue Culture. A Laboratory manual, Reinert J and Yeoman MM, Springer, 2000.

Reference Books:

1. Bioprocess Engineering: Basic Concepts, Shuler M. and Kargi F, PHI, 2012.
2. Introduction to Plant Tissue Culture, M.K Razdhan, Oxford & Ibh, January 2010.
3. You Too Can Do Plant Tissue Culture, Jose Kudakasseril, Notion Press, 2021,1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/103/102103016/

Course Code: BT5106	Biotechnology Laboratory - II	Credits 0-0-4: 2

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Prepare animal cell culture media and perform basic animal cell culture techniques.
CO2	Compose monolayer and suspension culture.
CO3	Manage cryopreserved cells.
CO4	Demonstrate scaffold fabrication.
CO5	Evaluate the cytotoxicity of drugs in animal cell culture systems.
CO6	Generate genetically engineered animal cells by gene transfer.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	3	-	2
CO2	2	-	3	-	1	2
CO3	3	2	-	2	1	2
CO4	3	2	-	3	-	2
CO5	3	2	-	3	1	2
CO6	3	2	-	2	1	2

Syllabus:

Advanced Stem cells and Tissue Engineering Laboratory:

1. Media Preparation.
2. Monolayer and suspension culture scale up.
3. Morphology of cells in culture.
4. Viability testing, Trypsinization.
5. Maintenance and Cryopreservation of cells.
6. Scaffold fabrication methods: salt leaching, lyophilization, biodegradation, biocompatibility, mechanical strength and porosity studies of scaffolds.

Animal Biotechnology Laboratory:

1. Revival of cryopreserved animal cells.
2. Animal cell counting and trypan blue viability assay.
3. Measurement of cellular metabolic activity by MTT assay.
4. Measurement of cellular cytotoxicity by LDH assay.
5. Detection of apoptosis by dual acridine orange/ethidium bromide (AO/EB) staining.
6. Transfection of animal cells with recombinant plasmid.

Learning Resources:

Text Books:

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, R. Ian Freshney, Wiley-Blackwell, 2016, 7th Edition.

Reference Books:

1. Animal Cell Culture & Technology, M. Butler, Taylor & Francis, 2003, 2nd Edition.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_me04/preview

Course code: BT5148	Seminar - I	Credits 0-0-2: 1

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Identify and chose appropriate topic of relevance.
CO2	Assimilate literature on technical articles of specified topic.
CO3	Write technical report.
CO4	Present a technical talk on the chosen topic.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	-	3	-	3
CO2	2	3	-	2	-	2
CO3	1	3	-	1	-	2
CO4	2	2	-	2	-	3

Syllabus:

There is no specific syllabus for this course. Student can choose any topic, of his / her choice, pertaining to Biotechnology. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Biotechnology for choosing their seminar topics. Student should review minimum of 10 to 15 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

Learning Resources:

Text Books:

1. Biotechnology Journals.
2. Research Articles / Reports available on Internet.
3. Biotechnology Textbooks, Handbooks.

Course code: BT5151	Advanced Bioseparation Technology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Categorize techniques used in bioseparation processes.
CO2	Design optimal bioseparation processes.
CO3	Analyze the principles of major unit operations and analytical techniques used in Bioseparations.
CO4	Select appropriate technique and equipment for a given bioseparation process.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	2	-
CO2	1	-	3	1	-	-
CO3	1	2	-	3	2	2
CO4	-	1	2	2	1	3

Syllabus:

Introduction to Bioseparation Process: Role and importance of bioseparations in biotechnological processes-Problems and requirements of bioproduct purification- Cost-cutting strategies- Characteristics of biological mixtures - Classification of bioproducts - Biological activity, Analysis of purity-Process economics. A few case studies.

Isolation of Products: Cell disruption methods for intracellular products – physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear) – chemical methods (alkali, detergents)– enzymatic methods. Centrifugation, different types of centrifuges and their theory. Membrane based separations micro and ultra-filtration theory, design and configuration of Membrane separation equipment and applications.

Chromatography: Classification of chromatographic techniques, size exclusion, ion exchange, hydrophobic, affinity chromatography – Scale-up of chromatography – Process considerations in Preparative liquid chromatography and HPLC, FPLC, Precipitation, Dialysis; Extraction and Drying. storage and packaging. Case studies.

Analysis of purified molecules: UV-Visible Spectroscopy, application of electrophoresis in analyzing macromolecules, 2D gel electrophoresis, MALDI-TOF, Enzyme and cell immobilization techniques.

Learning Resources:

Text Books:

1. Protein Downstream Processing: Nikolaos E. Labrou, Humana. 2020, 2nd Edition.
2. Bioseparations: Principles and Techniques, Sivasankar, Prentice Hall India Learning Private Limited, 2010.

Reference Books:

1. Product Recovery in Bioprocess technology, BIOTOL series, Butterworth Heinemann, 2010.
2. Principles of Downstream processing, Ronald & J. Lee, Wiley Publications, 2007.
3. Bioseparations: Science and Engineering, Harrison RG, Oxford University Press, 2003.

Online Resources:

1. https://onlinelibrary.wiley.com/doi/10.1002/elsc.201600033

Course Code: BT5152	Advanced Modelling, Simulation and Optimization of Bioprocesses	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Explain the Modelling Principles.
CO2	Evaluate kinetic parameters for Biological models.
CO3	Generate models for batch, semi continuous or fed batch operations.
CO4	Develop regression models and neural networks models.
CO5	Perform Design of Experiments.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	3	3
CO2	2	1	2	2	3	3
CO3	3	3	3	2	3	2
CO4	3	2	2	2	1	1
CO5	1	2	3	2	1	2

Syllabus:

Bioreactor Modeling: Introduction of Bioprocess modeling, Use of models, Classification of models, Definition of Lumped and Distributed Parameter Models, Modeling Principles, Steps in Modeling, Fundamental Laws Used in Process Modeling, First-Order Systems, Second-Order Systems, Complexity of the Model, Parameter Sensitivity.

Modeling approaches: General aspects of the modelling approach, general modelling procedure, simulation tools. Mass balance models: Batch operation, semi continuous, continuous operation, summary and comparison, biological kinetics, Michaelis-Menten equation, other enzyme kinetic models, kinetics of anaerobic degradation. biomass productivity.

Simulation examples: Biological reaction Dynamic simulation of batch, fed-batch steady and transient culture metabolism, Simulation of biological models using Berkeley Madonna, batch fermentation, chemostat fermentation, fed batch fermentation, kinetics of enzyme action, repeated fed batch culture, Lineweaver-Burk plot, steady-state chemostat, variable volume fermentation.

Optimization of Bioprocess: OFAT method, Response Surface Methodology and Neural network modeling and validation. Evaluation of model kinetic parameters, Bioprocess modeling using Superpro designer – Case studies.

Learning Resources:

Text Books:

1. Bioreactors: Analysis and design, Panda, Tapobrata, McGraw-Hill Education, 2011.

2. Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples, I. J. Dunn, E. Heinzle, J. Ingham, J. E. Pfenosil, Wiley-Vch Verlag GmbH & Co. KGaA, Weinheitn, 2003.

Reference Books:

1. Modeling and Control of Fermentation Processes, J.R. Leigh, Peter Peregrinus, London, 2000.

2. Handbook of food and bioprocess modelling techniques, Shyam S. Sablani et al., Taylor & Francis Group, LLC, 2006.

Online Resources:

1. http://38.100.110.143/model/index.html
2. https://www.youtube.com/watch?v=qAMhDOFdW3g
3. https://www.youtube.com/watch?v=OhFot__I_x8
4. https://www.youtube.com/watch?v=cSUPrSkemgo

Course Code: BT5153	Advanced Recombinant DNA Technology	Credits 3-0-0: 3

Prerequisites: Molecular Biology, Genetic Engineering

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Design suitable cloning strategies for bacteria, plant and animal cells.
CO2	Apply appropriate mutagenesis approach to generate desired genetic combination.
CO3	Devise cloning strategies for heterologous gene expression in bacteria and yeast.
CO4	Use appropriate gene transfer techniques for animals and plants.
CO5	Develop transgenic organisms for the benefit of society.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	1	3
CO2	3	2	2	3	3	3
CO3	3	2	2	3	1	3
CO4	3	2	2	3	3	3
CO5	3	2	3	3	3	3

Syllabus:

Molecular cloning and advanced vectors: Plasmids and Phage Vectors, Cosmids, phagemid and other advanced vectors: phage-derived PACs, BACs, YACs and gateway cloning vectors—cloning strategies.

Mutagenesis strategies: Changing genes – site directed mutagenesis, reverse mutagenesis, cassette mutagenesis. gene knockout, RNA interference, CRISPR-Cas9, transposon mutagenesis.

Cloning strategies in bacteria other than *E. coli* and yeasts: Cloning in gram negative and gram- positive bacteria—Different vectors and suitable cloning strategies. Integrative vectors for fungi, Yeast promoter systems for overexpression of genes, multipurpose vectors.

Gene transfer strategies: Gene transfer strategies and generation of transgenic plants and animals—Transfection techniques and use of suitable selectable markers, overexpression of transgenes, Agrobacterium mediated transformation, Direct DNA transfer method and use of viral vectors for plants and animals, Advance transgenic technologies.

Learning Resources:

Text Books:

1. Principles of gene manipulation and Genomics, Old RW and Primrose SB, Blackwell Scientific Publications, 2006, 7th Edition.
2. Advanced Bacterial Genetics: Use of Transposons and Phage for Genomic Engineering,

Kelly T. Hughes and Stanley R. Maloy, Methods in Enzymology, Vol. 421, Academic Press, 2007.

Reference Books:

1. Gene Cloning and DNA Analysis: An Introduction, Brown TA. Blackwell Publishing, 2016, 7th Edition.
2. Molecular Cloning: A Laboratory Manual. (3 volume set). Green, M. R. and Sambrook, J. Cold Spring Harbor Lab Press, 2012, 4th Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/103/102103013/

Course Code: BT5154	Biocomputing and Computational Biology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Comprehend the implications of sequence bioinformatic techniques in biotechnology.
CO2	Accomplish bioinformatics tasks in the Linux operating environment.
CO3	Execute programs in Python language for bioinformatic applications.
CO4	Implement programs in SQL language to access and manipulate databases.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	-	-	-
CO2	-	2	-	-	-	-
CO3	-	-	3	-	-	-
CO4	-	-	-	-	-	3

Syllabus:

Computational Biology: Introduction, Biological Databases and Data Storage, BLAST: BLAST Algorithm, Protein Analysis: Hydrophobicity Plotting, Protein Secondary Structure Prediction, Sequence Alignment: Dynamic Programming, Patterns in the Data: Protein Sequence Motifs, Position-Specific Weight Matrices, RNA Structure Prediction, Phylogenetics: Phylogenetic Analysis, Probability: All Mutations are not Equal (-ly Probable), Generating PAM and BLOSUM Substitution Matrices,

Biocomputing: Introduction to Unix/Linux: Context, Logging In, The Command Line and Filesystem, Working with Files and Directories, Permissions and Executables, Installing (Bioinformatics) Software, Command Line BLAST, The Standard Streams, Sorting, First and Last Lines, Rows and Columns, Patterns (Regular Expressions), Miscellanea.

Biocomputing: Programming in Python: Introduction to python, history of python, python features, writing python program, values and variables; numeric values, expressions, variables; legal variables, assigning values to variables, operators; arithmetic, assignment, comparison, logical and bitwise. List Methods, Tuples: Immutable Sequences, The tuple Function, Basic Tuple Operations. Control flow statements: simple if statement, if/else statement, if/elif statement, nested if statement, conditional expressions, while loop, for loop, continue and break statements.

Biocomputing: Programming in SQL: Introduction to SQL, role of SQL, SQL Features and Benefits, creation of Simple Database, Retrieving Data, Summarizing Data, Adding Data to the Database, Deleting Data, Updating the Database, Protecting Data, SQL Basics; Statements, Names, Table Names, Column Names, Data Types, Constants, Numeric Constants, String Constants, Date and Time Constants, Symbolic Constants, Built-In Functions, Missing Data (NULL Values), execution of Queries, Creation of Biological databases.

Learning Resources:

Text Books:

1. Computational Biology: A Hypertextbook, Scott T. Kelley, Dennis Didulo, ASM Press, 2018, 1st Edition.
2. Python for Bioinformatics, Jason Kinser, Jones and Bartlett Publishers, 2010, 1st Edition.
3. SQL: The Complete Reference, James R Groff, Paul N. Weinberg and Andy Oppel, McGraw-Hill Education, 2009, 3rd Edition.

Reference Books:

1. A Primer for Computational Biology, Shawn T. O'Neil, Oregon State University Press, 2017, 1st Edition.
2. Hands-on Database: An Introduction to Database Design and Development, Steve Conger, Pearson Education, 2015, 2nd Edition.

Online Resources:

1.https://open.oregonstate.education/computationalbiology
2.http://rosalind.info/problems/locations/

Course Code: BT5155	Biotechnology Laboratory - III	Credits 0-0-4: 2

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Collect extracts of intra and extracellular proteins from biological samples.
CO2	Practice cell destruction by sonication and enzymatic methods.
CO3	Analyze proteins using chromatographic techniques.
CO4	Examine gene expression by qRT-PCR and reporter assay.
CO5	Design mutation in specific location of the gene to obtain desired function.
CO6	Construct genetically engineered cells and produce recombinant products.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	-	-	1
CO2	2	3	-	-	-	-
CO3	1	-	-	3	1	2
CO4	3	2	2	3	2	3
CO5	3	1	2	3	2	3
CO6	3	2	3	3	2	3

Syllabus:

Advanced Bioseparation Technology Laboratory:

1. Extraction of Intracellular Proteins by cell disruption methods.
2. Centrifugation methods.
3. Precipitation methods.
4. Lyophilization.
5. Ion exchange chromatography.
6. Gel filtration chromatography.
7. Affinity chromatography.
8. NATIVE electrophoresis.
9. FPLC, HPLC, GC.

Advanced Recombinant DNA Technology Laboratory:

1. qRT-PCR to analyze gene expression.
2. Introducing mutation into a gene by DpnI method.
3. Assessing the promoter activity by reporter assay.
4. Gene deletion by homologous recombination method.
5. Integration of a foreign gene into the genome using integration vector.
6. Overexpression of a foreign gene under optimized environmental conditions.

Learning Resources:

Text Books:

1. Downstream Processing of Proteins: Methods and Protocols, Mohamed A. Desai, Humana Press, 2012.
2. Molecular Cloning: A Laboratory Manual (3 volume set). Green, M. R. and Sambrook, J. Cold Spring Harbor Laboratory Press, 2012, 4th Edition.

Reference Books:

1. Protein Purification: Principles and Practice, Springer, 2014, 3rd Edition.
2. Principles of Gene Manipulation and Genomics. Old, R. W. and Primrose, S. B. Blackwell Scientific Publications. 2006, 7th Edition.

Online Resources:

1. NPTEL: Biotechnology - Genetic Engineering & Applications

Course Code: BT5156	Biotechnology Laboratory - IV	Credits 0-0-4: 2

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Write and execute a program in Berkely Madonna software.
CO2	Develop program & simulate Batch, Semi continuous and Fed Batch reactors.
CO3	Design & simulate models for bioreactors using superpro designer.
CO4	Analyze biological sequence data using various computational biology tools.
CO5	Prepare basic programs in Python.
CO6	Apply the basics of SQL to programming.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	-	1	-
CO2	-	-	2	-	1	-
CO3	3	2	-	2	-	2
CO4	3	2	-	2	-	2
CO5	3	3	-	-	3	3
CO6	2	3	-	-	3	2

Syllabus:

Advanced Modelling, Simulation and Optimization of Bioprocesses Laboratory:

1. Simulation of Bioreactor models by Berkely Madonna software.
2. Demonstration of SuperPro Designer Software.
3. Bioprocess flow sheet development.
4. Material and Energy balance calculations for the production of a bio-product.
5. Designing, Modelling and Simulation of Batch, continuous Stirred Tank Bioreactor.
6. Economic analysis.

Biocomputing and Computational Biology Laboratory:

1. Sequence analysis with BLAST Suite & running NCBI BLAST in Batch Mode.
2. Protein analysis of Aquaporin-5.
3. Restriction Mapping and Genetic Engineering Tools: Spider silk: a work flow of analysis.
4. Exploration of short nucleotide sequences: Identifying inhibitor of kappa light polypeptide gene enhancer in beta-cells (IKBKAP).
5. Multiple sequence alignment and phylogenetic analysis of FOXP2.
6. Genome analysis of Olfactory genes using UCSC Genome Browser.
7. MicroRNAs and pathway analysis of GDF8.
8. Program to perform arithmetic calculations in python.
9. Program to find the length of the given sequence.
10. Program to reverse and concatenate the given sequence and apply string concepts.
11. Program to complement and reverse complement of DNA sequence.
12. Program to translation of central dogma.
13. Develop a Program for creation of biological database with fields (Accession number, gene name, protein name, expression system, sequence length).

Learning Resources:

Text Books:

1. Bioreactors: Analysis and design, Panda, Tapobrata, McGraw-Hill Education, 2011.
2. Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples, I. J. Dunn, E. Heinzle, J. Ingham, J. E. Pfenosil, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheitn, 2003.
3. Practical Bioinformatics, Michael Agostino, Garland Science, 2012, 1st Edition.
4. Python for Bioinformatics, Jason M. Kinser, Jones and Bartlett Publishers, 2020.
5. Hands-On Database: An Introduction to Database Design and Development, Steve Conger, Pearson Education, Inc., 2012.

Reference Books:

1. Modeling and Control of fermentation Processes, J.R. Leigh, Peter Peregrinus, London, 2000.
2. Handbook of food and bioprocess modelling techniques, Shyam S. Sablani et al., Taylor & Francis Group, LLC, 2006.
3. A Primer for Computational Biology, Shawn T. O'Neil, Oregon State University Press, 2017, 1st Edition.
4. Python for Bioinformatics, Jason M. Kinser, Jones and Bartlett Publishers, 2020.
5. SQL: The Complete Reference, Paul Weinberg, James Groff, Andrew Oppel, Mc Graw Hill, 2010, 3rd Edition.

Online Sources:

1. http://38.100.110.143/model/index.html
2. https://www.youtube.com/watch?v=qAMhDOFdW3g
3. https://nptel.ac.in/noc/courses/noc21/SEM2/noc21-cs75/

Course code: BT5198	Seminar - II	Credits 0-0-2: 1

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Identify and chose appropriate topic of relevance.
CO2	Assimilate literature on technical articles of specified topic.
CO3	Write technical report.
CO4	Present a technical talk on the chosen topic.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	-	3	-	3
CO2	2	3	-	2	-	2
CO3	1	3	-	1	-	2
CO4	2	2	-	2	-	3

Syllabus:

There is no specific syllabus for this course. Student can choose any topic, of his / her choice, pertaining to Biotechnology. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Biotechnology for choosing their seminar topics. Student should review minimum of 10 to 15 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

Learning Resources:

Text Books:

1. Biotechnology Journals.
2. Research Articles / Reports available on Internet.
3. Biotechnology Textbooks, Handbooks.

Course Code: BT5111	Advanced Fermentation Technology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:
At the end of the course, the student will be able to:

CO1	Explain the chronological development of the fermentation industry.
CO2	Classify bioreactors.
CO3	Demonstrate Fermentation kinetics.
CO4	Formulate media for fermentation.
CO5	Explain design and construction of bioreactor.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	2	3
CO2	2	1	3	2	3	3
CO3	2	1	2	3	2	2
CO4	2	2	3	2	2	2
CO5	2	2	3	2	2	2

Syllabus:

Introduction to Fermentation Process: Overview of fermentation industry, general requirements of fermentation processes, Gaden's Fermentation classification, basic configuration of fermenter and ancillaries, The isolation, preservation and improvement of industrially important microorganisms, Microbial growth kinetics.

Media for industrial fermentations: Media formulation and preparations-complex and synthetic media, sterilization, Development of Inocula for industrial fermentations.

Design of a Fermenter: Design and operation of fermenters, Basic concepts for selection of a reactor, Rheology of fermenter, Instrumentation and control, Aeration and agitation.

Bioreactor Selection and Application: Fermentation processes for production of SCP, enzymes, amino acids, citric acid, penicillin, Effluent treatment, and Fermentation economics.

Learning Resources:

Text Books:
1. Principles of Fermentation Technology, Stanbury, P.E., Whitaker, A., Hall, S., Butterworth Heinemann, 2002, 2nd Edition.
2. Comprehensive Biotechnology, Moo-Young, M., Pergamon Press, 2004, 1st Edition (Reprint).

Reference Books:
1. Biochemical Engineering Fundamentals, Bailey, J.E. and Ollis D.F., Mcgraw Hill Higher Education, 2001, 2nd Edition.
2. Principles of Microbe and Cell Cultivation, Pirt, S. J., Wiley, John & Sons, 2005, 1st Edition.

Online Resources:

1. https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-bt20/
2. https://nptel.ac.in/courses/102/106/102106053/

Course Code: BT5112	Molecular Virology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Illustrate the Structure and Replication of viruses.
CO2	Understand and explain the complexity of Viral Genomes.
CO3	Outline the molecular mechanisms used by viruses to exploit their hosts.
CO4	Study the mechanisms of pathogenesis, epidemiology and control.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	1	-	-	1	1
CO2	-	2	-	-	1	1
CO3	-	1	-	-	2	1
CO4	-	1	-	2	-	1

Syllabus:

Introduction to Virology, Classification & Structure, & Replication: Basic characteristics and classification of viruses, virion structure (non-enveloped viruses, enveloped viruses), viral replication: overview, recognition & attachment to host cell, penetration.

Structure and Complexity of Viral Genomes: Introduction to viral genomes, virus mutants, suppression, genetic interactions between viruses, non-genetic interactions between viruses, large' DNA genomes, small' DNA genomes, positive-strand RNA viruses, negative-strand RNA viruses, segmented and multipartite virus genomes, reverse transcription and transposition.

Mechanisms of Viral Pathogenesis & Control: Acquisition & infection of target tissue, cytopathogenesis (lytic & nonlytic infections, oncogenic viruses), human host defenses against viral infection, immunopathology, epidemiology of viral diseases, control of viral spread.

Learning Resources:

Text Books:

1. Principles of Virology, Volume 1: Molecular Biology, S.J. Flint, V.R. Racaniello, G. F. Rall and A.M. Skalka, ASM Press, 2015.

Reference Books:

1. Principles of Molecular Virology, Alan J. Cann, Elsevier Academic Press, 2015, 6th Edition.
2. Introduction to Modern Virology, Nigel Dimmock, Andrew Easton and Keith Leppard, Wiley-Blackwell, 2016, 7th Edition.

Online Resources:

1. http://www.virology.net

Course Code: BT5113	Protein Engineering	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Relate Protein structure to protein function.
CO2	Comprehend protein folding pathways.
CO3	Select appropriate techniques for protein engineering.
CO4	Understand the protein characterization techniques.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1	3	-	-
CO2	2	3	1	3	-	-
CO3	2	3	2	3	1	1
CO4	2	3	1	3	-	-

Syllabus:

The Relationship between Protein Structure and Function: Protein synthesis, protein structure, families of protein structures: alpha, alpha/beta, beta, etc., protein function and structure-function relationships. Ramachandran plot; Motifs of protein structures and their packing. Protein folding pathways in prokaryotes and eukaryotes; Structure of chaperones and role of chaperones in protein folding; Folding of single domain and multi-domain proteins; Inclusion bodies and recovery of active proteins.

Methods in Protein Engineering: Strategies for protein engineering; Protein Engineering with Random Mutation, Protein Engineering with site-specific mutation, PCR based methods for engineering proteins, Role of low-fidelity enzymes in protein engineering; Gene shuffling and Directed evolution of proteins; Antibody engineering.

Structural Analysis of Proteins: Similar structure and function of homologous proteins; Role of multiple alignment; Homology and ab- initio method for protein structure prediction; Phage display systems; Rational protein design, different databases and their uses.

Proteome analysis: Introduction to the concept of proteome, components of proteomics, proteomic analysis, importance of proteomics in biological functions, protein identification, protein arrays, protein chips and applications, cross linking methods, affinity methods, yeast hybrid systems, isotope labeling, protein identification with two-dimensional gel electrophoresis data and mass spectrometry data. Functional proteomics tools.

Learning Resources:

Text Books:

1. Protein Engineering and Design, Anton Torres, Syrawood Publishing House, 2017.
2. Protein Engineering: Design, Selection & Applications (Protein Biochemistry, Synthesis, Structure and Cellular Functions), Mallorie N Sheehan, Nova Science Publishers Inc; UK, 2011.

Reference Books:

1. Protein engineering in Industrial biotechnology, Ed. Lilia Alberghina, Harwood Academic Publishers, 2002.
2. Proteomics: Protein Sequence to Function, Pennington, S.R and M.J. Dunn, Viva Books, 2002.

Online Resources:

1. https://www.springer.com/gp/book/9783030568979
2. https://www.science.gov/topicpages/p/protein+engineering+study.html

Course Code: BT5114	Nutrigenomics	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Demonstrate the concepts of Nutrition and Genomics.
CO2	Explain the role of gene and its expressions in diseases.
CO3	Analyze the nutritional genomics in association with human diseases and metabolisms.
CO4	Evaluate the nutritional data using computational tools.

Course Articulation matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	1	1	3
CO2	2	2	3	1	3	2
CO3	2	2	3	2	3	3
CO4	2	2	2	1	3	3

Syllabus:

Introduction to Nutrigenomics: Genome, genomics, nutrigenetics, nutrigenomics: A brief introduction, primer on genomics and beyond, Genome-wide association studies. Nutrigenomics: measuring nutrition-responsive genome activity, Transcriptomics, Proteomics, and Metabolomics. Nutrigenetics: measuring interindividual response to nutrients, Genetic responses to individual nutrients.

Expression of Nutrigenomics: Nutrient–Gene Interactions: Lunasin Structure and Function, Lunasin Treatment of Prostate Cancer and Gene Expression Profiling, Lunasin-Induced Gene Expression Profiles, Genes Involved in Suppression of Cell Proliferation, Genes Involved in Protein Degradation, Modulation of Gene Expression by Dietary Iron, Zinc, Selenium.

Nutritional Metabolic responses: Nutrigenomic approaches to understand the transcriptional and metabolic responses, obesity, anti-obesity action of Luteolin, Inflammation, and Cardiometabolic syndrome. Applications of genomics and bioinformatics in nutrition. Nutritional genomics: cellular signaling and molecular targets, Vitamin-D on cardiovascular disease.

Advances in Nutrigenomics: Personalization the norm of Nutrigenomics, Public Health and Nutrigenomics, Public Health Applications of Nutrigenomics, Implementation and Evaluation. Biocomputation and analysis of complex datasets in Nutritional Genomics: Nutritional Genomics: Part of High-Throughput Biology, Proteomics and Metabolomics Data, Sources of Complexity in Nutritional Genomics, Data Sets in Nutritional Genomics, Level of Complexity in Gene Expression Experiments.

Learning Resources:

Text Books:

1. Nutritional Genomics, Jim Kaput Raymond L. Rodriguez, John Wiley & Sons, Inc, 2019.
2. Nutritional genomics, Wiyane R Bildak, Raymond L Rodriguez, CRC Press, Taylor & Francis Group, 2012.

Reference Books:

1. Nutrition and Genomics Issues of Ethics, Law, Regulation and Communication, David Castle, Nola M, Academic Press, Elsevier, 2014.
2. Nutrigenomics, Gerald Rimbach, Jurgen Fuchs, Lester Packer, CRC Press, Taylor & Francis Group, 2018.

Course Code: BT5115	OMICS Technology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Appraise the techniques and instrumentation used in genomics and transcriptomics research.
CO2	Recognize suitable proteomic techniques and instrumentation for identification, purification, and modifications of proteins.
CO3	Design a biological experiment by applying suitable genomics, transcriptomics and metabolomics technology.
CO4	Apply the precise proteomics technology to answer a specific biological question.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	2	-	2
CO2	-	-	-	2	-	2
CO3	2	3	-	3	-	2
CO4	2	-	-	3	-	3

Syllabus:

Genomics: Introduction to “omics” technology; genome sequence databases, cell lysis and nucleic acid extraction; conventional nucleic acid sequencing; next-generation sequencing technologies and instrumentation, fragmentation; single molecule real-time sequencing technology; strategies for aiding in analyses of data; microarray fabrication, hybridization & scanning equipment.

Proteomics and Transcriptomics: Protein purification techniques, analysis of protein – protein interactions, basic and high throughput techniques, analysis of proteome –Electrophoresis, proteome databases, BLAST and sequence alignments; gel imaging equipment and analysis software, mass spectrometry for gel-based proteomics, gel-independent separation & quantitative proteomics.

Metabolomics: Basic sample preparation methods, extraction, derivatization method for lipidomics; Extraction and analysis of metabolites; targeted metabolomics, assay development for small molecules, metabolomics data analysis, analysis of metabolic pathways, structural conformation of metabolites.

Learning Resources:

Text Books:

1. Introduction to Genomics, Lesk A, Oxford University Press, 2017, 3rd Edition.

2. Introducing Proteomics: From Concepts to Sample Separation, Mass Spectrometry and Data Analysis, Lovric, J, Wiley-Blackwell, 2011, 11th Edition.

Reference Books:

1. Principles of gene manipulation and genomics, Primrose SB, Twyman RM, John Wiley Blackwell, 2014, 7th Edition.

2. Genomics and Proteomics: Principles, Technologies & applications, Thangadurai D., Sangeetha J, CRC Press, 2015, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102103017/
2. https://nptel.ac.in/courses/102104056/
3. https://nptel.ac.in/courses/102101007/6

Course Code: BT5116	Biotechnology for Waste Management	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Identify salient aspects of biological processes for waste management.
CO2	Design of bioreactors for waste treatment.
CO3	Apply principles of bioremediation for handling waste.
CO4	Develop suitable biotechnological processes for hazardous waste management.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	2	3
CO2	2	1	3	2	3	3
CO3	2	1	2	3	2	2
CO4	2	2	3	2	2	2

Syllabus:

Introduction: Waste collection, Strategies for sustainable waste management, Microbial growth kinetics, Bioreactors for waste treatment, Instrumentation and control, Aeration and agitation, Effluent treatment. Bio-industrial waste management.

Bioreactors for wastewater treatment: Introduction to bioreactor, Aerobic System Biological processes for domestic and industrial wastewater treatments; Aerobic systems - activated sludge process, trickling filters, biological filters, rotating biological contractors (RBC), Fluidized bed reactor (FBR), expanded bed reactor, Inverse fluidized bed biofilm reactor (IFBBR) packed bed reactors air- sparged reactors.

Bioremediation: The characterization and bioremediation of contaminated sites, the superfund law, preliminary site assessment, site investigation techniques, and bioremediation technologies; and monitoring requirements. *In-situ* Bioremediation of Contaminated Ground Water; Phytoremediation of Contaminated Soil and Ground Water at Hazardous Waste Sites.

Hazardous Waste Management: Introduction - Xenobiotic compounds, recalcitrance. Hazardous wastes - biodegradation of Xenobiotics, Biological detoxification - market for hazardous waste management, biotechnology application to hazardous waste management. Introduction to Solid, Hazardous, and Radioactive Waste Disposal and Containment. Design of Landfill, Municipal Solid Waste Landfills.

Learning Resources:

Text Books:

1. Introduction to Hazardous Waste Management, Clifton Vanguilder, Mercury Learning & Information 2011, 1st Edition.
2. Microbial biodegradation and bioremediation, Surajit Das, Elsevier, 2014, 1st Edition.

Reference Books:

1. Wastewater Engineering Treatment and Reuse, Metcalf & Eddy, McGraw Hill Inc, India, 2017, 4th Edition.
2. Environmental biotechnology: principles and applications. Rittmann, B. E., & McCarty, P. L., Tata McGraw-Hill Education, 2020, 2nd Edition.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_bt41/preview
2. https://onlinecourses.nptel.ac.in/noc19_ce32/preview

Course Code: BT5117	Advanced Metabolic Pathway Engineering	Credits 3-0-0: 3

Prerequisites: Biochemistry, Genetic engineering

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Explain the concepts of cellular reactions and regulations.
CO2	Identify the appropriate metabolic pathways to produce a desired product or remediate a toxin.
CO3	Illustrate potential metabolic engineering strategies using quantitative metabolic models modeling.
CO4	Develop metabolic flux models using available tools and software and perform simulations.
CO5	Design effective strategies to implement genetic manipulations.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	1	-	2
CO2	3	-	2	3	-	2
CO3	3	-	1	2	-	2
CO4	3	-	2	3	-	2
CO5	3	-	1	3	-	2

Syllabus:

Basic concepts of Metabolic Engineering: Review of Cellular Metabolism: Transport Processes, Fueling Reactions, Biosynthetic Reactions, Polymerization, growth energetics, Comprehensive Models for Cellular Reactions. Comprehensive Models for Cellular Reactions: Stoichiometry of Cellular Reactions, Reaction Rates, Dynamic Mass Balances, Yield Coefficients and Linear Rate Equations. Material Balances and Data Consistency: The Black Box Model, Elemental Balances, Heat Balance, Analysis of Overdetermined Systems, Identification of Gross Measurement Errors.

Metabolic regulation and application: Metabolic regulation network at enzyme level and whole cell level, Basic concept and successful application of metabolic engineering with examples such as strain improvement, product overproduction, byproduct minimization, extension of substrate utilization range and product spectrum, xenobiotic degradation.

Systems metabolic modeling: Metabolic pathway synthesis algorithm, Metabolic flux analysis and its application, Concepts of Flux balance analysis (FBA), Regulatory on-off Minimization, (ROOM) and Minimization of metabolic adjustments (MOMA), Elementary mode, analysis, Extreme pathways, Determination of metabolic fluxes by isotope labeling, Metabolic control analysis (MCA).

Genome engineering of microbes: *In vivo* strain engineering: Rational and inverse metabolic engineering, strain engineering using In-out method, Recombineering method, zinc finger nucleases (ZFNs), Transcription activator-like effector nuclease (TALENs), CRISPR- CAS9 method.

Learning Resources:

Text Books:

1. Metabolic Engineering Principles and Methodologies, G. Stephanopoulos, A. Aristidou and J. Nielsen, Academic Press, 1998, 1st Edition.
2. Metabolic pathway engineering handbook: Fundamentals, C.S. Smolke, CRC press, 2010 and 1st Edition.

Reference Books:

1. An Introduction to Metabolic and Cellular Engineering, Miguel Antonio Aon, Sonia Cortassa, Alberto Alvaro Iglesias, David Lloyd, World scientific publishing company, 2002, 1st Edition.
2. Metabolic Engineering, Y. Lee and E. T. Papoutsakis, Marcel Dekker, 1999, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/105/102105086/

Course Code: BT5118	Infection and Immunity	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand basic concepts of the immune system.
CO2	Identify the cellular and molecular basis of immune responsiveness.
CO3	Describe the roles of the immune system in both maintaining health and contributing to disease.
CO4	Apply knowledge of immune responses to various pathogens by integrating genomics and proteomics with bioinformatics strategies.
CO5	Design the vaccine using bioinformatics tools.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	1	-	3
CO2	1	-	-	2	-	2
CO3	2	-	-	3	-	3
CO4	2	-	-	3	3	2
CO5	2	-	-	3	2	3

Syllabus:

Introduction to Immune System: Innate and Adaptive Immunity, Cells and Organs of the Immune system, Structure, Function and Classification of Immunoglobulins, Monoclonal and Polyclonal antibodies, Antibody Diversity, Basis of antigen-antibody interactions, B-cell and T-cell maturation, MHC: Antigen processing and presentation, B-cell and T-cell activation.

Immunodeficiency disorders: Immune response to infectious diseases - viral, bacterial, parasitic infections; Immunodiagnosis of infectious diseases, Immune response in Autoimmune disease and Cancer, AIDS and other immunodeficiencies, Immune system aging - Cardinal features, Age-related changes in B- cell and T-cell functional responses, Age-associated changes in lymphoid organs and soluble immunological mediators, Mechanisms and therapeutic targets.

Immunological Databases: SYFPEITHI-MHC-presented epitopes, IMGT, the international ImMunoGeneTics information system, IMGT ontology, IMGT Choreography, T-cell and B-cell epitope databases, Peptide and Allergen databases, Features of ADB, Allergome, SDAP, IEDB analysis, MHCBN-comprehensive database of MHC binding and non-binding peptides.

From immunome to Vaccine: Principles and strategy for developing vaccines, Prediction of immunogenicity, Vaccine design tools, Reverse Vaccinology, Immunomics-based vaccinology, Peptides with Antimicrobial Activity or Antibiotic Peptides, Future of Computational Modelling and Prediction Systems in Clinical Immunology.

Learning Resources:

Text Books:

1. Kuby Immunology, Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen, 2018, 8th Edition.
2. Immunoinformatics: Bioinformatic Strategies for Better Understanding of Immune Function, Gregory R Bock, Jamie A Goode, Wiley, 2003.

Reference Books:

1. Roitt's Essential Immunology, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 2017, 13th Edition.
2. Immunoinformatics (Immunomics Reviews), Christian Schonbach, Shoba Ranganathan, Vladimir Brusic, USA: Humana Press, 2010.

Online Resources:

1. https://www.nature.com/nri/
2. https://www.frontiersin.org/journals/immunology
3. https://www.journals.elsevier.com/immunoinformatics

Course Code: BT5119	Phytochemicals and Molecular Techniques in Plant Biotechnology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Comprehend the overview of occurring natural plant products.
CO2	Study of primary and secondary metabolites derivatives for medicinal use.
CO3	Understand the extraction of phytochemicals in natural and therapeutic applications.
CO4	Illustrate molecular techniques for extraction from plant-based sources and gene editing.
CO5	Apply the analytical methods for quantification of plant-based sources.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	-	-	3
CO2	-	3	-	-	-	3
CO3	2	-	-	3	-	3
CO4	1	-	-	3	2	-
CO5	-	-	-	3	2	-

Syllabus:

Introduction to Plant natural products: Introduction to plant natural products-history, classification, list of floral resources, general detection, extraction and characterization procedures. Anthocyanin: Sources, classification, extraction, isolation, identification and therapeutic applications.

Lignans, terepenes, saponins& volatile oils: Lignans and Neolignans: classification, natural sources and pharmacological applications, Terpenes: Classification, biosynthesis, origin of 5-carbons isoprene unit, head to tail coupling and tail-to tail coupling of isoprene units, Saponins: Sources, classification, physical and biological properties, Volatile Oils: Classifications, sources, medicinal and non-medicinal uses.

Phyto chemicals used in drug discovery: Drugs containing Tannins-Introduction, Definition, Classification, Nomenclature, Sources (*Terminalia chebula, Terminalia bellerica, Terminalia arjuna, Acacia catechu*), Drugs containing Resins: Introduction, Definition, Classification, Nomenclature, Sources (*Zingiber officinale*, *Capsicum annum*, *Curcuma longa*, *Cannabis sativa, Commifera mukul*), Natural products as markers for new drug discovery: The Role of natural products as potential new drug discovery. The Role of natural products chemistry in drug discovery.

Molecular techniques used in Plant Biotechnology: Isolation, purification and quantification of genomic DNA and RNA from plant extract, electrophoresis, PAGE, PCR, RT-PCR, Inter simple sequence repeats, sequence characterized amplified region, Genome Editing tools-ZFNs, TALENs and CRISPR-Cas9 used in plants Different methods (including industrial) for isolation and estimation of phytoconstituents from the following drugs with special emphasis

on HPLC and HPTLC: Instrumentation of HPLC, Preparative and micropore columns, Reverse phase columns, Mobile phase, stationary phase and detectors used in HPLC, HPTLC.

Learning Resources:

Text Books:

1. Organic chemistry - Chemistry of organic natural products. Vol. II. Goel publishing house, Meerut Agarwal, O. P, 2002.
2. Phytochemical methods – a guide to modern techniques of plant analysis, Chapman and Hall. Harborne, J. B. 2001, 3rd Edition.

Reference Books:

1. Molecular Markers and Plant Biotechnology, Rukum S Tomar, Monoj V. Parakhia, Sunil Patel, B.A Golakiy, New India Publishing Agency, 2010, 7th Edition.

Online Resources:

1. https://www.nature.com/subjects/plant-molecular-biology
2. https://link.springer.com/book

Course Code: BT5120	Statistical Programming	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Summarize basic principles of R-programming.
CO2	Construct and operate matrices, data frames and arrays.
CO3	Develop programs using R for file and data handling.
CO4	Analyze various data import, export concepts and data processing techniques.
CO5	Create various histograms using biological data.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	-	3	3
CO2	2	2	3	3	3	3
CO3	3	3	3	2	3	3
CO4	3	3	2	3	3	3
CO5	4	2	-	4	2	4

Syllabus:

Vectors in R: History and Overview of R, Introduction to S-programming, R- programming, Philosophy of S, R-studio, Packages in R, basic features of R; Calculating with R, Named storage, Functions, Listing the objects in the workspace, logical operators, arithmetic operators, boolean operators, vectors, extracting elements from vectors, vector arithmetic, simple patterned vectors, character vectors, factors, logical vector, named vectors.

Matrices in R: Matrices; Creating a matrix, Naming rows and columns, Subsetting a matrix, unit matrix, cross matrix, Computing covariance and correlation matrix, Using apply-family functions Lapply, sapply, vapply, mapply, dates and times, Built-in examples. Data frames, Creating a data frame, filtering data, Setting values, Setting values as a list, Setting values as a matrix factors, useful functions for data frames.

Matrices in Arrays: Loading and writing data on disk Arrays, array indexing, subsections of an array, the array function, mixed vector and array arithmetic generalized transpose of an array, matrix facilities, matrix multiplication, linear equations and inversion, eigen values and eigen vectors, the concatenation function, frequency tables from factors.

Data Handling: Reading and writing text-format data in a file, Importing data, Importing data using built-in functions, Importing data using the readr package, Reading and writing Excel/CSV worksheets, Reading and writing native data files, Reading and writing a single object in native format, Saving and restoring the working environment Loading built-in datasets. Visualizing data; Creating scatter plots, Customizing chart elements, Plotting lines in multiple periods, Plotting lines with points, Plotting a multi-series, Creating bar charts, pie

charts, histogram and density plots, box plots.

Learning Resources:

Text Books:

1. Learning R Programming, Kun Ren, Packt Publishing Ltd. 2012.
2. Beginning R, an introduction to statistical programming, Larry Pace, A press, 2018.

Reference Books:

1. Hands-On Programming with R: Write Your Own Functions and Simulations, Garrett Grolemund, O'Reilly, 2014.
2. R Programming for Bioinformatics, Robert Gentleman, CRC press, 2007.

Course Code: BT5121	Systems and Synthetic Biology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand the basic systems modelling and synthetic biology principles.
CO2	Identify the basic network biology concepts and principles.
CO3	Apply the modelling techniques to Develop systems biology based mathematical models independently.
CO4	Develop predictive systems models and synthetic networks independently.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	2	1	1
CO2	3	-	-	2	1	1
CO3	3	3	3	2	3	2
CO4	3	3	3	2	3	2

Syllabus:

Introduction: Systems biology basics; high throughput experimental techniques: gene array, protein array, two-hybrid systems; steepness, threshold phenomenon, ultra-sensitivity, steady state, dynamic (spatial-temporal) and stochastic models in system biology; Nonlinear Dynamics Analysis: Stability Analysis.

Molecular Networks: Types; Network Motifs and Dynamics; Simple network, Feed forward Loops, Single input modules, Emergent properties of networks: adaptation, homeostasis, bistability, oscillation.

Systems Models and Advancements: *E. coli* chemotaxis, Robustness patterning in fruit fly, Oscillatory systems - Circadian rhythm, synthetic oscillator; Bistable systems – Lac/ Trp Operon, Type II diabetes model, Synthetic switch, SIR models for disease; Whole cell modelling, Systems pharmacology, Personalized models, Systems Biology and Artificial Intelligence.

Synthetic biology: Introduction, application and tools; Simple synthetic networks – building and analysis; Synthetic switch and oscillators; Programmed population control, Synthetic chromosome, Synthetic bacterial cell; Synthetic Metabolic Pathway Engineering of microbes for various applications.

Learning Resources:

Text Books:

1. Introduction to Systems Biology, Uri Alon, Chapman & Hall/CRC Mathematical and Computational Biology, 2007.
2. Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts, Zoltan Szallasi, Jörg Stelling, Vipul Periwal, Princeton Hall of India, ISBN: 978-81-203-3172-3, 2007.

Reference Books:

1. Computational Analysis of Biochemical Systems, Eberhard O. Voit, Cambridge University Press, 2000, 1st Edition.
2. An Introduction to computational Systems Biology: System-level modelling of cellular networks, Karthick Raman, CRC press, Taylor and Francis Group, 2021.

Online Resources:

1. https://nptel.ac.in/courses/102/106/102106068/
2. https://www.ibiology.org/playlists/synthetic-biology/
3. Relevant research articles

Course Code: BT5122	Advanced Plant and Animal Biotechnology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Describe the nutrient requirements and factors influencing the plant tissue culture.
CO2	Illustrate the Invitro techniques and transgenic approach for improving the crop quality, secondary metabolites.
CO3	Explain advanced cell culture systems for use in *in-vitro* toxicity studies.
CO4	Demonstrate the importance of genetically engineered animal models for applications in drug development and disease research.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	2	1	3
CO2	3	1	3	3	2	3
CO3	3	-	-	3	1	3
CO4	3	1	-	3	2	3

Syllabus:

Plant Technology: Introduction to plant cell and tissue culture, types of tissue culture media composition and preparation. Cytodifferentiation *in-vitro*, Callus and Organogenesis, Micropropagation, Somaclonal variation and application in crop improvement, Applications of genetic engineering in plants, cellular totipotency, Somatic Embryogenesis and Artificial Seed Production, Cell Suspension Cultures, Cryopreservation of plant cells.

Plant transformation technologies: Direct methods of gene transfer, Agrobacterium Mediated Gene Transfer in plants, Ti and Ri Plasmids, screening of high yielding Cell Lines and extraction of Valuable Industrial Products, Bioreactors used in Plant Engineering, Biotic and Abiotic Elicitor- induction, Biotransformation using plant cell cultures, Secondary Metabolite production, Molecular farming and its applications (Plantibodies).

Animal cell culture and its applications: Introduction to animal cell culture, media preparation and sterilization methods, subculture and maintenance of cell lines, measurement of cell death: cytotoxicity and cell viability assays, cloning and gene transfer to animal cells, spheroid cultures, limitations of two-dimensional cell culture, three-dimensional cell culture systems and its applications. applications of animal cell culture: recombinant products, hybridoma technology.

Animal models in disease research: animal models in modern biomedical research, transgenic animals, criteria for choosing an animal model, animal models for tuberculosis, neurodegenerative disorders, rheumatoid arthritis, cancer research, animal models for enteric diseases, translational significance of animal models, epigenetics and animal models,

knockout mice, issues and concerns.

Learning Resources:

Text Books:

1. Plant Tissue Culture: Theory and Practice, Bhojwani. S.S. & Razdan. M.K, Elsevier Science Publishers, New York, 2005, 5th Edition.
2. Animal Biotechnology: Models in Discovery and Translation, Ashish Verma, Anchal Singh, Academic Press, 2019, 2nd Edition.

Reference Books:

1. Practical Application of Plant Molecular Biology. RJ Henry, Garland Science, 2012, 2nd Edition.
2. Animal Cell Culture & Technology, M. Butler, Taylor & Francis, 2003, 2nd Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/103/102103016/
2. https://onlinecourses.nptel.ac.in/noc20_me04/preview

Course Code: BT5161	Enzyme Engineering	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand the basic principles underlying enzyme mechanism.
CO2	Apply the concept for the process development of novel enzymes.
CO3	Illustrate enzymatic assays and enzyme reaction kinetics.
CO4	Identify molecular tools for improving the performance of enzymes.
CO5	Explain the industrial application of enzymes.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	1	-	2
CO2	3	3	3	3	-	2
CO3	3	-	2	3	-	2
CO4	3	2	-	3	-	2
CO5	-	-	2	-	3	2

Syllabus:

Basic concepts of enzyme: Introduction and chemical nature of enzymes, naming and classification of enzymes, specificity of enzyme action, monomeric and oligomeric enzymes, chemical nature of enzyme catalysis. Production of enzymes: Fermentation and separation process.

Enzyme kinetics: derivation of Michaelis-Menten equation for single substrate enzyme and concept of Km and Vmax, and Enzyme turnover number (Kcat), type of inhibitors and their effects on the enzyme catalyzed reaction, Kinetics of multi-substrate reaction: Sequential reactions and ping-pong reactions. Multienzyme complex and multifunctional enzymes, Kinetics of allosteric enzymes and enzyme regulation. Factors affecting enzyme activity. Methods to improve enzyme performance: Mechanisms and methods of stabilizing enzyme; Immobilization of enzymes; Immobilized enzyme reactions; Mass transfer, Film and Pore diffusion effects on kinetics of immobilized enzyme reactions. Reactor systems and engineering consideration.

Enhancing the performance of enzymes: Enzymes in non-conventional media, Regeneration of cofactors; Enzymes in nonconventional media. Protein engineering of enzymes: Site directed mutagenesis; Random mutagenesis; Rational design; De novo enzyme design; Designer enzymes; Engineering substrate specificity and enantioselectivity of enzymes

Applications of enzymes: commercial biotransformation processes, synthesis of fine chemicals, food processing, biofuels, energy and environment; Bio-medical applications of enzymes; Design of enzyme electrodes; Biosensors.

Learning Resources:

Text Books:

1. Enzymes Biochemistry, Biotechnology, Clinical chemistry, Palmer, T., Bonner, P., Wood Head Publishing, 2008, 2nd Edition.
2. Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, Irwin H. Segel, Wiley India Pvt. Ltd, 2010, 2nd Edition.

Reference Books:

1. Fundamentals of Enzyme Engineering, Yoo, Y.J., Feng, Y., Kim, Y.-H., Yagonia, C, Springer, 2017, 1st Edition.
2. Understanding Enzymes: Function, Design, Engineering, and Analysis, Allan Svendsen, CRC Press, Taylor & Francis Group, 2016, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/102/102102033/

Course Code: BT5162	Pharmaceutical Biotechnology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Explain the strategies in new drug discovery process.
CO2	Extend the knowledge of pharmaceutical manufacturing.
CO3	Outline the concept of pharmacodynamics and pharmacokinetics.
CO4	Analyze the quality control procedures in the production of various biopharmaceuticals.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	2	3
CO2	2	1	3	2	3	3
CO3	2	1	2	3	2	2
CO4	2	2	3	2	2	2

Syllabus:

Introduction to Pharmaceutical Biotechnology: An overview and history of biopharmaceutical industry, The business and the future of Biopharmaceuticals, Drug regulation and control, Scope and applications of biotechnology in pharmacy.

Drug discovery and Drug administration: Strategies for new drug discovery, finding a lead compound, combinatorial approaches to new drug discovery, pre-clinical and clinical trials. Routes of drug administration, membrane transport of drugs, absorption, distribution, metabolism and excretion of drugs. Factors modifying drug action, mechanism of drug action on human beings, receptor theory of drug action, pharmacogenomics, adverse effects of drugs and toxicology, Drug interactions.

Bioreactor selection and Operation: Production of pharmaceuticals by genetically engineered cells- hormones and vaccines. Regulatory issues in pharmaceutical products. Fermentation products in Pharmaceutical industry: Antibodies, Therapeutic proteins, Vitamins, Amino acids, Monoclonal Antibodies.

Quality control and Instrumentation: Quality control of antibiotic and non-antibiotic formulations using titrimetric, spectrophotometric, chromatographic methods as per IP/US Pharmacopoeia. Microbiological assays of vitamins and antibiotics. Sterility testing and stability testing of parenteral formulations.

Learning Resources:

Text Books:

1. Essentials of Medical Pharmacology, Tripathi, K.D., Jaypee Brothers Medical Publishers, 2008, 1st Edition.
2. Pharmaceutical Biotechnology, Dr. Oliver Kayser and Prof. Dr. Rainer H., Müller, Wiley, 2004, 1st Edition.

Reference Books:

1. Biopharmaceuticals: Biochemistry and Biotechnology, Walsh G., Wiley, 2013, 2nd Edition.
2. Pharmaceutical Biotechnology, Crommelin J.A. and Sindelar R.D., Routledge Taylor & Francis, 2003, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/108/102108077/
2. https://nptel.ac.in/courses/104/106/104106106/

Course Code: BT5163	Molecular pathogenesis	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Analyze human-pathogen interactions using modern understanding of Koch's postulates.
CO2	Understand the molecular basis of evolution of pathogens.
CO3	Select appropriate model to analyze specific interaction of host-pathogen.
CO4	Use suitable molecular technique to assess pathogenicity.
CO5	Relate the roles and regulations of virulence factors in pathogenicity.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	-	3	2	2
CO2	2	1	-	3	-	1
CO3	2	1	-	3	2	2
CO4	3	2	-	3	1	2
CO5	3	1	-	3	-	2

Syllabus:

Human microbiota and disease: Normal microbiota of human body and their interaction with host system. Characterization of human microbiota. Establishing connection between microbes and diseases—Koch's Postulates and its limitations. Modern alternatives to Koch's postulates, Concept of disease and virulence.

Molecular evolution of pathogens: Mechanisms of genetic variations, Different forms of mutations, chromosomal rearrangements, Horizontal gene transfer methods, Pathogenicity islands and pathogen evolution.

Molecular techniques and use of different models: Different animal and tissue culture models to measure pathogenicity—Experimental methods—LD_{50} and ID_{50} values estimation, competition assay, gentamicin protection and plaque assay, fluorescence microscopy methods. Different molecular approaches to identify pathogenic and host factors for establishing diseases.

Molecular mechanisms of pathogenicity: Strategies to evade host defense mechanisms—preinfection, colonization and evading host immunity. Production, secretion and delivery of different toxins and virulence factors. Different regulatory mechanisms for virulence genes, Quorum sensing.

Learning Resources:

Text Books:

1. Bacterial Pathogenesis: A Molecular Approach, Wilson, B. A., Salyers, A. A., Whitt, D. D. and Winkler, M. E. ASM Press, 2011, 3rd Edition.

Reference Books:

1. Molecular Pathology: The molecular basis of human disease, Wiliam coleman & Gregory Tsongalis, Academic Press, 2017, 2nd Edition.

2. Methods in Microbiology: Bacterial Pathogenesis, Vol. 27, Williams, P. Ketky, J and Salmond G, Academic Press, 1998.

Course Code: BT5164	Agricultural Biotechnology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Explain the concepts of Plant tissue culture techniques in agriculture and horticulture.
CO2	Understand the technology of Micorrizha using as Biofertilizers in agriculture.
CO3	Apply the applications of biotechnology in the field of agriculture.
CO4	Assess biosafety regulations in genetically modified crops.
CO5	Improve the quality character of commercial plants in oils and flavors.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	-	-	-	-
CO2	-	-	-	3	2	-
CO3	-	3	-	-	-	-
CO4	-	-	3	-	-	-
CO5	-	-	-	-	3	3

Syllabus:

Introduction to Agriculture: An introduction, Impact of Biotechnology on Agro-biodiversity; Biotechnology for Agriculture; Micropropagation Technology and its use in Agriculture. Role of biofertilizers and bio-pesticides in sustainable agriculture. Mass cultivation of microbial inoculants, plant growth promoting rhizobacteria diazotrophic microorganism, Free living and symbiotic nitrogen fixing microbes, Molecular basis of legume rhizobium symbiosis.

Biofertilizer in Agriculture: Mechanism of biological nitrogen fixation process. Study of nitrogen fixation, rhizobial nodulation gene and hydrogen uptake genes in nitrogen fixation process. Production of biofertilizers and applications of rhizobium, azotobacter, azolla and, micorrhiza: Applications in agriculture and forestry. Plant growth regulators in agriculture and horticulture.

Molecular application in Agriculture: Molecular aspects of biotic and abiotic stress responses and genetic engineering for drought, salinity and Temperature. Insect resistance – BT gene applications. Virus resistance – coat protein mediated, nucleocapsid gene and RNAi approach. Fungal resistance – PR proteins chitinase, beta glucanases. Nematode resistance - Nematode infestation and engineering for nematode resistance. Long shelf-life of fruits and flowers: use of ACC synthase, polygalacturanase, ACC oxidase. Male sterile lines: barstar and barnase systems. Genetic improvement of nutritional quality of oils.

Quality Improvement using Agricultural biotechnology: Improvement of qualitative characters – Nutritional value of storage products - elite strains rich in iron, protein and amino acids, golden rice and its colour – anthocyanines, betalaines, crocin and crocetins. Flavours – capsaicin, vanillin, stevioside thaumatin, The recent trends in agriculture.

Learning Resources:

Text Books:

1. Agricultural Biotechnology, Arie Altman, Marcel Dekker, Inc. 2012.
2. Biotechnology in Agriculture and Forestry, Bajaj YPS, Vol.22. Springer-Verlag.

Reference Books:

1. Agricultural Biotechnology at a Glance Dr. K.H. Singh Dr. Ajay Kumar Thakur, Dr. Nehanjali, Parmar science technology publisher; 2019,1st Edition.
2. Agricultural Biotechnology, H.D Kumar, Daya Publishing House, 2005.

Online Resources:

1. https://books.google.co.in/books/about/Agricultural_Biotechnology.
2. https://books.google.co.in/books/about/Agricultural_Biotechnology.

Course Code: BT5165	Machine Learning	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Explain the concepts involved in Machine learning.
CO2	Demonstrate various classification methods.
CO3	Apply SVM to solve biological problems.
CO4	Develop neural networks to solve classification problems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	3	3
CO2	3	3	2	1	3	3
CO3	3	2	3	1	3	3
CO4	3	3	2	2	3	3

Syllabus:

Introduction to Learning Methods: Introduction to Machine learning, why machine learning, when and where should use machine learning, types of systems of machine learning, block diagram of machine learning. Learning procedures; supervised and unsupervised learning, important algorithms in supervised learning, unsupervised learning, important algorithms in unsupervised learning, reinforcement learning, batch learning, online learning, instance-based learning, model-based learning.

Classification of Data: Classification, measures of performance, confusion matrix, recall, recall tradeoff, ROC, multi class classification, training a random forest classifier, multi-label classification, multi-output classification.

Support Vector Machines: Introduction to SVMs, Basic principles of classification, linear classifiers and nonlinear classifiers, regression, function of hyper plane, Kernel trick functions, clustering, law enforcement, computing, K-means clustering, SOM clustering, hierarchical clustering, Fuzzy clustering.

Applications of Neural Networks: Introduction to neural networks, differences between artificial neuron and natural neuron. Concept of perception, firing rules, architecture and topology of the neural networks, the learning process in NNs, transfer functions in neural network, Tensor flow. Artificial intelligence, Applications of Neural Networks to Secondary Structure Prediction, NN applications in Bioinformatics, SVM applications in Bioinformatics.

Learning Resources:

Text Books:

1. Machine Learning, Jason Bell, John Wiley & Sons, Inc, 2015.
2. Bioinformatics: The Machine Learning Approach, Pierre Baldi and Soren Brunak, MIT Press, 2nd Edition.

Reference Books:

1. Machine Learning, Rudolph Russell, Create Space Publishing, 2018.
2. Bioinformatics Sequence analysis, David W. Mount, Cold Spring Harbor Laboratory Press, 2nd Edition.

Online Resources:

1. https://nptel.ac.in/noc/courses/106/

Course Code: BT5166	Drug and Vaccine Informatics	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand the main components of a drug development project.
CO2	Design and analyze the lead molecules against the drug target.
CO3	Appraise the principles and concepts of protein structure, molecular dynamics simulations, and computer-aided drug discovery.
CO4	Learn and use various tools for *in silico* drug designing.
CO5	Perform and understand the interpretation of basic (statistical) analysis techniques on the resulting MD trajectories.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	3	3	3
CO2	3	2	-	3	3	3
CO3	2	-	-	3	-	3
CO4	3	-	-	3	-	3
CO5	3	3	-	3	-	3

Syllabus:

Insights into the Drug Design Process: Drug design process for a known protein target – Structure based drug design process, finding initial hits, Compound refinement, Ligand based drug design process, finding initial hits using online/offline software.

Installation of various drug design software, Introduction to protein structure and visualization tools: Pymol, VMD, Coot & Chimera. Generation and preparation of 3D optimized structure of “Ligand” and “Receptor” for Docking.

Molecular Docking: “Virtual library Preparation” of lead molecules, Docking of ligands into a receptor molecule, Flexible docking of ligand and target, Pharmacophore modelling of ligands, Pharmacophore-based database searching and de novo design of ligand against an active site.

Introduction to molecular dynamics simulation methods**,** Energy minimization and molecular dynamics (MD) target molecule**,** Force fields and parameterization**,** Estimates binding free energy of ligands and receptor, Introduction to molecular dynamics analysis methods.

Learning Resources:

Text Books:

1. Textbook of Drug Design and Discovery, Povl Krogsgaard-Larsen, Ulf Madsen, Kristian Stromgaard, CRC Press, 2017, 5th Edition.
2. Modern Methods of Drug Discovery, Gerhard Edwin Seibold, Alexander Hillisch & Rolf Hilgenfeld, Springer, 2003, 2nd Edition.

Reference Books:

1. Molecular Modelling for Beginners, Alan Hinchliffe, Wiley & Sons Inc, 2008, 2nd Edition.
2. Molecular Modeling and Simulation – An interdisciplinary Guide, Tamar Schlick, Springer, 2000, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/106/102106070/

Course Code: BT5167	Bioeconomy and Biorefineries	Credits 3-0-0: 3

Prerequisites: Biochemistry

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Compare oil and bioeconomy.
CO2	Analyze the biomass composition and structure.
CO3	Apply the concept of bio refinery to take over the oil dependent economy.
CO4	Utilize the synthetic biology and metabolic engineering principles for biofuels and biochemicals production.
CO5	Evaluate the standards and life cycle assessment of biofuels.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	2	1
CO2	3	2	3	3	3	1
CO3	3	1	3	3	3	1
CO4	3	2	3	3	3	2
CO5	1	2	2	2	2	1

Syllabus:

Introduction to Biofuels: Oil economy Vs Bio economy, working principle of IC engines, Biofuels in the global energy scene, National biofuel policy and law. Biofuel Feedstocks.

Biomass conversion and Bioprocess technologies: Classification of biofuels, Biomass composition and analysis. Biomass conversion technologies. First, second, third and advanced biofuels production technologies/process and challenges. Consolidated bioprocess engineering (CBP) for biofuels. Concept of Bio refinery: Biomass to value added compounds, Bioelectricity.

Synthetic biology and metabolic engineering for biofuels: Biomass converting enzymes and manipulations, Synthetic biology and metabolic engineering approaches (case studies) for biofuels production.

Analysis and assessment of Biofuels: Life Cycle assessment of biomass and biofuels, Standards of biofuels, Exergy analysis of biofuels.

Learning Resources:

Text Books:

1. Biofuels Engineering Process Technology, Caye M. Drapcho, Nhuan Ph Nghim, Terry H. Walker, McGraw Hill, New York, 2020, 2nd Edition.
2. Bioenergy Biomass to Biofuels and Waste to Energy, Anju Dahiya, Academic Press, 2020, 2nd Edition.

Reference Books:

1. Bioenergy Research: Advances and Applications, Vijai K. Gupta, Maria G. Tuohy, Christian P. Kubicek, Jack Saddler, Feng Xu, Elsevier B.V. Netherlands, 2014, 1st Edition.
2. Efficiency of Biomass Energy: An Exergy Approach to Biofuels, Power, and Biorefineries, Krzysztof J Ptasinski, John Wiley & Sons, 2015, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/104/102104057/

Course Code: BT5168	Advanced Bioprocess Instrumentation and Control	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand principles of Instrumentation and Control engineering.
CO2	Analyze different components of a control loop.
CO3	Inspect stability of the feedback control systems.
CO4	Design Biological Regulation and Control systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	-	-	-	1
CO2	2	3	2	2	-	2
CO3	3	3	2	-	-	1
CO4	2	2	2	-	3	2

Syllabus:

Control principles and their application in bioreactors: Open loop controller, closed loop controller - P, PI, PID, controller mechanism, final control element- control valve, valve characteristics, Block diagrams.

Transient response, Stability analysis and Frequency response: Transient response of simple control system, Tank in series, Stability analysis -Routh stability criterion; Frequency analysis, Bode plot.

Bioprocess control and Optimization: Measurement of process variables as the basis of bioprocess control. Applications of artificial intelligence (AI) approaches including fuzzy control, artificial neural network (ANN), and expert systems, to bioprocess control. Safety locks, interlock systems. Multivariable control; Model reference control; Adaptive control.

Biological System level Regulation and Control Analysis: Regulation of Glucose Insulin system, Respiratory Control system, Cardiac control system, Control analysis in systems and synthetic biology, Control analysis in drug delivery systems, Control Analysis in Systems and Synthetic Biology.

Learning Resources:

Text Books:

1. Process Systems Analysis and Control, Coughanowr D R., LeBlanc SE., McGraw-Hill, 2009, 3rd Edition.
2. Physiological control systems. Analysis, simulation, and estimation, Michael C K Khoo. Wiley, 2018, 2nd Edition.

Reference Books:

1. Control of Biological and Drug-Delivery Systems for Chemical, Biomedical and Pharmaceutical Engineering, Laurent Simon. Wiley, 2013.

Online Resources:

1. https://nptel.ac.in/courses/103/101/103101142/
2. https://engineeringmedia.com/

Course Code: BT5169	Advanced Biomaterials Engineering	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand common use and categorization of biomaterials as metals, ceramics and polymers and its chemical structure, properties and morphology.
CO2	Assess biocompatibility of materials.
CO3	Identify various applications of biomaterials.
CO4	Develop biomaterials and tissue culture scaffolds for specific applications.
CO5	Design bioreactors for specific biomaterials and applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	-	-	-	1
CO2	2	3	2	2	-	2
CO3	3	3	2	-	-	1
CO4	2	2	2	-	3	2
CO5	3	2	2	1	3	2

Syllabus:

Introduction to Biomaterials, Classification, Biomaterial Synthesis: Introduction, Property requirements of materials; Classification of Biomaterials: Metals and Metal alloys, Ceramics, Glass, Carbon, Polymers, composites, Natural Vs Genetically engineered materials, Biomaterials Vs Biological Materials, Nano Materials; Synthesis, characterization, and fabrication methods.

Biocompatibility of Biomaterials: Protein structure, interaction of proteins with synthetic materials. Surface engineering for biocompatibility; Characterization of cell material interactions; inflammatory responses; acute inflammation, chronic inflammation, foreign body response, assessment of material performance.

Biomaterial Applications: Orthopaedic, Orthodontic, Ophthalmic applications. Cardiovascular implants. Artificial vascular grafts. Skin repair/replacement materials. Scaffolds for tissue engineering and regenerative medicine applications, Biomaterials for drug delivery: Controlled Release applications.

Bioreactors Design, Entrepreneurship and Ethical Issues: Bioreactors for tissue engineering and bone engineering applications, Spinner flask bioreactor, rotating wall bioreactor, direct perfusion bioreactor and hollow fiber bioreactor; Ethical and legal Issues in Biomaterials and Medical Devices.

Learning Resources:

Text Books:

1. Biomaterials Science: An Introduction to Materials in Medicine, Buddy D. Ratner, Allan S Hoffman, Frederick J Schoen, Jack E Lemons, Academic Press, 2014, 3rd Edition.

2. Engineering of Biomaterials: Topics in Mining, Metallurgy and Materials Engineering Series, Carlos P. Bergmann, Santos dos V, Brandalise RN, Savaris M, Springer, 2017, 1st Edition.

Reference Books:

1. Biomaterials, Sujatha V. Bhat, Narosa Publishing house, 2010, 2nd Edition.
2. Biomaterials: An Introduction, Park J and Lakes R S. Springer USA, 2007, 3rd Edition.

Online Resources:

1. https://www.ibiology.org/speakers/robert-langer/

Course Code: BT5170	Medical Biotechnology	Credits 3-0-0: 3

Prerequisites: Cell biology, Molecular biology

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Develop an ability to use appropriate knowledge to analyze the molecular basis of diseases.
CO2	Implement the tools and techniques of biotechnology which provide a base for human healthcare.
CO3	Construct recombinant products for therapeutic applications.
CO4	Contribute to the advancement of knowledge in Medical & Pharmaceutical fields.
CO5	Apply appropriate techniques, resources, and modern tools.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	2	2	3
CO2	2	-	-	3	2	2
CO3	2	-	-	2	2	2
CO4	2	-	-	2	2	3
CO5	1	-	-	2	1	1

Syllabus:

Gene Therapy: Introduction, Types of Gene therapy: *In vivo* and *Ex vivo*; Somatic and Germline Gene therapy, Suicide Gene therapy - Suicide genes, bystander effect; Viral and non-viral vectors for Gene therapy, Clinical applications of Gene therapy, Safety and ethical issues in clinical gene therapy, Introduction and Methodologies involved in cellular therapy, Clinical applications of cellular therapy.

Antisense therapy: Concept of Gene silencing, Gene silencing techniques, Clinical applications of Gene silencing, Method of Antisense therapy, Therapeutic applications of Antisense technology.

RNA Therapy: Principal concept of mRNA pharmacology, Improving the translation and stability of mRNA, Immune-stimulatory activity of IVT mRNA, Structural modifications for tuning mRNA pharmacokinetics, Progress in improving mRNA delivery, Preclinical and clinical applications; MiRNA therapeutics.

Immunotherapy: Preface to Immunotherapy, Techniques involved in immunotherapy: Antibody phage display, Cr51 assay; Types of Vaccines, Construction and Clinical applications of Recombinant vaccines, Introduction and Therapeutic applications of Transgenics: Knock-out & Knock-in mouse, Xenomouse technology.

Learning Resources:

Text Books:

1. Medical Biotechnology, Judit Pongracz, Mary Keen, Churchill Livingstone, Elsevier, 2009, 1st Edition.
2. Medical Biotechnology, Jogdand S.N., Himalaya publications, 2011.

Reference Books:

1. Molecular Therapeutics, 21st Century Medicine, Pamela Greenwell, Michelle McCulley, John Wiley & Sons Ltd, 2007.

Online Resources:

1. https://www.nature.com/cgt/
2. https://www.nature.com/nrg/
3. https://www.nature.com/articles/nrd4278

Course Code: BT5171	Nanotechnology for Medicine and Healthcare	Credits 3-0-0: 3

Prerequisites: Elementary physics, Molecular Biology, Biochemistry

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Illustrate the basic principles of nanotechnology.
CO2	Classify physical, chemical and biological methods for synthesis of nanomaterials.
CO3	Identify nanostructures for drug delivery and gene therapy.
CO4	Apply the concepts of nanotechnology for biosensors, bioseparation and other healthcare applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	-	-	-
CO2	-	2	-	-	-	-
CO3	2	3	2	3	1	1
CO4	2	3	1	3	-	-

Syllabus:

Structural and Functional principles of nanobiotechnology: Introduction to nanotechnology, Types of nanomaterials: Nanoparticles, Nanowires, Nanotubes, Thin films and Multilayers, Properties of Nanomaterials, Biomolecules as Nanostructures, Molecular Motors.

Synthesis and characterization of nanomaterials: Methods of preparation of nanomaterials, Nanoparticle synthesis using microbes, Basic characterization techniques: Electron microscopy, Atomic force microscopy, Photon correlation spectroscopy. Functionalization of nanomaterials for biological applications.

Nanobio-Analytics: Luminescent quantum dots for biological labelling. Applications of nanomaterials in optical and electrochemical biosensors. Nanomaterials in Bioseparation, Nanotechnology for cancer diagnosis

Nanobiotechnology in Medicine and Health: Nanostructures for drug delivery, Nanovesicles; Nanospheres; Nanocapsules, Magnetic nanoparticles; Liposomes; Dendrimers, Targeting, Routes of delivery and advantages, Cellular uptake mechanisms of nanomaterials, Drug-Photodynamic therapy, gene therapy. Recent trends in nanobiotechnology, Nanotoxicology, Nanotechnology in tissue engineering.

Learning Resources:

Text Books:

1. Nanotechnology –a gentle introduction to the next big idea, M. Ratner and D. Ratner, Pearson education, Latest edition, 2007.
2. Nanotechnology-Science, Innovation and opportunity, L. E. Foster, Person education inc, Latest edition, 2007.

Reference Books:

1. Nanobiotechnology: Concepts, Applications and Perspectives, Christof M. Niemeyer, Chad A. Mirkin, 2004.
2. Nanobiotechnology: An Introduction, Clive Jarvis, 2018.

Online Resources:

1. https://www.nanowerk.com/nanobiotechnology.php

Course Code: BT5172	Entrepreneurship, IPR, Biosafety & Bioethics	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:
At the end of the course, the student will be able to:

CO1	Realize the importance of embarking on self-employment.
CO2	Understand the commercial knowhow for biotechnological ventures.
CO3	Identify issues in protection of biotechnology inventions.
CO4	Assess the biosafety risks and suggest containment requirements.
CO5	Adapt with bioethics principles.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	-	-	3
CO2	-	3	2	-	2	3
CO3	1	2	-	2	3	3
CO4	-	2	-	2	2	3
CO5	-	-	3	-	2	3

Syllabus:

Entrepreneurship: Introduction to biotechnology entrepreneurship; five essential elements for growing biotechnology clusters; characteristics of successful biotechnology leaders; understanding biotechnology product sectors; technology opportunities: evaluating the idea, understanding biotechnology business models and managing risk; licensing the technology: biotechnology commercialization strategies, intellectual property protection strategies for biotechnology innovations; biotechnology products and their customers: developing a successful market strategy; ethical considerations for biotechnology entrepreneurs.

Intellectual property Rights: Biotechnology and intellectual property; patentability of biotechnology inventions in India; patentability of biotechnology under the international patent regime; legal, social and policy implications of genetic patents; intellectual property protection to bioinformatics, genomic databases and open source analogy to biotechnology; implications of genetic patents on human genetic resources.

Biosafety: Hazard identification: microbial flora of humans and microbial virulence factors; laboratory-associated infections; hazard assessment: risk assessment of biological hazards; hazard control: design of biomedical laboratory and specialized biocontainment facilities; primary barriers and equipment-associated hazards; primary barriers: biological safety cabinets, fume hoods, and glove boxes; aerosols in the microbiology laboratory; personal respiratory protection; standard precautions for handling human fluids, tissues, and cells; decontamination in the microbiology laboratory; special environments: biological safety and security in teaching laboratories; biosafety in the pharmaceutical industry; biosafety considerations for large-scale processes.

Bioethics: Bioethics and ethics; cloning; human enhancement; bio-information; security and defence; food and energy security; bio-ownership; human justice; non-human animals; the living and non-living environment.

Learning Resources:

Text Books:

1. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies, Craig Shimasaki, Elsevier Science, 2020, 2nd Edition.
2. Biotechnology and Intellectual Property Rights: Legal and Social Implications, Kshitij Kumar Singh, Springer Nature; 2015, 1st Edition.

Reference Books:

1. Biological Safety: Principles and Practices, Dawn P. Wooley, Karen B. Byers, ASM Press, 2017, 5th Edition.
2. Bioethics: An Introduction, Marianne Talbot, Cambridge University Press, 2012, 1st Edition.

Online Resources:

1. https://www.biotech.co.in/en/publications-0

Course Code: BT5173	Research Methodology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Summarize the concepts of Research and types of research.
CO2	Illustrate research problems and ethics in scientific Research.
CO3	Make use of scientific tools in Research design and analysis.
CO4	Create a Report on the research carried out.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	2	3	2	3	2	3
CO3	2	3	3	3	2	3
CO4	2	3	3	2	3	3

Syllabus:

Introduction to Research Methodology: Introduction to research: Motivation and objectives, Research approach, research process, significance research, criteria for good research, research methods vs. methodology. Types of research– descriptive vs. analytical, applied vs. fundamental, quantitative vs. qualitative, conceptual vs. empirical.

Research formulation: Defining and formulating the research problem, selecting the problem, technique involved in defining a problem, literature review and technical reading, analysis and synthesis of prior art, bibliographic databases. Ethics in research, scientific conduct and misconduct.

Research design and methods: Basic principles, features of good design, observation and facts, laws and theories, features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, hypothesis, development of models, developing research plan – exploration, description, diagnosis, and experimentation. Execution of the research, data collection and analysis.

Reporting and thesis writing: Structure and components of scientific reports, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, thesis writing – different steps and software tools in the design and preparation of thesis, layout, structure (chapter plan), Illustrations and tables, bibliography, referencing and footnotes. Scholarly publishing – IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability.

Learning Resources:

Text Books:

1. Research Methodology: Methods and Techniques, C.R. Kothari, New Age International (P) Ltd. Publishers, 2014.
2. Engineering Research Methodology, A Practical Insight for Researchers, Dipankar Deb, Rajeeb Dey, Valentina E. Balas, Springer Nature Singapore Pvt Ltd, 2019.

Reference Books:

1. Research Methodology in the Medical and Biological Sciences, Petter Laake, Haakon Breien Benestad, and Bjorn Reino Olsen, Elsevier, 2007.

Course Code: BT5174	Applied Environmental Microbiology	Credits 3-0-0: 3

Prerequisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Describe environmental challenges by developing a fundamental understanding of the microbial communities and processes in natural and built environments.
CO2	Predict the effect of environmental parameters and operational factors on performance.
CO3	Understand the role of microbes in biological processes in different ecosystems.
CO4	Explain the microbial ecosystem and role of mix culture microbes in the biological wastewater treatment process.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	2	3
CO2	2	1	3	2	3	3
CO3	2	1	2	3	2	2
CO4	2	2	3	2	2	2

Syllabus:

Introduction: cell elements and composition Cell and its composition, cytoplasmic membrane Prokaryotic cell division Microbes and their environmental niches Historical roots of microbiology Nucleic acids and amino acids DNA structure, replication, and manipulation Protein and its structure Regulation Microbial nutrition Light microscopy, 3D Imaging, AFM, Confocal scanning laser microscopy.

Microbial energetics and diversity: Stoichiometry and bioenergetics Oxidation-reduction NAD, energy-rich compounds and energy storage Mathematics of microbial growth Glycolysis Respiration Citric-acid cycle Catabolic Alternatives Phototrophy, Chemolithotrophy, anaerobic respiration (Nitrate and Sulfate reduction; Acetogenesis; Methanogenesis; Metal, Chlorate, and organic electron acceptors).

Microbial metabolism and functional diversity of bacteria: Prokaryotic diversity Classical taxonomy Origin of life Tree of life Major catabolic pathways Catalysis and enzymes Energy conservation Sugars and polysaccharides, amino acids, nucleotides, lipids.

Microbial ecosystems: Population, guilds, and communities Environments and microenvironments Microbial growth on surfaces Environmental effects on microbial growth.

Environmental genomics and microbial ecology: genetic exchange Environmental genomics Microbial ecology Horizontal and vertical gene transfer: Replication, Transformation Transduction.

Bioremediation and wastewater microbiology: Bioremediation and examples, Acid mine drainage, Enhanced metal recovery, Wastewater microbiology.

Drinking water microbiology: Drinking water microbiome and treatment, Microbial instability, Water borne microbial diseases.

Solid waste microbiology: Antimicrobial resistance, Landfills, Leachate, Anaerobic degradation phases, Antimicrobial resistance.

Learning Resources:

Text Books:

1. Environmental Microbiology, Ian L. Pepper, Charles P. Gerba and Terry J Gentry, Academic Press, 2014, 1st Edition.
2. Environmental Microbiology, Ralph Mitchell, Ji-Dong Gu, Wiley-Blackwell, 2010, 2nd Edition.

Reference Books:

1. Environmental Biotechnology: Principles and Applications, Bruce E. Rittmann, and Perry L. McCarty, McGraw-Hill, 2017, 2nd Edition.
2. Brock Biology of Microorganisms, Madigan, M, Bender K. S, Buckley D.H, Sattley W. M, and Stahl D.A. Brock, Pearson, 2020, 16th Edition.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ce07/preview

Course Code: BT6147	Comprehensive Viva-Voce	Credits 0-0-0: 2

Prerequisites: Both I & II Semester course work of I year

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Assimilate knowledge of different courses studied.
CO2	Develop overall comprehension about Biotechnology.
CO3	Analyse real life Biotechnology problems with theoretical knowledge learned.
CO4	Interpret and Articulate solutions to real life Biotechnology problems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	3	3
CO2	3	-	1	3	3	3
CO3	3	-	1	3	3	3
CO4	3	-	2	3	3	3

Syllabus:

Entire course of study (All the required courses studied) up to II Semester of I Year.

Learning Resources:

1. Reading Material of all the courses.
2. Case Studies/Industrial training reports.
3. Mini projects taken up.

Course Code: BT6149	Dissertation Work Part-A	Credits 0-0-0: 12

Prerequisites: Both I & II Semester course work of I year should be completed

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Define Research Problem Statement.
CO2	Critically evaluate literature in chosen area of research & establish scope of work.
CO3	Develop a detailed study methodology.
CO4	Carryout pilot theoretical study/experiment.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	3	3
CO2	3	2	1	3	3	3
CO3	3	2	1	3	3	3
CO4	3	-	2	3	3	3

Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his / her dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. Students are required to submit a dissertation report on the research work carried out by him/her.

Learning Resources:

1. Journal Publications.
2. Conference / Seminar Proceedings.
3. Handbooks / Research Digests/ Textbooks.

Course Code: BT6199	Dissertation Work Part-B	Credits 0-0-0: 20

Prerequisites: Both I & II Semester course work of I year should be completed

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Expand on the defined Research Problem statement.
CO2	Formulate the objectives and plan experimental / theoretical study.
CO3	Conduct Laboratory/analytical studies.
CO4	Analyse Data, develop models and offer solutions.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	3	3	3
CO2	3	2	1	3	3	3
CO3	3	2	1	3	3	3
CO4	3	3	2	3	3	3

Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his / her dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. Students are required to submit a dissertation report on the research work carried out by him/her.

Learning Resources:

1. Journal Publications.
2. Conference / Seminar Proceedings.
3. Handbooks / Research Digests/ Textbooks.
4. Previous thesis books.

NOTE: Refer to the following link for the guidelines to prepare dissertation report:

https://www.nitw.ac.in/main/PGForms/NITW/