NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

Minor in

BIOTECHNOLOGY

SCHEME OF INSTRUCTION AND SYLLABI

(for B.Tech. students other than Biotechnology)

(Effective from 2021-22)

DEPARTMENT OF BIOTECHNOLOGY

SCHEME OF INSTRUCTION

Minor Program in – Biotechnology

S. No.	Course Code	Course Name	L	T	P	Credits	Sem.
1	BTM01	Essential Biochemistry	2	0	2	3	III
2	BTM02	Foundations in Cell Biology	2	0	2	3	IV
3	BTM03	Principles of Bioprocess Engineering	2	0	2	3	V
4	BTM04 BTM05	Elements of Bioseparations Technology / Systems Biology for Engineers	2	0	2	3	VI
5	BTM06 BTM07	*In silico* Drug Discovery / Introductory Modelling Simulation and Optimization of Bioprocesses	2	0	2	3	VII
6	BTM99	Mini Project	0	0	6	3	VIII
Total			**12**	**0**	**14**	**18**	

Course Code: BTM01	ESSENTIAL BIOCHEMISTRY	Credits 2-0-2: 3

Pre-Requisites: None

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

CO1	Identify the structure and functions of biomolecules
CO2	Understand complex biochemical pathways and metabolism
CO3	Determine the kinetic parameters of enzymatic reactions
CO4	Estimate and separate biomolecules using Chromatography and Electrophoresis
CO5	Demonstrate biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents

Syllabus:

Introduction: The Facts of Life, Water: The Medium of Life, pH, acids, bases, buffers, weak bonds and covalent bonds. Thermodynamics of Biological Systems.

Molecules of Life: Amino acids and Peptides: Classification of amino acids, Structure and properties of amino acids, Peptide bond and peptide Proteins: Structure and Classification of Proteins. Primary structure, Secondary structure, Tertiary structure and Quaternary structure, aggregated proteins, Structural importance in function, denaturation and renaturation. Nucleic acids: Structure of nucleic acids, Structure of DNA, specialized secondary structures, Principle kinds of RNA and their structures, Carbohydrates: Structure and functions of carbohydrates and glycoproteins. Lipids: Structure of Fats and Oils, Phospholipids, membrane lipids, Vitamins: Introduction, classification and functions of vitamins, disease of vitamins deficiency.

Metabolism: Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway, The Citric Acid Cycle, Amino Acid Oxidation, Oxidative Phosphorylation and Photophosphorylation, DNA Metabolism, RNA Metabolism, Protein Metabolism, Analytical techniques in biochemistry for small molecules and macro- molecules for quantification.

Enzymes: Enzymes and Enzyme Kinetics: Enzymes as biological catalysts, classification, Examples of enzymes catalyzed reactions, Michaelis–Menten approach to enzyme kinetics, and mechanism of enzyme action

Laboratory: Any five experiments

1. Qualitative analysis of carbohydrates, amino acids and proteins.
2. Quantitative estimation of protein by Biuret method and Lowry method.
3. Quantitative estimation of reducing sugars by DNS method.
4. Quantitative estimation of total sugars by anthrone method.
5. Quantitative estimation of DNA by diphenylamine method.
6. Quantitative estimation of RNA by orcinol method.
7. Determination of absorption maxima (λ_{max}).
8. Estimation of nucleic acids andprotein purity by spectrometric analysis.
9. Quantitative estimation of protein and nucleic acids concentration by UV-absorption method.
10. Effect of substrate concentration and determination of Michaelis–Menten parameters V_{max}& K_m.

11. Separation of amino acids by thin layer chromatography
12. Determination of molecular weight of a protein by SDS-PAGE.

Learning Resources:

Text Books:

1. Lehninger Principles of Biochemistry, David L. Nelson,Michael M. Cox, W. H. Freeman and Company, 2017, 7th Edition.
2. Biochemistry, Reginald H. Garrett, Charles M. Grisham, Cengage Learning, 2017, 6thEdition.
3. Practical Biochemistry: Principles and Techniques, Keith Wilson and John Walker, Cambridge University Press,2000, 5thEdition.

Reference Books:

1. Harpers Illustrated Biochemistry, Victor Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly and P. Anthony Weil, Tata McGraw – Hill, 2015, 30thEdition.
2. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Jr., and LubertStryer, Macmillan, 2015, 8thEdition.

Online Resources:

1. https://nptel.ac.in/courses/104/105/104105076/

Course Code: BTM02	FOUNDATIONS IN CELL BIOLOGY	Credits 2-0-2:3

Pre-Requisites: BTM01

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

CO1	Understand cell theory and cellular compartmentalization
CO2	Describe structure and function of the plasma membrane and cell organelles.
CO3	Comprehend the molecular mechanisms of cell cycle.
CO4	Relate the importance of cell cycle on cancer development
CO5	Explain the role of apoptotic cell death in cellular development
CO6	Perform cell manipulation techniques used in basic cell biology research.

Syllabus:

Introduction to Cell, Structure and Function: Discovery of cells & Basic properties of cell, Cell theory; Cell complexity, Different classes of cells; Prokaryotic & Eukaryotic cell. Structural organization and function of intracellular organelles, Cell membrane components, Basics of membrane transport systems.

Cell Division and Cell Cycle: Mitosis, meiosis, cell cycle checkpoint, molecular mechanics of cell cycle, role of cyclin dependent kinases in controlling the cell cycle, cell death and cell renewal.

Cell Signaling: Introduction to cell signaling, Intracellular signaling and types of signal receptors, Signal Transduction by hormones - Steroid / Peptide hormones, Concept of Secondary messengers.

Stem Cells and Cancer: Embryonic and adult stem cells, Cell differentiation, Cancer biology basics, Characteristics of Cancer Cells, Types of Tumors, Molecular Basis of Cancer – Proto oncogene, Tumor Suppressor gene.

Laboratory: Any five experiments.

Demonstration of microscopes, determining the cell concentration using hemocytometer, smear preparation and staining (bacteria, animal and plant cells), cell division – mitosis, microscopic determination of cell viability using membrane permeability assay, fluorescent labeling and microscopic detection of cellular components (direct and indirect labeling).

Learning Resources:

Text Books:

1. The Cell: A Molecular Approach, Geoffrey M. Cooper, Robert E Hausman, Oxford University press, 2015, 7thEdition.
2. Karp's Cell and Molecular Biology, Karp, G., Iwasa, J., Marshall, W. Wiley, 2019. 9thEdition.

Reference Books:

1. Molecular Biology of the Cell, Bruce Alberts, Alexander D. Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts: Garland Science, 2015, 6thEdition.

2. Laboratory Investigations in Cell and Molecular Biology, Allyn A. Bregman, Wiley, 2001, 4th Edition.

Online Resources:

1. The Cell, An Image Library (http://www.cellimagelibrary.org/home)
2. The Hidden Life of the Cell (https://www.dailymotion.com/video/x1f26gz)

Course Code: BTM03	PRINCIPLES OF BIOPROCESS ENGINEERING	Credits 2-0-2:3

Pre-Requisites: None

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

CO1	Understand the roles and responsibilities of a bioprocess engineer
CO2	Understand sterilization techniques and estimate the sterilization time
CO3	Comprehend rheology of fermentation fluids& determine power requirement in bioreactors
CO4	Develop design equations for bioreactors & calculate oxygen demand for cell growth.
CO5	Understand the scale up concepts for bioprocesses.
CO6	Identify sensors and instruments needed for measurement and control

Syllabus:

Introduction to Bioprocessing: Role of a bioprocess engineer, Kinetics of microbial growth, substrate utilization and product formation; Simple structured models, Design of fermentation media.

Sterilization: Media sterilization; kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilization, sterilization of air and filter design, Radiation and chemical sterilization.

Batch, Fed-Batch and Continuous Processes: Operation of batch, continuous and fed-batch processes and industrial applications, Comparison of batch, fed-batch and continuous processes.

Rheology of Fermentation Fluids: Newtonian and non-Newtonian fluids, Aeration and agitation, power requirement for gassed and un-gassed systems, time calculation for mixing.

Mass Transfer in Bioreactors: Theories of mass transfer, metabolic oxygen demand, measurement of KLa, Maximum cell concentration

Instrumentation in Bioreactors: On-line and off-line measurement various types of microbial and enzyme reactors, Bioreactor Considerations for Animal Cell Culture and plant cell culture. Fermentation: Structured and Unstructured Models, Optimization of Fermentation media.

Laboratory: Any five experiments.

Growth kinetics of bacteria in a fed-batch reactor, enzyme immobilization, microbial death kinetics, residence time distribution, fluidized bed bioreactor for cell cultivation, determination of mixing time and power number in chemostat, effect of temperature, pH substrate concentration on enzyme activity, inhibition kinetics and estimation of biomass.

Learning Resources:

Text Books:

1. Bioprocess Engineering Principles. By Paulin M. Doran. Elsevier Science & Technology Books, 2008, 2nd Edition.
2. Biochemical Engineering Fundamentals, Second Edition, James E. Bailey, David F. Ollis.

Mc Graw Hill, 2004, 2nd Edition.
3. Bioprocess Engineering Basic Concepts 2nd Edition, Michael Shuler, FikretKargi. Prentice-Hall India, 2006, 2nd Edition.

Reference Books:

1. Bioprocess Engineering: Kinetics, Mass Transport, Reactors and Gene Expression by Wolf. R. Vieth. A Wiley-Inter science Publication, 2009, 1st Edition.
2. Principles of fermentation technology, P F Stanbury and A Whitaker, Pergamon press, 2005, 3rd Edition.

Online Resources:

1. https://www.kgi.edu/news/what-is-bioprocess-engineering/
2. https://www.labmanager.com/big-picture/bioprocessing-overview-and-trends/the-basics-of-bioprocess-engineering-25963

Course Code: BTM04	ELEMENTS OF BIOSEPARATIONS TECHNOLOGY	Credits 2-0-2:3

Pre-Requisites: BTM03

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

CO1	Understand separation techniques used in downstream process
CO2	Design and optimize downstream processes
CO3	Understand the requirements for successful operation of downstream processes
CO4	Understand the principles of major unit operations used in downstream processing of biopharmaceuticals.

Syllabus:

Scope of Bioseparations Technology: Importance of Bioseparations technology in biotechnology, Characteristics of products, criteria for selection of bio-separation techniques. Economics of bioseparations in biotechnology, cost-cutting strategies

Recovery of Intracellular Products: Cell disruption methods – physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear) – chemical methods (alkali, detergents) – enzymatic methods.

Solid- Liquid Separation: Centrifugation: Principles of centrifugation, various centrifuges; basket centrifuge, tabular centrifuge, disc-bowl centrifuge. Membrane separation processes: Basic principles of membrane separation, different types of membranes, criteria for selection of membranes.

Chromatography: Principles of chromatographic separation methods, different types of chromatographic methods, ion – exchange chromatography, gel chromatography, affinity chromatography etc. Applications in bio-processing. Electrophoresis of proteins, Protein Precipitation, Dialysis; Extraction and Freeze Drying.

Laboratory: Any five experiments.

Extraction of intracellular proteins by cell disruption methods, centrifugation methods, precipitation methods, dialysis, lyophilization, ion exchange chromatography, gel filtration chromatography, affinity chromatography, tangential filtration methods, NATIVE electrophoresis, storage methods for isolated products.

Learning Resources:

Text Books:

1. Bioseparations: Downstream Processing for Biotechnology, Paul A. Belter, Wiley-Blackwell, 2008, 1st Edition.
2. Bioseparations: Principles and Techniques, Sivasankar, Prentice Hall India, 2010, 1st Edition.
3. Downstream Process Technology, Prasad, Prentice Hall India, 2010,1st Edition.

Reference Books:

1. Product Recovery in Bioprocess technology, BIOTOL series, Butterworth –Heinemann,

2010, 1st Edition.
2. Principles of Downstream processing, by Ronald & J. Lee, Wiley Publications, 2007, 1st Edition.
3. Handbook of Bioseparations, Ahuja S, Academic Press, 2000, 1st Edition.
4. Bioseparations: Science and Engineering, Harrison RG, Oxford University Press, 2003, 1st Edition.
5. Protein Purification: Principles and Practice: Scopes, Robert K, Springer, 2014, 3rd Edition.
6. Downstream Processing of Proteins: Methods and Protocols, Mohamed A. Desai, Humana Press, 2012, 1st Edition.

Online Resources:

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

Course Code: BTM05	SYSTEMS BIOLOGY FOR ENGINEERS	Credits 2-0-2:3

Pre-Requisites: BTM01, BTM03

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

CO1	Understand basic, advanced principles of systems biology and biological networks applications
CO2	Understand networks behavior and emergent properties of biological networks/ systems
CO3	Apply kinetics principles to develop systems level mathematical models in biology
CO4	Create predictive mathematical models of biological interaction networks to explore their emergent behavior
CO5	Draw insights form systems level models/ studies for biotechnological and biomedical applications

Syllabus:

Systems Biology Fundamentals: Introduction to systems biology; high throughput experimental techniques: gene array, protein array, two-hybrid systems; model formulation based on enzyme kinetics, Michaelis-Menten kinetics, mass actions kinetics, Hill equation, steepness, threshold phenomenon, ultra-sensitivity, steady state, dynamic and stochastic models in system biology.

Molecular Networks to Cellular Behavior: Emergent properties of biological networks; complexity, adaptability, biostability, robustness and evolvability; introduction to network motifs, elements of transcription networks, dynamics and response time of simple gene regulation, autoregulation, feed forward loops (FFLs), temporal expression programs and global structure

Case Studies, Computations Tools and Applications: Signal transduction networks, E. coli chemotaxis network, infection model, robustness patterning in development- morphogen profiles, fruit fly patterning, threshold and negative feedback loop in rhythmic processes (oscillations) of complex biological system, Computational tools and software packages, Synthetic biology: building and analyzing synthetic networks, systems pharmacology, Systems Biology and Artificial Intelligence.

Laboratory: Any five experiments

Dynamics of a simple gene regulation, Dynamics of small interaction network with coupled ODE, Bi-stable Switch and Multi-stability, Dynamics of Circadian Rhythm and limit cycle, Dynamics of MOTIFs, Pattern formation using PDE. Dynamics of Prey-predatory model, Dynamics of SIR model and disease spread.

Learning Resources:

Text Books:

1. Introduction to Systems Biology, Uri Alon, Chapman and Hall / CRC Mathematical and Computational Biology, 2007, 1st Edition.

2. Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts, Zoltan Szallasi, JörgSterlling, Vipul Periwal, Prentice Hall of India, 2007, 1st Edition.

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. CRC press, Taylor and Francis Group, 2021, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/106/102106068/
2. https://www.ibiology.org/bioengineering/challenges-in-synthetic-biology/

Course Code: BTM06	*IN SILICO* DRUG DISCOVERY	Credits 2-0-2: 3

Pre-Requisites: None

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

CO1	Understand the concept of structure-function relationship of lead molecules in drug discovery
CO2	Understand the process of target identification in drug discovery
CO3	Apply proteomics and genomics techniques in drug-discovery and design process
CO4	Understand the drug delivery systems
CO5	Design new drugs using computational methods

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.

Stereochemistry in Drug Design: Peptides, Peptidomimetics. Bonded and non - bonded interactions, Drug delivery systems for proteins, peptides with special reference to oral & nasal routes. Delivery consideration of biotechnological products: Stability profile, Barriers to peptides, protein delivery, Delivery of protein and peptide drugs, Toxicity profile characterization, druggable targets.

Computational Approaches: Quantification of Molecular diversity and design of compound libraries, physicochemical concept of in drug design. History of QSAR, 2D-QSAR; 3D-QSAR, descriptors of QSAR, Tools and techniques of QSAR, Parameters Used in QSAR, Applications of QSAR, 3D pharmacophore hypothesis

Introduction to Docking: Scoring functions, Docking Process – Protein Preparation, Building the ligand, setting the bounding box, running the docking calculations. Molecular docking software and their utilities in drug design. High-throughput screening.

Laboratory: Any five experiments

Design and 2D sketching of ligand /drug, introduction to protein structure and visualization tools, generation and preparation of 3D optimized structure of ligand and receptor for docking, docking of receptor-ligand and analysis of results, docking of protein-protein and analysis of results, estimation of binding free energy of ligands and receptor, introduction to molecular dynamics simulation methods, introduction to molecular dynamics analysis methods.

Learning Resources:

Text Books:

1. Textbook of Drug Design and Discovery, PovlKrogsgaard-Larsen, Ulf Madsen, Kristian Stromgaard, CRC Press, 2017, 5th Edition.
2. Modern Methods of Drug Discovery, Gerhard Edwin Seibold, Alexander Hillisch, Rolf Hilgenfeld, Birkhauser, 2003, 1st Edition.
3. Modern Biopharmaceuticals: Design, Development and Optimization. JorgKnablein, Wiley

– VCH, 2005, 1st Edition.
4. Molecular Modelling, Principles & Applications, Andrew R. Leach, Addison Wesley Longman, Singapore, 1996, 1st Edition.
5. Molecular Modelling and Simulation – An interdisciplinary Guide, Schlick, Tamar, Springer, 2010, 1st Edition.
6. David C Young: Computational Drug Design (A guide for computational and medicinal chemists) Wiley & Sons, Inc., New Jersey, USA, 2009, 1st Edition.

Reference Books:

1. Molecular Modelling for Beginners, Alan Hinchliffe, Wiley & Sons Ltd. 2008, 2nd Edition.
2. Advanced Drug Design and Development: A medicinal Chemistry Approach. Kourounakis Taylor and Francis, 1994, 1st Edition.
3. Computational medicinal chemistry for drug discovery, Patrick Bultinck, Marcel Dekker, CRC Press, 2004, 1st Edition.

Course Code: BTM07	INTRODUCTORY MODELLING, SIMULATION AND OPTIMIZATION OF BIOPROCESSESS	Credits 2-0-2: 3

Pre-Requisites: BTM03

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

CO1	Understand modeling principles
CO2	Formulate balance equations
CO3	Analyze batch, semi continuous / fed batch operation
CO4	Develop enzyme and growth kinetic models
CO5	Comprehend bioreactor modeling
CO6	Develop models for biological systems

Syllabus:

Introduction to Modeling: - Modeling principles, use of models for understanding, design and optimization of bioreactors, concepts of models, types of models., use of models in bioprocess.

Classification of Models: Mathematical model, Physical models, static and dynamic models, analytical and mathematical models, linear and nonlinear models, stable and unstable models, steady state and transient models, descriptive and normative models, distributed lag model, mechanistic models, structured and unstructured models, segregated and un segregated models

Approaches for Model Development: Mass balance models, formulation of balance equations, types of mass balance equations, balancing procedure, continuous stirred tank bioreactor, tubular reactor, component balances for reacting systems, constant volume continuous stirred tank reactor, semi-continuous reactor with volume change, steady-state oxygen balancing in fermentation, bioreactor modeling, biomass productivity, modeling of tubular plug flow bioreactors, simulation examples of biological reaction, processes using Berkeley Madonna, batch fermentation, chemostat fermentation, fed batch fermentation, kinetics of enzyme action, repeated fed batch culture

Laboratory: Any five experiments

Bioprocess Modeling using SuperPro Designer: Flow sheeting of the bioprocess using SuperPro designer, design of various bioreactors using SuperPro designer, case studies of bioprocess optimization.

Learning Resources:

Text Books:

1. Bioreactors: Analysis and Design, Panda, Tapobrata, McGraw-Hill Education, 2011, 1st Edition.
2. Biological Reaction Engineering: Dynamic Modeling Fundamentals with Simulation Examples, I. J. Dunn, E. Heinzle, J. Ingham, J. E. Pfenosil, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheitn, 2003, 1st Edition.

Reference Books:

1. Modeling and Control of fermentation Processes, J.R. Leigh, Peter Peregrinus, London, 2000, 1st Edition.
2. Hand book of food and bioprocess modeling techniques, Syam S. Sablani, Taylor & Francis Group, LLC, 2006, 1st Edition.

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